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Ambiguity Aversion, Comparative Ignorance, and Decision Context

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People typically find bets less attractive when the probability of receiving a prize is more vague or ambiguous (Ellsberg, 1961). According to Fox and Tversky's (1995) *comparative ignorance hypothesis,* ambiguity aversion is driven by the comparison with more familiar events or more knowledgeable individuals, and diminishes or disappears in the absence of such a comparison. In this paper we emphasize that "comparative ignorance" refers to the state of mind of the decision maker. We extend the comparative ignorance hypothesis by documenting four new ways in which decision context can affect willingness to act under uncertainty that do not rely on the comparative-noncomparative evaluation paradigm used in previous studies. First, people find uncertain bets more attractive when preceded by questions about less familiar items than when preceded by questions about more familiar items. Second, the preference to bet on more familiar domains is less pronounced for the first domain evaluated on a survey than for later domains. Third, people find bets less attractive when they are provided with diagnostic information that they do not know how to use, compared to when they are provided with no such information. Finally, people are sensitive to the relative competence of their counterpart when playing a simple competitive (matching pennies) game, but not when playing a

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noncompetitive (coordination) game that has the same mixed strategy Nash equilibrium.

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Most choices in life have uncertain consequences. Decisions to undergo surgery, invest in a mutual fund, or purchase insurance must be made without knowing in advance whether the operation will be successful, the fund will outperform the market, or there will be a need to make a claim on the policy. Occasionally, the decision maker knows precise probabilities of potential outcomes. For instance, a gambler in a Monte Carlo casino might recognize that the probability of a roulette wheel landing "red" is 18/37; a patient in a health clinic might be told that 1 in 40,000 people inoculated for measles experiences an adverse reaction. More often, however, decision makers are required to judge the likelihood of relevant events for themselves based on computation, intuition, and/or hearsay, with some degree of imprecision or vagueness. This contrast between clear and vague probabilities was first discussed by Knight (1921), who distinguished between *risk*, which can be represented by precise probabilities, and (*unmeasurable*) *uncertainty*, which cannot. He argued that entrepreneurs earn economic rents for bearing uncertainty. Meanwhile, Keynes (1921) distinguished between judged *probability*, which represents the balance of evidence in favor of a particular proposition, and the *weight* of evidence, which represents the quantity of evidence supporting that balance. Keynes asserted that people should be more willing to bet on probabilities that are supported by a higher weight of evidence.

The contrast between clear and vague probabilities was disregarded by later theorists. Subjectivists (e.g., Ramsey, 1931) have argued that degree of belief should be measured by preference between bets, and thereby assumed that vagueness does not influence choice independently of belief strength. Although Savage (1954) explicitly addressed the topic of vague probabilities, he dismissed its relevance to choice in his development of subjective expected utility theory (pp. 57–60).

Interest in the problem of vague probabilities was revived by Ellsberg (1961), who argued that people generally prefer to bet on known rather than unknown probabilities. Ellsberg's simplest demonstration involves two urns, each containing 100 balls. The first urn contains 50 red balls and 50 black balls, whereas the second contains red and black balls in an unknown proportion. When asked to bet on a blind draw from an urn, most people express no particular color preference, but they would rather bet on the clear (50-50) urn than on the vague (unknown probability) urn. This pattern of preferences violates expected utility theory because the subjective probabilities of red and black, derived from preferences, cannot sum to one for both urns. Ellsberg's own interpretation was that in addition to the utility of outcomes and the probability of events determining them, decision makers consider a "third dimension," which he called *ambiguity*, defined as "a quality depending on the amount, type, and

'unanimity' of information, and giving rise to one's degree of 'confidence' in an estimate of relative likelihoods" (p. 657). Thus, Ellsberg drew a distinction between judgment and willingness to act:

> An individual . . . can always assign relative likelihoods to the states of nature. But how does he *act* in the presence of uncertainty? The answer to that may depend on another judgment, about the reliability, credibility, or adequacy of his information. (p. 659)

The preference to bet on clear rather than vague probabilities has been demonstrated in numerous studies using variations of Ellsberg's original paradigm. Researchers have typically operationalized and modeled the degree of ambiguity as the range or variance of the second-order probability distribution, interpreting ambiguity aversion as a reluctance to bet on vaguer probabilities (for a comprehensive review of this literature, see Camerer & Weber, 1992).

A more recent stream of research emphasizes instead the decision maker's confidence in his or her knowledge or information (e.g., Frisch & Baron, 1988; Heath & Tversky, 1991). In particular, Heath and Tversky (1991) conducted a series of experiments comparing people's willingness to bet on their uncertain beliefs with their willingness to bet on chance events. Contrary to the ambiguity aversion hypothesis, they found that people prefer to bet on their vague beliefs in situations where they feel especially competent or knowledgeable, though they prefer to bet on chance when they do not. In one test of Heath and Tversky's competence hypothesis, participants were asked to choose among bets involving three sources of uncertainty: the winner of professional football games, the winner of various states of the 1988 presidential election, and the results of random draws from an urn containing a known proportion of winning balls. Participants who said they knew a great deal about football and little of politics preferred betting on football games rather than on chance events that they considered equally probable. However, these participants preferred betting on chance events rather than on political events that they considered equally probable. Analogously, participants who knew a great deal about politics and little of football exhibited the opposite pattern, preferring politics to chance and chance to football. The preference to bet on more familiar sources of uncertainty has since been replicated in a number of studies (e.g., Taylor, 1995; Tversky & Fox, 1995; Keppe & Weber, 1995; Taylor & Kahn, 1997). It may provide a partial explanation for the commonly observed preferences to invest in the domestic stock market over foreign markets (see e.g., French & Poterba, 1991; Kilka & Weber, 2000) and the telephone company in one's home state over other states (Huberman, 2001).

The competence hypothesis suggests that ambiguity aversion (or, more generally, "source preference") is governed by the decision maker's appraisal of his or her knowledge of relevant events rather than some second-order measure of probability vagueness. Furthermore, Fox and Tversky (1995) argued that perceived competence only affects decisions to the extent that this dimension is brought to mind. According to their *comparative ignorance hypothesis*, ambiguity aversion is driven by a comparison with more familiar sources of uncertainty or more knowledgeable people (which makes the notion of competence

more salient), and is not as pronounced in the absence of such a comparison (where the notion of competence is less salient). This represents a sharp break from previous accounts of decision under uncertainty because it asserts that a particular uncertain prospect may be more or less attractive depending on whether or not a contrasting state of knowledge is salient.

Virtually every empirical study of ambiguity aversion and competence effects reported before 1995 relied on a within-subject design in which all participants evaluated multiple sources of uncertainty. In several experiments, Fox and Tversky (1995) documented ambiguity aversion in *comparative* contexts in which each participant evaluated lotteries with both clear and vague probabilities (a within-subject design), but found that the effect was greatly diminished or disappeared entirely in *noncomparative* contexts, in which different participants evaluated each lottery in isolation (a between-subject design). Additionally, these researchers showed that participants who were told that more knowledgeable people would be making the same choice were much less likely to bet on their prediction than participants who were not told about such experts. Further evidence from market studies has shown that the pronounced difference in prices for clear versus vague bets, observed when both bets are traded together, diminishes or disappears entirely when these bets are traded in separate markets (Sarin & Weber, 1993).

Chow and Sarin (1999) have obtained data that lend further credence to the comparative ignorance hypothesis. First, they replicated the finding that the preference for known probabilities over unknown probabilities diminishes in the absence of an explicit comparison between sources of uncertainty, though in the studies that they report the preference persists even in non-comparative settings (see Chow & Sarin, 2001).[1] Second, they found that the preference for known over unknown probabilities is amplified when participants are made aware of the fact that another participant or group of participants is evaluating the other kind of bet. Third, participants preferred betting on known probabilities to betting on so-called "unknowable" probabilities (i.e., in which probabilities are presumably unknown to anyone), and they preferred betting on "unknowable" probabilities to betting on "unknown" probabilities (i.e., in which they are told that another person knows the relevant probability).

It is important to emphasize, as Fox and Tversky (1995, p. 599) did, that the distinction between comparative and noncomparative assessment refers to the state of mind of the decision-maker rather than the experimental manipulation of context. We suggest two important corollaries to the comparative ignorance hypothesis: (1) any feature of the decision context that makes a contrasting state of knowledge more salient should exacerbate source preference;

[1] Note that the presence of ambiguity aversion in noncomparative contexts does not necessarily contradict the comparative ignorance hypothesis. As Fox and Tversky (1995) point out: ". . . there is no guarantee that subjects in the comparative conditions actually perform the suggested comparison, or that subjects in the noncomparative conditions did not independently generate a comparison. In Ellsberg's two-color problem, for example, [some] people who are presented with the vague urn alone may spontaneously invoke a comparison to a 50-50 urn, especially if they have previously encountered such a problem." (p. 599)

and (2) source preference is inherently relative so that absolute willingness to act under uncertainty depends on the particular standards of comparison that are available to the decision maker. Note that Fox and Tversky (1995) and Chow and Sarin (1999) demonstrated comparative ignorance effects by juxtaposing a familiar prospect with an unfamiliar prospect or by explicitly mentioning other people who are more (or less) knowledgeable. The present observations suggest that one can produce comparative ignorance effects through a broader array of experimental manipulations. The purpose of this paper is to provide more general support for the comparative ignorance hypothesis using four novel manipulations of decision context that do not rely on the comparative-noncomparative elicitation paradigm. In particular, we demonstrate comparative ignorance effects (1) within an entirely comparative context, (2) in a context that shifts from noncomparative to comparative, (3) within an entirely noncomparative context, and (4) in a strategic (interactive) context.

In a first set of studies, all participants are reminded of contrasting states of knowledge (i.e., the context is comparative for all participants) yet the specific nature of this comparison varies by condition. Here we argue that a participant's relative rather than absolute degree of perceived competence will govern her willingness to bet. In a second set of studies, all participants evaluate a relatively clear and relatively vague source of uncertainty, but the order in which sources are presented varies by condition. Here we argue that the context shifts from noncomparative for the first source to comparative for the second source so that the salience of contrasting states of knowledge is higher when evaluating the second source than when evaluating the first source. In a third set of studies, all participants encounter a noncomparative context, but we attempt to make a superior state of knowledge more salient by providing diagnostic information that only an expert could use to forecast relevant outcomes. Here we predict that the addition of such information will make most of our naïve participants less willing to bet. In a final study, we explore comparative ignorance effects in the context of simple strategic interactions. Here we argue that the relative competence of one's counterpart should be especially salient and therefore influence choices. We conclude with a discussion in which we summarize the present results, discuss related work, suggest potential applications, and articulate possible directions for future research.

COMPARATIVE IGNORANCE IN A COMPARATIVE CONTEXT

Fox and Tversky (1995) argued that ambiguity aversion is driven by the contrast between a person's limited knowledge about an event and his or her superior knowledge about another event. However, these authors remain agnostic concerning: (1) the extent to which comparison enhances the attractiveness of the more familiar bet versus the extent to which it diminishes the attractiveness of the less familiar bet; and (2) the extent to which the specific nature of the contrast affects willingness to act. It could be, for example, that a bet's attractiveness is governed by a person's absolute degree of knowledge—but only when that knowledge is made salient by any sort of contrast. It seems

more plausible, however, that a person's assessment of her degree of competence or incompetence is itself an inherently relative construct. Just as a baseball batting average is meaningless in the absence of a standard of comparison (to a reference group and/or one's past performance), other measures of competence often depend on the specific object of comparison. When a person is reminded of more familiar domains or people with greater knowledge or skill, she will feel relatively incompetent; when she is reminded of less familiar domains or people with lesser knowledge or skill, she will feel relatively competent. This account predicts that within a comparative decision context, people will value an uncertain prospect more highly when they are reminded of an inferior state of knowledge than when they are reminded of a superior state of knowledge. The first two studies test this hypothesis.

Study 1

We recruited 110 law students at Willamette University, which is located in Salem, Oregon. Participants completed a one-page survey in a classroom setting for which they received no compensation. We presumed that these students would be highly familiar with Salem weather, moderately familiar with the weather in San Francisco, and relatively unfamiliar with the weather in Istanbul, Turkey. We asked participants how much they would be willing to pay to bet on each side of a proposition that offered a fixed prize if the temperature in a particular city were above or below a specified value. The exact wording was as follows:

> Imagine that you have been offered a ticket that will pay you $100 if the afternoon high temperature in {CITY} is at least 65 degrees Fahrenheit one week from today. What is the most you would be willing to pay for such a ticket?
>
> The most I would be willing to pay is $_____
>
> Imagine that you have been offered a ticket that will pay you $100 if the afternoon high temperature in {CITY} is less than 65 degrees Fahrenheit one week from today. What is the most you would be willing to pay for such a ticket?
>
> The most I would be willing to pay is $_____

Approximately half the respondents priced prospects based on Salem temperature followed by prospects based on San Francisco temperature; the remaining respondents priced prospects based on Istanbul temperature followed by prospects based on San Francisco temperature. The order of complementary prospects (at least 65 degrees/less than 65 degrees) was otherwise counterbalanced. According to the present account, San Francisco bets should be more attractive when they are preceded by the relatively unfamiliar Istanbul bets than when they are preceded by the relatively familiar Salem bets.

Eleven participants who violated stochastic dominance or neglected to answers all of the questions were excluded from the analysis. Let $c(SF_{ist} \geq 65)$ denote willingness to pay for the prospect that offers $100 if the temperature in San Francisco is at least 65 degrees one week in the future, where this prospect follows prospects contingent on future temperature in Istanbul. For

each respondent we added his willingness to pay for complementary bets. Mean sums are listed in Table 1 (with standard errors in parentheses). For instance, the lower left cell presents the mean value of $c(SF_{sal} < 65) + c(SF_{sal} \geq 65)$. Results support our prediction. Respondents were willing to pay an average of \$16.18 more to bet on San Francisco temperature in the condition in which they were made to feel relatively competent (Form *B*) compared to the condition in which they were made to feel relatively incompetent (Form *A*), an increase of 74% ($t(97) = 2.88$; $p < .005$, one-tailed).

The same pattern holds for the individual bets. Participants priced the prospect that offered "\$100 if . . . San Francisco is . . . *less than* 65 degrees . . ." higher when this bet followed the (unfamiliar) Istanbul prospects than when this prospect followed the (familiar) Salem prospects, $c(SF_{ist} < 65) = 16.62$, and $c(SF_{sal} < 65) = 11.42$ ($t(97) = 1.60$, $p < .06$). Similarly, $c(SF_{ist} \geq 65) = 21.54$, and $c(SF_{sal} \geq 65) = 10.51$ ($t(97) = 3.31$, $p < .001$).

Note that respondents were willing to pay no less to bet on the unfamiliar Istanbul than they were willing to pay to bet on the familiar Salem ($t(97) = -1.01$, *n.s.*). This result is consistent with the comparative ignorance hypothesis if one assumes that the first item on the survey was evaluated in a noncomparative manner. We will have more to say about such order effects in the next section of this paper.

Study 2a

One might be concerned that the results of Study 1 are driven by the comparative ignorance effect plus a demand effect: participants are not ambiguity averse for the first source of uncertainty evaluated on the survey, but they feel some normative pressure to price bets on more familiar sources of uncertainty higher than bets on less familiar sources. In order to rule out such an account we attempted to induce a state of comparative ignorance (or competence) by drawing people's attention to a more (or less) familiar source of uncertainty—without asking them to price a contrasting bet. We recruited 95 people waiting for flights at O'Hare International airport in Chicago. The survey was administered shortly before presidential elections were to take place in the United States, Russia, and the Dominican Republic (June, 1996). Participants were presented with the following items:

TABLE 1

Results of Study 1

	Form A ($n = 49$)	Form B ($n = 50$)
1st item	Salem \$26.23 (3.39)	Istanbul \$31.62 (4.12)
2nd item	SF \$21.98 (2.88)	SF \$38.16 (4.79)

Note. Table cells present mean sums of willingness to pay for complementary bets on future temperature in the designated city (standard errors are listed in parentheses).

The two leading candidates for president of Russia are Boris Yeltsin and Gennady Zyuganov.

Who do you think will win? (Circle one)
Yeltsin Zyuganov

Which would you rather receive? (Circle one)
$50 for sure
$150 if I am right about the Russian election

For roughly half the participants, these questions were preceded by an item that primed their knowledge of a *more* familiar event:

The two leading candidates in this year's election for president of the United States are Bill Clinton and Bob Dole.

Who do you think will win? (Circle one)
Clinton Dole

For the remaining participants, these questions were preceded by an item that primed their knowledge of a *less* familiar event:

The two leading candidates in this year's election for president of the Dominican Republic are Leonel Fernández and José Francisco Peña Gómez.

Who do you think will win? (Circle one)
Fernández Gómez

According to the comparative ignorance hypothesis, respondents should be more willing to bet on their knowledge of the Russian election when they have been made to feel relatively competent (by first considering the Dominican Republic election) than when they have been made to feel relatively incompetent (by first considering the American election). Indeed, 72% of respondents ($n = 46$) chose to bet on their prediction about the Russian election when they had been first reminded about the less familiar Dominican Republic, whereas only 37% of respondents ($n = 49$) chose to bet on their prediction when they had first been reminded about the more familiar American election ($z = 3.66$, $p < .001$). There was no significant difference in choices for Yeltsin versus Zyuganov between the two experimental conditions.

Study 2b

We replicated this effect two weeks before the 1998 state elections in Germany. We approached students ($N = 143$) in a library on the campus of the University of Mannheim, and asked them to complete the following survey. We presume that students in Mannheim had a great deal of knowledge concerning the upcoming nation-wide election in which Helmut Kohl was facing Gerhard Schröder, a moderate amount of knowledge concerning the elections in the distant German state of Mecklenburg-Vorpommern that involved candidates from the leading CDU and SPD parties (among others), and very little knowledge concerning the upcoming U.S. Senate race in the state of Kentucky. Roughly half the participants were asked about Kentucky (item *a*) before Mecklenburg-Vorpommern; the remaining participants were asked about the nationwide election (item *a′*) before Mecklenburg-Vorpommern.

1. For the following elections in 1998, please check the candidate or political party that, according to your opinion, is going to win the election or receive the majority of the vote:
   a) U.S. Senatorial Election in the State of Kentucky, November 3, 1998
      Scotty Baesler [ ] *Jim Bunning* [ ]
   a′) General election, Bundestag, Sept. 27, 1998
      Helmut Kohl [ ] *Gerhard Schröder* [ ]
   b) State election in Mecklenburg-Vorpommern, Sept. 27, 1998
      CDU [ ] *SPD* [ ]

2. Which of the following alternatives would you prefer?
   A payment of 50DM for sure [ ]
   OR
   100 DM if your forecast for the election in Mecklenburg-Vorpommern is correct and nothing if you are incorrect. [ ]

Results echo those of the previous survey: 55% of respondents ($n = 74$) chose to bet on their prediction concerning the state election when they had first been asked about the unfamiliar U.S. Senate race, whereas only 38% ($n = 73$) bet on their prediction when they had first been asked about the more familiar German national election ($z = 2.10$, $p < .01$). Again, there was no significant difference by experimental condition in choices of the CDU versus SPD party.

COMPARATIVE IGNORANCE IN A SHIFTING CONTEXT: ORDER EFFECTS

Researchers have long known that the order of presentation can influence responses to various items in a survey due to priming, norms of conversational implicature, and for a variety of other reasons (for a review, see Sudman, Bradburn, & Schwarz, 1996). Recently, Moore (1999) presented participants with pairs of multiattribute outcomes that included one "superficially attractive" option and one "normatively superior but superficially unattractive" option. Moore argued that the first option provides a context for the second so that both options are priced higher when the superficially attractive option comes first. For instance, in one study participants priced a 7-ounce serving of ice cream in a 5-ounce cup (superficially attractive because the cup is overfilled) and an 8-ounce serving in a 10-ounce cup (normatively superior because it contains more ice cream, but superficially unattractive because the cup is underfilled). When pricing the larger then smaller serving participants reported a mean willingness-to-pay of $2.02 and $1.84, respectively; however, when pricing the smaller then larger serving participants reported mean willingness-to-pay of $2.44 and $2.60, respectively.

The comparative ignorance hypothesis suggests a related variety of order effects when people evaluate uncertain prospects. Recall that the studies reported by Fox and Tversky (1995) demonstrate that source preference diminishes or disappear in a noncomparative context. We suggest that like participants in Moore's (1999) studies of decisions under conflict, participants in studies of decision under uncertainty are likely to evaluate the first prospect on a survey in a noncomparative manner, and this item is likely to provide a (comparative) context for the second item. Indeed, one of the striking patterns

to emerge from Study 1 was that the first group of respondents was willing to pay no more to bet on future temperature in a familiar city (Salem) than the second group was willing to pay to bet on future temperature in an unfamiliar city (Istanbul). This pattern suggests that subsequent bets on San Francisco did not provide a comparative context; moreover, the difference in prices for San Francisco bets between conditions suggests that the first city did indeed provide a comparative context for the second. Study 3 was designed to provide more direct evidence for the notion that the (subjective) context can shift from noncomparative to comparative as participants proceed through a survey. In particular, the present account predicts that when a survey contains bets that vary in their familiarity, source preference will be more pronounced for later sources than for the first source evaluated.

Study 3

We recruited a new sample of 108 law students at Willamette University (located in Salem, Oregon). Participants were asked to report how much they were willing to pay for a pair of prospects that offered $100 if the temperature in a familiar city (Salem) would be *at least* 65 degrees and *less than* 65 degrees, and a second pair of prospects that offered $100 if the temperature in an unfamiliar city (Istanbul) would be *at least* 65 degrees and *less than* 65 degrees. We counterbalanced the order in which complementary bets (at least 65 degrees versus less than 65 degrees) were presented as well as the order in which the cities were presented. Wording of the surveys followed the format used for Study 1. Our prediction is that source preference will be more pronounced for the second pair of bets than for the first pair of bets.

Eight participants who violated dominance or failed to provide complete responses were excluded from the analysis. As in Study 1 we added for each participant his or her willingness to pay for complementary bets. Mean sums for each city are listed in Table 2 (standard errors are listed in parentheses). The results generally conform to our prediction: when we compare willingness to pay for the first city evaluated by participants in the two groups, the familiar Salem bets were priced only $2.82 higher than the unfamiliar Istanbul bets ($t(98) = 0.56$, *n.s.*); however, when we compare willingness to pay for the second city evaluated, this difference increases sharply to $16.00 ($t(98) = 2.90$, $p < .005$). The interaction is marginally significant ($t(98) = 1.39$, $p < .09$).

A similar pattern of enhanced source preference for sources evaluated second

TABLE 2

Results of Study 3

	Order A ($n = 51$)	Order B ($n = 49$)
1st item	Salem $26.83 (3.89)	Istanbul $24.01 (3.17)
2nd item	Istanbul $20.37 (3.30)	Salem $36.37 (4.47)

Note. Table cells present mean sums of willingness to pay for complementary bets on future temperature in the designated city (standard errors are listed in parentheses).

was observed among individual bets. We begin with the "at least 65 degrees" bets. Participants were willing to pay $6.02 more to bet on Salem than Istanbul when these cities were listed first on their respective surveys (i.e., comparing Order A respondents with Order B respondents), but participants were willing to pay an average of $15.26 more to bet on Salem than Istanbul when these cities were listed second on their respective surveys (i.e., comparing Order B respondents with Order A respondents) ($t(98) = 2.19$, $p < .05$). Similarly, for "less than 65 degrees" bets, participants were willing to pay an average of $2.93 *less* to bet on Salem than Istanbul when these cities were listed first, but $0.84 *more* to bet on Salem than Istanbul when these cities were listed second ($t(98) = 0.60$, *n.s.*).

The preceding study documents order effects, consistent with the comparative ignorance hypothesis, in a brief pencil-and-paper task in which prospects were presented to participants on the same page of a questionnaire. One might wonder if order effects would be displayed when participants complete a more involving task. Data reported by Fox and Tversky (1995; study 2) provide such a test. Respondents priced a clear bet involving a draw from a bag containing one red ping-pong ball and one green ping-pong ball, and a vague bet involving the draw from a bag containing two ping-pong balls, each of which could be either red or green. Participants were first asked to guess the color of the ball to be drawn. Next they were asked to make a series of choices between receiving $20 if their guess is correct (and nothing otherwise) or receiving $$X$ for sure. Respondents marked their choices on a response sheet that listed the various sure amounts ($$X$) in descending order from $19.50 to $0.50 in steps of 50 cents. They were informed that some participants would be selected at random to play for real money. For these participants, one choice would be selected at random, and the participant would either receive $$X$ or play the bet, depending on the preference that they had indicated. Half of the respondents who priced both clear and vague bets received a description of the clear bet followed by a description of the vague bet and priced these bets in the same order. Half of the respondents who priced both bets received descriptions and were asked to price bets in the opposite order. Cash equivalents were estimated by the midpoint between the lowest amount of money that was preferred to the uncertain bet and the highest amount of money for which the bet was preferred.

Table 3 presents the mean cash equivalent for each bet (with the standard error in parentheses). Results of this analysis are even stronger than the results of the previous study. When we compare responses to the first item across

TABLE 3

Reanalysis of Study 2 from Fox and Tversky (1995)

	Order A ($n = 26$)	Order B ($n = 26$)
1st item	Clear $8.92 (.584)	Vague $9.56 (.807)
2nd item	Vague $7.50 (.783)	Clear $10.56 (.761)

Note. Table cells present mean certainty equivalents for clear or vague probability bets (standard errors are listed in parentheses).

conditions, the clear bet was priced \$0.64 lower than the vague bet ($t(50) = -.64$, *n.s.*); however, when we compare responses to the second item across conditions, the clear bet was priced \$3.06 higher than the vague bet ($t(50) = 2.80$, $p < .005$). This interaction is significant ($t(50) = 1.96$, $p < .05$).

COMPARATIVE IGNORANCE IN A NONCOMPARATIVE CONTEXT

The preceding results suggest that a subjective state of comparative ignorance can be manipulated in ostensibly comparative contexts—either by manipulating the specific nature of the comparison or by varying the order of events. In the following studies we attempt to induce a subjective state of comparative ignorance without explicitly introducing a comparison. Our approach was to provide participants with information that could be used by experts to predict relevant outcomes, but which most participants lack relevant expertise to utilize. We reason that providing participants with information that they do not know how to use will induce a state of comparative ignorance because it naturally reminds them that there are people who do have sufficient expertise to use such information.

Study 4a

We asked undergraduates in an introductory psychology class at Stanford ($N = 104$) to assess the inflation rate in Holland, presumably an unfamiliar domain to most. One group of the participants were provided with additional diagnostic information that someone with extensive training in economics might find useful, but that undergraduates would presumably find less useful. The following item was embedded in a larger questionnaire packet that included several unrelated items, which students completed for course credit.

1. Do you think that the inflation rate in Holland over the last year is greater than or less than 3.0%?
   - *less than* 3.0%
   - *at least* 3.0%

2. Now, which of following do you prefer? (circle one)
   - Receive \$ 50 for sure
   - Receive \$ 150 if your [guess about/estimation of] the inflation rate in Holland is correct

Approximately half the participants were also provided with the following information.

> Over the last year, Holland's Gross Domestic Product (GDP) has grown by 0.5%. Their unemployment rate is currently 4.8%. The overnight money market interest rate is 7.72%. As you know, this information can be used to help predict the inflation rate in a country.

From a normative standpoint, providing students additional data that are diagnostic of the inflation rate can only increase the accuracy of their prediction. This information should therefore increase willingness to bet unless participants updated their subjective probability distributions so that they were

centered closer to the cutoff of 3%. Such a shift in probability seems unlikely because the vast majority of our respondents, (undergraduate psychology students) lacked advanced training in economics. That said, if such a shift in belief did occur, the proportion of people estimating inflation above versus below 3% should have been closer to .50 in the high information condition. However, we observed no significant difference in forecasts between experimental conditions.

The present account suggests that the addition of information will typically intimidate students by reminding them that they are comparatively ignorant. Results support this prediction: in the control condition ($n = 54$), 56% of subjects favored a bet on their "guess" about the inflation rate. However, when provided with added information ($n = 50$), only 36% of subjects favored a bet on their "estimation" of the inflation rate ($z = 2.05$, $p < .05$).

Study 4b

In order to replicate this effect we approached second-year business students at the University of Mannheim. Because these participants would be more familiar with European economic indicators than participants in the previous study, we asked them to evaluate economic indicators in North America. Students completed the survey in a classroom setting and received no compensation for their participation.

1. Do you think that the inflation rate in Canada over the last year is greater than or less than 2.0%?
   - *Less than* 2.0%
   - *At least* 2.0%

2. Now, which of following do you prefer?
   - Receive DM 50 for sure
   - Receive DM 150 if your estimation of the inflation rate in Canada is correct

Roughly half the respondents were also provided with the following information.

> Over the last year, Canada's Gross Domestic Product (GDP) has grown by 1.5%. Their unemployment rate is currently 9.7%. The yield on 10-year treasury bonds is 5.7%. As you know, this information can be used to help predict the inflation rate in a country.

Results again conform to our prediction. There was no significant difference in forecasts of Canadian inflation between conditions. In the control condition ($n = 68$), a small minority of respondents (10%) opted for the certain payment. However, when provided with additional information ($n = 62$), more than twice the proportion of respondents (21%) avoided betting on their estimate by opting for the certain payment ($z = 1.68$, $p < .05$).

COMPARATIVE IGNORANCE IN AN INTERACTIVE

Although there have been a number of studies examining ambiguity aversion and competence effects in individual decision making, there has been a paucity of work exploring such phenomena in interactive decision making. Of course,

expected utility theory (EU) was originally axiomatized for application to the analysis of behavior in games (von Neumann & Morgenstern, 1944). Traditionally, non-cooperative game theory derives solution concepts based on the assumption of expected utility maximization. More recently, some theorists have argued that individuals treat decisions under strategic uncertainty the same as they do decisions under naturalistic uncertainty, and that the usual solution concepts (e.g., iterated dominance, pure and mixed-strategy Nash equilibria, correlated equilibria) can be derived from common or mutual knowledge assumptions plus EU maximization (e.g., Brandenberger, 1992).

Some behavioral game theorists have begun to question the assumption that strategic (endogenous) uncertainty is treated the same as naturalistic (exogenous) uncertainty. In particular, Camerer and Karjalainen (1994) observed that strategic uncertainty entails ambiguity. They presented participants with games modeled after Ellsberg's 2-color and 3-color problems as well as a median effort coordination game, and found that most respondents would rather bet on a chance device (e.g., the flip of a coin) than against the play of another person (e.g., one who faces a choice between two strategies with symmetric consequences).

The results of Camerer and Karjaleinen (1994) can be explained readily by the comparative ignorance hypothesis if one considers that strategic interactions necessarily entail an assessment of one's counterpart—and this assessment should therefore make a contrasting state of knowledge salient. One would predict, further, that the preference for chance would be enhanced when one feels incompetent relative to one's counterpart and diminished when one feels competent relative to one's counterpart. Furthermore, although this pattern should hold for competitive games, we expect that it will diminish or disappear for games that are viewed as noncompetitive because participants should prefer to maximize collective competence. Study 5 was designed to test these predictions.

Study 5

Participants were 148 MBA students at Duke University who completed a number of brief surveys in exchange for a donation to a charity. We told participants that some people would be selected at random to be given $10 and also play one of their choices at the end of the session for real money. Each participant then completed a three page questionnaire. The first two pages described both a competitive game ("matching pennies") and a noncompetitive game (coordination with no apparent focal strategy), the order of which was counterbalanced.

The survey began as follows: "In this game, you and another person will select an investment. Combined, your selection and the other person's selection produce outcomes for each of you according to the following table." The instructions made clear that each participant would play only one round of the game and that strategy choices would be revealed simultaneously.

The payoff matrix for the competitive game was presented as follows:

		Other person selects:	
		Yahoo	Amazon.com
You select:	Yahoo	You lose $10 Other wins $10	You win $10 Other loses $10
	Amazon.com	You win $10 Other loses $10	You lose $10 Other wins $10

The payoff matrix for the noncompetitive game was presented as follows:

		Other person selects:	
		Yahoo	Amazon.com
You select:	Yahoo	You lose $10 Other loses $10	You win $10 Other wins $10
	Amazon.com	You win $10 Other wins $10	You lose $10 Other loses $10

Participants were then asked which of two ways they would rather play the game:

1. The other person selects an investment.
2. The other person flips a coin, and selects the investment specified by the coin flip (Heads = Yahoo, Tails = Amazon.com).

Note that both games have a mixed-strategy Nash equilibrium in which both players choose each pure strategy with .5 probability. Moreover, the conditions were absolutely symmetric, and there would be no opportunity for advance communication between participants. Hence, playing another person (option 1) should be strategically equivalent to playing against a coin flip (option 2) for both games.

On the final page, participants provided a percentile rank for their mathematical score on the Graduate Management Admission Test (GMAT) relative to other students in the room.[2] They also indicated whether they preferred to play each of the games with a counterpart whose mathematical GMAT score was either above or below the median for their group. We will refer to these options as the "high-GMAT" and "low-GMAT" counterpart, respectively.

We predicted that participants would find the competitive game more attractive when they felt comparatively competent than when they felt comparatively ignorant, despite the fact that relative competence is normatively irrelevant for play in such symmetric games. Results seem to support our prediction. In the competitive game, participants expressed a slight preference in favor of the coin flip (57% preferred the coin, $z = 1.65$, $p < .05$). Moreover, most expressed

[2] This test is required for all applicants to most MBA programs including Duke University.

a preference to play against a low-GMAT rather than high-GMAT counterpart (60%, $z = 2.46$, $p < .01$). Finally, recall that we asked participants to rank themselves relative to others in the room on their GMAT scores. In this case 68% of respondents ranked themselves above the median and 51% ranked themselves in the first quartile, exhibiting pronounced self-enhancement bias (see Taylor & Brown, 1988). However, when we conduct a median split on these responses, we find that participants who ranked themselves lowest on the GMAT were more eager to play against a coin flip (66% preferred the coin) whereas those who ranked themselves highest on the GMAT were more eager to play against a classmate (47% preferred a coin flip). This difference is statistically significant ($z = 2.30$, $p = .01$).

The noncompetitive game gave rise to a very different pattern, also consistent with our prediction. First, participants were much more eager to play this game with a person rather than a coin flip: 72% preferred strategic uncertainty to risk ($z = 5.23$, $p < .00001$). Second, participants indicated a strong preference to play the cooperative game with a high-GMAT rather than low-GMAT counterpart (63%, $z = 3.11$, $p < .001$). However, participants' impression of their own competence was a less decisive factor in the noncompetitive game than it was for the competitive game: 26% of the group that rated themselves lowest on the GMAT preferred to play against the coin and 30% of those who rated themselves highest on the GMAT favored the coin ($z = 0.55$, *n.s.*).

In sum, Study 5 lends credence to the notion that the perceived relative competence of one's counterpart may affect decision making under strategic uncertainty—even when the measure of competence is irrelevant to the game at hand. The pattern that we observed cannot be reconciled easily with the prediction of expected utility theory (which predicts indifference between playing against a coin flip or against a person for both games) or the ambiguity aversion hypothesis (which predicts a preference to play against a coin flip for both games). Of course, the observed pattern of results might be rationalized if participants felt that a more clever counterpart could somehow wield greater influence over the outcome of the game (despite the fact that there was no focal strategy and no opportunity for advance communication or learning in this one-shot game). Although this interpretation attributes the observed pattern of results to variations in subjective probabilities, we assert that such dubious reasoning by decision makers would amount to overgeneralization of the principle that it is best to bet in situations where one feels comparatively competent. Regardless, further research on comparative ignorance effects in strategic decision making would seem to be warranted.

DISCUSSION

The results of the studies presented in this paper cast further doubt on the traditional interpretation of ambiguity aversion as a reluctance to bet on less precise probabilities (see Camerer & Weber, 1992). Instead, they support Heath and Tversky's (1991) interpretation that ambiguity aversion reflects reluctance to bet in situations where the decision maker feels less knowledgeable or

competent forecasting relevant outcomes. Moreover, the present studies lend further support to Fox and Tversky's (1995) comparative ignorance hypothesis, which asserts that ambiguity aversion is driven by the contrast with less ambiguous events or with more knowledgeable individuals, and diminishes or disappears in the absence of such a comparison. We elaborate this hypothesis, noting that: (1) any feature of the decision context that makes a contrasting state of knowledge more salient should exacerbate ambiguity aversion; and (2) the absolute degree of ambiguity aversion exhibited depends on the decision maker's relative knowledge concerning the contrasting states that are available.

In previous demonstrations of the comparative ignorance effect, researchers relied on the comparative-noncomparative elicitation paradigm, in which ambiguity aversion was induced by: (1) juxtaposing sources of uncertainty about which the decision maker has contrasting knowledge, or (2) explicitly reminding decision makers of others who are more knowledgeable. The present paper extends and provides broader support for the comparative ignorance hypothesis using four novel experimental paradigms. First, we show that when a comparative context is induced, it is the *relative* level of contrasting states of knowledge that influences absolute willingness to act (Study 1). Moreover, it is possible to induce such a contrast without an explicit choice or pricing task—but by merely asking the decision maker to make a prediction concerning a more or less familiar event (Study 2). Second, we argue that the subjective context can shift from noncomparative to comparative over the course of making decisions. We provide evidence that source preference is more pronounced for the second source of uncertainty evaluated on a survey than the first (Study 3). This result is not only interesting on a theoretical level, but also suggests an important methodological caveat: researchers investigating decisions under uncertainty should be aware of the possibility that the context may shift over the course of an experiment in ways that affect the attractiveness of bets to participants. At a minimum, careful counterbalancing would seem to be crucial if one is to obtain reliable measurement of preferences in decision under uncertainty. Third, our studies suggest that comparative ignorance can be induced by providing people with diagnostic information that only an expert would know how to use (Study 4). We reason that this is because such information makes the expert's superior state of knowledge more salient to the non-expert decision maker. Finally, we have demonstrated that the relative competence of one's counterpart influences willingness to act under strategic uncertainty in a competitive game, and the absolute competence of one's counterpart influences willingness to act in game that is viewed as noncompetitive (Study 5). We close with comments concerning the interpretation of comparative ignorance effects, implications of the present findings for the study of decision under uncertainty, and some applications of this research outside the laboratory.

Interpretation of Comparative Ignorance Effects

We have attributed the finding that ambiguity aversion is amplified when prospects are evaluated jointly to a state of confidence or vulnerability that is

induced when contrasting states of knowledge are made more salient. Recently, Hsee, Blount, Loewenstein, and Bazerman (1999) have argued that such demonstrations of the comparative ignorance effect can also be explained by the more general *evaluability hypothesis*: attributes receive more weight when evaluated jointly rather than separately, especially when they are difficult to evaluate or interpret in isolation. Hence, one's level of relevant knowledge (or the degree of ambiguity in judged probabilities) might be considered an important attribute of a prospect that is difficult to evaluate in isolation but not when prospects are evaluated jointly. Note that the evaluability hypothesis posits that one's degree of competence receives greater weight in joint evaluation because this dimension becomes more *evaluable*, whereas the comparative ignorance hypothesis posits that one's degree of competence receives greater weight in joint evaluation because it becomes more *salient*. Indeed, it may not be possible to distinguish these two accounts using the joint-separate evaluation paradigm. It is worth noting, however, that although recent work on the evaluability hypothesis (Hsee et al., 1999) suggests that attributes are more evaluable when reference points or distributional information is available, it does not otherwise specify a procedure for determining, *ex ante*, the evaluability of an attribute. One contribution of previous work on the comparative ignorance effect is that it has isolated perceived competence as a critical attribute that gives rise joint-separate preference reversals among uncertain prospects, rather than, say, the judged probability of target events. To wit, Fox and Tversky (1995, study 5) showed that there was no significant difference between joint and separate evaluation when participants priced a prospect that would pay $100 if the temperature in Palo Alto would be above 70 degrees two weeks in the future (a relatively likely event) and a prospect that would pay $100 if the temperature in Palo Alto would be below 65 degrees three weeks in the future (a relatively unlikely event). More importantly, the present studies extend the comparative ignorance hypothesis well beyond the joint-separate evaluation paradigm, providing new recipes for producing comparative ignorance effects. In particular, we have shown that even when a single prospect is evaluated by all participants, one can influence its attractiveness by merely asking a question about a comparable event that is more or less familiar (Study 2) or by providing diagnostic information that is useless to participants (Study 4) or by embedding the decision in the context of a strategic interaction (Study 5). None of these patterns falls within the purview of the evaluability hypothesis.

We have interpreted ambiguity aversion and competence effects as instantiations of source preference in which choices between prospects depend not only on the degree of uncertainty (i.e., subjective probability) but also on its source (e.g., San Francisco temperature versus Istanbul temperature). The comparative ignorance hypothesis asserts that the decision maker's confidence acting under uncertainty can be bolstered or undermined when contrasting states of knowledge are made more salient. One may question whether manipulations that affect a decision maker's "confidence" in her forecasts influence subjective probability rather than source preference. The results presented in this paper do not seem to support such a conjecture. In studies 1 and 3, we demonstrated

source preference by showing both greater willingness to bet on an event drawn from one source than an event drawn from another source *and* greater willingness to bet against the first event than against the second (e.g., $c(SF_{ist} < 65) > c(SF_{sal} < 65)$ and $c(SF_{ist} \geq 65) > c(SF_{sal} \geq 65)$; see Study 1 above). If such an effect is mediated by a shift in belief it would require that the subjective probabilities for complementary events are higher in familiar than unfamiliar domains and only in comparative contexts. Such a pattern does not accord with previous studies that generally find judged probabilities of complementary events sum to one (see Tversky & Koehler, 1994; Fox & Tversky, 1998; but see Macchi, Osherson, & Krantz, 1999; Kilka & Weber, 2001). In studies 2a, 2b, 4a, and 4b, we asked participants to indicate which of two alternatives they thought was more likely (e.g., Yeltsin wins the election or Zyuganov wins the election), then indicate whether they would prefer to receive a sure payment or bet that their forecast was correct. It seems unlikely that asking a question about an entirely independent event or providing technical information to a naïve subject population would shift beliefs. Moreover, if beliefs had shifted then this should have been reflected in a shift in forecasts made by participants across experimental conditions. However, we observed no such shift in beliefs in any of these studies. Finally, Study 5 and the study of Fox and Tversky (1995) that we reanalyzed as a companion to Study 3 relied on symmetry of strategic interactions and games of chance to induce probabilities of 0.5 in all cases. Of course one cannot rule out the possibility that wishful or magical thinking perturbed subjective probabilities for some participants within comparative contexts. However, if subjective probabilities shifted they did so in a manner entirely consistent with the comparative ignorance hypothesis. (For more on the interaction of beliefs and preferences in decision under uncertainty, see Fox & See, in press; Fox & Tversky, 1998).

Although we have obtained no evidence of shifts in probability in the present studies, future research might explore whether it is possible to produce comparative ignorance-like effects in studies of calibration. In particular, two-alternative forced choice tasks typically require participants to select one of two potential answers to a question of factual knowledge, then judge the probability that the answer selected was correct. Hence, the judge is called on to quantify his or her degree of subjective confidence, which might be perturbed in similar ways to those described in this paper. For instance, suppose an American student is asked to indicate whether Barcelona or Madrid is the capital of Spain (a medium-familiarity item) then judge the probability that his answer was correct. The student's judged probability for this item might be lower if he had just been asked whether Washington, D.C. or New York City is the capital of the United States (a high-familiarity item) than if he had just been asked whether Astana or Pavlodar is the capital of Kazakstan (a low-familiarity item).

Source Preference versus Source Sensitivity

We have interpreted ambiguity aversion as an instance of source *preference*, which should be distinguished from source *sensitivity* (Tversky & Fox, 1995;

Tversky & Wakker, 1995; Wu & Gonzales, 1996; Wu & Gonzalez, 1999). The descriptive analysis of decision under risk indicates that the impact of a given event on the value of a prospect is greater when it turns an impossibility into a possibility or a possibility into a certainty than when it merely makes an uncertain event more or less probable (Kahneman & Tversky, 1979; Tversky & Kahneman, 1992). For example, increasing the probability of winning a fixed prize from 0 to 0.1 or from 0.9 to 1.0 has a greater impact than increasing the probability from, say, 0.3 to 0.4. Hence, sensitivity to changes in probability is typically more pronounced near the end points of the probability scale. Tversky and Fox (1995) have further shown that this pattern, called bounded subadditivity, is more pronounced for uncertainty than for chance (i.e., for vague than for clear probabilities), and Kilka and Weber (2001) have documented an instance in which bounded subadditivity is more pronounced for a less familiar source of uncertainty than a more familiar source of uncertainty. Note that source preference and source sensitivity are logically independent, and that people sometimes prefer one source of uncertainty to a second source of uncertainty even though they are less sensitive to the former than the latter. For instance, participants in one of Tversky and Fox's (1995) studies preferred betting on football than on chance, but they exhibited greater subadditivity (i.e., less sensitivity) for football bets than for chance bets.

Although models based on decision weights or nonadditive probabilities (e.g., Quiggin, 1982; Gilboa, 1987; Schmeidler, 1989; Tversky & Wakker, 1995) can accommodate source sensitivity, they do not provide a satisfactory account of source preference because they do not distinguish between comparative and noncomparative evaluation. A major obstacle to modeling the comparative ignorance effect is that it requires prior specification of the decision maker's subjective assessment of his or her competence evaluating the event in question relative to standards of comparison that happen to come to mind when the decision is made. Although the availability of contrasting states of knowledge can be experimentally manipulated, as we did in the preceding studies, it cannot easily be measured and incorporated into a formal model.

Possible Applications

The effects of decision context on people's willingness to act under uncertainty that we have documented in the foregoing studies could have important applications outside the laboratory. The manipulation of comparative ignorance in comparative contexts (Studies 1 & 2) suggests that absolute willingness to act under uncertainty is greatly influenced by the particular standards of comparison to which a person happens to be exposed. For instance, a novice stock trader may feel more comfortable investing in stocks of companies with which she is moderately familiar when she is reminded of unfamiliar stocks than when she is reminded of very familiar stocks. The order effects that we have documented (Study 3) imply that when options are presented in a series, the attractiveness of relatively unfamiliar prospects will be enhanced if they are presented first (in a noncomparative context), whereas the attractiveness

of relatively familiar prospects will be enhanced if they are presented later (in a comparative context). Hence, an opportunity to invest in the domestic stock market and an opportunity to invest in an emerging market index may *both* seem more attractive when presented to potential investors in order of increasing familiarity (emerging . . . domestic) than when presented in order of decreasing familiarity (domestic . . . emerging). The manipulation of comparative ignorance in noncomparative contexts (Study 4) suggest that there is a danger in presenting people with relevant information that they do not know how to use. For example, a medical patient may be less inclined to undergo surgery if he is provided with an abundance of technical medical information; a litigant may be more eager to settle a case if she is overloaded with arcane legal considerations that bear on the outcome of trying her case in court. Indeed, Wakker, Timmermans, and Machielse (2001) recently report that clients of a Dutch insurance company express greater willingness to purchase supplemental health insurance (to cover the cost of a deductible) after they have been presented detailed information on average medical expenses across seven categories, despite the fact that this information did not seem to alter their beliefs concerning the likelihood of making a claim. The authors conclude that ". . . insurance decisions with numerical information about the downsides added is more unfamiliar, even though the knowledge of the clients is larger" (p. 21).

The present paper demonstrates convincingly that ambiguity aversion is greatly influenced by features of the context in which a decision is made. We have identified four novel methods for producing such context effects that cannot be reconciled with prevailing economic models of ambiguity aversion. These demonstrations provide converging support for the comparative ignorance hypothesis that do not rely on the joint-separate elicitation paradigm that was used in previous studies. According to this hypothesis it is the salience of contrasting states of knowledge—a transient state of mind—that governs willingness to act under uncertainty. One potentially fruitful direction for future research would be to more thoroughly catalog factors that affect this state of mind. Such an enterprise may suggest an approach that integrates the psychology of attention and memory into the analysis of choice under uncertainty.

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