AUDITOR DECISION MAKING UNDER AMBIGUITY:
A TEST OF THE EINHORN AND HOGARTH AMBIGUITY MODEL

DISSERTATION

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by
Daphne Main
To my mother,
Eleanor Wingate Elliott Main,
who always said
“This too shall pass.”
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Chapter I
Introduction

An auditor makes many decisions in forming an opinion on a set of financial statements. Many of these decisions are based on predictions of the outcomes of future events. Often, the auditor has only limited knowledge of the probability that a particular outcome at issue will occur (e.g., as with a contingent event), or will occur in a particular way. This condition may be described by the term “ambiguity,” where ambiguity is defined as the case where there is some defining information about the underlying probability distribution, but not enough to define a unique probability distribution for the data. The extent to which auditors’ decisions are influenced by the presence or absence of ambiguity may have implications for audit efficiency and effectiveness (e.g., if auditors add too large or too small a “cushion” to their estimates of amounts related to contingent events, over- or under-auditing may result).

Given that ambiguity may be so pervasive in an audit, it is surprising that the topic has not been more thoroughly addressed. Prior research on ambiguity in auditing has examined personality factors of auditors that relate to how ambiguity is handled (e.g., ambiguity tolerance or intolerance, e.g., Dermer [1973] and Faircloth & Ricchiute [1981]) or has suggested various systems of logic that may be useful in the evaluation of ambiguous audit evidence (e.g., Larsson & Chesley [1986] and Shafer & Srivastava [1987]). However, the cognitive processes underlying audit judgments made under ambiguous circumstances have not been examined.
Einhorn and Hogarth [1985, 1986; Hogarth & Einhorn, 1988; Hogarth, in press] have presented a descriptive model of decision making under ambiguity. In this study, I extended that ambiguity model to the domain of audit decision making. Frequently, the appropriateness of decision models is limited to the context for which they were developed, so it is necessary to test the descriptive and predictive validity of a model in the domain of interest before applying and extending it [Hammond, 1986]. The experimental audit tasks required subjects to use professional judgment in an audit situation involving two levels of ambiguity (nonambiguous and ambiguous), varying dollar amounts, and varying levels of probability of the outcomes of concern. Subjects were also asked to perform several urns-and-balls tasks such as those originally used by Ellsberg [1961] to demonstrate the effects of ambiguity on choice. The auditors' performance on these tasks were compared with the performance of other subject groups and with their performance on the audit judgment tasks.

The study is organized as follows: Decision making theories under uncertainty are discussed, including the normative theory of subjective expected utility and some of its modifications, and also the descriptive ambiguity model of Einhorn and Hogarth [1985, 1986; Hogarth & Einhorn, 1988; Hogarth, in press]. Prior relevant research in auditing and accounting decision making under uncertainty is discussed. The research, testing the applicability of the ambiguity model to the auditing context, is then described. The results are reported and discussed in relation to the decision making theories reviewed, the prior research, and the audit practice issues. Samples of the experimental materials and the debriefing questionnaire for this study are included as the appendices.
Chapter II
Previous Research

Decision making in any field can involve uncertainty, which may vary in degree and in kind. All aspects of a decision problem, including the nature of each possible outcome, the probability of the occurrence of each outcome, the worth to the decision maker of each outcome, and of course the actual outcome itself, may be uncertain.\(^1\) An additional influence on the perception of uncertainty is the emotional consequence of a decision, such as regret or elation (e.g., Pitz & Sachs [1984] and Bell [1982]).

The type of uncertainty defined as “risk” involves simply not knowing which of two or more well-specified outcomes will occur as a result of a known probabilistic process (e.g., will a deuce occur when a card is drawn from a fair deck?).\(^2\) Researchers have described uncertainty, or degree of knowledge about the probability of the occurrence of an event, as a continuum: from risk (one known probability distribution) to ignorance (no idea about the probability distribution). The region of knowledge between the extremes is defined as ambiguity. Therefore, in ambiguity, the uncertainty runs not only to the identity of the outcome that will occur, but also to the underlying probability distribution (e.g., the number of deuces in the deck may not be known).

---

\(^1\)See Berkeley and Humphreys [1982] and Conrath [1967] for a discussion of the different types of uncertainty.

\(^2\)Risk in the dictionary sense of exposure to the chance of injury or loss is \emph{not} what risk means in decision making theories such as subjectively expected utility theory. Risk as defined in these theories and as used in this paper describes only the situation wherein possible outcomes and the probability of obtaining each outcome are known, but the outcome that will occur is not known.
An example may serve to make these distinctions concrete:

Consider Miss Julie who is invited to bet on the outcome of three different tennis matches. As regards match A, she is very well-informed about the two players... [and she] predicts that it will be a very even match and a mere chance will determine the winner. In match B, she knows nothing whatsoever about the relative strengths of the contestants (she has not even heard their names before) and she has no other information that is relevant for predicting the winner of the match. Match C is similar to match B except that Miss Julie has happened to hear that one of the contestants is an excellent tennis player, although she does not know anything about which player it is, and that the second player is indeed an amateur so that everybody considers the outcome of the match a foregone conclusion (Gärdenfors & Sahlin [1982], pp. 361-362).

The description of match A fits most closely with the definition of risk and the description of match B, with the definition of ignorance. Match C describes ambiguity: there is some defining information but not enough to identify a single process that will generate the outcome.

During the past forty years, the most active researchers investigating decision making have been economists and psychologists [Hammond, Mumpower, & McClelland, 1980]. The impetus in economics came from the development of expected utility theory [von Neumann & Morgenstern, 1947] and later modifications\(^3\) which are discussed in Section 2.1. Decision making research in psychology has examined the assumptions and predictions of the expected utility model and its variants and also the cognitive processes underlying decision making, such as judgment (evaluating options or making predictions) and choice (selecting an option). Einhorn and Hogarth’s [1985, 1986] descriptive model of decision making under ambiguity is discussed in Section 2.2. Section 2.3 describes the research on relevant auditing and accounting decision making under uncertainty.

\(^3\) Schoemaker [1982] provides a review of EU and its variants up to 1981 and discusses the use of this family of models as a descriptive, predictive, and prescriptive theory. Weber and Camerer [1987] discuss the recent developments concerning EU and SEU.
2.1 Expected Utility Theory and Variants

Expected utility theory (EU) [von Neumann & Morgenstern, 1947] was constructed as a model of decision making when the possible outcomes are known and when known probabilities are associated with those outcomes, that is, decision making under risk; EU assumes that the utility (i.e., subjective worth) of each possible outcome may differ among individuals. EU assumes the existence of objective probabilities that describe the likelihood that an outcome will occur (e.g., the likelihood that heads will occur on the flip of a fair coin is .50). Objective probabilities are derived from observable frequencies (e.g., in the long run, heads will occur on 50% of the flips of a fair coin).

Subjectively expected utility theory (SEU) [Savage, 1954] is an extension of EU that permits the use of subjective or “personal” probabilities to express a person’s degrees of belief as to the likelihood that each possible outcome will occur and as to whether a particular outcome is repeatable (e.g., the probability that heads will occur when a fair coin is flipped) or not repeatable (e.g., the probability that an earthquake would occur in October 1989). Subjective probabilities are inferred from an individual’s willingness to bet on the occurrence of a possible outcome (i.e., if you are willing to bet on outcome X over outcome Y, you presumably believe that X is more probable than Y).

Both EU and SEU are axiomatic systems (sets of logical principles) that specify a unique criterion for rational choice: that a decision maker will maximize his or her utility by selecting the option with the highest expected (or subjectively expected) utility. Expected utility (or subjectively expected utility) for a set of outcomes \( x \) is the sum of the utility of each outcome, \( O_i \), multiplied by its respective probability (or subjective probability), \( p_i \), or:

\[
E[U(x)] = \sum p_i U(O_i) \tag{1}
\]

A key assumption in both EU and SEU is that the probabilities associated with the possible outcomes are completely independent of the utilities of the outcomes; that is,
the worth of an outcome does not influence the likelihood of its occurrence. Because SEU relies on subjective probabilities, it is the more general of the two theories and consequently has become the primary theory used to study individual decision making in economics [Fishburn, 1988]. Only SEU will be considered in this study.

SEU assumes that individuals hold consistent preferences and coherent beliefs [Fishburn, 1988]. An individual holds consistent preferences if he or she can rank-order options consistently according to his or her utility for each option. Ranking preferences consistently implies three important axioms: transitivity, dominance, and invariance. Transitivity implies that if Jones prefers A to B, and B to C, she will prefer A to C. However, transitivity may be violated if Jones uses a choice strategy, such as lexicographic choice, wherein options are not completely evaluated before they are compared [Tversky, 1969].

Dominance may exist when the options have several dimensions and an individual has preferences across the dimensions. If one option is deficient across all dimensions when compared with the other options, it is said to be dominated by the other options. Since the criterion for rational choice is to select the option with the highest subjectively expected utility, the dominated option is never chosen. Violations of this axiom can occur if the choice problem is structured in such a way that the dominance is not obvious [Kahneman & Tversky, 1979; Goldstein & Einhorn, 1987].

Invariance of preference implies that preference for one outcome over another should remain constant regardless of how the options are presented and how preferences are elicited. Repeatedly, studies have shown that preference is indeed affected by irrelevant aspects of the choice problem, such as the way it is worded [Tversky & Kahneman, 1981, 1986], the response mode (e.g., whether the preference is elicited by presenting a choice between two lotteries or by asking subjects to state the price they would pay for the gamble [Billings & Scherer, 1988]), the format of the choice options [Raiffa, 1961], and linear transformations of choice pairs (e.g., by translating winnings into losses [Keller, Sarin, & Weber, 1986]).
The coherent beliefs assumed in SEU are expressed as probabilities that follow the laws of probability theory. The crucial requirement for coherence is that the probability that a particular event will occur (e.g., the probability that it will snow today) and the probability that its complement will occur (e.g., the probability that it will not snow today) must sum to one. This condition is known as the additivity of probabilities.

Knight argued that the term "probability" should be reserved for repeatable outcomes (i.e., events for which frequencies of occurrence can be tabulated) since a decision maker faced with a nonrepeatable outcome "forms the best estimate he can of the outcome of his actions, [and] he is likely also to estimate the probability that his estimate is correct" (p. 226 [1921]). Neither estimate may be based on frequency data, but rather on opinion. After many years, some theorists (e.g., Kahneman & Tversky’s [1979] prospect theory or Shafer’s [1976] theory of evidence) have returned to Knight’s distinction between probabilities and degrees of belief in the occurrence of an outcome. These theorists prefer terms such as "decision weights" or "belief function" to describe the estimation of likelihood of an uncertain event’s occurrence. Indeed, some revisions of SEU to enhance its predictive ability have permitted subjective probabilities of the outcomes to be nonadditive (e.g., Fellner [1961], Karmarkar [1978]). However, SEU or its revisions do not provide any description of how an individual determines the weighting placed on the possible outcomes in a decision problem.

2.2 Ellsberg’s Paradox

Almost immediately upon publication of SEU in 1954, individual choice behavior was shown, by means of several counterexamples known as choice paradoxes, not to be in accordance with its predictions. The paradox of interest to the current study is the one devised by Ellsberg [1961], which demonstrated that the assumption that probabilities provide an adequate description of the weights placed on utilities is
unwarranted.

The following scenario illustrates Ellsberg’s Paradox: Imagine two urns, each filled with red and black balls. Urn I contains 100 balls, but the proportion of red to black balls is unknown. Urn II contains 100 balls; 50 are red and 50 are black. If you guess correctly the color of a ball to be drawn at random from an urn, you win $100. When Urn I is to be used, would you bet on red, bet on black, or be indifferent between the colors? When Urn II is to be used, how would you bet? Now, if a red ball must be drawn in order to win, which urn would you choose, or would you be indifferent? If a black ball must be drawn in order to win, which urn would you choose, or would you be indifferent?

In the first instance, when a ball is to be drawn from one urn or the other, most people are indifferent between red and black. This implies that both the known probability (Urn II) and the subjective probability (Urn I) are .50 for each color. Recall in SEU that subjective probability is inferred from a person’s willingness to bet on a particular option. In the second instance, when winning the bet depends on drawing a ball of the correct color, most subjects select the nonambiguous urn (II). These results point to a contradiction. Expressing indifference between colors when the bet is within Urn I or within Urn II implies a subjective probability of .50 for each color. However, choosing a specific urn when the bet is to win on the draw of a specific color ball implies that the subjective probability of drawing the winning color from the chosen urn is greater than .50 (and less than .50 in the urn not chosen). Choosing the same urn (generally Urn II) for a bet on black and then a bet on red implies that the probability of drawing a ball of a winning color is greater than .50 for both colors within that urn. Since the known probability of obtaining either color from Urn II is .50, this choice pattern violates a law of probability (namely, additivity). Ellsberg labelled this choice pattern that violates the additivity rule of probability theory for the nonambiguous urn “ambiguity avoidance”. Ellsberg [1961] noted that ambiguity may be reduced by collecting additional information (e.g, drawing a sample
from the ambiguous urn). He cautioned, however, that quantity of information does not by itself eliminate ambiguity, especially "when there are questions of reliability and relevance of information and particularly when there is conflicting opinion and evidence" (p. 659, emphasis in the original). The notion that the reliability of information must be considered was stressed by Gärdenfors and Sahlin [1982] in their extension of Bayesian decision theory to include the "epistemic reliability" of data (i.e., if several probability distributions might fit the data, the decision maker may have more defining information about some distributions than about others and thus should give the former more credence).

Raiffa [1961] argued that a rational believer in SEU would not exhibit the pattern of results shown by Ellsberg, but to show how this believer would comply with SEU. Raiffa had to rewrite the paradoxical problem to highlight the aspects the urns had in common. This in itself was a violation of the invariance axiom, because the "correct" decision should result regardless of how the problem is presented.

Roberts [1963] and Savage [1972] proposed that people exhibiting the choice pattern observed in the Ellsberg Paradox have merely made a mistake that they would have avoided had they understood the tenets of rational decision making. However, arguments for following SEU strictly have failed to persuade most of these "irrationalists" ⁴ to change their choices in the Ellsberg Paradox [Curley, Yates, & Abrams, 1986; MacCrimmon, 1968; MacCrimmon & Larsson, 1979; Slovic & Tversky, 1974]. In addition, subjects have been willing to pay more for an option fitting the description of risk than for an ambiguous option of the same expected value, thus revealing that they place less value on an ambiguous outcome than on one that involves only risk [Becker & Brownson, 1964; Yates & Zukowski, 1976].

Eellsberg (see footnote, Becker and Brownson [1964]) suggested that ambiguity might be sought actively as well; he offered the following example (tested empirically by Einhorn & Hogarth [1988]): Consider two urns, each containing 1,000 balls. The

---

⁴The irrationalists included, it must be noted, Savage and Marschak, among other well-known economists [Ellsberg, 1961].
balls in the first urn are numbered from 1 to 1,000; thus, the probability of drawing a specifically-numbered ball is .001. The balls in the second urn also are numbered, but any one number from 1 to 1,000 could appear any number (up to 1,000) of times. If you had to bet on drawing a specifically-numbered ball, which urn would you select? Ellsberg suggested that some people would pick the ambiguous urn (i.e., ambiguity seeking) in the belief that it might offer a higher probability of winning. The experimental results [Einhorn & Hogarth, 1988] were that 35% of a group of MBA students did indeed choose the ambiguous urn (43% chose the onambiguous urn, and 22% were indifferent between the urns). These subjects had been exposed to expected utility notions. Recall that SEU would hold that the two urns are equivalent, so that the decision maker should be indifferent between the two urns.

Theorists have proposed modifications of SEU that would maintain its axiomatic structure but nevertheless would enable it to generate behavioral predictions that take the paradoxes into account. One tactic has been to incorporate probabilities that are nonadditive (i.e., the probabilities that an event and its complement will occur need not sum to one) [e.g., Fellner, 1961; Karmarkar, 1978]. Another tactic has been to weaken the axioms and also to permit nonadditivity of the probabilities [e.g., Fishburn, 1988; Schmeidler, in press; Quiggin, 1982; Yaari, 1987]. These models predict the observed paradoxical behavior, but they fail to provide any description of the cognitive processes underlying the assessment of ambiguity or, indeed, the assessment of uncertainty in general.

2.3 A Descriptive Model of Decision Making Under Ambiguity

Einhorn and Hogarth [1985; 1986; Hogarth & Einhorn, in press; Hogarth, in press] have proposed a descriptive model (the E-H ambiguity model) of the process underlying decision making under ambiguity, where ambiguity is defined, as it was earlier in this paper, as not being able to establish a single probability distribution for a set of known possible outcomes. Recall that being able to specify one such probability
distribution is the definition of risk. As the number of probability distributions that cannot be ruled out increases, ambiguity increases.

The E-H ambiguity model describes and predicts both ambiguity avoidance and ambiguity seeking as observed in the Ellsberg examples cited in the preceding section. The model incorporates four factors that have been observed in empirical studies to influence decision making under uncertainty: the existence of ambiguity (e.g., Becker & Brownson [1964]; Curley et al. [1986]; Ellsberg [1961]; Yates & Zukowski [1976]; the size of the initial probability values provided (e.g., Ellsberg’s two examples [.50 and .001] cited in the prior section); whether the decision task involves a gain or a loss (e.g., Cohen, Jaffray, & Said [1985]; MacCrimmon & Larsson [1982]); and the outcome size, generally defined as the dollar amount at stake (e.g., Kahneman & Tversky [1979]).

Einhorn and Hogarth use a process of anchoring and adjustment to model the process by which decision makers generate their subjective probability values in ambiguous circumstances. The anchor is an initial estimate of the probability that an event will occur; it may come from experts, from memory, or from historical data, or it may be a best guess. The anchor probability is adjusted by a cognitive process in which other possible values around it are considered. The greater the perceived ambiguity, the more extensive is this appraisal of other possible values. For example, if an individual is attempting to judge the likelihood that a nuclear power accident will occur, he/she may anchor on the estimate provided by the experts and may try out larger and smaller probabilities as he or she considers, among other factors, the reliability of the experts, the forthrightness of the utility company running the plant, and the track record (if any) of the relevant technology.

The judged probability that the outcome event will occur can be written as follows:

\[ S(p_A) = p_A + (k_G - k_S) \]  \hspace{1cm} (2)

where
\( p_A \) is the anchor probability.

\( k_G \) represents the weighting of the probabilities above the anchor that have been considered, and

\( k_S \) represents the weighting of the probabilities below the anchor that have been considered.

The judged probability, \( S(p_A) \), is bounded by 0 and 1, inclusive.

The assumptions\(^5\) underlying the net adjustment, \((k_G - k_S)\), are:

\[
k_G = f(\theta, p_A, \rho)
\]  
\( (3) \)

and

\[
k_S = f(\theta, p_A, \lambda)
\]  
\( (4) \)

where both

\( k_G \) and \( k_S \) are increasing functions of the perceived degree of ambiguity, \( \theta \);

\( k_G \) is a decreasing function of the anchor, \( p_A \), and

\( k_S \) is an increasing function of \( p_A \) (i.e., if the anchor is close to 1 or 0, there is more range for consideration below or above the anchor, respectively);

and

\( \rho \) and \( \lambda \) represent the weighting of the probabilities considered above and below the anchor, respectively, and are increasing functions of the absolute size of outcomes (i.e., as the dollar amount involved increases, the more the other probabilities considered around the anchor are weighted).

\(^5\) The adjustments, \( k_G \) and \( k_S \), are stated as implicit functions because Hogarth [in press] noted that it was disadvantageous to impose a specific functional form on the model. The E-H ambiguity model originally contained as an exponent an additional factor describing an individual’s attitude towards ambiguity (\( \beta \)) in a particular decision. Apparently, when \( \beta \) is less than 1, the function is always non-monotonic on the range between 0 and .50. [personal communication, Hogarth, June 2, 1989]. Regardless, the predictions of the model and the psychological assumptions on which it rests remain unaltered.
Recall that SEU and its variants assume that outcomes and probabilities are independent (i.e., the subjective values of utility and probability do not depend on each other).

2.3.1 Effect of the Location of the Anchor Probability

If the anchor is 0, any adjustment must be positive (to a value greater than the anchor); if the anchor is 1, any adjustment must be negative (to a value smaller than the anchor). These constraints, which are due to the limits of the available range of values, imply that small anchor probabilities will tend to be overweighted and large anchor probabilities will tend to be underweighted. To grasp this notion, think of being offered either a known zero chance to win $1,000 or an ambiguous zero chance to win $1,000 [Hogarth & Einhorn, 1988]. Most people would prefer the ambiguous zero chance because there might be the possibility, however slim, of winning. Similarly, think of being offered either an option of either certainly losing $1,000 or an ambiguous probability of 1 of losing $1,000. Some people would prefer the ambiguous option because there might be the possibility, again however slim, of avoiding the loss. Both of these examples illustrate “ambiguity seeking.” Everywhere else, ambiguity tends to be avoided.

The net result of the adjustment process depends on the location of the anchor probability and on the relative weighting of values above and below the anchor. The location of the anchor is crucial because the range within which to consider other probabilities may be constrained by how close the anchor is to 0 or 1. A feature of the E-H ambiguity model is that it allows asymmetric ranges of values to be considered. The width of each side of the considered range around the anchor is determined jointly by the available range between the anchor and the nearest endpoint and by the size of the outcome.6

6 All SEU variants that incorporate nonadditive probabilities (e.g., Kahn & Sarin’s [1988] variant which is a mean-variance model) require the width of the range of possible values around the initial estimate to be symmetric, thus compelling the range of values that can be considered to depend on the initial probability value. Therefore, at very low and at very high probabilities (i.e., those close
2.3.2 Effect of Outcome Sign

Einhorn and Hogarth [1985; 1986] suggested that whether a situation is perceived as a loss or a gain will have differential effects on the weighting of alternative probabilities. Outcomes in the E-H ambiguity model are assumed to be evaluated by a function similar to the value function in prospect theory [Kahneman & Tversky, 1979].\(^7\) Outcomes are evaluated as gains or losses relative to a reference point, often the status quo, rather than relative to a final wealth position as in SEU. The value function is assumed to be concave below (i.e., the second derivative of the curve is negative) for gains and convex below for losses (i.e., the second derivative is positive) and to be steeper for losses than for gains (see Figure 1). Therefore, the E-H ambiguity model predicts different responses to the combination of ambiguous probabilities and the dollar size of the outcome depending on the sign (positive or negative) of the outcome.\(^8\)

In the E-H ambiguity model, individuals are assumed to be cautious, rather than optimistic, when making decisions under uncertainty (see Isen & Geva [1987], Norem & Cantor [1986]). For losses, a cautious individual would weight probabilities greater than the anchor more heavily than probabilities less than the anchor (i.e., would consider a loss to be more likely to occur than the anchor probability indicates). For gains, a cautious individual would weight probabilities less than the anchor more heavily than probabilities greater than the anchor (i.e., would consider a gain to be less likely to occur than the anchor probability indicates).

\(^7\)Prospect theory was devised to describe choice behavior under risk (simple outcome uncertainty).

\(^8\)Evidence is accumulating that a “dual-probability function” is necessary to describe the apparent psychological differences in how individuals perceive the likelihoods of the occurrence of gains and losses (see, for example, Isen & Geva [1987], Luce & Narens [1985], Nygren [1988], and Currim & Sarin [1988]).
Figure 1.
Value Function from Prospect Theory (after Kahneman & Tversky [1979]).
2.3.3 Effect of Outcome Size

The outcome size (the absolute size of the dollar amount involved) is assumed to influence the weight of the probability values considered around the anchor through the effects of $\rho$ and $\lambda$. It is assumed that as the absolute dollar amount increases, more weighting is given to the other possible probability values considered. As absolute size increases for possible gains, more weight is given to probabilities less than the anchor (therefore resulting in net underweighting); for possible losses, more weight is given to probabilities greater than the anchor (therefore resulting in net overweighting). These weightings follow from the underlying assumption of the decision maker as cautious, as described in the previous section (that is, the larger the dollar amount involved, the more cautious a decision maker would be).

2.3.4 The Net Effect of the Adjustment

If the anchor, $p_A$, is located at .50, there is an equal width of range above and below the anchor. If the values considered above and below .50 are differentially weighted, the judged probability, $S(p_A)$, will not equal .50. If the values below .50 are more heavily weighted, $S(p_A)$ will be less than .50. If an individual’s judgments of many anchors are taken, and if all else is held constant, a judged probability curve can be constructed such that at some point, $p_C$ (for crossover), $S(p_A)$ is equal to $p_A$, because the range restriction around the anchor counterbalances the effects of the weighting. In Figure 2, $p_C$ would be between 0 and .50. The judged probability values of the complementary anchors (i.e., $S(p_A)$ and $S(1 - p_A)$) would not be additive, but rather would be subadditive (less than 1).

Similarly, if the values above an anchor of .50 were more heavily weighted in the adjustment process, $S(p_A)$ would be greater than .50. Again, if an individual’s judgments of many anchors are taken, the judged probability curve constructed will show a $p_C$ between .50 and 1. See Figure 3. If $p_C$ is greater than .50, then the sum of the complementary judged probabilities, $S(p_A) + S(1 - p_A)$, will be superadditive
Figure 2.

Ambiguity Weighting Function for Positive Outcomes (Values below the anchor probability are weighted more heavily than those above—as if the positive outcome is less likely to occur) (after Hogarth, in press).
Figure 3.

Ambiguity Weighting Function for Negative Outcomes (Values above the anchor probability are weighted more heavily than those below—as if the negative outcome is more likely to occur) (after Hogarth, in press).
(greater than 1).

For mathematical simplicity, both of the resulting ambiguity functions are assumed to have a single crossover point. The location of the crossover point, \( p_C \), depends on the relative weighting of possible probability values greater and smaller than the anchor in the adjustment process. The extent of perceived ambiguity, \( \theta \), affects the difference between the anchor and the judged probability value, \( S(p_A) \). The greater the perceived ambiguity, the more extreme the ambiguity function will appear to be (i.e., if the diagonal line in Figures 2 and 3 represents all points where the judged probability is equal to the anchor, then as ambiguity increases, the further the judged probability curve would be from the diagonal).

If individuals are cautious, as the model assumes they are, judged probability values, \( S(p_A) \), will usually be subadditive in gain situations (see Figure 2) because of a tendency to overweight values below the anchor (that is, to discount the likelihood that a gain will occur). Conversely, in loss situations, \( S(p_A) \) values will usually be superadditive (see Figure 3) because of a tendency to overweight values above than the anchor (that is, to expect the worst to happen). Exceptions to these general trends will occur in three instances: at anchor values of either 0 or 1 because of the range restrictions (e.g., if the anchor is 0, since one can consider only probability values greater than 0, a small portion of the ambiguity function will appear superadditive; similarly, if the anchor is 1 a small portion will appear subadditive), and also when the crossover point is equal to the anchor at .50 because the range effects are then exactly counterbalanced by the weighting.

### 2.3.5 Summary of Predicted Effects

The shapes of the curves corresponding to gains, or positive outcomes, and to losses, or negative outcomes, lead to the following predictions of behavior under ambiguity:

\[ ^9 \text{Recall that individual differences will lead to unique specific functional forms for each participant. However, the curves should have the same general shape. Thus no specific predictions using a precise definition of “closeness” are made.} \]
In a positive outcome (gain) situation, unless the anchor probability is low (i.e., less than the crossover point, subjects will underestimate the probability of the positive outcome. In a negative outcome (loss) situation, unless the anchor probability is high (i.e., greater than the crossover point), subjects will overestimate the probability of the negative outcome. If, however, the anchor, \( p_A \), is close to the crossover probability, \( p_C \), the effect of ambiguity will be negligible. Subjects will overweight the probability associated with the ambiguous option in a positive outcome situation when the anchor probability is low, and underweight in a loss situation when the anchor probability is high. As outcome size (absolute dollar amount) increases, more weight will be placed on other probability values considered around the anchor, resulting in more extreme judged probabilities.

2.4 Empirical Findings with the Ambiguity Model

Einhorn and Hogarth [1985; 1986] have tested their ambiguity model on both judgment and choice tasks. The judgment tasks [Einhorn and Hogarth, 1985] examined how the number of reports for and against an outcome (e.g., the number of witnesses reporting that a blue car, rather than a green car, was involved in a hit-and-run accident) affected subjects’ assessment of likelihood; ambiguity was manipulated by varying the number of reports for each possible outcomes (e.g., equal numbers of people said the car was green or blue [high ambiguity] versus nine people said it was green and one said it was blue [low ambiguity]). Nonlinear regression models of each subject’s judgments under ambiguity were constructed to check for fit with the E-H ambiguity model. The majority of subjects (28 of 32) gave results consistent with the model. Tests of parameter values using one-way repeated-measures ANOVA indicated that parameter values were more alike within subjects than between subjects. Individual differences for the adjustment from the anchor and for the direction (sign) of the adjustment were stable.

Another experiment in the first study [Einhorn & Hogarth, 1985] tested whether
an individual’s choices among gambles (ambiguity avoiding, ambiguity neutral, or ambiguity seeking) could be predicted from the regression estimates of his or her \( \theta \) (measure of the individual’s perception of ambiguity) and \( \beta \) (measure of the individual’s response to ambiguity) obtained in the inference tasks referred to in the preceding paragraph. The experimenters predicted 61% of subjects’ choices correctly.

The role a subject takes in a decision influences how he or she reacts to ambiguity (avoiding, indifference, seeking). Apparently, the role provides a perspective (frame) on the dollar amount at stake (outcome) as being a gain or a loss [Einhorn & Hogarth, 1986; Hogarth, in press]. Roles that have been examined are plaintiff or defendant in choosing to settle out of court or go to trial, buyer or seller of insurance in determining the price of insurance coverage, and buyer or seller of equipment determining a price at which a purchase or a sale would occur with or without a warranty [Einhorn & Hogarth, in press; Hogarth, in press; Hogarth & Kunreuther, 1985, 1989, in press]. In these studies, ambiguity was manipulated by stating that the subject “could be very confident in” or “experienced considerable uncertainty about” the stated probability (only moderate to high probabilities were included). The predictions of the model were upheld: For large perceived losses at high probabilities, subjects sought ambiguity (for example, defendants chose to gamble by going to court rather than to incur a certain large loss by settling out of court); otherwise, subjects avoided ambiguity by choosing a sure loss (such as by buying the equipment with a warranty instead of taking the gamble of breakdown without a warranty). For perceived gains, subjects avoided ambiguity at moderate to high probabilities (e.g., the plaintiffs chose not to gamble by going to court and possibly losing the sure amount of settlement).

A related study [Hogarth & Kunreuther, 1989] asked members of a professional actuarial society to set prices for insurance premiums when the possible losses (small and large) could be either independent or correlated.\(^{10}\) The probability of a loss (.001.

\(^{10}\)Correlated losses imply a systematic failure such that if one unit fails and needs work under warranty, other units probably will fail. Independent losses do not imply a relationship between failures; rather, failure is seen as a random event.
.01, .10) was either ambiguous or nonambiguous. Of the 89 subjects, 40 voluntarily supplied detailed comments about how they had determined the premium. Actuaries did not appear to follow an SEU strategy in developing premiums; rather, they seemed to use some sort of adjustment process in which the expected value of the loss was used as the anchor. Hogarth and Kunreuther [1989] note that the apparent use of expected value as the anchor may contradict a detail (that the initial probability value is the anchor) of the E-H ambiguity model, but does leave intact the assumed cognitive process of anchoring and adjustment.

To summarize, the E-H ambiguity model was formulated to describe and predict individuals' judgments and choices when the specific outcome that will occur is not known (as in risk) and when the probabilities of the occurrences of the possible outcomes are uncertain. The model has been tested under a variety of conditions: with both within-subjects and between-subjects designs, in both judgment and choice tasks, in laboratory and questionnaire studies, with different types of subjects (undergraduates, MBA students, actuaries), and in different contexts (abstract balls-and-urns choices, evidence evaluation, insurance-premium setting, and court-settlement decisions). This study extends the E-H ambiguity model to the domain of audit decision making and investigates the model's implications for auditors.

2.5 Relevant Research in Auditing and Accounting

Several general areas of research in auditing and accounting relevant to the current study are identified: audit and accounting decision making that assumes EU or SEU, the use of anchoring and adjustment as a heuristic, and manipulation of uncertainty as a factor. No research applying the E-H ambiguity model to auditing or accounting, either published or in working paper form, has been located.\textsuperscript{11}

\textsuperscript{11}In Research Opportunities in Auditing: The Second Decade, Ashton, Kleinmuntz, Sullivan, and Tomassini [1988] propose the issues being investigated in this study as open topics for audit research.
2.5.1 Studies based on EU and SEU

Barrett and O'Malley [1976] investigated the levels of probability that a client would lose a lawsuit at which student subjects would issue a qualified opinion on the client's financial statements and at which they would issue a disclaimer of opinion. The possible dollar amount at stake for the hypothetical client ranged from less than 1% to more than 800% of total assets. The subjects appeared to use an expected value approach whereby higher probabilities were required for smaller dollar amounts and lower probabilities were required for larger dollar amounts. This study was completed before the issuance of Statement of Financial Accounting Standards No. 5, "Accounting for Contingencies" [FASB, 1975].

Schultz and Reckers [1981] varied materiality level (6% or 14% of operating income) to assess the probability level at which audit partners would require disclosure of a loss contingency (outcome of a lawsuit and expropriation of assets in a foreign country). Again, many subjects used an expected value approach to determine the probability at which the likelihood of occurrence of the loss could be considered reasonably remote (generally, less than 40%, regardless of the materiality of the dollar amount) so that the contingency would not need to be disclosed. The authors noted that this approach is inconsistent with the process implied in FAS No. 5 [FASB, 1975], which is to evaluate separately the degree of materiality, the probability of the occurrence of a confirming event, and the estimability of the amount.

Newton [1977] asked audit partners to provide the probability level at which an amount would become material enough under different levels of uncertainty to cause them to qualify their opinions on a company's financial statements. Utility curves were constructed for each subject by a probability equivalence process using abstract gambles. A subject's responses to two audit cases (valuation of marketable securities and contingent loss from a lawsuit) were compared to his or her utility curve to determine if the risk-averseness (i.e., concavity of the subject's utility curve) observed in the abstract case could predict his or her selections in the audit cases. The expected
utility model failed to explain the pattern of results obtained in the study. Some partners stated that the probability of the occurrence of a loss should not be used at all in establishing if an amount was material enough to require qualification of an opinion.

Lewis [1980] tested for auditors’ homogeneous utilities that are assumed by EU for consensus to exist. His task examined audit partner decisions on how a product liability lawsuit should be reported in a client’s financial statements at two levels of materiality. Auditors with a minimum of five years experience from four Big-8 firms ranked the desirability of pairs of six possible outcomes generated from the following sets: three outcomes relating to the financial statements (accrue, disclose, not disclose), and two outcomes relating to disposition of the lawsuit (client held liable or not). The pairwise correlations among rankings were more consistent (thus indicating homogenous utility) within firms than between firms at both levels of materiality and were more consistent between firms for the higher materiality condition than for the lower condition.

Several studies have tested for the choice pattern found in an SEU counterexample known as the Allais Paradox. The Allais Paradox contradicts the invariance axiom of SEU (see Section 2.1). R. Ashton [1979] found that MBA students’ choices in a capital-budgeting scenario were consistent with the invariance axiom. However, he noted that many subjects used an expected-value strategy, which yields results that would appear consistent with SEU. A. Ashton [1980] translated the Allais paradox into several audit contexts (bidding on a municipal audit, opinion formulation on a technically unresolved matter) and had partners and managers respond to the both the abstract and the audit tasks. The rates of violations of the invariance axiom were lower in the audit contexts than in the abstract case. She argued that context could affect the subjects’ perception of the structure of the problem.

A. Ashton [1985] also investigated the Ellsberg Paradox in a similar fashion, using the same subjects as in the Allais Paradox study. The subjects responded to the
original Ellsberg paradox (see Section 2.2 for a description). The subjects were given four audit cases (two possible firm failures, a lawsuit outcome, and whether current value accounting will be required). They were asked to state if they would rather bet on the outcomes of the audit uncertainties or on drawing a black card from a well-shuffled deck, or if they would be indifferent. The gambles in the audit tasks, however, were not comparable to the set of gambles used in the Ellsberg task; that is, the gamble corresponding to drawing a specifically colored ball from the ambiguous urn to win $100 or receive nothing was phrased in the audit tasks as stating indifference or a preference between outcomes between receiving $1,000 if the client did not go bankrupt (or did not lose the lawsuit) or if it did go bankrupt (or lost the lawsuit). Most subjects were indifferent between urns in the Ellsberg task, but expressed a preference for the client’s remaining solvent or winning the lawsuit. Selecting this option is not surprising because the alternative outcome might have unpleasant ramifications for the auditor (e.g., loss of client, potential lawsuits by disgruntled financial statement users). Due to the nonequivalence of the uncertain cases, the conclusions drawn about auditors’ not violating SEU in the audit context versions of the Ellsberg paradox must be qualified.

2.5.2 Anchoring and Adjustment

Joyce and Biddle [1981] investigated possible anchoring and adjustment by auditors as a heuristic strategy for the use of probabilistic information [Kahneman & Tversky, 1974]. Joyce and Biddle attempted to test for the inappropriate use of anchoring and adjustment in evaluating the incidence of management fraud and in deciding on the extent and timing of substantive tests of accounts receivable. The authors gave subjects varying sized anchors of fraud incidence and obtained the expected varying differences in estimated incidence. In the accounts receivable task, subjects were asked for the extent and timing of substantive testing, given different levels of strength of internal control. No results were obtained relating to anchoring and adjustment with
the accounts receivable tasks. However, the task for accounts receivable had nothing to do with "risk, probability or frequency judgments—the domains for which the heuristics were developed" (Shanteau [1989], p. 168); thus, the null results are not surprising.

Kinney and Uecker [1982] tested for and found anchoring and adjustment in auditors' evaluations of compliance testing results. A proposed Statement on Auditing Standards on audit sampling had suggested two permissible methods of estimating population error rates: fractile assessment and probability (risk) assessment. In the fractile assessment method, subjects estimate confidence intervals; the probability assessment method requires subjects to assess the probability (or the risk) that the population value exceeds some specified value. Kinney and Uecker assumed the anchor in the fractile assessment method would be the sample error rate while the anchor in the probability assessment method would be even odds (50:50). They hypothesized that the anchor in the fractile assessment task would lead to an understatement of the true error rate (i.e., an understated achieved upper precision limit for the population error rate) and that the anchor in the probability assessment task would lead to an overstatement of the true error rate (i.e., an overstated achieved risk that the population error rate exceeded the maximum allowable rate). The hypotheses were confirmed by comparing the auditor-generated rates with a statistical evaluation of the sample results. Because the fractile method led to consistently understated assessments, the Auditing Standards Board eliminated it from the final version of SAS No. 39 [AICPA, 1981].

Butler [1986] investigated what value auditors might use for an "internal anchor" in their judgmental evaluation of compliance test samples and substantive test test of details samples. The most common anchor for the assessment of tolerable risk of errors used by auditors (who had an average of five years experience) appeared to be at .05 or .10, not .50 as suggested by Kinney and Uecker [1982]. Butler suggested that experienced auditors apparently acquire a base-rate for errors from experience
which may lead them to discount sample results and possibly incorrectly accept an account balance as within the limits of tolerable error when it is not.

2.5.3 Uncertainty

Bamber and Snowball [1988] examined how degree of formalization of audit procedure (audit structure) and degree of task uncertainty might affect consensus among auditors and desired extent of consultation with others (e.g., peers or specialists). Uncertainty in the confirmation of accounts receivable was manipulated by increasing the severity of problems discovered (three levels) as the audit progressed. Auditors from more structured firms did not exhibit a greater degree of consensus, but did wish to consult with others more often than did auditors from less structured firms.

Waller and Felix [1984] modelled the auditor's opinion formulation process by applying schema concepts from memory research in cognitive psychology and Shafer's belief function\textsuperscript{12} for evaluating ambiguous evidence. They did not test this model. Larsson and Chesley [1986] discussed the usefulness for auditors of Shafer’s belief function and a system devised by Larsson to describe probabilities not known with certainty. Shafer and Srivastava [1987] also have proposed the use of Shafer's belief function for evidence evaluation in auditing.

Hilton and Swieringa [1980] examined how degree of initial uncertainty in a highly abstract urns-and-balls task might affect subjects’ recognition that information would become worth more as uncertainty increased. Dyckman, Hofstedt, and Murdock [1971] had MBA students choose between ambiguous and nonambiguous abstract gambles and found only a mild willingness to pay to avoid ambiguity. However, the authors noted that there were some problems with their experimental design, so that their conclusions must be evaluated cautiously.

\textsuperscript{12}Shafer's [1976] theory of evidence uses a nonadditive belief function rather than probabilities to assign weights to unreliable evidence.
2.5.4 Summary

From a review of the literature, auditors apparently do use anchoring and adjustment as a cognitive strategy and do appear to respond to degrees of uncertainty. Whether or not EU or SEU can adequately predict auditor choice behavior has not been firmly established. I have not located any reference to researchers’ applying the E-H ambiguity model in either the auditing or accounting domains. A comparison of the predictions of the E-H ambiguity model with those expected under conditions of risk (i.e., corresponding to conditions described by SEU) would indicate the extent and possible location of the "cushion" or allowance that auditors may propose when judging the adequacy of estimated amounts in the client’s financial statements. Certainly, the results of audit decision making under ambiguity may be compared to those obtained under nonambiguity to obtain some idea of how ambiguity differentially influences auditor judgment.
Chapter III
Research Framework and Hypothesis Development

This study was designed to extend the E-H ambiguity model to the domain of audit decision making. Responses to ambiguity were tested with audit tasks that require professional judgment as well as the abstract Ellsberg tasks. The latter testing was performed to allow for comparisons of auditors with other subject groups as well as within study comparisons on tasks.

The E-H ambiguity model suggests that responses to ambiguity are mediated by the following factors: the degree of ambiguity perceived in the situation, the location between 0 and 1 of the anchor probability, the dollar amount at issue (outcome size), and whether the dollar amount is perceived as a positive or a negative amount (relative gain or loss). The operationalization of these four factors in the audit setting will be discussed in Section 3.1.

The E-H ambiguity model parameters can be expressed in audit terms as follows. $S(p_A)$ is the judged likelihood of occurrence of an estimate such as the resolution of a contingent event. The anchor value, or initial estimate of this likelihood, $p_A$, may come from sources such as outside experts, the previous year’s working papers, evidential matter collected from compliance and substantive testing, analytical reviews, the client’s personnel, or the auditor’s memory. The perceived degree of ambiguity, $\theta$, depends on how familiar and stable the process is that generates the audit value. Consider, for example, the audit task of estimating a client’s warranty liability. If the product has been manufactured by a well-established process and if material or labor quality have not changed, the uncertainty the auditor faces may correspond to
the notion of a single probability distribution (i.e., risk). If, on the other hand, the auditor has encountered a new product manufactured by a new process, the uncertainty may correspond to the notion of a number of possibilities for the underlying probability-generating distribution (i.e., ambiguity).

The effect of dollar size might best be operationalized by the concept of materiality, since auditors tend to be more concerned about the relative dollar size of an item than about its absolute dollar size. The number of substitute values considered for the anchor probability is increased by an increasing degree of perceived ambiguity (θ) and by an increasing degree of materiality of the absolute dollar amount (ρ and λ). The substitute probability values above and below the anchor are weighted differently depending on whether the outcome is positive or negative in relation to the reference point (assumed to be the recorded value in the unaudited financial statements). The location of the anchor probability constrains the range of the other probabilities above and below the anchor that can be considered.

The audit tasks used to test the E-H ambiguity model's applicability to audit decision making will involve both negative and positive relative outcomes for an audit client. The existence of ambiguity, the relative outcome size of the dollar amounts involved, and the size of the anchor probability value (outcome size multiplied by the probability of the outcome may be thought of as the materiality of the amount involved) were varied to measure the range of auditor response to ambiguity on one audit procedure. These matters are discussed in subsequent subsections.

3.1 Audit Task

An example of an auditing task involving ambiguous probabilities is the evaluation of a loss contingency. FAS No. 5 “Accounting for Contingencies” [1975] defines a contingency as an uncertainty that will be resolved when a future event either occurs or does not occur. Loss contingencies (which include the uncollectibility of accounts receivable, obligations under warranties, and unfavorable outcomes of pending litiga-
tion) are to be recorded in the financial statements if two conditions are met: it is probable (likely) that an asset has been impaired or a liability has been incurred and the amount of the loss can be reasonably estimated. If the loss has only a remote (or slight) chance of occurring, then it is neither accrued nor disclosed. If the loss is reasonably possible (defined as the likelihood of occurrence falling between likely and slight), then it should be disclosed in the notes to the financial statements only.\textsuperscript{13}

If the amount of the loss cannot be determined, disclosure is required when the likelihood of the loss is either probable or reasonably likely. Further, if a range can be established within which the loss will fall, but no one dollar amount is better than any other, then the minimum amount in the range should be accrued and the top of the range disclosed in the notes.

The implied process of dealing with loss contingencies is that the dollar loss and the likelihood of loss are determined separately. Generally, the contingent loss in dollars in known before the likelihood of loss.\textsuperscript{14} Given this prescribed behavior of considering the amount of the loss separately from the likelihood of the loss in dealing with loss contingencies, then the E&H model may provide insight into auditors’ judgment process. The procedures outlined in FAS No 5 and FASB Interpretation No. 14 do not apply to immaterial amounts, so if the auditors chose to treat a dollar amount as an audit difference as opposed to an audit error, immateriality may be inferred. If the unit dollar amount is not at question, the auditors’ disposition of the amount as accrual, disclosure, neither, or both accrual and disclosure should give an idea of how likely they thought the contingent event was. The experimental audit tasks were designed to test the E&H model in an audit task that provides the closest mapping of the model. Warranty obligation was chosen as the audit task requiring the least amount of supporting documentation while still requiring professional judg-

\textsuperscript{13}Gain contingencies (e.g., future tax benefits of operating loss carryforwards or favorable outcomes of pending litigation) are not recorded in the financial statements until they are realized, but if a gain is likely to occur, it is disclosed in a note to the financial statements.

\textsuperscript{14}An exception to this rule is the disclosure of a probable lawsuit before anyone has filed a claim; such an instance may occur with plane crashes occurring just prior to the balance sheet date. The airline should disclose the crash in the notes.
ment similar to that required in other evaluations of contingent liabilities such as the evaluation of the allowance for doubtful accounts.

3.1.1 Positive and Negative Outcome Scenarios

To create positive and negative outcome scenarios that are comparable (1) in terms of their effects on a company’s financial statements (e.g., whether an accrual in the statements is required versus disclosure in the notes only) and (2) in how the probabilities are generated and used (e.g., whether the probability is the likelihood that an event will occur as opposed to the probability being used as to express confidence in an opinion about a value [Peterson & Pitz, 1988]), I relied on the reference point (which determines whether an amount is a gain or a loss) assumed in the value function incorporated in the E-H ambiguity model. I assumed that an auditor would be sympathetic to a client’s viewpoint within the bounds set by independence and conservatism and therefore would reflect the client’s perspective as to whether an outcome is positive or negative.\(^{15}\) I used the same task—the estimation of a warranty obligation—for both positive and negative outcomes, but varied the reference point by changing the unaudited recorded (book) value of the liability. If the recorded value is “too low,” the auditor presumably would estimate a larger amount; this can be thought of as a negative outcome for the client because it will reduce net income.\(^{16}\) If the recorded value is “too high,” the auditor presumably would estimate a smaller amount; this can be thought of as a positive outcome for the client because it will increase net income. See the examples of the experimental auditing tasks in Appendix A.

3.1.2 Ambiguity

Ambiguity was operationalized at two levels by stating that independent experts who have evaluated the likelihood of failure of a component either agree or disagree about

\(^{15}\)See Schultz and Reckers [1981] for audit partner comments supporting this supposition.

\(^{16}\)I further assume that the client is not interested in taking a “big bath” at the moment.
the probability of failure (the anchor probability). In the nonambiguous case, the experimental materials explained as follows: "the experts agree with the company's estimate that the failure rate will be \( x \) components for every 100 widgets sold." In the ambiguous case, the experimental materials stated that "the experts' estimates of the failure rate vary widely. After evaluating the reports, your best estimate of the failure rate is \( x \) components for every 100 widgets sold." Hogarth and Kunreuther [in press] used such a manipulation so that the anchor probability would be the same for both ambiguous and nonambiguous groups. Stating the anchor in this manner also avoids the issue of how the experts' opinions were aggregated (see Genest & Zidek [1986]). Experts\(^\text{17}\) were used as the source of the anchor probability in both the positive and negative outcome scenarios to avoid confounding the source of the anchor probability with the ambiguity factor.

3.1.3 Outcome Size

Outcome size was operationalized by varying the amount of the replacement cost (loss) per unit from $10 to $100 to $1,000 to obtain a range of amounts corresponding to immaterial, borderline material, and very material. The cost factor multiplied by the anchor probability generated values that varied in the materiality of the amount in question, since it is this relative classification of amounts that generally is important to auditors, rather than the absolute dollar amount. The maximum possible liability varied from $100,000 to $1,000,000 to $10,000,000. As noted in many auditing textbooks, $1,000,000 would probably be material for a small company, but probably not for General Motors. The materiality of the the expected value of the outcome can be thought of as three discrete categories: immaterial (1% of operating income), borderline material (10% of operating income), and highly material (100% of operating income).

\(^{17}\text{Recall that Ellsberg [1961] suggested conflict among experts as a source of ambiguity.}\)
3.1.4 Anchor Probabilities

Five levels of probability were used to cover the range from very low to very high: .01, .10, .50, .90, .99. With all five levels, decision weighting curves for a subject at each level of materiality (i.e., three curves per subject) could be constructed under both positive and negative outcome scenarios under each level of ambiguity (see Figures 2 and 3 for hypothetical examples of these functions). These curves were compared to the shape of the theoretical curves of the E-H ambiguity model and inspected for the location of the crossover point, $p_C$, and for evidence of over- and under-weighting near the end points as predicted by the model. It is easier to identify trends graphically than by inspecting tables of numbers.

3.1.5 Subject Responses

The responses to be collected are a subject’s reasonable estimate of the warranty liability, justification of that amount\(^{18}\) (which may be expressed as rough calculations) to provide some insight into the subjects’ thought process, and the amount that the subject would suggest be recorded as an error either on the worksheet summarizing passed (i.e., individually immaterial) audit differences or on the worksheet for audit adjustments. Additionally, if “audit adjustment” is chosen, the subjects must choose its disposition: either as disclosure to the notes (indicating some uncertainty about the amount involved or the likelihood of occurrence is only reasonably likely) or as accrual so that it appears on the face of the financial statements.

3.2 Research Hypotheses

The research design and the statistical tests performed are described in Chapter 4, “Methods,” and Chapter 5, “Results.”

The following research hypotheses are generated for the audit tasks. It is assumed that the auditor would be a cautious decision maker; that is, to act as if positive

\(^{18}\)Since auditors must provide justification of their decisions in the audit work papers, this requirement should not affect the subjects’ thought processes in an untoward manner.
outcomes are less likely to occur than the objective probability would indicate, and that negative outcomes are more likely to occur than the objective probability would indicate. The dependent variables are (1) the ratio of the estimated liability to the maximum possible liability (i.e., 100% of sales) and (2) the ratio of the booked liability to the maximum after the error amount is handled as either an audit difference or as an adjustment. The ratio rather than the absolute dollar amount is chosen as the dependent variables because there are three different maximum possible liability amounts corresponding to each of the three levels of replacement cost per unit. Further, the ratio yields a value between zero and one, and could be thought of as the subjective probability of the occurrence of the contingent event.

The following hypotheses are based on the predictions of the E-H model, but stated in terms of the audit task. The first four hypotheses relate to the negative outcome task.

**H1** When the probability of a contingent event's occurrence is ambiguous, the ratio of the estimated liability to the maximum possible liability will be larger than when the probability is nonambiguous.

Auditors will suggest a larger dollar amount for the liability when the probabilities are ambiguous than when the probabilities are nonambiguous. A cautious decision maker might want to provide for a larger margin of error if he or she is uncertain about the outcome.

**H2** As replacement cost per unit becomes larger, the ratio of estimated liability to the maximum possible liability will become increasingly larger.

Auditors will suggest proportionately larger dollar amounts for the warranty liability as the cost per unit increases. The greater the auditor's exposure, the more protection might be desired.

**H3** As the probability of the contingent event's occurrence increases, the ratio of estimated liability to the maximum possible liability will be increasingly greater,
though it will increase at a decreasing rate (i.e., will show a curvilinear shape similar to Figure 3).

Because the E-H ambiguity model’s probability weighting function for losses (see Figure 3) is steeper near $p = 0$, it converges to the function for losses under non-ambiguity (i.e., risk). Furthermore, at probabilities above the crossover point, the ambiguity function underweights the probability of a loss so that it appears less likely to occur. The behavior predicted here is suggestive of ambiguity seeking (by underweighting the anchor probability) on the auditor’s part if the estimated liability is less than the expected value at higher probabilities.

**H4** The ratio of estimated liability to maximum possible liability will diverge at higher probabilities of a contingent event’s occurrence across all levels of outcome size.

This interaction for negative outcomes is the result of two conflicting forces: the general overweighting of the anchor probability, which is derived from the assumption of cautious decision making, and the convexity below of the value function for negative outcomes. The overweighting of the anchor leads to suggested dollar amounts that increase at a decreasing rate, but the concave below value function leads to suggested dollar amounts that are increasing at an increasing rate. The net result will appear less extreme (i.e., the curve will be closer to the diagonal in Figure 3) than the corresponding results for gains. The amount chosen by the auditor at higher levels of materiality will be greater than the amounts chosen at lower levels of materiality.

The following research hypotheses are generated for the *positive* outcome task.

**H5** When the probability of a contingent event’s occurrence is ambiguous, the ratio of the estimated liability to the maximum possible liability will be larger than when the probability is nonambiguous.

Auditors will suggest a larger dollar amount for the estimated warranty obligation
under ambiguity than under nonambiguity. A cautious decision maker might want to provide for a larger margin of error if he or she is uncertain about the outcome.

**H6** As replacement cost per unit becomes larger, the ratio of estimated liability to the maximum possible liability will be increasingly larger.

Auditors will suggest proportionately larger dollar amounts for the warranty liability as the cost per unit increases. The greater the auditor’s exposure, the more protection might be desired.

**H7** As the probability of the contingent event’s occurrence increases, the ratio of estimated liability to the maximum possible liability will be increasingly greater, and it will increase at an increasing rate (i.e., will show a curvilinear shape similar to Figure 2).

Because the E-H ambiguity model function for gains (see Figure 2) is steeper near \( p = 1 \), it converges to the proposed function for gains under nonambiguity. At probabilities below the crossover point, the ambiguity function overweights the probability of a gain so that it appears more likely to occur. The behavior predicted here is suggestive of ambiguity seeking (by overweighting the anchor probability) on the auditor’s part if the estimated liability is greater than expected value at lower probabilities.

**H8** The ratio of estimated liability to the maximum possible liability will converge at higher probabilities of a contingent event’s occurrence across all levels of outcome size.

This interaction for positive outcomes is the result of two complementary forces, the general underweighting of anchor probabilities, based on the assumption of cautious decision making, and the concave below value function for positive outcomes. Both the overweighting of the anchor and the concave below value function (which implies risk aversion) lead to suggested dollar amounts that increase at an increasing rate. The net result will appear more extreme (i.e., the curve would be further from the diagonal in Figure 2) than the corresponding results for losses.
Chapter IV
Methods

4.1 Pilot Testing

The experimental materials were developed to test the model using evaluation of a contingent liability (as described in detail in Chapter III); estimating a fair balance for a warranty obligation. This task was chosen to capture professional judgment in a task that could be described without a lot of supporting documentation (as is required for the evaluation of the allowance of doubtful accounts) and could be fairly realistically subject to different amounts of uncertainty.

The task was commented upon by four former auditors from several different public accounting firms, and by the retired national senior technical partner of a Big-Eight firm. An audit manager of the public accounting firm providing subjects for the experiment vetted the experimental materials for both content and wording prior to pilot testing.

Due to audit season time pressures, pilot testing could not be completed under circumstances similar to the experimental conditions (testing in a group, supervised by the experimenter). Because the nine third-year senior auditor volunteers had to complete the materials in one sitting on their own time, the decision was made to split them into two groups given the materials at different times so that any worthwhile suggestions from the first group could be incorporated before the second group received the materials. Each of the four subjects in the first group received one of the four versions of the tasks. The five subjects in the second group all
received ambiguous versions of the tasks to ensure that the manipulation would be effective. The second batch also responded to very pointed questions about the tasks in the debriefing questionnaire at the end of the materials; otherwise the experimental materials the subjects received contained the same number of audit scenarios (15), Ellsberg tasks (6), and demographic and other debriefing questions as the actual experimental booklets.

Pilot test materials were distributed to the subjects by and returned to the firm experiment coordinator in sealed envelopes to protect their privacy. The time to complete the pilot test booklets ranged from 40 minutes to one hour and 20 minutes.

Changes to the experimental materials from pilot testing primarily concerned the debriefing questionnaire, in terms of order and content, and the general instructions to the subjects.

4.2 Experiment 1

Experiment 1 consisted of the audit tasks and its related debriefing questionnaire.

4.2.1 Subjects

Subjects were audit seniors from a large accounting firm who had met as part of a firm training session. Although the subjects were tested in a large group, they worked individually, using a response booklet and following written instructions. The experimenter observed the subjects while they completed the tasks.

Of the 98 participants, fourteen were eliminated for various reasons, leaving 84 subjects who provided useable responses for Experiment 1. The reasons are summarized in Table 1. The subjects who altered the time frame of the problem and the subject who made arithmetic mistakes on every scenario were eliminated, even though their responses could have been recalculated based on their work shown. However, it would be impossible to determine how they would have responded to the questions about how the error should be handled (as a difference or as an adjustment). The
Table 1.
Reconciliation of Participating Subjects with Useable Booklets

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Participants</td>
<td>98</td>
</tr>
<tr>
<td>Did not complete tasks</td>
<td>2</td>
</tr>
<tr>
<td>Incorrectly reduced estimate for part year</td>
<td>8</td>
</tr>
<tr>
<td>Incorrectly doubled estimate</td>
<td>2</td>
</tr>
<tr>
<td>Provided a range for an estimate</td>
<td>1</td>
</tr>
<tr>
<td>Arithmetic errors on every scenario</td>
<td>14</td>
</tr>
<tr>
<td>Total useable booklets</td>
<td>84</td>
</tr>
</tbody>
</table>

person providing a range for the estimate of liability was eliminated because of the subjective judgment required to determine a point estimate from the range provided. The subjects providing useable responses appeared to have a fairly homogeneous and representative background as auditors. Table 2 provides details.

4.2.2 Procedure

Materials: Each experimental booklet contained a letter from the experimenter requesting participation in an experiment on professional judgment in auditing, general instructions, the research tasks (as described in Chapter III), and a debriefing questionnaire.

The debriefing questionnaire (see Appendix C) asked for the subject’s educational level attained, professional certification, months of audit experience, industry composition and financial health of their clients, age, and gender. It also solicited comments about the experiments. As a manipulation check, subjects rated how ambiguous the particular set of scenarios they completed was and whether they thought their suggested adjustments were positive or negative, depending on the scenario they
### Table 2.
Demographic Information

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean</th>
<th>Median</th>
<th>Mode</th>
<th>Missing Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age in years</td>
<td>26.13</td>
<td>25</td>
<td>25</td>
<td>9</td>
</tr>
<tr>
<td>Months of Audit Experience</td>
<td>38.47</td>
<td>37.5</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td>Months of Audit Experience with the same firm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Financial Health of audit clients (1 = very poor to 10 = very good)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>37.13</td>
<td>36</td>
<td>36</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>6.40</td>
<td>6</td>
<td>6</td>
<td>1</td>
</tr>
</tbody>
</table>

### Gender

- Male: 47
- Female: 30
- No Response: 7

### Certification Status

- CPA: 64
- Passed Exam: 6
- Conditioned: 12
- CA: 2

### Educational Level Achieved

- Bachelor's: 70
- Master's: 11
- No Response: 3

### Geographic Location of Office

- Foreign: 5
- Northeast: 20
- Southeast: 19
- Gulf States: 8
- Midwest: 11
- Rocky Mtns.: 7
- Southwest: 8
- Pacific NW: 2
completed. Subjects were told that if they would like to know to the results of the study on its completion, to provide their names and addresses on the removable blank last sheet of the booklet and to hand it in separately to maintain their anonymity.\(^{19}\)

**Independent Variables:** Variables manipulated in experiment 1 were the ambiguity implicit in the descriptions of the anchor probability values (ambiguous or non-ambiguous), whether the amount represents a gain or loss for the client, the anchor probability values (.01, .10, .50, .90, .99), and the materiality of the dollar amount involved (immaterial, borderline material, and highly material).

**Dependent Variables:** For experiment 1, the subjects suggested their estimate for the warranty liability, provided a brief justification (rationale) for the amount selected, and suggested an amount to be recorded as a monetary error in a summary worksheet. The subjects were asked to indicate how they reached their judgment (e.g., they might calculate expected value and add a "cushion").

The estimate dependent variable was transformed by taking the ratios of the estimated liability to the appropriate maximum possible liability to eliminate the effect of the unequally spaced levels of replacement cost. The transformed estimate variable was used for all subsequent analyses, and is referred to henceforth as the *estimate dependent variable*.

Because the error dependent variable depended in amount on whether the response was in relation to zero cost or 100% of cost having been recorded on the client's books (i.e., which reference point condition the subject received), these were equated by subtracting the error from the appropriate maximum cost to obtain the end result of the error process. This number was equivalent to the amount recorded as the error amount in the zero reference point condition. As done for the estimate dependent variable, the ratio of the resulting amount to the maximum possible liability was taken to remove the effect of the unequal spacing of the replacement cost factor. This

\(^{19}\)Almost one-half (39/84) of the subjects handed in their name and address.
amount then was combined with the dependent variable requesting the subject’s recommended disposition of the error (i.e., to record as an audit difference or to book as an audit adjustment). The combination resulted in a zero error amount booked if the disposition to be made was an audit difference, that is, the amount of warranty liability (zero or the maximum possible for the level of replacement cost) that the client had recorded as the unaudited amount of warranty liability would not be changed by the auditor. The transformed error dependent variable was used for all subsequent analyses and is henceforth referred to as the em error dependent variable.

**Design:** Experiment 1 was designed as a $2 \times 2 \times (3 \times 5)$ mixed between- and within-subjects factor design, with ambiguity and outcome sign as between-subjects factors, and replacement cost and likelihood of failure factors as within-subjects factors. The two levels of the ambiguity factor were treated as a between-subjects factor in experiment 1 to avoid possible differential carryover effects [Greenwald, 1976], because the subjects might realize that the primary factor of interest is ambiguity versus non-ambiguity. Due to time constraints, the positive or negative outcome factor were treated also as a between-subjects factor. Subjects were assigned randomly to one of the four possible between-subjects scenarios. Each subject received each of the 15 combinations of the five levels of probability and the three levels of materiality. These within-subjects factors were presented in the experimental booklets in individually randomized order with the restriction that each combination must appear at least once as the first task.

The audit judgment tasks were assigned randomly to subjects (see Appendix A for example tasks). Subjects were asked to respond to the questions in the order in which they appeared, and not to flip back and forth. The experimenter was present to observe the subjects while they completed the experimental task, which should have enhanced subjects’ attention to the tasks [Anderson, 1981]. The study took most subjects less than an hour to complete, with only three subjects who were left in the testing room at the hour’s end.
4.3 Experiment 2

The second experiment consisted of the Ellsberg tasks, the abstract balls-and-urns questions designed to show ambiguity avoiding and ambiguity seeking behavior, and the related debriefing questions. The Ellsberg tasks are described in detail in Chapter 2.2 and appear in Appendix B.

4.3.1 Subjects

Because the tasks are designed to test the effects of ambiguity and outcome sign on judgment, subjects should not choose on the basis of an irrelevant characteristic of the data. Subjects were asked to state if they had chosen on the basis of color preference; nineteen said yes. No other researcher has ever asked their subjects if this were the case; it is included here as a potential confound and caveat to others engaging in this research.

4.3.2 Procedure

All subjects completed the Ellsberg tasks between the experimental audit tasks and the debriefing questionnaire. The six variations of the Ellsberg tasks were placed between the audit tasks and the debriefing questionnaire in the response booklet to avoid differential carryover effects that might arise because this series of tasks involved obviously choosing between ambiguous and nonambiguous urns. They were presented to subjects in individually randomized orders to avoid any unintentional order effect.

Materials: Subjects' responses to the abstract questions were collected to compare auditors as a group to other subject groups' (e.g., Einhorn and Hogarth's [1988] MBA students) responses to the same questions, as well as an intra-study comparison of the effects of ambiguity and outcome sign.

The first task, known as Ellsberg's Paradox, uses a known probability value of .50 for the nonambiguous urn to demonstrate ambiguity avoidance. Ellsberg devised
the second task to demonstrate ambiguity seeking; it involves drawing a specifically-numbered marble from either an urn containing 1,000 consecutively-numbered marbles or an urn containing numbered marbles of unknown composition (i.e., at low probabilities of a positive outcome). Einhorn and Hogarth [1985, 1986] suggested that ambiguity seeking would occur at high probabilities of a negative outcome. A third task, which extends the Ellsberg tasks to incorporate this suggestion, was tested in the urns-and-marbles context by making the nonambiguous urn contain a large percentage of “losing” marbles (e.g., 990 red marbles and 10 black marbles) to be compared with an urn containing an unknown proportion of marbles of the two colors.

**Independent Variables:** The variables manipulated in the Ellsberg tasks were the probability levels and the sign of the outcome. The probability levels are .001, .50, and .99; they were chosen to replicate the original tasks and extend the urn context to demonstrate ambiguity seeking at a high probability of a loss. The sign of the outcome indicates whether it is positive (gain) or negative (loss). The size of the outcome was held constant (at $100) for purposes of comparability with prior research and to avoid confounding probability value and outcome size.

**Dependent Variables:** The subjects chose between the ambiguous and the non-ambiguous urns or stated their indifference between the urns for each of the three tasks.
Chapter V
Results

5.1 Characteristics of the Data

5.1.1 Possible Confounds

Subject demographic variables were collected and analyzed for their influence on the results. See Table 2 for details. Subjects were divided into two groups based on the level of ambiguity to which they had been assigned randomly. PROC TTEST [SAS Version 5.18, 1985] was applied. No significant mean differences on demographic variables between levels were found. Similarly, subjects were split into two groups based on the reference point condition to which they had been assigned randomly and PROC TTEST applied. No significant mean differences on demographic variables between levels were found. It may be concluded that these subject demographic variables cannot explain any significant group differences on the experimental factors.

To capture any possible confounding of results with task characteristics (e.g., boredom and degree of care), subjects were asked directly about these behaviors. See Table 3 for the questions and the frequencies of responses. These confounds were examined in a manner similar to the demographic variables. Again, the subjects were split into groups based on levels of between-subjects factor levels (ambiguity and reference point) and compared using PROC TTEST. No mean group differences were found between levels of the between-subjects factors. In general, it may be concluded that these possible confounds were not responsible for the observed differences among the groups on the experimental tasks. Though subjects became bored completing
Table 3.
Possible Confounds due to Task Characteristics.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you get bored while completing the fifteen versions of the audit tasks?</td>
<td>67</td>
<td>17</td>
</tr>
<tr>
<td>If you circled yes, about how many scenarios did it take you to get bored?</td>
<td>3.66</td>
<td>4</td>
</tr>
<tr>
<td>Please check the line corresponding to how you approached the audit tasks:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>56 More carefully in the beginning, less carefully towards the end.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 Less carefully in the beginning, more carefully towards the end.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>18 As carefully towards the end as in the beginning.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 Not very carefully for each scenario.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Are warranties common in the industries that you usually audit?</td>
<td>14</td>
<td>70</td>
</tr>
<tr>
<td>Was the estimation of the warranty liability difficult to complete for you,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>given your level of experience with this type of task?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes 12</td>
<td>69</td>
<td>9</td>
</tr>
</tbody>
</table>

fifteen tasks, the effects of the boredom appears to have lead to a particular strategy being adhered to for the entire series. While there may be some reduction in reliability or attention to the scenarios, there did not appear to be any highly discrepant values when the responses were compared. Boredom is also an issue on an actual audit as well.

The issue of subject motivation warrants a fuller discussion. One possible explanation of the experimental task results might be that subjects behaved more carelessly, and therefore in a more risk-taking fashion than they might in the field. To counteract this charge, consider the individually random ordering of treatment combinations that subjects received. If subjects tended to become less thoughtful as they became bored, the random ordering would tend to evenly distribute the more careless responses across treatment combinations. Further, also consider the non-ambiguous, zero reference point condition in which very little variability existed in
subjects’ responses across the fifteen treatment conditions received. Random assignment of subjects to between-subject treatment combinations should have eliminated any clumping of hypervigilant subjects to that particular treatment condition; in fact, the subjects in that cell became bored more quickly than the other subjects (mean scenarios to boredom was 2.26).²⁰

Several checks were run to verify that the experimental factor manipulations had been accepted by the subjects. The results of these checks appear in Table 4. The results of PROC TTEST on the manipulation check questions indicate that subjects in the ambiguous condition expressed a significantly higher level of uncertainty in the ambiguous condition about both the likelihood of failure of the product and in their own estimate than did subjects in the nonambiguous condition. Subjects (79.5%) in the zero reference point condition indicated that their suggested adjustments would have a negative impact on the client’s financial statements through the income decreasing impact of the adjustment. Subjects (69%) in the maximum reference point condition indicated that their suggested adjustments would have a positive impact on the client’s financial statements.²¹

5.2 Experiment 1

To conduct a valid analysis of variance, the sample data should meet three assumptions to draw valid inferences about the population of interest: the data should be drawn from a normally distributed population, have equal variances, and represent independent observations. The last assumption was covered by the random assignment of subjects to treatment conditions. The first two assumptions were tested directly as described below.

²⁰The means in the other cells were: nonambiguous, maximum reference point: 4.3 scenarios; ambiguous, zero reference point: 4.08 scenarios; ambiguous, maximum reference point: 3.13 scenarios.
²¹Six, or 14%, of these subjects stated that their adjustments had a negative impact on the client’s financial statements; one wrote that he or she couldn’t remember the impact of his/her adjustment, one defined a negative effect on the client’s financial statement in terms of an audit as “fighting with the controller about booking an adjustment,” another defined the negative effect as “having to qualify the opinion,” and the rest responded with a “decrease to income.”
<table>
<thead>
<tr>
<th>Table 4. Manipulation Checks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>How much uncertainty did you think surrounded the likelihood of product failure for the Lyon Company?</strong> Subjects placed a mark on a continuous linear scale from 1 (very low uncertainty) to 10 (very high uncertainty).</td>
</tr>
<tr>
<td><strong>Overall:</strong></td>
</tr>
<tr>
<td>Mean: 5.63  Median: 5.25  Mode: 4, 8.</td>
</tr>
<tr>
<td><strong>Between Levels of Ambiguity:</strong></td>
</tr>
<tr>
<td>Nonambiguous Mean ($N = 40$): 4.50  Ambiguous Mean ($N = 44$): 6.65</td>
</tr>
<tr>
<td>t test: -4.42 ($df = 82$, $p &lt; .0001$)</td>
</tr>
<tr>
<td><strong>Overall, how much uncertainty did you think surrounded your estimates of the Lyon Company’s warranty liability?</strong> Subjects placed a mark on a continuous linear scale from 1 (very low uncertainty) to 10 (very high uncertainty).</td>
</tr>
<tr>
<td><strong>Overall:</strong></td>
</tr>
<tr>
<td>Mean: 5.75  Median: 6  Mode: 4, 5, 6, 8.</td>
</tr>
<tr>
<td><strong>Between Levels of Ambiguity:</strong></td>
</tr>
<tr>
<td>Nonambiguous Mean ($N = 40$): 4.59  Ambiguous Mean ($N = 44$): 6.81</td>
</tr>
<tr>
<td>t test: -4.99 ($df = 82$, $p &lt; .0001$)</td>
</tr>
<tr>
<td><strong>How do you think your estimates of Lyon’s warranty liability across the various scenarios generally affected Lyon’s financial statements?</strong> (Response code: -1 for negative, 0 for no effect, and 1 for positive.)</td>
</tr>
<tr>
<td>Overall: Negatively 37  Positively 29  No Effect 15  Missing 3</td>
</tr>
<tr>
<td>Overall: Mean: -0.111  Median: 0</td>
</tr>
<tr>
<td><strong>Between Levels of Sign:</strong></td>
</tr>
<tr>
<td>Zero Reference Point (Negative Outcome): Mean ($N = 39$): -0.821</td>
</tr>
<tr>
<td>Maximum Reference Point (Positive Outcome):</td>
</tr>
<tr>
<td>Mean ($N = 42$): 0.548</td>
</tr>
<tr>
<td>t test (with unequal variances): -10.53 ($df = 63$, $p = .0001$)</td>
</tr>
</tbody>
</table>
The data were run through PROC UNIVARIATE [SAS Version 5.18, 1985] with the plot normal option. Tests of normality were accomplished with the Shapiro-Wilk test and found to be to be highly nonnormal for the 15 repeated measures dependent variables across the entire sample and for the 15 repeated measures dependent variables within each of the four between-subjects cells. Further, plots of the residuals yielded a horizontal rectangular shape (rather than the desired amorphous shape) to the error terms, indicating nonnormality of the error terms.

Inspection of the variances of the estimate dependent variable among the 2x2 between-subjects cells indicated that one cell (the nonambiguous, zero reference point cell) had zero variance for nine of the 15 repeated measures and the remaining six had very small variances. The other three cells had variances which ranged from 100 to 1000 times larger. See Table 5 for details.

A one-way ANOVA was run on the expected mean square error as the dependent variable to statistically test for the differences among cell variances; the null of equal mean square error for the liability estimate was rejected ($F_{3,80} = 4.86, p = .0037$). A Scheffé test to locate differences among the means indicated differences between the (nonambiguous, zero reference point cell) and the (ambiguous, maximum reference point cell), but not among any other combinations of cells. The means and 95% confidence intervals may be found in Table 6.

A one-way ANOVA was run on the expected mean square error as the dependent variable to test for differences among cell variances; the null of equal mean square errors for the error dependent variable was rejected ($F_{3,80} = 13.01, p = .0001$). A Scheffé test to locate differences among the means indicated differences among the nonambiguous, zero reference point cell, the nonambiguous, maximum reference point cell, and with both the ambiguous cells. See Table 7 for the results of the ANOVAs.²²

²²For both of these dependent variables, Tukey’s HSD and the Bonferroni multiple comparison tests were run as well because the Scheffé test is very conservative in determining significant mean differences. The same results were obtained.
Table 5.
Descriptive Statistics
of the Ratio of Estimated Liability
to Maximum Possible Liability
by Cell\(^a\)

<table>
<thead>
<tr>
<th>Cost &amp; Likelihood</th>
<th>Nonambiguous Cell</th>
<th>Ambiguous Cell</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>mean</td>
<td>variance</td>
</tr>
<tr>
<td>$10, .01</td>
<td>.010</td>
<td>.0000</td>
</tr>
<tr>
<td>R</td>
<td>.100</td>
<td>.0000</td>
</tr>
<tr>
<td>E</td>
<td>.500</td>
<td>.0000</td>
</tr>
<tr>
<td>F</td>
<td>.900</td>
<td>.0000</td>
</tr>
<tr>
<td>$10, .99</td>
<td>.991</td>
<td>$5 \times 10^{-6}$</td>
</tr>
<tr>
<td>P</td>
<td>.009</td>
<td>$5 \times 10^{-6}$</td>
</tr>
<tr>
<td>O</td>
<td>.999</td>
<td>.0003</td>
</tr>
<tr>
<td>I</td>
<td>.500</td>
<td>.0000</td>
</tr>
<tr>
<td>N</td>
<td>.900</td>
<td>.0000</td>
</tr>
<tr>
<td>T</td>
<td>.991</td>
<td>.0009</td>
</tr>
<tr>
<td>$1000, .01</td>
<td>.019</td>
<td>.0008</td>
</tr>
<tr>
<td>Z</td>
<td>.100</td>
<td>.0000</td>
</tr>
<tr>
<td>E</td>
<td>.500</td>
<td>.0000</td>
</tr>
<tr>
<td>$1000, .90</td>
<td>.900</td>
<td>.0000</td>
</tr>
<tr>
<td>O</td>
<td>.991</td>
<td>$10 \times 10^{-6}$</td>
</tr>
<tr>
<td>R</td>
<td>.089</td>
<td>.0553</td>
</tr>
<tr>
<td>E</td>
<td>.229</td>
<td>.1041</td>
</tr>
<tr>
<td>F</td>
<td>.512</td>
<td>.0030</td>
</tr>
<tr>
<td>$10, .90</td>
<td>.919</td>
<td>.0016</td>
</tr>
<tr>
<td>P</td>
<td>.990</td>
<td>.0004</td>
</tr>
<tr>
<td>O</td>
<td>.023</td>
<td>.0010</td>
</tr>
<tr>
<td>I</td>
<td>.096</td>
<td>.0004</td>
</tr>
<tr>
<td>N</td>
<td>.500</td>
<td>.0000</td>
</tr>
<tr>
<td>T</td>
<td>.905</td>
<td>.0005</td>
</tr>
<tr>
<td>$1000, .99</td>
<td>.989</td>
<td>.0004</td>
</tr>
<tr>
<td>$1000, .01</td>
<td>.020</td>
<td>.0008</td>
</tr>
<tr>
<td>$1000, .10</td>
<td>.100</td>
<td>.0007</td>
</tr>
<tr>
<td>M</td>
<td>.495</td>
<td>.0005</td>
</tr>
<tr>
<td>A</td>
<td>.861</td>
<td>.0312</td>
</tr>
<tr>
<td>X</td>
<td>.969</td>
<td>.0116</td>
</tr>
</tbody>
</table>

\(^a\)The median and mode for each combination were the same as the stated likelihood (see Column 1).
Table 6.
Cell by Cell Means and 95% Confidence Intervals for the Estimate Dependent Variable

<table>
<thead>
<tr>
<th>Cost &amp; Likelihood</th>
<th>Mean &amp; C.I.</th>
<th>Mean &amp; C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>R $10,01</td>
<td>.0100 ± .0000</td>
<td>.1190 ± .1345</td>
</tr>
<tr>
<td>E $10,10</td>
<td>.1000 ± .0000</td>
<td>.1667 ± .0956</td>
</tr>
<tr>
<td>F $10,50</td>
<td>.5000 ± .0000</td>
<td>.5495 ± .0540</td>
</tr>
<tr>
<td>$10,90</td>
<td>.9000 ± .0000</td>
<td>.9357 ± .0374</td>
</tr>
<tr>
<td>P $10,99</td>
<td>.9905 ± .0011</td>
<td>1.0009 ± .0276</td>
</tr>
<tr>
<td>O $100,01</td>
<td>.0095 ± .0011</td>
<td>.0677 ± .0978</td>
</tr>
<tr>
<td>I $100,10</td>
<td>.0987 ± .0028</td>
<td>.1611 ± .0963</td>
</tr>
<tr>
<td>N $100,50</td>
<td>.5000 ± .0000</td>
<td>.4929 ± .0774</td>
</tr>
<tr>
<td>T $100,90</td>
<td>.9000 ± .0000</td>
<td>.8821 ± .0808</td>
</tr>
<tr>
<td>$100,99</td>
<td>.9911 ± .0015</td>
<td>.9690 ± .0488</td>
</tr>
<tr>
<td>= $1000,01</td>
<td>.0195 ± .0136</td>
<td>.0638 ± .0978</td>
</tr>
<tr>
<td>Z $1000,10</td>
<td>.1000 ± .0000</td>
<td>.1469 ± .0889</td>
</tr>
<tr>
<td>E $1000,50</td>
<td>.5000 ± .0000</td>
<td>.5202 ± .0623</td>
</tr>
<tr>
<td>R $1000,90</td>
<td>.9000 ± .0000</td>
<td>.8691 ± .0937</td>
</tr>
<tr>
<td>O $1000,99</td>
<td>.9911 ± .0015</td>
<td>.9338 ± .0990</td>
</tr>
<tr>
<td>R $10,01</td>
<td>.0886 ± .1068</td>
<td>.1326 ± .1446</td>
</tr>
<tr>
<td>E $10,10</td>
<td>.2286 ± .1465</td>
<td>.2000 ± .1148</td>
</tr>
<tr>
<td>F $10,50</td>
<td>.5119 ± .0248</td>
<td>.5425 ± .0529</td>
</tr>
<tr>
<td>$10,90</td>
<td>.9190 ± .0183</td>
<td>.9043 ± .0421</td>
</tr>
<tr>
<td>P $10,99</td>
<td>.9895 ± .0096</td>
<td>.9721 ± .0444</td>
</tr>
<tr>
<td>O $100,01</td>
<td>.0229 ± .0145</td>
<td>.0689 ± .0336</td>
</tr>
<tr>
<td>I $100,10</td>
<td>.0957 ± .0089</td>
<td>.1270 ± .0201</td>
</tr>
<tr>
<td>N $100,50</td>
<td>.5000 ± .0000</td>
<td>.5022 ± .0526</td>
</tr>
<tr>
<td>T $100,90</td>
<td>.9048 ± .0099</td>
<td>.8913 ± .0388</td>
</tr>
<tr>
<td>$100,99</td>
<td>.9886 ± .0094</td>
<td>.8430 ± .1449</td>
</tr>
<tr>
<td>= $1000,01</td>
<td>.0205 ± .0126</td>
<td>.0492 ± .0468</td>
</tr>
<tr>
<td>$1000,10</td>
<td>.1005 ± .0116</td>
<td>.1678 ± .0875</td>
</tr>
<tr>
<td>M $1000,50</td>
<td>.4952 ± .0099</td>
<td>.4630 ± .0496</td>
</tr>
<tr>
<td>A $1000,90</td>
<td>.9000 ± .0000</td>
<td>.8563 ± .0814</td>
</tr>
<tr>
<td>X $1000,99</td>
<td>.9900 ± .0000</td>
<td>.9039 ± .0973</td>
</tr>
</tbody>
</table>
Table 7.
Summary Table of One-Way ANOVA on the Cell Variances for the Ratio of the Estimated Liability to the Maximum Possible Liability.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell</td>
<td>1.3636</td>
<td>3</td>
<td>0.4545</td>
<td>4.86</td>
<td>.0037</td>
</tr>
<tr>
<td>Error</td>
<td>7.4795</td>
<td>80</td>
<td>0.0935</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>8.8431</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Summary Table of One-Way ANOVA on the Cell Variances of the Booked Liability\(^a\) to the Maximum Possible Liability.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>$F$</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell</td>
<td>1.0529</td>
<td>3</td>
<td>0.3510</td>
<td>13.01</td>
<td>.0001</td>
</tr>
<tr>
<td>Error</td>
<td>2.1588</td>
<td>80</td>
<td>0.0261</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>3.2118</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Booked amount resulting from the disposition of the error dependent variable.
Various transformations known to be useful for right-skewed distributions and nonhomogeneous variance (e.g., logarithmic, inverse, and square root) were attempted and failed due to the existence of zero-valued dependent variables. The dependent variables were transformed into proportions of the maximum cost of replacement to remove the effect of the unequal spacing of the replacement cost factor levels. This transformation did not lead to any reduction of assumption violations, even after applying a transformation suggested for proportional data, $2 \arcsin \sqrt{Y}$ [Neter, Wasserman, & Kutner, 1983] because of the zero responses.

5.2.1 Analysis of the Estimate Dependent Variable

Though no main effect of ambiguity on means was found, the significant differences among the cells with respect to variance do indicate an effect due to ambiguity on the subjects’ responses. See Table 7. Because the predictions made from the E-H model were conditioned on the reference point factor (yielding a positive or negative outcome), two 2X(3x5) ANOVAs were run, one for each level of outcome sign. This was seen as a reasonable compromise to the full four-factor ANOVA, since the cell variances were fairly homogeneous within the outcome sign factor. The results of this analysis for the estimate dependent variable are reported in Tables 8 and 9. The predictions of the E-H model are main effects conditioned on outcome sign (called either the maximum or zero reference point condition in this study) for ambiguity, replacement cost, and likelihood of failure, as well as an interaction between replacement cost and likelihood of failure. The results of the ANOVA on the estimate dependent variable for the zero reference point condition (negative outcome sign) were essentially significant for both the predicted conditional likelihood of failure factor ($p = .0522$) and the unexpected conditional interaction of ambiguity and likelihood of failure ($p = .0637$), but failed to achieve the predicted significance for the replacement cost factor. The ANOVA on the estimate dependent variable for the maximum reference point (positive outcome sign) confirmed the prediction of the existence of conditional
Table 8.
ANOVA for the Zero Reference Point Condition for the Estimate Dependent Variable.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambiguity (A)</td>
<td>0.0858</td>
<td>1</td>
<td>0.0858</td>
<td>0.82</td>
<td>0.3699</td>
</tr>
<tr>
<td>Replacement Cost (C)</td>
<td>0.0567</td>
<td>2</td>
<td>0.0284</td>
<td>1.71</td>
<td>0.1879</td>
</tr>
<tr>
<td>Likelihood of Failure (D)</td>
<td>0.6084</td>
<td>4</td>
<td>0.1521</td>
<td>2.40</td>
<td>0.0522</td>
</tr>
<tr>
<td>AxC</td>
<td>0.0633</td>
<td>2</td>
<td>0.0317</td>
<td>1.91</td>
<td>0.1554</td>
</tr>
<tr>
<td>AxD</td>
<td>0.5761</td>
<td>4</td>
<td>0.1440</td>
<td>2.28</td>
<td>0.0637</td>
</tr>
<tr>
<td>CxD</td>
<td>7.4088</td>
<td>8</td>
<td>0.9261</td>
<td>21.58</td>
<td>0.0001</td>
</tr>
<tr>
<td>AxCxD</td>
<td>0.0211</td>
<td>8</td>
<td>0.0026</td>
<td>0.43</td>
<td>0.9043</td>
</tr>
<tr>
<td>S/A</td>
<td>3.9604</td>
<td>38</td>
<td>0.1042</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxCxS/AC</td>
<td>1.2614</td>
<td>76</td>
<td>0.0166</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxDxS/AD</td>
<td>9.6205</td>
<td>152</td>
<td>0.0633</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxCxDxS/ACD</td>
<td>1.8758</td>
<td>304</td>
<td>0.0062</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of subjects in the nonambiguous condition = 19; number in ambiguous condition = 21.

Table 9.
ANOVA for the Maximum Reference Point Condition for the Estimate Dependent Variable.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambiguity (A)</td>
<td>0.0037</td>
<td>1</td>
<td>0.0037</td>
<td>0.08</td>
<td>0.7804</td>
</tr>
<tr>
<td>Replacement Cost (C)</td>
<td>0.4868</td>
<td>2</td>
<td>2.2434</td>
<td>10.20</td>
<td>0.0001</td>
</tr>
<tr>
<td>Likelihood of Failure (D)</td>
<td>2.9056</td>
<td>4</td>
<td>0.7264</td>
<td>8.45</td>
<td>0.0001</td>
</tr>
<tr>
<td>AxC</td>
<td>0.0108</td>
<td>2</td>
<td>0.0054</td>
<td>0.23</td>
<td>0.7982</td>
</tr>
<tr>
<td>AxD</td>
<td>0.7809</td>
<td>4</td>
<td>0.1952</td>
<td>2.27</td>
<td>0.0637</td>
</tr>
<tr>
<td>CxD</td>
<td>0.1319</td>
<td>8</td>
<td>0.0165</td>
<td>0.82</td>
<td>0.5895</td>
</tr>
<tr>
<td>AxCxD</td>
<td>0.1577</td>
<td>8</td>
<td>0.0197</td>
<td>0.98</td>
<td>0.4550</td>
</tr>
<tr>
<td>S/A</td>
<td>1.9634</td>
<td>42</td>
<td>0.0467</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxCxS/AC</td>
<td>2.0034</td>
<td>84</td>
<td>0.0239</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxDxS/AD</td>
<td>14.4413</td>
<td>168</td>
<td>0.0860</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxCxDxS/ACD</td>
<td>6.7930</td>
<td>336</td>
<td>0.0202</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Number of subjects in the nonambiguous cell = 23; number in the ambiguous cell = 21.
replacement cost and likelihood of failure main effects for the negative outcome sign factor, and indicated an unexpected conditional interaction between ambiguity and likelihood of failure that was essentially significant ($p = .0637$). Plots of the means of the interaction of likelihood of failure and replacement cost are shown in Figures 4 and 5.

For the zero reference point condition, the 95% confidence intervals include the anchor (objective) probability, which implies no significant differences between the subjective probability (resulting from the ratio of estimated liability to maximum possible liability) and the objective probability. For the maximum reference point condition, the 95% confidence intervals indicate that all replacement cost levels differ from expected value at the 1 of 100 likelihood of failure condition and the borderline and very material cost levels differ from expected value at the 99 of 100 likelihood of failure condition. See Table 10 for details. These differences and their direction from the objective probability are consistent with the predictions of the E-H model of general overweighting of low probabilities and underweighting of high probabilities. Cell-by-cell plots for both reference point conditions are shown in Figure 6. All 95% confidence intervals around these means include the level-appropriate objective probability on a cell-by-cell basis. The differences in significance are due to the variability of each cell as indicated by the ANOVA on mean square errors as noted earlier (and as depicted in Figure 6).

5.2.2 Analysis of the Error Dependent Variable

Recall that the error dependent variable represents the amount of liability that the auditor-subject would actually recommend to his or her manager as the amount the client should have recorded on its books, based on their error dollar amount and error disposition (passed audit difference or audit adjustment). This amount represents the effective end result of the senior auditor's professional judgment process.

Though the error dependent variable cell variances were relatively homogenous
Figure 4.
Estimate of the Liability in the Zero Reference Point Row or the interaction of replacement cost and likelihood of failure (as the ratio of the estimate to the maximum possible liability).
Figure 5.
Estimate of the Liability in the Maximum Reference Point Row or the interaction of replacement cost and likelihood of failure (as the ratio of the estimate to the maximum possible liability).
Table 10.
Row Means and 95% Confidence Intervals for the Estimate Dependent Variable

<table>
<thead>
<tr>
<th>Cost and Likelihood</th>
<th>Zero Reference Point Means &amp; 95% C.I.</th>
<th>Max Reference Point Means &amp; 95% C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10,.01</td>
<td>.0673 ± .0704</td>
<td>.1116 ± .0806</td>
</tr>
<tr>
<td>$10,.10</td>
<td>.1350 ± .0494</td>
<td>.2136 ± .0887</td>
</tr>
<tr>
<td>$10,.50</td>
<td>.5213 ± .0280</td>
<td>.5284 ± .0295</td>
</tr>
<tr>
<td>$10,.90</td>
<td>.9188 ± .0197</td>
<td>.9114 ± .0230</td>
</tr>
<tr>
<td>$10,.99</td>
<td>.9960 ± .0140</td>
<td>.9804 ± .0230</td>
</tr>
<tr>
<td>$100,.01</td>
<td>.0400 ± .0502</td>
<td>.0469 ± .0365</td>
</tr>
<tr>
<td>$100,.10</td>
<td>.1315 ± .0496</td>
<td>.1120 ± .0220</td>
</tr>
<tr>
<td>$100,.50</td>
<td>.4963 ± .0391</td>
<td>.5011 ± .0265</td>
</tr>
<tr>
<td>$100,.90</td>
<td>.8906 ± .0408</td>
<td>.8977 ± .0202</td>
</tr>
<tr>
<td>$100,.99</td>
<td>.9795 ± .0249</td>
<td>.9124 ± .0767</td>
</tr>
<tr>
<td>$1000,.01</td>
<td>.0428 ± .0502</td>
<td>.0355 ± .0249</td>
</tr>
<tr>
<td>$1000,.10</td>
<td>.1246 ± .0455</td>
<td>.1357 ± .0467</td>
</tr>
<tr>
<td>$1000,.50</td>
<td>.5106 ± .0316</td>
<td>.4784 ± .0259</td>
</tr>
<tr>
<td>$1000,.90</td>
<td>.8838 ± .0475</td>
<td>.8588 ± .0552</td>
</tr>
<tr>
<td>$1000,.99</td>
<td>.9610 ± .0508</td>
<td>.9350 ± .0549</td>
</tr>
</tbody>
</table>
Figure 6.
Cell by Cell Plots for the Estimate Dependent Variable.
within each level of ambiguity but not within outcome sign, the two 2x(3x5) ANOVAs still were conducted on each level of outcome sign. This decision was made because the predictions are for the outcome sign factor, not by level of ambiguity. Further, the effect of severely unequal variance on equal sample size is to inflate the Type I error rate two to four percentage points above the assumed significance level, with the effect more severe for unequal sample sizes [Rogan & Keselman, 1977]. Given that the significance levels achieved in the analyses are no greater than .0001, the fear of unwarranted rejection of the null is lessened. Nonetheless, the differences in variances do indicate a significant difference in response to ambiguity, though not through the predicted effects on central tendency.

As predicted by the model, significant main effects were found at both levels of the reference point factor for the replacement cost and likelihood of failure factors as well as significant interactions of these two factors (p < .0001 for all factors). See Tables 11 and 12 for details.

However, contrary to the predictions made with the model under the assumption of cautious decision makers were the direction of the interaction of the replacement cost and likelihood of failure factors. See Figures 7 and 8. The obtained results are predicted by the E-H model if the decision maker were assumed to be optimistic, rather than cautious, in his or her attitude towards positive and negative outcomes. In the zero reference point condition (the negative outcome for the client because it requires an income decreasing adjustment), the ratios of the amount booked to the maximum possible liability indicates a subjective probability that is significantly underweighted compared to the objective probability. A cautious decision maker is predicted to overweight the likelihood of a negative event’s occurrence. In the maximum reference point condition (the negative outcome for the client because it requires an income decreasing adjustment), the ratios of the amount booked to the maximum possible liability indicate a subjective probability that is significantly overweighted compared to the objective probability. A cautious decision maker is predicted to un-
Table 11.
ANOVA for the Zero Reference Point Condition
for the Error Dependent Variable.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambiguity (A)</td>
<td>0.0002</td>
<td>1</td>
<td>0.0002</td>
<td>0.00</td>
<td>0.9795</td>
</tr>
<tr>
<td>Replacement Cost (C)</td>
<td>12.8233</td>
<td>2</td>
<td>6.4117</td>
<td>70.10</td>
<td>0.0001</td>
</tr>
<tr>
<td>Likelihood</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of Failure (D)</td>
<td>23.8585</td>
<td>4</td>
<td>5.9646</td>
<td>49.52</td>
<td>0.0001</td>
</tr>
<tr>
<td>AxC</td>
<td>0.1632</td>
<td>2</td>
<td>0.0816</td>
<td>0.89</td>
<td>0.4140</td>
</tr>
<tr>
<td>AxD</td>
<td>0.4393</td>
<td>4</td>
<td>0.1098</td>
<td>0.91</td>
<td>0.4586</td>
</tr>
<tr>
<td>CxD</td>
<td>7.4088</td>
<td>8</td>
<td>0.9261</td>
<td>21.58</td>
<td>0.0001</td>
</tr>
<tr>
<td>AxCxD</td>
<td>0.4030</td>
<td>8</td>
<td>0.0504</td>
<td>1.17</td>
<td>0.3145</td>
</tr>
<tr>
<td>S/A</td>
<td>8.7867</td>
<td>38</td>
<td>0.2312</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxCxS/AC</td>
<td>6.9509</td>
<td>76</td>
<td>0.0915</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxDxS/AD</td>
<td>18.3067</td>
<td>152</td>
<td>0.1204</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxCxDxS/ACD</td>
<td>13.0467</td>
<td>304</td>
<td>0.0429</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 12.
ANOVA for the Maximum Reference Point Condition
for the Error Dependent Variable.

<table>
<thead>
<tr>
<th>Source</th>
<th>SS</th>
<th>df</th>
<th>MS</th>
<th>F</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ambiguity (A)</td>
<td>0.3726</td>
<td>1</td>
<td>0.3726</td>
<td>1.35</td>
<td>0.2525</td>
</tr>
<tr>
<td>Replacement Cost (C)</td>
<td>11.4665</td>
<td>2</td>
<td>5.7332</td>
<td>67.07</td>
<td>0.0001</td>
</tr>
<tr>
<td>Likelihood</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>of Failure (D)</td>
<td>73.6709</td>
<td>4</td>
<td>18.4188</td>
<td>63.68</td>
<td>0.0001</td>
</tr>
<tr>
<td>AxC</td>
<td>0.0133</td>
<td>2</td>
<td>0.0067</td>
<td>0.08</td>
<td>0.9250</td>
</tr>
<tr>
<td>AxD</td>
<td>0.2748</td>
<td>4</td>
<td>0.0687</td>
<td>0.24</td>
<td>0.9168</td>
</tr>
<tr>
<td>CxD</td>
<td>5.8854</td>
<td>8</td>
<td>0.7357</td>
<td>12.85</td>
<td>0.0001</td>
</tr>
<tr>
<td>AxCxD</td>
<td>0.0486</td>
<td>8</td>
<td>0.0061</td>
<td>0.11</td>
<td>0.9990</td>
</tr>
<tr>
<td>S/A</td>
<td>11.3381</td>
<td>41</td>
<td>0.2765</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxCxS/AC</td>
<td>7.0090</td>
<td>82</td>
<td>0.0855</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxDxS/AD</td>
<td>47.4349</td>
<td>164</td>
<td>0.2892</td>
<td></td>
<td></td>
</tr>
<tr>
<td>AxCxDxS/ACD</td>
<td>18.7738</td>
<td>328</td>
<td>0.0572</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 7.

Liability That Would Be Booked in the Zero Reference Point Row as the result of the interaction of replacement cost and likelihood of failure. (The ratio of liability actually booked to the maximum possible liability.)
Figure 8.
Liability That Would Be Booked in the Maximum Reference Point Row as the interaction between replacement cost and likelihood of failure. (The ratio of liability actually booked to the maximum possible liability.)
Table 13.
Row Means and 95% Confidence Intervals
for the Error Dependent Variable

<table>
<thead>
<tr>
<th>Cost and Likelihood</th>
<th>Zero Reference Point Means &amp; 95% C.I.</th>
<th>Max Reference Point Means &amp; 95% C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10.01</td>
<td>.0005 ± .0007</td>
<td>.8207 ± .1125</td>
</tr>
<tr>
<td>$10.10</td>
<td>.1125 ± .0503</td>
<td>.4252 ± .1327</td>
</tr>
<tr>
<td>$10.50</td>
<td>.1550 ± .0858</td>
<td>.9318 ± .0529</td>
</tr>
<tr>
<td>$10.90</td>
<td>.2250 ± .1267</td>
<td>.9818 ± .0239</td>
</tr>
<tr>
<td>$10.99</td>
<td>.3728 ± .1568</td>
<td>.9682 ± .0464</td>
</tr>
<tr>
<td>$100.01</td>
<td>.0270 ± .0505</td>
<td>.3038 ± .1361</td>
</tr>
<tr>
<td>$100.10</td>
<td>.0613 ± .0561</td>
<td>.4093 ± .1262</td>
</tr>
<tr>
<td>$100.50</td>
<td>.4131 ± .0719</td>
<td>.6932 ± .0790</td>
</tr>
<tr>
<td>$100.90</td>
<td>.8181 ± .0863</td>
<td>.9614 ± .0470</td>
</tr>
<tr>
<td>$100.99</td>
<td>.8433 ± .1088</td>
<td>.9252 ± .0747</td>
</tr>
<tr>
<td>$1000.01</td>
<td>.0366 ± .0507</td>
<td>.2582 ± .1224</td>
</tr>
<tr>
<td>$1000.10</td>
<td>.1084 ± .0478</td>
<td>.3618 ± .1193</td>
</tr>
<tr>
<td>$1000.50</td>
<td>.4944 ± .0384</td>
<td>.5625 ± .0548</td>
</tr>
<tr>
<td>$1000.90</td>
<td>.8650 ± .0587</td>
<td>.8793 ± .0547</td>
</tr>
<tr>
<td>$1000.99</td>
<td>.9253 ± .0713</td>
<td>.9293 ± .0672</td>
</tr>
</tbody>
</table>

derweight the likelihood of a positive event's occurrence. As may be seen in Table 14, the 95% confidence interval around the row means indicate that six of 15 means in the zero reference point condition and 12 of 15 means in the maximum reference point condition significantly differ from the expected value.

Note that the cell-by-cell plots in Figure 9 do not differ in general shape due to ambiguity.

Plots of the means indicate that the ordering of the replacement levels in each reference point condition is different: immaterial > borderline > very material for the maximum reference point condition, and the reverse (very material > borderline > very material) for the zero reference point condition. The predicted direction for both reference point conditions was an increasing ratio of the error amount to the maximum possible amount as replacement cost increases.
Figure 9.
Liability That Would Be Booked Cell by Cell
(as the ratio of liability actually booked to the maximum possible liability).
Table 14.
Cell by Cell Means and 95% Confidence Intervals
for the Error Dependent Variable

<table>
<thead>
<tr>
<th>Cost Level &amp; Likelihood</th>
<th>Mean &amp; C.I.</th>
<th>Mean &amp; C.I.</th>
</tr>
</thead>
<tbody>
<tr>
<td>R $10,.01</td>
<td>.0005 ± .0011</td>
<td>.0004 ± .0001</td>
</tr>
<tr>
<td>E $10,.10</td>
<td>.0737 ± .0217</td>
<td>.1476 ± .0990</td>
</tr>
<tr>
<td>F $10,.50</td>
<td>.1316 ± .1086</td>
<td>.1762 ± .1389</td>
</tr>
<tr>
<td>$10,.90</td>
<td>.1895 ± .1810</td>
<td>.2571 ± .1907</td>
</tr>
<tr>
<td>P $10,.99</td>
<td>.3126 ± .2269</td>
<td>.4271 ± .2322</td>
</tr>
<tr>
<td>O $100,.01</td>
<td>.0011 ± .0015</td>
<td>.0505 ± .0989</td>
</tr>
<tr>
<td>I $100,.10</td>
<td>.0263 ± .0217</td>
<td>.0929 ± .1075</td>
</tr>
<tr>
<td>N $100,.50</td>
<td>.4474 ± .0757</td>
<td>.3821 ± .1236</td>
</tr>
<tr>
<td>T $100,.90</td>
<td>.9000 ± .0000</td>
<td>.7440 ± .1636</td>
</tr>
<tr>
<td>$100,.99</td>
<td>.8868 ± .0717</td>
<td>.8038 ± .1665</td>
</tr>
<tr>
<td>= $1000,.01</td>
<td>.0132 ± .0148</td>
<td>.0579 ± .0986</td>
</tr>
<tr>
<td>Z $1000,.10</td>
<td>.0842 ± .0178</td>
<td>.1302 ± .0923</td>
</tr>
<tr>
<td>E $1000,.50</td>
<td>.5000 ± .0000</td>
<td>.4893 ± .0760</td>
</tr>
<tr>
<td>R $1000,.90</td>
<td>.9000 ± .0000</td>
<td>.8333 ± .1145</td>
</tr>
<tr>
<td>O $1000,.99</td>
<td>.9384 ± .1091</td>
<td>.9133 ± .1020</td>
</tr>
<tr>
<td>R $10,.01</td>
<td>.7877 ± .1822</td>
<td>.8509 ± .1483</td>
</tr>
<tr>
<td>E $10,.10</td>
<td>.5238 ± .2070</td>
<td>.3352 ± .1746</td>
</tr>
<tr>
<td>F $10,.50</td>
<td>.9286 ± .0814</td>
<td>.9348 ± .0743</td>
</tr>
<tr>
<td>$10,.90</td>
<td>.9905 ± .0136</td>
<td>.9739 ± .0455</td>
</tr>
<tr>
<td>P $10,.99</td>
<td>.9571 ± .0881</td>
<td>.9783 ± .0450</td>
</tr>
<tr>
<td>O $100,.01</td>
<td>.2543 ± .1943</td>
<td>.3511 ± .2023</td>
</tr>
<tr>
<td>I $100,.10</td>
<td>.4005 ± .1976</td>
<td>.4174 ± .1740</td>
</tr>
<tr>
<td>N $100,.50</td>
<td>.6476 ± .1041</td>
<td>.7348 ± .1219</td>
</tr>
<tr>
<td>T $100,.90</td>
<td>.9476 ± .0892</td>
<td>.9739 ± .0455</td>
</tr>
<tr>
<td>$100,.99</td>
<td>.9100 ± .1285</td>
<td>.9391 ± .0909</td>
</tr>
<tr>
<td>= $1000,.01</td>
<td>.2129 ± .1740</td>
<td>.2996 ± .1821</td>
</tr>
<tr>
<td>$1000,.10</td>
<td>.3552 ± .1813</td>
<td>.3678 ± .1697</td>
</tr>
<tr>
<td>M $1000,.50</td>
<td>.5238 ± .0495</td>
<td>.5978 ± .0961</td>
</tr>
<tr>
<td>A $1000,.90</td>
<td>.8757 ± .0832</td>
<td>.8826 ± .0797</td>
</tr>
<tr>
<td>X $1000,.99</td>
<td>.9286 ± .1076</td>
<td>.9300 ± .0905</td>
</tr>
</tbody>
</table>
Table 15.
Possible Confounds for the Ellsberg Tasks.

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Missing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Did you get bored while completing the marbles tasks?</td>
<td>34</td>
<td>48</td>
<td>2</td>
</tr>
<tr>
<td>Were you able to treat the marbles tasks separately?</td>
<td>72</td>
<td>10</td>
<td>2</td>
</tr>
<tr>
<td>Did you feel any need to provide consistent answers?</td>
<td>41</td>
<td>39</td>
<td>4</td>
</tr>
<tr>
<td>Was $100 a significant amount for you to win?</td>
<td>60</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>Was $100 a significant amount for you to lose?</td>
<td>66</td>
<td>14</td>
<td>4</td>
</tr>
<tr>
<td>Did you choose based on a color preference?</td>
<td>19</td>
<td>63</td>
<td>2</td>
</tr>
</tbody>
</table>

5.3 Experiment 2

As discussed in Chapter 2, that the Ellsberg tasks were abstract marbles-and-urns tasks designed to show ambiguity avoidance and ambiguity seeking under specified conditions. Subjects responded to all six versions of the tasks presented in individually randomized order after completing the experimental audit tasks.

5.3.1 Possible Confounds

Subjects were asked to respond to a series of questions about the Ellsberg tasks. These included whether they became bored while completing the tasks, if the dollar amount involved was sufficient to induce careful consideration of the alternatives, and if they had a color preference in choosing between marbles. See Table 15 for details. Note that 57% of subjects did not become bored and around three quarters said that $100 was a significant amount of money for them to wager.  

Subjects were split into two groups, one on the basis of the level of ambiguity  

23Interestingly, there were six persons who said that $100 was not a significant amount to win, but that it was a significant amount to lose. Recall that this phenomenon was mentioned by Kahneman & Tversky [1979] as the pain from the loss of a certain amount being greater than the pleasure from receiving that same amount. Note in Figure 1 that the slope of the loss function is steeper to reflect this.
treatment levels and the other on the basis of reference point levels, and tested for any mean differences on their responses to the debriefing questions as well as their choices on the Ellsberg tasks themselves. No significant mean differences were found for either pair of groups.

5.3.2 Results of the Ellsberg Tasks

Ellsberg [1961] found patterns of choices on the marbles-and-urns tasks (see Question Sets 1 and 2 in Appendix B) that he labeled ambiguity averse, ambiguity seeking, or ambiguity indifferent. These patterns require that the subject be indifferent between drawing a red or a black ball from Urn I and also from Urn II, because in both instances either knowledge or best guess indicate that each urn contains 50 red and 50 black balls. In the ambiguity averse pattern, the subject then chooses both times the urn containing the known 50:50 proportion; in the ambiguity seeking pattern, the urn of unknown composition is selected both times. In the ambiguity indifferent pattern, the subject continues to be indifferent to the urn from which the ball is drawn. The last pattern is in accordance with SEU, because being indifferent to drawing a particular color ball from an urn implies a subjective probability of 50% for either color ball in that urn. This pattern is suggested by the use of LaPlace’s criterion as the basis for choice: assume a uniform distribution in the face of no defining information. To have an urn preference is accepted by decision theorists to imply that the color ball in question is in a higher proportion in that urn than in the other.

As predicted for the gamble involving a 50% chance of winning $100, more subjects would exhibit ambiguity avoiding behavior than the indifference as predicted by SEU: slightly over two-fifths of the subjects selected the nonambiguous urn from which to draw the potentially winning marble versus slightly over a quarter of the subjects exhibited behavior in accordance with SEU theory. Only 6% of the subjects were ambiguity seeking. Surprisingly, just under a quarter of the subjects exhibited
various other patterns of choice that could not be classified into the above categories. For a gamble involving a 50% chance of losing $100, the proportion choosing the non-ambiguous urn rose to nearly half, with slight decreases in the other three categories. See Table 16 for details.

For the 1 in 1000 chance of winning $100, again two-fifths of the subjects selected the nonambiguous urn from which to draw, and over a quarter of the subjects were indifferent between the urns. As predicted, the proportion of ambiguity seeking increased—to nearly one-third. For the 1 in 1000 chance to lose $100, the number still ambiguity seeking was still high (26.2%), the number indifferent remained unchanged, and almost half (45.2%) chose the nonambiguous urn. The uniform distribution assumed by SEU for the ambiguous urn would again be similar to the known: each number has a 1 in 1000 chance of appearing. See Table 16 for more details.

As predicted for the high probability of a loss (990 losing balls out of 1000), a high proportion of subjects (virtually 60%) selected the ambiguous urn. Slightly less than 10% were indifferent between the urns and 31% were ambiguity avoiding. For the high probability of a gain, a switch between urns was evident, though not as large as might be expected: 58.3% chose the urn with a known 990 winning balls out of 1000, but still over one-third chose the ambiguous urn. Only 7.1% of the subjects were indifferent between the urns. Unfortunately, when designing this task as an extension to the earlier abstract tasks to demonstrate ambiguity seeking at a high probability of a loss, I did not consider what the uniform distribution would be for the ambiguous urn: the uniform distribution should work out to be the same as the nonambiguous urn. That did not happen here: the uniform distribution for the ambiguous urn would be 50 red to 50 black. The task as devised did not provide an adequate test of SEU because it could be argued that subjects chose on the basis of LaPlace’s criterion. Therefore, these results will not be discussed in further detail as they are too ambiguous to provide much insight.

There are sufficient results obtained from this exercise to compare the responses
Table 16.
Results of the Ellsberg Tasks.

Gamble at probability level of .50

<table>
<thead>
<tr>
<th>Sign of Outcome</th>
<th>Ambiguity Avoiding Pattern</th>
<th>Ambiguity Seeking Pattern</th>
<th>Expected Value Pattern</th>
<th>Other</th>
</tr>
</thead>
<tbody>
<tr>
<td>Win $100</td>
<td>36 (42.9)</td>
<td>5 (6.0)</td>
<td>23 (27.4)</td>
<td>20 (23.8)</td>
</tr>
<tr>
<td>Lose $100</td>
<td>39 (46.4)</td>
<td>4 (4.8)</td>
<td>22 (26.2)</td>
<td>19 (22.6)</td>
</tr>
</tbody>
</table>

Gamble at probability level of .001

<table>
<thead>
<tr>
<th>Sign of Outcome</th>
<th>Ambiguous Urn</th>
<th>Nonambiguous Urn</th>
<th>Indifferent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Win $100</td>
<td>26 (31.0)</td>
<td>34 (40.5)</td>
<td>24 (28.9)</td>
</tr>
<tr>
<td>Lose $100</td>
<td>22 (26.2)</td>
<td>38 (45.2)</td>
<td>24 (28.6)</td>
</tr>
</tbody>
</table>

Gamble at probability level of .99

<table>
<thead>
<tr>
<th>Sign of Outcome</th>
<th>Ambiguous Urn</th>
<th>Nonambiguous Urn</th>
<th>Indifferent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Win $100</td>
<td>29 (34.5)</td>
<td>49 (58.3)</td>
<td>6 (7.1)</td>
</tr>
<tr>
<td>Lose $100</td>
<td>50 (59.5)</td>
<td>26 (31.0)</td>
<td>8 (9.5)</td>
</tr>
</tbody>
</table>
Table 17.
Comparison of Ellsberg Task Results
Between Einhorn and Hogarth [1988] and the Current Study
(in percentages)

<table>
<thead>
<tr>
<th>Probability</th>
<th>Ambiguous Urn</th>
<th>Nonambiguous Urn</th>
<th>Indifferent Between Urns</th>
<th>Other Pattern</th>
<th>Subject Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>$= 0.50$</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Win</td>
<td>19</td>
<td>47</td>
<td>34</td>
<td>N.A.</td>
<td>E&amp;H (n=133)</td>
</tr>
<tr>
<td>$$100$</td>
<td>6</td>
<td>43</td>
<td>27</td>
<td>24</td>
<td>Auditors (n=84)</td>
</tr>
<tr>
<td>Lose</td>
<td>14</td>
<td>30</td>
<td>56</td>
<td>N.A.</td>
<td>E&amp;H (n=133)</td>
</tr>
<tr>
<td>$$100$</td>
<td>5</td>
<td>46</td>
<td>26</td>
<td>24</td>
<td>Auditors (n=84)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Probability</th>
<th>Ambiguous Urn</th>
<th>Nonambiguous Urn</th>
<th>Indifferent Between Urns</th>
<th>Subject Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>$= 0.001$</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Win</td>
<td>35</td>
<td>43</td>
<td>22</td>
<td>E&amp;H (n=138)</td>
</tr>
<tr>
<td>$$100$</td>
<td>31</td>
<td>40</td>
<td>29</td>
<td>Auditors (n=84)</td>
</tr>
<tr>
<td>Lose</td>
<td>5</td>
<td>75</td>
<td>20</td>
<td>E&amp;H (n=141)</td>
</tr>
<tr>
<td>$$100$</td>
<td>26</td>
<td>45</td>
<td>29</td>
<td>Auditors (n=84)</td>
</tr>
</tbody>
</table>

* N.A. = Not Applicable.

of auditors to those of the MBA students studied by Einhorn and Hogarth [1988].
Einhorn and Hogarth presented their subjects with only part of the Ellsberg task (see Questions Sets 1 and 2 in Appendix B); that is, the question of drawing a specific color ball from either the ambiguous or nonambiguous urn, as well as the questions relating to the low probability of a loss (Question Sets 3 and 4). Thus, their subjects had no opportunity to display the variety of responses found when the full set of questions in the Ellsberg task were asked. Table 17 compares the auditors with the MBA students in the Einhorn and Hogarth [1988] study.

For the medium probability of a gain, the proportions of ambiguity avoiding and indifference were not very different. For the medium probability of a loss, the auditors
Table 18.
Comparison of Ellsberg Task Results
on the Choice of Urn Questions
Between Einhorn and Hogarth [1988] and the Current Study
(in percentages)

<table>
<thead>
<tr>
<th>Probability = 0.50</th>
<th>Ambiguous Urn</th>
<th>Nonambiguous Urn</th>
<th>Indifferent Between Urns</th>
<th>Mixed Pattern</th>
<th>Subject Group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Win</td>
<td>19</td>
<td>47</td>
<td>34</td>
<td>N.A.</td>
<td>E&amp;H (n=133)</td>
</tr>
<tr>
<td>$100</td>
<td>9.5</td>
<td>57.1</td>
<td>27.4</td>
<td>6.0</td>
<td>Auditors (n=84)</td>
</tr>
<tr>
<td>Lose</td>
<td>14</td>
<td>30</td>
<td>56</td>
<td>N.A.</td>
<td>E&amp;H (n=133)</td>
</tr>
<tr>
<td>$100</td>
<td>8.3</td>
<td>57.1</td>
<td>30.0</td>
<td>4.8</td>
<td>Auditors (n=84)</td>
</tr>
</tbody>
</table>

appear half again as much to be ambiguity avoiders and less than half as indifferent than the MBA students. How much of this is due to the availability of various other patterns of choice exhibited by the auditors may be partly addressed by examining the auditors' responses to the last two questions only. Table 18 compares the auditors' responses to the last two questions only with the MBA students' responses. Of the 84 sets of responses, nine (about 11%) were not consistent in the choice of urns.24 As may be seen in Table 15, regardless of the win or lose nature of the gamble, the auditors are considerably less indifferent and more of ambiguity avoiding than the MBA students at a medium likelihood.

For the low probability of a gain (refer back to Table 14), the auditors do not differ very much from the MBA students; however, the auditors are far more willing than the MBAs to choose the ambiguous urn in the low probability of a loss version (26% versus 5%). There are fewer auditors than MBAs (45% versus 75%, respectively) choosing the nonambiguous urn, and in this case there are more auditors willing to be indifferent between the urns than MBA students.

24Subjects' responses at no time were a combination of urns and indifference.
Overall, auditors exhibited ambiguity avoiding behavior at the medium probability of a gain and ambiguity seeking at a low probability of a loss, as predicted by the theory for the optimistic viewpoint.
Chapter VI
Discussion

6.1 Experiment 1

6.1.1 Results

The experimental audit task investigated the effects of ambiguity, outcome sign, replacement cost level, and likelihood of failure replicates and extends the previous work of Einhorn and Hogarth on the E-H ambiguity model. The extensions are to a new subject group (auditors), a new task (estimation of warranty liability), and a new factor (replacement cost). The replications cover some factors (e.g., probability levels) and the source of ambiguity (whether experts agree or not).

Possible confounding factors were evaluated and no significant differences were found for any of the subject or task characteristics tested among the four between-subject groups. This suggests that these groups were similar on these characteristics and that the random assignment of subjects to treatment groups and the random ordering of scenarios for each subject was successful. These characteristics cannot account for the significant differences that were obtained for either experimental task.

Across both dependent variables, the group differences due to ambiguity were not indicated by significant differences in central tendency as predicted by the E-H model, but rather by significant differences in variability, with all the ambiguous cells exhibiting more variability in auditor judgments. For the estimate dependent variable, the variability differences were part of an apparent interaction between ambiguity and reference point where in the nonambiguous zero reference point condition an expected
value strategy was utilized, but in the ambiguous, maximum reference point condition, a variety of strategies appeared to be employed by these auditors. The variability differences for the error dependent variable were on ambiguity alone; however, the means of the reference point conditions for the error dependent variable cancelled each other out when combined to test for mean differences. See Figure 7, 8, and 9. As predicted by the E-H model, the general underweighting of low likelihoods of failure and overweighting of high likelihoods of failure by these auditors were obtained for both dependent variables and for all conditions of the between-subjects factors. See Figures 4 through 9.

Contrary to the predictions of the E-H model, for the estimate dependent variable, the outcome size made no significant difference on the deviation from expected value, perhaps because of the auditors' use of expected value as an anchor. Also, contrary to the predictions of the E-H model, the lowest replacement cost level for the error dependent variable resulted in ratios that were significantly more deviant than the highest replacement cost level, perhaps due to materiality judgments by the subjects.

Plots of the interaction between replacement cost and likelihood of failure conditioned on the reference point indicated values of the estimate dependent variable essentially related to expected value (after considering the 95% confidence intervals around the means). This finding is contrary to the generalized version [Hogarth & Einhorn, in press] of the E-H model, which predicts that simulation will occur around the anchor probability even in situations corresponding to the definition of risk. However, the expected value results could be predicted by SEU (assuming that no adjustment has taken place). SEU has been discussed as a more restricted version of the E-H ambiguity model (i.e., the E-H model collapses to SEU under certain conditions [Curley, 1987].

Contrary to the assumption made about the auditor being "cautious" under the E-H model, similar plots for the error dependent variable indicated subjective probability values that significantly underweighted the likelihood of failure in the zero
reference point (negative outcome) condition and significantly over weighted the likeli hood of failure in the maximum reference point (positive outcome) condition. These results are more in line with an assumption that the decision maker is optimistic, rather than cautious.

These results will be discussed in relation to SEU and the E-H models of decision making, the \textit{a priori} predictions of this study, as well as the implications of this study for accounting research and practice.

\subsection*{6.1.2 Findings in Relation to Subjectively Expected Utility Theory}

SEU requires certain conditions (namely, consistent and coherent beliefs) to hold for it to be valid. As many have found before, from Ellsberg on (e.g., Ellsberg [1961], Kahneman & Tversky [1979], Fishburn [1988], Einhorn & Hogarth [1985, 1986, 1988, in press]), the subjects in this study exhibited behavior inconsistent with the axioms that comprise SEU, especially invariance of preferences and the additivity of probabilities. The former requires preferences to be unaffected by how the decision problem is described and the latter requires any subjective probability estimate of an event and its complement to sum to one. With respect to invariance of preference, in this study the subjects should have produced the same judgments (but did not) about the estimate and the error, regardless of the reference point and the degree of ambiguity.

Similarly, the average subjective likelihoods of failure for $p=.01$ and $p=.99$, $p=.10$ and $p=.90$, and $p=.5$ across each cell should have summed to one (exhibited additivity). As may be observed in across the cell-by-cell plots (Figure 6), the only cell that approximates this ideal is the nonambiguous, zero reference point estimate condition. In this cell, virtually all subjects took a straight expected value approach to producing an estimate of the liability. Recall from Table 5, that the other cells in the estimate dependent variable condition exhibited considerably more variability around the mean. When subjects were asked for the error amount they would suggest that
the client record on its books, the very material condition for that cell was still close to expected value, while the immaterial condition only achieved 30% of expected value at \( p = .99 \), contrary to the predictions of the SEU model. In the other three cells, similar differences between the estimate and error dependent variables were found (see Figure 9). Thus both essential axioms of SEU were violated, which disconfirms the theoretical predictions of SEU.

6.1.3 Findings Consistent with E-H Model and Study Predictions

The predictions generated from the E-H model for the audit tasks were predicated on the subjects approaching the decisions with a cautious attitude because auditors are trained to be independent (that is, to evaluate the client's condition in an unbiased manner and not to be an advocate for the client [AICPA, 1989]). Predictions from the E-H model for both reference point conditions and both dependent variables were that (1) a larger mean proportion of the maximum possible liability would be found in the ambiguous condition than the nonambiguous condition and (2) as the replacement cost per unit increased, the proportion of replacement cost provided would increase. For the zero reference point condition (which was assumed to be a negative outcome condition because any adjustment would decrease income), two specific predictions were made: (1) the proportion of the liability estimated or booked (via the error and its disposition) would increase at an increasing rate as the likelihood of failure increased and (2) the proportions of liability estimated or booked would diverge as the likelihood of failure increased, with a higher proportion of high replacement cost observed across all likelihood values. For the maximum reference point condition (which was assumed to be a positive outcome because any adjustment would increase income), two specific predictions were made: (1) the proportion of the liability estimated or booked (via the error and its disposition) would increase at an decreasing rate as the likelihood of failure increased and (2) the proportions of liability estimated or booked would converge as the likelihood of failure increased, with a
higher proportion of high replacement cost observed across all likelihood values.

The general overweighting of low probabilities and underweighting of high probabilities observed in the responses is predicted by the E-H model. Decision makers are assumed to consider other possible probability values around the anchor probability where the quantity of other possibilities is influenced by the existence of ambiguity and the range above and below the anchor. At very high and very low probabilities, the available range on either side of the objective probability is assumed to influence most strongly the subjective weighting process, thus producing the underweighting and overweighting phenomena. In negative outcome situations, reweighting would correspond to conservative behavior and underweighting to nonconservative behavior; in positive outcome situations, the converse holds. This has been a consistent finding in prior studies by Hogarth and his colleagues [Einhorn & Hogarth, 1985, 1986: Hogarth & Kunreuther, 1988, 1989] as well.

The current study found an interaction between replacement cost (a factor equivalent to outcome size) and the likelihood of failure for both the estimate and the error dependent variables. See Tables 8, 9, 10, and 11. Hogarth and Kunreuther [in press] noted that they were not able to confirm this prediction for ambiguity in the negative outcome ambiguous or nonambiguous situations for either hypothetical or "real money" tasks. This interaction may have been significant for auditors because they use the combination of the number of units involved (held constant in this study), the likelihood of failure, and the replacement cost to determine the dollar amount involved (essentially equivalent to the expected value of the warranty obligation) to classify the dollar amounts as immaterial, very material, or in the borderline range requiring professional judgment for its disposition.

6.1.4 Findings Consistent with E-H Model but not Study Predictions

A major assumption underlying the predictions for this study was that auditors were cautious decision makers and, within the bounds of the professional standards of con-
duct as outlined by GAAS and GAAP, would take the client’s viewpoint as to what was a positive and a negative outcome. The means of the estimate dependent variable in both reference point conditions were not significantly different from the expected value, as determined by 95% confidence intervals around the means. This could imply that the estimate, “the reasonable estimate for the account balance,” might generally be unaffected by either the reference point or the degree of ambiguity. However, significant differences in variability of responding existed between the almost perfectly consistent expected-value strategy undertaken in the nonambiguous, zero reference point cell and the variability exhibited in the ambiguous, maximum reference point cell. This indicates that ambiguity did influence individual auditor behavior (as also noted by Bamber & Snowball [1988]), but not aggregate auditor behavior. The other two dependent variables collected were the dollar amount the subject would suggest for the error amount for the audit workpapers and the subject’s recommended disposition of the error (to record as a difference or to book as an adjustment). Together these yield the practical result of the amount that is recommended to the manager as what should appear in the audited financial statements. The only expected difference between this variable and the estimate was for the error amount to be more conservative than the estimate (i.e., closer to 100% of cost). However, the combination of the two yielded results that contradicted the assumption made about the decision maker being cautious. The data are more consistent with the decision maker taking an “optimistic” viewpoint towards positive and negative outcomes.

The E-H model handles optimism by reversing the predictions for the cautious decision maker as follows: The interaction between outcome size and probability for negative outcomes results in concave below curves (signifying that the decision maker believes that the negative outcome is less likely to occur than the objective probability would indicate); for positive outcomes results in concave above curves (signifying that the decision maker believes that the positive outcome is more likely to occur than the objective probability would indicate). The error dependent variable, which is the
result of two judgments\textsuperscript{25}, appeared to be more sensitive to the effects of ambiguity as evidenced by the extreme deviance of the scores.

Most prior studies using the E-H model have not found this "optimistic" type of behavior. In the study of actuaries setting prices for warranty cost [Hogarth & Kunreuther, 1988], the subjects produced the predicted overweighting of the likelihood of failure at low probabilities (which ranged from .001 to .10). The task of an actuary in this job is to prevent a decrease in the insurance firm's net income from not producing a high enough premium to cover costs and provide for a profit. Likewise, the study using real money gambles [Hogarth & Einhorn, in press] found a conservative approach towards losses and gains. Hogarth's [in press] study of competitive decision making under ambiguity did find differences between subjects on whether to go to court or settle out-of-court depending on whether they were the plaintiff or the defendant. Defendants wanted to go to court when there was a high probability (.80) of losing a lawsuit while plaintiffs wanted to settle for a smaller amount to avoid the possible loss of money, should the judgment go against them. Conversely, when there was a medium (.50) probability of the plaintiff winning, the defendants wanted to settle for the smaller sure loss and the plaintiffs wanted to go to court for a possible larger amount. Further, Schneider and Lopes [1986] found significant differences in rankings of preferred gambles depending on whether a subject had been pre-identified as a "risk seeker" or a "risk avoider." These classifications were based on a subject's desire for security versus desire for high aspiration level. Perhaps the auditor's inferred viewpoint is one of optimism because going concern problems are not very common (depending of course on the industry) and client relations are a higher priority.

As can be seen in Figures 7 and 8, the subjects do appear to "give the client the benefit of the doubt" in both reference point conditions. In the maximum reference point condition, the amounts are reduced from 100% of possible cost (though

\textsuperscript{25}One judgment is required to determine the dollar amount and the second judgment is to decide whether the amount is material enough to warrant the cost of changing the books.
not down to expected value) with the higher replacement cost condition receiving a larger proportional downward adjustment (which results in more income) than the low replacement cost level.\textsuperscript{26} Similarly, in the zero reference point condition, the balance is written up from zero, but generally not all the way up to expected value (except at low likelihoods of failure, but the means are not significantly different from the expected value).

Based on statements the subjects made in responding to the questions: “In terms of an audit, what does a negative or positive outcome mean to you?” many (73 of 84 subjects) did respond, congruent with my assumption, that income decreased or that income increased, respectively; however, 25 \textsuperscript{27} responded that a negative outcome was one that entailed arguing with the client or other unpleasant behavior on the client’s part (for a positive outcome, 30 subjects said the converse or getting to tell the client “good news”). In conjunction with the auditors’ optimistic judgments, these comments might indicate that some senior auditors (who are on the frontlines in dealing with clients) may not be necessarily thinking in terms of potential lawsuits against the firm for negligence (which are a relatively rare occurrence), but rather they might be considering such issues as client retention and smooth client relations in making their judgments. Granted the senior in-charge’s judgments of amounts and choices of disposition are not necessarily what is ultimately recorded in the client’s books of account; however, these judgments may well influence the managers and partners who review the workpapers.

According to the Auditing Standards Board’s Standards for Fieldwork [AICPA, 1988], auditors are to be independent evaluators of the client’s financial representations; that is, to make a fair and impartial judgment of the client’s financial statements, and not to let the client’s booked amounts sway their judgments (i.e., anchoring-and-adjustment on the client’s account balances should not occur). The

\textsuperscript{26}That the low replacement cost level is adjusted the least may be explained by materiality: the amount is too insignificant to bother with.

\textsuperscript{27}Some subjects provided multiple definitions to the questions.
E-H model does propose anchoring-and-adjustment to be the cognitive process underly-
ning the proposed simulation that occurs; however, it occurs on the objective proba-
bilities provided. Anchoring-and-adjustment on the objective probabilities might be
acceptable under GAAS because the likelihood (or even the expected value of the
liability\textsuperscript{28}) had independent confirmation of its value by external experts (professors
of engineering, in this case).

The results of this study indicate that the initial estimates of the account balance
do not significantly differ when the client’s recorded value is compared; however, the
undesirable anchoring-and-adjustment appears to occur when considering whether
to recommend as an adjustment or to pass as a difference any discrepant amounts
between the client’s booked amount and the auditor’s estimate. The client’s booked
amount exerts a powerful influence as can be seen in Figures 7 and 8. To this end, it is
reassuring that the very material error dependent variable are influenced the least by
the client’s booked amount; that is, that significantly smaller proportional amounts
were not sought at high likelihood of failure and high replacement cost. However,
the differences between reference point conditions are still significantly different, es-
pecially at low probabilities of failure (which, as noted earlier, are more commonly
encountered in an audit than high probabilities of failure). In the maximum outcome
condition, the auditor may not write the liability all the way down to expected value
because it might appear to be too liberal. After all, they are bringing the client
very good news that expenses should decrease in real dollar terms, for example, from
$10,000,000 to $2,500,000 at the 1 of 100 likelihood of failure condition.

Along these lines, recent analytic work by Antle and Nalebuff [1988] suggests that
auditors may not be as conservative as is commonly believed. They posit that the
published financial statements are the result of negotiations between the auditor and
management, and as such, will never reflect a net income that smaller than the true
net income. The auditor is assumed to hold one of three stances: tough, business as

\textsuperscript{28}Recall that Hogarth & Kunreuther [1988] found actuaries apparently adjusting the expected
value of the loss instead of just the probability of loss.
usual, or accommodating. In the latter two stances, the auditor may offer the client some generous amount for net income, knowing that the client will probably accept it and thus preclude the need for further auditing. The result of their mathematical analysis indicates that the auditor will never be tough, and the optimal solution is to “offer” the client a generous amount for net income. This predicted action may be seen in the behavior described in the preceding paragraph.

Another explanation might be that some residual uncertainty or suspicion of unexpressed problems may exist because the client had booked the maximum amount in the first place. However, recall that the manipulation check between outcome sign level (or on ambiguity level for that matter) did not reveal any significant group mean differences\(^{29}\) for what the subjects thought about the controller not being sure about the amount to record for the liability (most comments were along the line of “typical”, “unsophisticated”, or “the client wants us to do their work”). Therefore, this possible interpretation seems unlikely.

### 6.1.5 Findings Inconsistent with the E-H Model

The first inconsistent finding is that there were no differences of central tendency for ambiguity, but rather significant differences in variability of responses related to ambiguity. Recall that one definition of ambiguity is the existence of variance around the mean, or second order uncertainty, so this finding can be considered consistent with the literature on uncertainty. The insignificant differences between the means may arise from use of an expected-value approach to estimating the account balance and individual idiosyncratic anchoring-and-adjustment processes may have created greater noise or variance between groups on the ambiguity and reference point factors which reduces any mean differences.

The second inconsistent finding is that the largest outcome size did not generate the largest deviation from the expected value. Indeed, the ordering of the deviations

\(^{29}\)These means were compared via \(t\)-tests on the two between-subjects factors.
were the reverse of what was predicted by the E-H model: immaterial > borderline material > very material. This result may stem from the notion of materiality: if it is truly an insignificant amount in relation to the financial statements as a whole (e.g., $1,000, the expected value in the $10 and 1 of 100 likelihood of failure condition), then it may as well be left alone.\textsuperscript{30} Actuaries’ premiums for different low (.001 to .10) probability of loss did exhibit the predicted relationship; however, they also appeared to exhibit the predicted viewpoint of caution in approaching the task [Hogarth & Kunreuther, 1988]. The role the auditors take towards the client’s liability and related expense amount apparently is not one similar to an “insurer.” \textsuperscript{31} On the other hand, this may stem from the apparent “optimism” towards the client’s financial condition exhibited by the subjects.

Another inconsistent finding is the almost pure expected value strategy observed in the nonambiguous zero reference point condition for the estimate. The E-H model suggests that even for a nonambiguous situation (i.e., one that closely approximates risk), simulation of other possible probability values would occur. Notice, however, the expected value strategy disappeared at least for the immaterial cost condition for the estimate dependent variable. See Figures 4 and 5. Further, this behavior may be described by the E-H model, if it is assumed that the decision maker is not simulating other possible values for the objective probability or is assigning zero weights to the simulated values.

6.2 Experiment 2

6.2.1 Findings in Relation to Subjectively Expected Utility Theory

As found in previous studies [Ashton, 1982; Einhorn & Hogarth, 1985, 1988; Ellsberg, 1961] using the balls-and-urns tasks, many auditors did not follow SEU in making

\textsuperscript{30}I am, of course, assuming that the amount is not relevant for another reason, such as an illegal payment or from a transaction between the corporation and one of its officers.

\textsuperscript{31}Though auditors may have been perceived as an insurer of fairly presented financial statements by the courts as indicated in recent lawsuits against auditors.
their choices. As mentioned in the results section, nearly a quarter of the subjects responded to the traditional Ellsberg tasks in an uninterpretable manner—neither in accordance with SEU nor with ambiguity seeking or ambiguity avoiding behaviors. This behavior may reflect inconsistent judgment processes or possible carelessness on the subject’s part.

6.2.2 Findings in Relation to E-H Model

The predicted ambiguity avoidance at a medium probability of a gain and ambiguity seeking at a low probability of a gain were obtained. However, ambiguity seeking at a low probability of a loss was more prominent for the auditors than for the Einhorn & Hogarth’s MBA students. This behavior is in accordance with the optimistic decision maker assumption as mentioned in the discussion of the audit task results. Because auditors so frequently deal with low probabilities of a loss (doubtful accounts, loan loss reserves, etc.), they may realize just how infrequently the event may occur. The specific differences between auditors and MBA students on this aspect were not explored in this study.

6.2.3 Findings in Relation to the Experimental Audit Task

The subjects appeared to take similar attitudes towards the Ellsberg tasks as they did towards the audit tasks: their choices indicated more optimism in loss situations and more caution in gain situations than would be expected if the decision maker was assumed to be cautious. This implies some consistency between these tasks for the auditors’ behavior. However, these results should not be extrapolated to infer that these auditors would behave similarly in other situations. MacCrimmon [1986] found no correspondence between managers’ stated risk attitudes on different decisions, e.g., a person might skydive but only be willing to invest in government securities.

Several possible explanations may exist for the optimistic attitude observed on both tasks in this study: boredom/carelessness, inexperience with tasks, experience
with low probability events, or experimental nature of the tasks. Given that subjects displayed an optimistic attitude on both tasks, and that subjects were less bored on the Ellsberg tasks than on the audit tasks, then boredom cannot explain the overall finding of optimism. Einhorn and Hogarth’s [1985] first study with the ambiguity model had subjects make judgments on 48 scenarios, during which they might have gotten bored; however, they found results suggesting a cautious attitude.

Although not very many subjects had experience dealing with warranty obligations per se, the same could be said for subjects having experience with balls-and-urns tasks as well. This may appear to argue for inexperience leading to optimistic-type behavior; however, the judgments required of subjects in other studies were not necessarily in their realm of competence (e.g., judging the veracity of eyewitness reports) and yet these subjects’ behavior reflected that subjects took a cautious attitude.

Auditors deal with low probability events and their resolution in the course of an audit. This firsthand experience may train the auditor to not overweight the likelihood of low probability events. However, this does not explain why the auditors appear to be acting as if the positive outcome events are more likely to occur and negative outcome events are less likely to occur than the objective probabilities would indicate.

That the tasks did not involve real money or real clients may account for the optimistic results, because the auditors have nothing at stake in their judgments. To protect against this argument were the verbal and written request to perform the tasks as they would on the job, the careful work shown by many subjects in the justification section, and the presence of the experimenter during while they completed the tasks. Subjects in the court case scenarios [Hogarth, 1988] were able to produce optimistic behavior in experimental tasks, so it is not without the realm of possibility.

Curley, Yates, and Abrams [1986] found that individuals avoided ambiguity when their judgments might be evaluated by others. The only evaluator of the auditors’ work was the experimenter in this study, but the same situation existed in Curley et
al.’s study as well.

An underlying reason that might explain the results for both the audit task and the abstract Ellsberg tasks is that auditors are experienced enough to realize that the base rate of problems is low.\textsuperscript{32} This experiential understanding of the “lowness” of a low probability may have carried over to the Ellsberg task. Understanding why auditors are responding in an optimistic manner should be investigated.

6.3 Implications

Method A major issue to consider in any study of decision making is to understand what perspective the subject is taking because, as can be seen here, it has such a strong influence on the results. This notion of decision perspective, or framing [Tversky & Kahneman, 1974], is inherent in the prospect theory value function used as part of the E-H model. In studies not specifically of the framing phenomenon, the subject’s perspective is either ignored or assumed to be in accordance with professional standards (e.g., independence). In this study, the subjects were asked specifically if they had considered the impact on the client’s financial statements when determining what amount they would recommend be recorded as an error: 64 (out of 81 subjects [or 79%] providing a response) said they did. In this case, the behavior inferred from the results agreed with the self-report; however, the two may not always coincide. For example, some written comments to this question were strongly worded, e.g., “NO! Never! We are supposed to be objective!”\textsuperscript{33}

Another methodological implication relates to the response to ambiguity being expressed as differences in means or in variances. This raises the question of whether a statistical technique such as ANOVA or another linear model concerned with mean differences is appropriate in understanding the effects of uncertainty on decision making. Einhorn and Hogarth [1985] originally had incorporated a factor for individual

\textsuperscript{32}For example, junior auditors have been accused of finding fraud under every bush, a propensity they lose through experience.

\textsuperscript{33}This subject seemed to be ignoring how an item is determined to be material or not.
differences that nonlinearized their model; it was removed because it did not behave mathematically as desired in describing behavior [Hogarth, personal communication, Feb. 12, 1989], but the psychological assumptions remained unchanged. Kahn and Sarin [1989] have shown that incorporating the functional form of the normal distribution into their model more accurately predicts subjects' responses to uncertainty.\textsuperscript{34} Anchoring-and-adjustment processes have been modelled as weighted averages Lopes, 1981], which essentially make a linear function nonlinear.

**Past Research**  This study has implications for prior research in relation to both practice and method issues. First, in most audit behavioral research the subjects have not been questioned about the perspective (i.e., in this study, whether they cautious or optimistic) they were taking on the task presented. This can seriously affect the interpretability of, or the inferences drawn from, the results. Second, studies which assumed that subjects are behaving in an independent fashion may rest on unexamined assumptions because auditors have multiple and often competing objectives in the performance of an audit. These include evaluating the fairness of the client's financial presentation, getting the job done at or under budget, and smooth relations with the client (which includes not having the client complain about one to one's manager as well as more cooperation from the client in completion of the audit).

**Practice**  The E-II model was devised strictly as a descriptive model of behavior under ambiguity. However, the description of behavior it produces may be compared to the professional standards of the conduct of an audit and the result evaluated for its desirability. For example, the goal of both the firm and the profession in evaluating a client's financial records is to render an independent opinion that the statements fairly reflect these underlying records; however, the individual evaluator may have a different set of goals in mind when performing the evaluation. The auditor in the

\textsuperscript{34}Recall that Kahn and Sarin permitted only a symmetric range of alternative probabilities to be considered on either side of the anchor.
competitive audit market today worries about performing a proper audit while trying to avoid losing the client. Therefore, if the client is obstreperous, it may be difficult (at least for a senior auditor, based on some of their comments) to insist on conservative estimates for items requiring professional judgment. Another explanation for the observed optimism might be the subjects’ experience with non-problem firms.

The E-H model has had stronger support for its predictions under the assumption of a cautious decision maker on the loss side when real money rather than a hypothetical amount is involved. The surprising results of this study with respect to the optimistic viewpoint taken by the auditors may have stemmed from the subjects seeing the zero reference point condition as indeed a negative outcome for the client, but wanting to reduce the reduction of income by adjusting the liability balance by no more than an amount corresponding to expected value. The expected value calculation does provide a defensible rationale for the auditor in discussions with the client. The maximum reference point the subjects may have seen a positive outcome for the client because the amount of the error booked did increase income, yet perhaps they felt they could insist on a protective cushion since the client had already booked the maximum possible liability. If the amount was immaterial, the subjects have passed on the adjustment in both reference point conditions for that very reason: the amount was too inconsequential with which to bother. At high probabilities, the consistently less than expected value amount may reflect a belief that not all the items that are defective will be returned for replacement under warranty.

No matter what the reason for the auditor’s behavior under the various conditions, accounting firms and the profession need to establish guidelines to cover these situations. It may be argued, that regardless of reference point, the estimates for the account balance across all conditions were essentially the same. Perhaps some rules of thumb could be devised such as the use of expected value (or at least a range of 5 to 10% around expected value) within the range of materiality. More research is necessary to establish what amount ultimately is recommended by managers and
partners for the client. As group estimates were closer to expected value than were individual estimates, another alternative might be to have several auditors evaluate the evidence independently and average their estimates before subjecting the estimate to the above process.

**Theory of Auditing** Based on these results, a theory of auditing behavior needs to incorporate a push-pull mechanism: push towards the client’s viewpoint and pull away from the client’s viewpoint. The push side includes the pressure to keep the client happy so it won’t seek a new auditor and the pressure for the individual auditor to produce the audit at or under budget. The pull side includes the desire to avoid litigation over a negligent audit and the code of professional ethics requiring the auditor to be independent. These factors may provide the psychological explanation for the auditor stances proposed in the Antle and Nalebuff [1988] study: tough guy, business as usual, or accommodating. As discussed earlier, these influences have different strengths at different levels in the firm. This undoubtedly has led to the internal control procedure of the review process: the higher the position in the firm the more global the view may be taken, so that these competing forces may be balanced.

**Revisions of the E-H Model** The model needs to be refined to predict attitude that may be taken in a particular case. At one time, a factor for individual differences had been incorporated into the model. The results in this study suggests that it may be necessary to reintroduce such a factor or to include a context factor.

The process detail of what constitutes the anchor that is adjusted in the cognitive process should be addressed. While some people adjusted the objective probability explicitly, the vast majority calculated expected value and adjusted that amount. Even in pretesting with intermediate financial accounting students who claimed to have never heard of expected value concepts, the most common anchor was their explicitly calculated expected value. Perhaps the probability as anchor might be retained for nonmonetary tasks, but the model was specified for dollar outcomes. What
is unknown is if the underlying cognitive process is the same whether probabilities or
the expected value is used as the anchor.

6.4 Limitations and Extensions of the Study

Several limitations restrict the generalizability of this study. For one, the study does
not sample several tasks from the loss and gain domains [Hammond, 1987]. This
was not feasible at this early stage of investigation, given the time constraints of
subjects who are busy professionals. Testing the model with different tasks certainly
is a possibility for additional studies.

The subjects may have suffered from loss of motivation, as the tasks were repet-
itive. However, recall that the manipulation checks indicated no difference among
between-subject treatment levels on boredom ratings as well other subject groups'
cautious behavior on repetitive tasks. Further, given that the scenarios were individ-
ually randomized with the restriction that each scenario appear first at least once,
the effects of boredom within a cell should have been spread across all treatment
combinations.

The information provided to subjects was condensed with no feedback or consulta-
tion permitted and, consequently, the obtained results may not reflect actual behavior
in the field. The responses requested of the subjects, however, were ones required of
them in the field, including the need to provide justification of their judgment for the
audit workpapers.

The high levels of likelihood of failure are not common in practice so this may
have distorted responses. However, all subjects could think of products or industries
with high failure rates (e.g., innovative computer hardware and thrifts), so this aspect
of the experiment apparently was not beyond subjects' audit experiences. Subjects
did exhibit more convergence at high probabilities in terms of the error variable (i.e.,
by choosing to book the entire amount of the loss).

Future experimental changes would include asking the subjects to justify their
error amount and its disposition, since this dependent variable is the most affected by ambiguity and reference point. Rewording the Ellsberg tasks, especially that of the high probability of a gain/loss set, would overcome the nonequivalence to LaPlace’s Criterion. Only asking the one question from the medium probability of a gain/loss set as did Einhorn and Hogarth [1988] would make the comparison between subject groups more easily accomplished.

Extensions to this study include examining what happens to the senior auditor’s judgment as it is passed along the chain of command as well as manager and partner responses to ambiguity. Another extension would be to use subjects from different accounting firms to test if firm structure influences auditors’ response to ambiguity. Different audit tasks should be evaluated for how ambiguity and reference point influence audit judgment. An additional area of interest is how the order in which audit evidence is received together with ambiguity influences audit judgment.
List of References


Appendix A
Examples of the Experimental Audit Tasks

Instructions:
In the following pages you will find fifteen scenarios asking you to estimate the warranty liability for a manufacturer of widgets. The product is purposefully disguised so that all of you will be on equal footing with respect to industry specialization.

Consider the company to be the same company (e.g., same size, same management, and so forth) in each scenario, but treat each scenario as a separate case. Only certain items change from scenario to scenario; these have been put in bold-face to make it easier for you to find them. You may assume that the company has been your firm’s client for five years and has had stable earnings and unqualified opinions during that time. Nothing else in their operations has changed from last year except for the situation outlined in the scenario.

Please treat the task as if you were performing it on an actual job. Use your professional judgment in estimating the liability and in determining the amount that you would recommend to your manager to be recorded as either a passed audit difference or an audit adjustment.

Please answer the questions in the order in which they appear. Do not go back to pages you have completed for reference or to change any response! Thank you.
Example of Nonambiguous, Zero Reference Point Scenario

You are a senior auditor working on the audit of the financial statements of The Lyon Corporation at June 30, 1989 and for the year then ended. Lyon manufactures widgets of various types. Lyon’s net sales total $100,000,000, with total assets of $67,000,000. An individually material item is greater than 5% to 10% of operating income ($10,000,000), that is, greater than $500,000 to $1,000,000. You are finishing the work on the warranty liability. You have accumulated the following information:

- The controller was not sure what amount to record as the warranty liability, so it appears in Lyon’s trial balance and unaudited financial statements at $0.
- The warranty liability relates to one part, the “XY component,” of a new line of “slim-line” widgets that Lyon introduced in April 1989. This is the only Lyon product carrying a warranty. The warranty period is one year from the date the slim-line widget is sold; the warranty covers replacement of the component if it fails during that time period.
- The company sold 10,000 slim-line widgets during the fiscal year ending June 30, 1989.
- Lyon’s production manager believes that none of the XY components will fail until the slim-line widget has been in use for at least 6 months (none had failed at 6/30/89). The production manager and Lyon’s controller estimate that the cost of replacing an XY component will be $100.
- Lyon has retained professors of engineering at three major universities to estimate how many XY components will need to be replaced during the warranty period, and the replacement cost. They agree with Lyon that the component is not likely to fail during the first six months the slim-line widget is in use and that the estimated replacement cost is reasonable. Their estimates of the failure rate agree with the estimate of Lyon’s production department; consensus is that 1 XY component will fail for every 100 slim-line widgets sold.

Question: In your opinion, what is a reasonable estimate for Lyon’s warranty liability at 6/30/89?

$ ________

Please briefly indicate your reasoning here (including rough calculations) as if you were providing justification to your manager:

What amount would you suggest be recorded as an error on either the worksheet summarizing passed audit differences or the worksheet summarizing audit adjustments? (Please circle your choice of worksheet.)

$ ________ audit difference ________ audit adjustment

How would you recommend the estimate of warranty liability be presented? Please circle your choice.

footnote disclosure only on the financial statements only
neither disclose it nor book it both book it and disclose details
Example of Ambiguous, Maximum Reference Point Scenario

You are a senior auditor working on the audit of the financial statements of The Lyon Corporation at June 30, 1989 and for the year then ended. Lyon manufactures widgets of various types. Lyon’s net sales total $109,000,000, with total assets of $67,000,000. An individually material item is greater than 5% to 10% of operating income ($10,000,000), that is, greater than $500,000 to $1,000,000. You are finishing the work on the warranty liability. You have accumulated the following information:

- The controller was not sure what amount to record as the warranty liability, so it appears in Lyon’s trial balance and unaudited financial statements at $1,000,000.
- The warranty liability relates to one part, the “XY component,” of a new line of “slim-line” widgets that Lyon introduced in April 1989. This is the only Lyon product carrying a warranty. The warranty period is one year from the date the slim-line widget is sold; the warranty covers replacement of the component if it fails during that time period.
- The company sold 10,000 slim-line widgets during the fiscal year ending June 30, 1989.
- Lyon’s production manager believes that none of the XY components will fail until the slim-line widget has been in use for at least 6 months (none had failed at 6/30/89). The production manager and Lyon’s controller estimate that the cost of replacing an XY component will be $100.
- Lyon has retained professors of engineering at three major universities to estimate how many XY components will need to be replaced during the warranty period, and the replacement cost. They agree with Lyon that the component is not likely to fail during the first six months the slim-line widget is in use and that the estimated replacement cost is reasonable. However, their estimates of the failure rate vary widely. Your best estimate of the rate, based on your study of the experts’ reports, is that 1 XY component will fail for every 100 slim-line widgets sold. You do not have a high degree of confidence in your best estimate.

Question: In your opinion, what is a reasonable estimate for Lyon’s warranty liability at 6/30/89?

$ 

Please briefly indicate your reasoning here (including rough calculations) as if you were providing justification to your manager:

What amount would you suggest be recorded as an error on either the worksheet summarizing passed audit differences or the worksheet summarizing audit adjustments? (Please circle your choice of worksheet.)

$ 

audit difference audit adjustment

How would you recommend the estimate of warranty liability presented? Please circle your choice.

footnote disclosure only on the financial statements only
neither disclose it nor book it both book it and disclose details
Appendix B
Ellsberg Tasks

Instructions for Part II
Please circle your response to the following questions. Treat each set of questions as a separate situation. Please respond as if you were actually playing the games.

[Note: The following question sets were presented on separate pages, unnumbered, and in individually randomized order.]

Question Set 1—Win  Imagine two urns, each filled with red and black marbles. Urn I contains 100 marbles, but the proportion of red to black marbles is unknown. Urn II contains 100 marbles; 50 are red and 50 are black. If you guess correctly the color of a marble to be drawn at random from an urn, you win $100, otherwise you win nothing.

1. If Urn I were used, would you bet on red, bet on black, or be indifferent between the colors?

   Red    Black    Indifferent

2. If Urn II were used, would you bet on red, bet on black, or be indifferent between the colors?

   Red    Black    Indifferent

3. If a red marble must be drawn in order for you to win, from which urn would you choose to draw, or would you be indifferent?

   Urn I    Urn II    Indifferent

4. If a black marble must be drawn in order for you to win, from which urn would you choose to draw, or would you be indifferent?

   Urn I    Urn II    Indifferent
Question Set 2—Lose  Imagine two urns, each filled with red and black marbles. Urn I contains 100 marbles, but the proportion of red to black marbles is unknown. Urn II contains 100 marbles: 50 are red and 50 are black. If you guess incorrectly the color of a marble to be drawn at random from an urn, you lose $100, otherwise you lose nothing.

1. If Urn I were used, would you bet on red, bet on black, or be indifferent between the colors?

<table>
<thead>
<tr>
<th></th>
<th>Red</th>
<th>Black</th>
<th>Indifferent</th>
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</thead>
</table>

2. If Urn II were used, would you bet on red, bet on black, or be indifferent between the colors?

<table>
<thead>
<tr>
<th></th>
<th>Red</th>
<th>Black</th>
<th>Indifferent</th>
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3. If a red marble must be drawn in order for you not to lose $100, from which urn would you choose to draw, or would you be indifferent?

<table>
<thead>
<tr>
<th>Urn I</th>
<th>Urn II</th>
<th>Indifferent</th>
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4. If a black marble must be drawn in order for you not to lose $100, from which urn would you choose to draw, or would you be indifferent?

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<tr>
<th>Urn I</th>
<th>Urn II</th>
<th>Indifferent</th>
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Question Set 3—Win  Imagine two urns, each filled with 1,000 marbles. The marbles in Urn I are numbered from 1 to 1,000; thus the probability of drawing a specifically-numbered marble is .001. The marbles in Urn II are also numbered, again from 1 to 1,000, but any one number can appear from 0 to 1,000 times. If you bet on a specific number to be drawn, you will win $100.

1. If you were to bet on marble number 687 to be drawn, which urn would you choose, or would you be indifferent?

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<th>Urn I</th>
<th>Urn II</th>
<th>Indifferent</th>
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Question Set 4—Lose  Imagine two urns, each filled with 1,000 marbles. The marbles in Urn I are numbered from 1 to 1,000; thus the probability of drawing a specifically-numbered marble is .001. The marbles in Urn II are also numbered, again from 1 to 1,000, but any one number can appear from 0 to 1,000 times. If you bet on a specific number to be drawn, you will lose $100.

1. If you were to bet on marble number 687 to be drawn, which urn would you choose, or would you be indifferent?

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<tr>
<th>Urn I</th>
<th>Urn II</th>
<th>Indifferent</th>
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Question Set 5—Lose  Imagine two urns, each filled with red and black marbles. Urn I contains 1,000 marbles, but the proportion of red to black marbles is unknown. Urn II contains 1,000 marbles; 990 are red and 10 are black. If the marble to be drawn is a certain color, you lose $100.

1. If the marble to be drawn is red, would you choose Urn I or Urn II, or would you be indifferent?

   Urn I   Urn II   Indifferent

Question Set 6—Win  Imagine two urns, each filled with red and black marbles. Urn I contains 1,000 marbles, but the proportion of red to black marbles is unknown. Urn II contains 1,000 marbles; 990 are red and 10 are black. If the marble to be drawn is a certain color, you lose $100.

1. If the marble to be drawn is black, would you choose Urn I or Urn II, or would you be indifferent?

   Urn I   Urn II   Indifferent
Appendix C
Debriefing Questionnaire

Instructions for Part III

Please answer the following questions about the study. *Feel free to add your comments to any question.* Please do not change your responses to previous questions.

[Note that the spacing between questions has been reduced for inclusion in the dissertation.]

1. Did you get bored while completing the fifteen versions of the audit tasks? Please circle your response:
   
   Yes   No
   
   If you circled “yes”, about how many scenarios did it take you to get bored? Comments?

2. Please check the line corresponding to how you approached the audit tasks:
   
   — More carefully in the beginning, less carefully towards the end.
   
   — Less carefully in the beginning, more carefully towards the end.
   
   — As carefully towards the end as in the beginning.
   
   — Not very carefully for each scenario.
   
   Comments?

3. Were you able to treat each audit scenario as a separate case?   Yes   No
   
   If not, at what point did you stop considering them to be separate cases?

4. What do you think this study is investigating?
5 At what point did you arrive at your answer to Question 3? Check the appropriate line.
— just now while responding to these questions.
— after reading the first scenario.
— while working the scenarios.
— after completing the scenarios.
— while completing the marbles tasks.

6 Have you had any training in how to estimate warranties or other contingencies? Please circle your response.
* Yes  No
If yes, please briefly describe the procedure that you were taught.

And is this the procedure you used to complete the task?  Yes  No
If no, why not?

7 Are warranties common in the industries that you usually audit?  Yes  No

Was the estimation of the warranty liability difficult to complete for you, given your level of experience with this type of task?  Yes  No  Please comment.

Of the likelihood of failure and replacement cost, which is more important in reaching your estimate of warranty liability? Why?

likelihood  cost  _____________is more important

What contingencies or other estimates are common in the industries you usually audit?

8 How much uncertainty did you think surrounded the likelihood of product failure for the Lyon Company? Please place a mark on the line below to represent your response.

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<td>10</td>
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<td>very high uncertainty</td>
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9 Overall, how much uncertainty did you think surrounded your estimates of the Lyon Company’s warranty liability? Please place a mark on the line below to represent your response.

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<tr>
<td>very low uncertainty</td>
<td>very high uncertainty</td>
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10 How do you think your estimates of Lyon’s warranty liability across the various scenarios generally affected Lyon’s financial statements? Please circle your response.

- negatively
- no effect
- positively

In terms of an audit, what does a negative effect on the client’s financial statements mean to you?

And what does a positive effect on the client’s financial statements mean to you?

11 Did you consider the impact of your estimate (or suggested error to be recorded) on the client’s financial statements at all while completing the task? Please comment.

12 Do you find in practice that it is unusual to make audit adjustments that are income increasing for the client?

- Yes
- No

13 Based on your audit experiences, what usually happens if a client has “overestimated” its expenses?

14 Please list any products or industries that come to mind which have experienced high failure rates.

Have you had any audit experience with high failure rates? Briefly describe.

15 Did you think more information was necessary to complete the audit task?

- Yes
- No

If yes, what did you think was missing?

16 What did you think about the client when you read that the controller was not sure about what amount to record for the warranty liability?

17 What audit tasks do you find involve a lot of uncertainty in their completion?

Are there specific situations that you find involve more uncertainty than others (e.g., a new client)?

How do you usually resolve the uncertainty in these audit tasks and situations?

18 Any other comments you would like to make?
19. Did you get bored while completing the marbles tasks in Part II? Yes No
Comments?

Were you able to treat the marbles tasks separately? Yes No
Did you feel any need to provide consistent answers for questions that appeared to be paired? Yes No
Was $100 large enough to be a significant amount for you to win? Yes No
Was $100 large enough to be a significant amount for you to lose? Yes No
Did you base your choices on any preference for one color over another? Yes No
Any comments on the marbles tasks?

20. Were any of the instructions (at any point in these materials) ambiguously worded so that you were not sure what was expected of you?
Yes No
If yes, what was the problem?

Please answer the following questions about your auditing experience.

21. How long have you been in audit practice?
______ years and ______ months.

22. How much of this has been with this firm?
______ years and ______ months.

23. What is your highest level of education? (Please check the appropriate line.)
— Bachelor’s degree.
— Some graduate level courses.
— M.B.A.
— M.Acc.
— J.D.
— Other (please specify)

24. Are you a C.P.A.? Yes No
If not, circle the parts of the exam you have passed:
Practice Auditing Law Theory
25 In what geographic area is your office? ____________________________
   (be as specific as you wish, e.g., the name of the city)

26 What percentage of your public accounting experience has been spent in the following areas?

Manufacturing _______ Extractive Industries _______
Health Care _________ Banking and Finance _______
Retailing _________ Insurance _______
High Tech _________ Service Industries _______
Government _________ Entertainment _______
Construction _________ Other (please specify) _______

____________________________________

27 How would you characterize the average financial condition of the clients that you have audited? Please mark on the line.

___________________________________________
1 2 3 4 5 6 7 8 9 10
very poor average very good

28 Please estimate the percentage of your clients with gross sales in the following ranges:

less than 5 million ______
between 5 million and 30 million ______
between 30 million and 50 million ______
between 50 million and 100 million ______
between 100 million and 500 million ______
greater than 500 million ______

You may choose not to answer the following questions if you'd prefer. This information is being collected solely to establish that this particular group of audit seniors is similar to the population of seniors.

29 What is your age? _______

30 What is your gender?  F  M

Thank you very much for your time and effort on this study.

If you would like to know the results of the study, please write your name and address on the following blank page and hand it in separately to preserve your anonymity.