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Ambiguity Seeking in Multi-attribute Decisions: Effects of Optimism and Message Framing

VICKI M. BIER and BRAD L. CONNELL
University of Wisconsin-Madison, Madison, WI, USA

ABSTRACT

This paper investigates the influence of message framing and personality variables on preferences over ambiguity in the context of multi-attribute decision scenarios. Undergraduate subjects responded to scenarios in which one of two medical treatments was associated with ambiguous probabilities of treatment effects. Probabilities were either positively or negatively framed. Subjects indicated their degree of preference for one treatment over the other. Subjects' optimism, trait anxiety, health locus of control, need for cognitive structure, and current mood were measured. In two separate studies, subjects preferred ambiguity when probabilities were positively framed, and were neutral toward ambiguity when probabilities were negatively framed. Also, in both studies the preference for ambiguity in positively framed scenarios was greater for more optimistic subjects. The unexpected finding of ambiguity seeking may be associated with the use of different decision strategies in multi-attribute versus single-attribute decisions.

KEY WORDS Ambiguity aversion Ambiguity seeking Optimism Framing

BACKGROUND

Ambiguity aversion is the tendency of decision makers to prefer gambles involving known probabilities over equivalent gambles with ambiguous (i.e. uncertain) probabilities. Ellsberg (1961) first documented this phenomenon, and noted that it is persistent even among expert subjects who know that it is normatively incorrect.

Since then, ambiguity aversion has been repeatedly demonstrated not only in simple monetary lotteries (Yates and Zukowski, 1976) but also in applied contexts such as investment choice (MacCrimmon, 1968), medical decisions (Curley *et al.*, 1984; Ritov and Baron, 1990), insurance decisions (Einhorn and Hogarth, 1985, 1986; Hogarth and Kunreuther, 1985), warranty pricing (Einhorn and Hogarth, 1986), environmental risk (Viscusi *et al.*, 1991), and auctions (Sarin and Weber, 1993). Hypothesized mediators of ambiguity aversion have included both structural aspects of the decision problem and also personality characteristics of the decision makers; see Hazen (1992) and Camerer and Weber (1992) for reviews.

The present investigation was conceived with three goals in mind: (1) to explore possible personality correlates of ambiguity aversion; (2) to assess potential interactions of message framing with those personality variables; and (3) to generalize past findings of ambiguity aversion to decisions involving tradeoffs on more than one attribute.

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Life Orientation Test (Scheier and Carver, 1985):
In uncertain times, I usually expect the best.
If something can go wrong for me, it will. (reverse scored)

Spielberger Trait Anxiety Scale (Spielberger *et al.*, 1968):
I feel nervous and restless.
I feel pleasant. (reverse scored)

Health Locus of Control Scale (Wallston *et al.*, 1976):
If I take care of myself, I can avoid illness.
Good health is largely a matter of good fortune. (reverse scored)

Need for Cognitive Structure (Jackson, 1967):
It upsets me to go into a situation without knowing what I can expect from it.
I like to be with people who are unpredictable. (reverse scored)

Exhibit 1. Sample questions from personality scales

Personality correlates of ambiguity aversion

Several researchers have speculated about the possible role of personality characteristics as mediators of ambiguity aversion (e.g. Sherman, 1974; Curley *et al.*, 1984; Winkler, 1991). In addition, several theoretical models of ambiguity aversion (Einhorn and Hogarth, 1985; Kahn and Sarin, 1988; Sarin and Winkler, 1992) include parameters to account for individual differences.

In fact, Einhorn and Hogarth (1985; Study 3) were able to demonstrate consistent individual differences between subjects in preferences over ambiguity. However, they did not relate this difference to known personality variables. Also, Sherman (1974) reported a correlation between ambiguity aversion and a scale measuring 'intolerance of ambiguity'. However, that study has not been replicated, and there is no other empirical literature to date relating personality variables to ambiguity preferences. Linking preferences over ambiguity to measurable personality variables would be an important step in understanding the sources of ambiguity aversion.

The present investigation originally examined the relationship of ambiguity preferences to three personality variables; anxiety, optimism, and locus of control. Subsequently, we also considered need for cognitive structure, which is conceptually similar to intolerance for ambiguity (Sherman, 1974). Exhibit 1 presents sample items from these scales.

With regard to optimism or pessimism, Curley *et al.* (1984) found that ambiguity avoiders tend 'to believe that their actual chances of success are worse in the ambiguous situation', suggesting a link with pessimism. Similarly, Einhorn and Hogarth (1985) speculated that ambiguity preferences may be related to optimism or pessimism. More generally, past work has found optimism useful in predicting other behaviors, such as active coping efforts, motivation, and persistence (Scheier and Carver, 1985; Taylor and Brown, 1988). We hypothesized that optimists would expect ambiguity to be resolved in their favor, and hence exhibit ambiguity seeking.

With regard to other personality variables, Winkler (1991) has suggested anxiety as a possible cause of ambiguity aversion. In addition, we hypothesized that subjects who feel a strong sense of control (Rotter, 1966; Wallston *et al.*, 1976) over their lives might prefer ambiguous options. Finally, we expected that subjects high in need for cognitive structure (Jackson, 1967) might be ambiguity averse.

Effects of message framing

Past work (Goldsmith and Sahlin, 1982; Curley and Yates, 1985; Einhorn and Hogarth, 1986; Kahn and Sarin, 1988) suggests that ambiguity aversion is likely to occur for high probabilities of gain

(or small probabilities of loss), with ambiguity seeking for high loss probabilities (and small gain probabilities). Based on the probability sizes in our scenarios, we initially expected to find ambiguity aversion in both the positive and negative frames in our study. Thus, the study was not designed to replicate past results regarding framing and ambiguity aversion. Rather, our goal was to investigate possible interactions between message framing and personality variables.

In particular, positive and negative wording might evoke different reactions from people with different personalities. For example, optimists may prefer ambiguity only in positively framed scenarios. We hoped that such interactions, if found, would shed additional light on the mechanisms underlying preferences over ambiguity.

Multi-attribute decision scenarios

As pointed out by Winkler (1991), 'Much of the evidence regarding decision making under ambiguity has arisen from simple experimental situations, and the role of ambiguity in the real world is not clear'. In particular, in previous studies (e.g. Curley *et al.*, 1984, 1986; Curley and Yates, 1985; Einhorn and Hogarth, 1985; Hogarth, 1989; Kahn and Sarin, 1988), subjects were generally asked to choose between alternatives that differed only with regard to the presence or absence of ambiguity, and in some cases the mean gain or loss to be received.

In contrast, most real-world decisions involve tradeoffs among multiple attributes. For example, a person deciding which job to take will consider not only salary but also location, working environment, and prospects for advancement. Decision scenarios that vary only in the presence or absence of ambiguity allow researchers to hold other aspects of the problem constant, but are atypical of decisions that subjects usually make in real life. Therefore, these scenarios may not engage the same cognitive processes that are normally employed in decision making. By contrast, through the use of multi-attribute scenarios, we attempted to engage subjects in the types of tradeoffs typically found in real-world decisions.

STUDY 1

One-hundred-forty University of Wisconsin-Madison undergraduates participated for extra credit in their introductory psychology course. There were 81 female and 59 male subjects. Their mean age at their last birthday was 18.7 years. Seven-page questionnaire packets comprised the experimental materials. The first page was the Life Orientation Test (LOT) (Scheier and Carver, 1985), which measures optimism/pessimism. The second page was the Health Locus of Control Scale (HLC) (Wallston *et al.*, 1976), which measures perceived control over one's health outcomes. The third page was the Spielberger Trait Anxiety Scale (STA) (Spielberger *et al.*, 1968). The final four pages described medical treatment scenarios.

Study design

Our goal in creating the scenarios used in this study was twofold: (1) to enhance the realism and complexity of the scenarios by varying other salient factors in addition to ambiguity; and (2) to assess the effects of ambiguity without confounding by those factors. This required a more complex design than would otherwise have been necessary.

Each of our scenarios included information about a disease, and the effectiveness and side effects of two potential treatments. The side effects, and the probabilities of either side effects or treatment effectiveness, differed for the two treatments in each scenario. In addition, one of the treatments

Two drugs, Mevistatin and Lovicor, have been found to significantly reduce the level of serum cholesterol in most people, thus reducing their likelihood of having a heart attack. Both drugs must be taken for the rest of the patient's life to keep cholesterol levels down. Mevistatin and Lovicor have been compared with high-risk patients who have over a 50% chance of having a heart attack within the next five years. While both drugs are effective at lowering cholesterol levels, Mevistatin can cause occasional episodes of muscle weakness and dizziness that sometimes cause serious accidents, and Lovicor can cause small kidney stones that are sometimes painful.

1. 9% of patients who take Mevistatin experience occasional episodes of muscle weakness and dizziness. One study shows that **8% (14%)** of patients who take Lovicor develop small kidney stones, while another study shows that **14% (8%)** of patients who take Lovicor develop small kidney stones.
2. 91% of patients who take Mevistatin experience no side effects. One study shows that **92% (86%)** of patients who take Lovicor experience no side effects, while another study shows that **86% (92%)** of patients who take Lovicor experience no side effects.
3. One study shows that **6% (12%)** of patients who take Mevistatin experience occasional episodes of muscle weakness and dizziness, while another study shows that **12% (6%)** of patients who take Mevistatin experience occasional episodes of muscle weakness and dizziness. 11% of patients who take Lovicor develop small kidney stones.
4. One study shows that **94% (88%)** of patients who take Mevistatin experience no side effects, while another study shows that **88% (94%)** of patients who take Mevistatin experience no side effects. 89% of patients who take Lovicor experience no side effects.

Exhibit 2. Sample scenario

was ambiguous. This was achieved by presenting two probabilities, ostensibly from two different studies; the same mechanism for creating ambiguity was used by Viscusi *et al.* (1991). The discrepant probabilities varied by either $\pm 3\%$ or $\pm 5\%$. Based on pilot test results, these discrepancies were large enough to ensure an effect, but not so large as to undermine the perceived validity of the cited hypothetical studies.

To reduce the variance in preferences caused by treatment differences other than ambiguity, several versions of each scenario were pilot tested, and we selected treatment descriptions that were equally desirable in the absence of ambiguity. Despite this, preferences among treatments varied widely between subjects. To reduce error variance without an excessive sample size, a repeated-measures design with four different scenarios was used. In each questionnaire all four scenarios corresponded to the same cell in the experimental design; the independent variables were thus varied between subjects.

Eight versions of each scenario were created, corresponding to the cells of a $2 \times 2 \times 2$ (Ambiguity $\times$ Framing $\times$ Probability Order) factorial design. The independent variables were: which treatment was ambiguous; whether messages were positively or negatively framed; and the order of the probability estimates for the ambiguous treatment. A sample scenario is presented in Exhibit 2; all eight versions of this scenario are shown.

In paragraphs 1 and 2 ambiguity is associated with the second treatment, while in paragraphs 3 and 4, the first treatment is ambiguous. The effect of ambiguity can therefore be assessed by comparing the relative preference for one treatment over the other when the ambiguous probabilities are associated with treatment 1 versus treatment 2. Similarly, in paragraphs 1 and 3 the message is negatively framed (emphasizing the probability of a negative outcome), while paragraphs 2 and 4 are positively framed. Finally, the order of the two probabilities used to create ambiguity was varied; the differing probability orders are given in bold type.

Subjects indicated their relative treatment preferences using a 1–9 scale, with scores less than 5 indicating a preference for treatment 1. Subjects also indicated which treatment they would select

if forced to choose. Thus, we had two dependent variables: the mean preference for treatment 1 versus treatment 2; and the number of times treatment 1 was chosen in the forced choice. However, the forced choice format was less sensitive, so only the preference results are reported here. Finally, subjects were asked to describe the most important reasons for their choice.

The primary dependent measure was the mean preference rating on the 1–9 scale, averaged over the four treatment scenarios. The influence of ambiguity was assessed by comparing subjects' mean preferences when ambiguity was associated with treatments 1 and 2, respectively. For example, if subjects had significantly lower mean preference scores (reflecting greater preference for treatment 1) when treatment 1 was ambiguous, this would reflect ambiguity seeking. Thus, a significant main effect of ambiguity could indicate either ambiguity aversion or ambiguity seeking. The effects of other variables (such as personality and message framing) are indicated by interactions between those variables and ambiguity.

Results

A statistical analysis was performed to determine: (1) whether there was net ambiguity aversion or ambiguity seeking; (2) whether subjects' preferences were influenced by personality characteristics; and (3) whether there were framing effects. Subjects' written comments were also analyzed to determine which factors they considered in their treatment choices.

A three-way between-subjects ANOVA was performed on the preference ratings, using all three manipulated variables (Ambiguity, Framing, and Probability Order). The only significant effect here was a Framing × Ambiguity interaction, $F(1,131) = 7.02$, $p < 0.01$. Based on Fisher's LSD test, there was significant ambiguity seeking in the positive frame ($p < 0.01$), with nonsignificant ($p = 0.29$) ambiguity aversion in the negative frame. This finding was unexpected.

Effects of personality characteristics

Each of the three measured personality variables (optimism, anxiety, and locus of control) was analyzed separately. No significant effects of anxiety or locus of control were found, so no further analyses of those scales were conducted. The analysis of LOT revealed a Framing × Ambiguity effect $F(1,123) = 8.157$, $p = 0.005$, as well as an Ambiguity × LOT interaction, $F(1,123) = 5.415$, $p = 0.022$, and a marginally significant Framing × Ambiguity × LOT three-way interaction, $F(1,123) = 3.042$, $p = 0.084$.

To aid in interpreting these results, the LOT was trichotomized. LOT scores ranged from 11 to 30, with a mean of 20.8. Subjects were classified as follows: pessimistic, LOT $\leqslant$ 19 ($n = 47$); moderate, LOT = 20, 21, 22 ($n = 41$); and optimistic, LOT > 22 ($n = 51$). Consistent with past findings (e.g. Taylor and Brown, 1988), our pessimistic group was not actually very pessimistic; however, the three groups were of roughly equal size. A four-way ANOVA was performed, including the three manipulated variables and the categorized LOT. Results indicated a Framing × Ambiguity interaction, $F(1,115) = 7.13$, $p = 0.009$, and a Framing × Ambiguity × LOT interaction, $F(2,115) = 3.69$, $p = 0.028$. The three-way interaction is shown in Exhibit 3.

Effects of framing

To clarify the Framing × Ambiguity × LOT interaction, separate analyses of each framing condition were performed. The means in the negative frame were in the direction of ambiguity aversion, but no significant effects were obtained, so no further analyses of this frame were conducted.

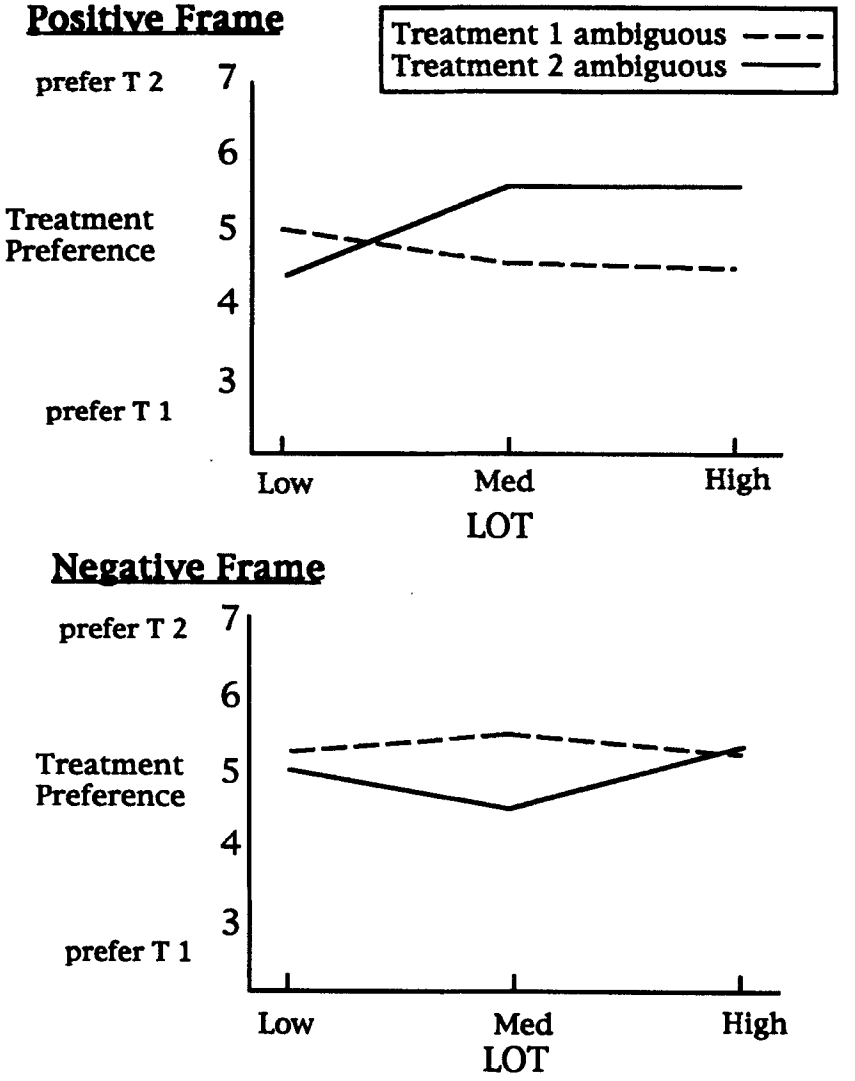

Exhibit 3. Treatment preferences by framing, LOT, and ambiguity in Study 1. Higher scores indicate a preference for treatment 2. The dashed lines correspond to cases in which treatment 1 was ambiguous; for the solid lines, treatment 2 was ambiguous. Therefore, when the dashed line is higher than the solid line, this indicates ambiguity aversion, and conversely. In the positive frame (top panel), the LOT × Ambiguity interaction was significant ($p = 0.029$), with significant ambiguity seeking for moderate ($p = 0.015$) and optimistic ($p = 0.009$) subjects. No significant effects were observed in the negative frame (bottom panel)

The positive frame showed a main effect of ambiguity, $F(1,63) = 6.23$, $p = 0.015$, with subjects generally preferring the ambiguous treatment. There was also an Ambiguity × LOT interaction, $F(2,63) = 3.75$, $p = 0.029$, with moderate and optimistic subjects preferring the ambiguous option. Based on *post-hoc* comparisons using Fisher's LSD test, the trend toward ambiguity aversion was not significant for pessimists ($p = 0.37$), but a significant preference for ambiguity was found for both moderate ($p = 0.015$) and optimistic ($p = 0.009$) subjects.

Effects of scenario type

This study was not designed to compare the effects of ambiguity in side effects versus treatment effectiveness. However, an informal *post-hoc* analysis revealed that the overall Framing × Ambiguity interaction occurred primarily when ambiguity was associated with side effects, rather than treatment effectiveness. However, the side-effect scenarios had relatively extreme probabilities, while the treatment-effectiveness scenarios had more moderate probabilities, confounding the effects of Probability Size and Scenario Type. The effects of optimism were similar for both scenario types.

Qualitative results

A total of 560 decision descriptions (four for each of the 140 subjects) were obtained. None of the subjects mentioned uncertainty about probabilities as a factor in their decisions, and only one of the 560 descriptions even mentioned that there were two different study results for one of the treatments. This confirms that the role of ambiguity in the experimental design was not transparent to our experimental subjects, and suggests that they may not have consciously considered the ambiguous nature of the probability estimates to be important.

In the treatment-effectiveness scenarios, subjects generally attributed their decisions to the differences in survival/death rates and/or tradeoffs between side effects and survival. In the side-effect scenarios, subjects discussed the differential severity of the side effects, but rarely mentioned the probability of side effects. Subjects' descriptions were always written in the same frame as the scenarios they read, suggesting that the role of framing was not transparent to our subjects.

Limitations

The above results suggest that subjects preferred ambiguity when probabilities were positively framed. This finding was unexpected. Therefore, we considered the possibility that we may have inadvertently manipulated ambiguity in the wrong direction. In particular, subjects may have inferred that more research had been done on the ambiguous treatment (for which the results of two studies were provided) than for the unambiguous treatment (with only one set of results cited). Also, subjects' choices may have been influenced by the fact that the ambiguous treatment was mentioned more often in the treatment descriptions. These hypotheses could not be ruled out without further study.

Another key result was the effect of optimism on preferences over ambiguity. This effect was in the expected direction. However, the fact that this was an exploratory study (rather than a targeted investigation of optimism in particular) increased the likelihood that this finding was due to chance, and created a need for replication. Finally, while *post-hoc* investigation suggested that ambiguity seeking occurred primarily for ambiguous side effects (rather than ambiguous treatment effectiveness), this study was not designed to test that hypothesis. Therefore, a second study was conducted.

STUDY 2

To address the limitations discussed above, an additional study was performed. In addition to addressing the limitations of Study 1, we also included mood as a possible mediator of the effects of optimism, since mood influences decision making (Johnson and Tversky, 1983; Isen, 1984) and may be correlated with optimism. Mood was assessed using the Positive Affect/Negative Affect Scale (PANAS) (Watson *et al.*, 1988); this scale contains separate positive and negative affect subscales, which are typically uncorrelated. We also studied interactions between ambiguity preferences and need for cognitive structure (NCS) (Jackson, 1967).

Two-hundred-fifty-six undergraduates participated for extra credit in their introductory psychology course. There were 128 female and 117 male subjects; 11 subjects did not indicate their gender. Mean age at last birthday was 19.1 years. The experimental materials for this study included three personality scales (for optimism, mood, and need for cognitive structure), eight hypothetical medical treatment scenarios, and a questionnaire asking subjects if and how they used the ambiguous probabilities when making their decisions.

Study design

Four new medical treatment scenarios were developed and pilot tested, to unconfound the effects of probability size and scenario type. The new scenarios included two with moderate probabilities of side effects, and two with extreme probabilities of treatment effectiveness. The eight scenarios thus formed a 2 × 2 within-subjects manipulation of probability size and scenario type, with two repeated measures. In addition, the order in which the scenarios were presented was counterbalanced using an eight-sided Latin square.

Thus, this study involved three independent variables varied between subjects (which treatment was ambiguous, positive versus negative framing, and the order of the ambiguous probability estimates), and two independent variables varied within subjects (probability size and scenario type). As before, there were two dependent variables (the mean preference for treatment 1 versus treatment 2, and the number of times treatment 1 was chosen in a forced choice); only the preference results are reported.

Scenarios were similar in form to those in Study 1, with two key differences. First, two consistent probability estimates (i.e. 'Two studies both found . . .') were provided for the unambiguous treatment, to rule out the possible inference that more research had been done on the ambiguous treatment. Second, the scenarios were reworded so that each treatment was mentioned the same number of times, to ensure that the two treatments were equally salient. A questionnaire explicitly asking how subjects used the ambiguous probability estimates was also added to the study after the first eight subjects had been run.

Results

First, a five-way mixed ANOVA was performed on the preference scale ratings, using all five manipulated variables (Ambiguity, Framing, Probability Order, Scenario Type, and Probability Size). The Framing × Ambiguity interaction found in Study 1 was replicated, $F(1,248) = 5.65$, $p < 0.02$. As in Study 1, there was a significant preference for the treatment with the ambiguous probabilities in the positive frame, $F(1,126) = 9.09$, $p = 0.003$, and no significant effect of ambiguity in the negative frame. There was also a marginally significant main effect of ambiguity seeking, $F(1,248) = 3.59$, $p = 0.059$, due to the strong ambiguity seeking in the positive frame.

Within-subjects analysis revealed a significant three-way interaction between Scenario Type, Probability Size, and Ambiguity. On closer inspection this was due primarily to idiosyncratic results from a single scenario. Thus, the results do not indicate systematic effects of either Scenario Type or Probability Size. There were also no significant effects involving Probability Order.

Effects of personality and mood

Optimism, mood, and need for cognitive structure were each analyzed in a three-way ANOVA with Ambiguity and Framing. No significant effects were observed in analyses of positive affect, negative affect, or NCS, so no further analyses of those scales were conducted.

In the analysis of LOT there was a marginally significant three-way Framing × Ambiguity ×

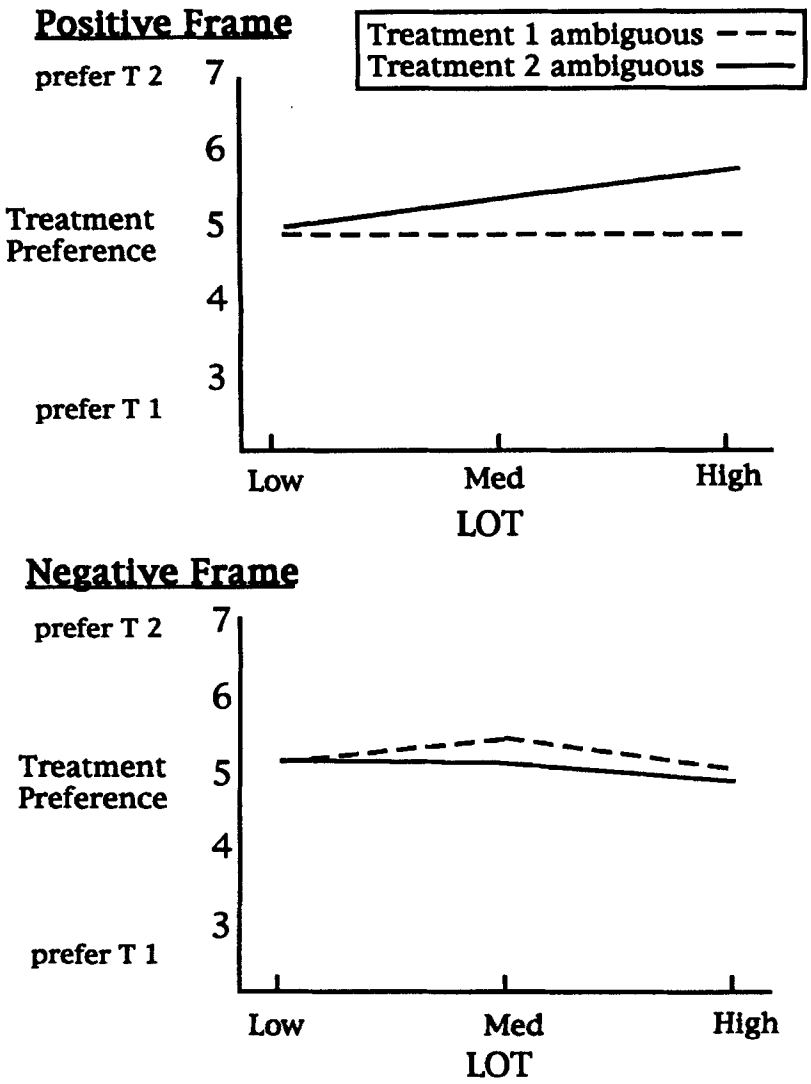

Exhibit 4. Treatment preferences by framing, LOT, and ambiguity in Study 2. As in Exhibit 3, higher scores indicate greater preference for treatment 2. Therefore, when the dashed line is higher than the solid line, this indicates ambiguity aversion. In the positive frame (top panel), there was significant ambiguity seeking for the most optimistic subjects ($p = 0.001$). There were no other significant effects of ambiguity

LOT three-way-interaction, $F(1,248) = 3.09, p = 0.08$. This result replicates the finding that optimism mediates preferences over ambiguity.

In analyses of the effects by frame, the Ambiguity × LOT interaction was not significant in either frame. However, the pattern of results was similar to that in Study 1, with greater ambiguity seeking among optimists than pessimists in the positive frame (see Exhibit 4). As before, the LOT was trichotomized, so that the effect of ambiguity at each level of optimism could be tested. There was significant ambiguity seeking in the positive frame among the most optimistic subjects ($p = 0.001$), as in Study 1. However, ambiguity seeking was not significant for moderate subjects ($p = 0.15$). There were no other significant effects of ambiguity.

Qualitative results

Decision explanations were similar to those in Study 1, with subjects most often mentioning tradeoffs among the severity of side effects, survival rates, and the length and type of treatment. Only three subjects mentioned that there were two studies of each treatment, and none of those referred to ambiguity or uncertainty about the study results.

Most subjects did not discuss how they used the discrepant probabilities, even when explicitly asked. Although most subjects could not articulate how they used these probabilities, this did not reflect lack of effort, since many subjects wrote detailed explanations; they just did not mention ambiguity. Fifty-nine per cent reported not using the stated probabilities at all; among those who did report using probabilities, most did not refer to ambiguity. Subjects who reported not using probabilistic information were influenced primarily by aversiveness of side effects or other treatment costs, while those who did report using probabilistic information were influenced by both treatment costs and probability size.

Among subjects who reported using the discrepant probabilities, the most common approach was to average the two values. Other reported approaches included selecting a probability that the subject believed was most likely to apply to him or her, or picking the higher of the two probabilities.

Discussion of Study 2

In this study, we again found ambiguity seeking in the positive frame; the trend toward ambiguity aversion in the negative frame, present in Study 1, was virtually absent in this study. We also found greater ambiguity seeking for more optimistic subjects. Although the effect of optimism was less strong in this study than in Study 1, optimists were still more ambiguity seeking than pessimists in the positive frame.

The replication of Study 1 allows us to rule out artifactual explanations for our results. First, the lack of significant effects involving Probability Order allows us to rule out the possibility that our subjects focused primarily on only one of the discrepant probabilities. In addition, by providing two consistent probability estimates for the unambiguous treatment, we prevented subjects from concluding that more research had been done on the ambiguous treatment. Also, by rewording the scenarios so that each treatment was mentioned the same number of times, we ruled out the possibility that the ambiguous treatment was chosen because it was more salient.

Finally, the results of the within-subjects manipulation of Probability Size and Scenario Type demonstrate that the ambiguity seeking we observed is not dependent on either of those variables. Although we did find net ambiguity aversion for one scenario in Study 2, the observed ambiguity seeking was not limited to a particular probability size or scenario type.

GENERAL DISCUSSION

The research described here demonstrates that decision makers are ambiguity seeking in at least some circumstances where the literature would lead us to expect ambiguity aversion. It also shows that the effect of ambiguity depends on both message framing and the decision maker's level of optimism.

Ambiguity seeking

Our most surprising result is that we found ambiguity seeking where we expected to find aversion. This finding cannot be explained entirely by the effects of optimism. Although we found greater ambiguity seeking among more optimistic subjects, we discovered net ambiguity seeking in the positive frame in both studies. It is also unlikely that our subjects were unusually optimistic (and thus more ambiguity seeking than subjects in previous studies), since the mean LOT scores in our studies were slightly lower than the norms published by Scheier and Carver (1985).

The ambiguity seeking we observed also cannot be explained solely as a framing effect. While we found ambiguity seeking in the positive frame, studies by Einhorn and Hogarth (1986), Kahn and Sarin (1988), and Hogarth (1989) all found ambiguity aversion in the positive frame at probability levels comparable to those used in our study. Their results are also consistent with findings by Goldsmith and Sahlin (1982) and Curley and Yates (1985), although those earlier studies did not explicitly manipulate framing. Thus, framing effects from past research do not explain our findings.

It is possible that the ambiguity seeking we found is specific to the medical context of our decision scenarios. In fact, one reviewer suggested that medical treatments may be 'culturally defined as places where hope is appropriate'. This seems unlikely to explain our findings, since Curley *et al.* (1984) and Ritov and Baron (1990) found ambiguity aversion rather than seeking even in the medical context. However, differences between our decision scenarios and theirs may account for the discrepancy in results.

We believe that the most plausible explanation for the differences between our results and past findings is the multi-attribute nature of our decision scenarios, which may have engaged different cognitive processes from those engaged in past ambiguity research. Other researchers (e.g. Montgomery, 1983; Johnson, 1984, 1989; Biggs *et al.*, 1985; Bettman and Sujan, 1987; Jarvenpaa, 1990; Payne *et al.*, 1992; Kleinmuntz and Schkade, 1993) have found that the nature of the decision task can affect the way information is processed. Although researchers have not yet demonstrated that the choice of decision strategy can affect preferences over ambiguity, this may be due to the lack of variability in the decision tasks used in most previous ambiguity research.

In particular, the fact that our subjects were required to make tradeoffs among multiple attributes may have diminished the salience of ambiguity. By contrast, in the classic Ellsberg (1961) ball-and-urn paradigm and variations, ambiguity is the most salient feature of the problem. This difference may have elicited the use of different decision strategies, a hypothesis supported by the fact that our subjects only rarely mentioned the presence of ambiguity.

Optimism

Our second finding is that preferences over ambiguity depend on subjects' dispositional optimism. However, optimists exhibited net ambiguity seeking only when scenarios were positively framed. This suggests that positive framing may have caused optimistic subjects to regard the true probability as closer to the favorable end of the ambiguous range.

The finding that preferences over ambiguity are related to optimism, but not to anxiety, argues against the claim that 'modifications in the standard model should involve utilities, which reflect preferences, instead of probabilities' (Winkler, 1991). Rather than experiencing sleepless nights, as hypothesized by Winkler, in our scenarios subjects appear to have adopted more favorable subjective probabilities when stated probabilities were ambiguous.

In addition to shedding light on preferences over ambiguity, our findings regarding optimism may also help to resolve debates about the nature of optimism. In particular, Smith *et al.* (1989) proposed that the LOT may simply measure neuroticism and a tendency to experience negative affect. The finding that ambiguity seeking is influenced by optimism, but not by anxiety or mood,

implies that the LOT reflects individual differences distinct from neuroticism or affective processes. The LOT may be especially relevant to processing of uncertainty, so decision making under uncertainty may be an appropriate context for studying this aspect of personality.

Since optimism is one of few personality variables that have been shown to influence preferences over ambiguity, it would be desirable to replicate this finding in more traditional ball-and-urn ambiguity research scenarios. If the effects of optimism occur only with multi-attribute scenarios, and do not mediate preferences over ambiguity in simpler scenarios, this would support our hypothesis that the two types of scenarios elicit different decision strategies.

We believe that the multi-attribute tradeoffs subjects were asked to make in our studies are representative of the types of decisions made in everyday life. Virtually all real-world decisions involve tradeoffs on multiple attributes. If the way our subjects processed ambiguous probabilities is indeed typical of real-world decisions, then ambiguity seeking and the influence of optimism may be surprisingly pervasive in human decision making.

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Authors' biographies:

Vicki M. Bier is an Assistant Professor in the Department of Industrial Engineering at the University of Wisconsin. She received her PhD in 1983 from the Massachusetts Institute of Technology. Her research interests are in decision analysis, risk analysis, and risk perceptions.

Brad L. Connell is a Doctoral Candidate in the Department of Psychology at the University of Wisconsin. His research interests are in self-concept, decision making, and health psychology.

Authors' address:

Vicki M. Bier and **Brad L. Connell**, University of Wisconsin-Madison, 1513 University Avenue, Room 451, Madison, WI, USA.