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An examination of ambiguity aversion: Are two heads better than one?

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Abstract

Ambiguity aversion has been widely observed in individuals' judgments. Using scenarios that are typical in decision analysis, we investigate ambiguity aversion for pairs of individuals. We examine risky and cautious shifts from individuals' original judgments to their judgments when they are paired up in dyads.

In our experiment the participants were first asked to specify individually their willingness-to-pay for six monetary gambles. They were then paired at random into dyads, and were asked to specify their willingness-to-pay amount for the same gambles. The dyad's willingness-to-pay amount was to be shared equally by the two individuals. Of the six gambles in our experiment, one involved no ambiguity and the remaining five involved different degrees of ambiguity. We found that dyads exhibited risk aversion as well as ambiguity aversion. The majority of the dyads exhibited a cautious shift in the face of ambiguity, stating a smaller willingness-to-pay than the two individuals' average. Our study thus confirms the persistence of ambiguity aversion in a group setting and demonstrates the predominance of cautious shifts for dyads.

Keywords: ambiguity of probabilities, ambiguity aversion, risk aversion, group decision, dyads.

1 Introduction

Much theoretical and experimental research in decision analysis has examined how *individuals* do and should make choices and set prices they are willing to pay for risky and ambiguous options. But, not as much focus has been placed on decisions made by *groups*, though group decisions are common. It would be helpful to understand the relationship between individual decisions and group decisions by first examining the simplest setting of pricing a lottery. As a start in this direction, the primary question we address here via an experiment is "When decision makers act in a two-person group (called a 'dyad'), do they exhibit more or less ambiguity aversion than observed in individual settings?"

We note that in some situations such as forecasting (e.g., the Delphi technique) two heads are indeed better than one. In the context of monetary policy, Blinder and Morgan (2005) find that groups make better decisions than individuals. It is therefore natural to examine how decisions under ambiguity differ when made individually versus when these are made by dyads. Many real world decisions are entrusted to groups in the hope that the collective wisdom will prevail. Will individuals in our scenarios share their knowledge and see the light that the probability of winning is (due to the construction of our scenarios) at least 0.5 and therefore become less ambiguity averse?

Risk aversion is consistent with rational decision making and has been observed in a variety of settings. The evidence on ambiguity aversion has been mixed. Raiffa (1961) argued that a rational decision maker should not be ambiguity averse. Fox and Tversky (1995) found that ambiguity aversion disappears when individuals evaluate a single gamble (in a non-comparative setting), and Chow and Sarin (2001) found that ambiguity aversion is reduced when making separate evaluations. Sarin and Weber (1993) found that, in market settings, ambiguity aversion is reduced in independent auctions but not in simultaneous auctions.

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We have at least two reasons to expect less ambiguity aversion (and thus higher prices) in dyads. First, two people, in face-to-face discussion, may more fully understand the ambiguous setting they are facing. Because our subjects know, in our scenarios, that they can choose either side of the bet, a discussion between two subjects may lead to a realization that the probability of winning is at least 0.5. Second, individual blame or regret should be moderated in a group setting.

1.1 Ambiguity

In decisions under uncertainty the probabilities of the underlying events can often be imprecise, vague, or ambiguous. Ellsberg (1961) demonstrated that this can lead to *ambiguity aversion*, on top of any existing *risk aversion* of a decision maker. Camerer and Weber (1992) reviewed the many studies that have examined how individuals react to probabilistic ambiguity. While much is now known about how an individual decision maker reacts to ambiguity, little is known about how groups react. Our primary aim in this paper is to examine whether ambiguity aversion persists in dyad's decision making.

Ambiguity affects choices in both simple-context tasks, such as choice between monetary gambles (Ellsberg, 1961; Slovic & Tversky, 1974; Curley, Yates & Abrams, 1986), and context-rich tasks, such as patient decision making (e.g., Curley, Eraker & Yates, 1984), use of accounting information to investigate cost variances (Ho, Keller, and Keltyka, 2001), managerial choices between options for allocating resources to earn returns (Ho, Keller, and Keltyka, 2002, 2005), other business decisions (e.g., Camerer & Weber, 1992; Einhorn & Hogarth, 1986; Hoch & Ha, 1986; Hogarth & Kunreuther, 1989; Taylor, 1995), and sports and politics (Heath & Tversky, 1991). Although the predominant pattern is ambiguity aversion, Roca, Hogarth and Maule (2006) found recently that, when endowed with an ambiguous option, people can choose to retain the ambiguous option rather than exchange it for an unambiguous one.

1.2 Group risk aversion

An examination of ambiguity aversion necessitates an examination of risk aversion, to separate out the two effects. The literature on group risk aversion is large (see Baron and Kerr (2002) for a recent review and our discussion of the earlier literature in section 2.1). Most articles focus on *risky and cautious shifts,* which refer to the shifts in the risk attitude as we go from individual decisions to group decisions. A risky shift means the group takes more risks than the average individual in the group, and a cautious shift means the opposite. Our experiment was designed to elicit individuals' and dyads' willingness-to-pay (WTP) for ambiguous gambles, to directly examine the effects of ambiguity on the price of a gamble.

We chose to limit the group size to dyads (i.e., groups of two people). Many decisions are made by dyads, such as marriage partners, business partners, two-person teams with one marketing representative and one technical representative, etc. Further, we minimized the risk-sharing complexities by requiring the individuals to equally divide the cash inflows and outflows. Such equal sharing portrays a joint decision with the realization of the same outcome by all, and is common in organizational settings. Examples include joint decisions of a household, acquisition decisions by a team of managers, and committee decisions such as choice of a conference venue. These two restrictions helped us to better focus on ambiguity aversion.

1.3 Our study

We examine the following two questions:

1. Do risk aversion and ambiguity aversion persist in dyads?

2. Which is a more dominant shift (cautious, neutral, risky) under risk and ambiguity?

The participants were a total of 70 MBA students who volunteered for our experiments at the University of California, Irvine and the University of Wisconsin-Parkside. At each campus the participants answered a questionnaire individually first and then were paired into dyads at random. The dyads filled in another questionnaire.

This paper is organized as follows: A review of related literature is next. Then the method and the results are presented. The paper concludes with a discussion of the observed shifts and the conclusion.

2 Research background

2.1 Choice shift research

In the early 1960's, groups were found to exhibit so-called "risky shifts," being more risk-taking on the average than individuals on specific choice dilemma scenarios (Stoner 1961, 1968); Wallach, Kogan, & Bem, 1962). Rim (1967) and Swap and Miller (1969) examined risky shifts in dyads, and Bennett *et al.* (1973) examined the effects of group size on risky shifts. After this phenomenon had been named the "risky-shift phenomenon," groups facing different questions were seen to shift to greater caution, so-called "cautious shifts" (see, e.g., Nordhoy, 1962). So the phenomenon was then called a "choice shift." Thus, there was "group exaggeration" or "polarization" of risk-taking tendencies, rather than moderation. Davis (1992) contains a discussion of group decision tasks and risk. BarNir (1998) also provided a review and meta-analysis and noted that larger groups are more likely to shift to risk. Houghton et al. (2000) examined cognitive biases of individuals and teams in judging risks and found that groups were more affected by the law of small numbers bias than were individuals. Such a result could lead to groups appearing more risk taking since they perceive the probability of failure to be lower than it really is. Krizan and Baron (2007) examined the impact of outgroup positions on group polarization.

The structure of the lottery can lead to different polarization results, even when there is no added social context. Davis et al. (1974) conducted an experiment to gather individual and group decisions about the attractiveness ratings of duplex bets. Group shifts depended on the expected value of bets. Individual preference distributions were positively skewed for bets with negative expected values and negatively skewed for bets with positive expected values. Group distributions were exaggerations of those from the individuals. Bets with near zero expected value yielded no shifts. But then the group decisions clustered more closely (symmetrically) around the modal choice category. The social decision scheme model (Davis, 1973, 1982; Stasser, 1980) was used to predict this data. Assuming a simple majority can essentially mandate the choice or else (lacking a majority) pluralities of subgroups can get the group to choose their own preference with a probability equal to their proportion in the group, predicted group ratings match well the observed data. Zajonc et al. (1968) conducted a similar experiment with trial-by-trial choices among events.

2.2 Probabilistic ambiguity research

Ellsberg (1961) demonstrated the paradox that two options, which should be indifferent according to expected utility, will often not be indifferent if one has unambiguous probabilities and the other has ambiguous probabilities. Ellsberg's original example created ambiguity by not knowing how many balls of each color there were in an urn. In practical decisions, a probability can be ambiguous due to vagueness, imprecision, conflicting information, lack of knowledge, etc. Frisch and Baron (1988) emphasized that the subjective experience of missing information relevant to a prediction may lead to ambiguity aversion. Following Ellsberg, a number of studies have been conducted to investigate the effects of such ambiguity on individuals, see, e.g., Kahn and Sarin (1988), Hogarth and Kunreuther (1989). Kunreuther (1989), and Kunreuther et al. (1995) examined ambiguity in insurance decisions.

Little has been done to extend ambiguity research results to groups. Sarin and Weber (1993) discussed whether ambiguity effects found with a single person making a one-time choice or judgment persist in market settings with multiple people, acting individually, setting prices over multiple time periods. They found that the market setting did not generally eliminate ambiguity aversion, however, ambiguity aversion was significantly less in independent auctions than in simultaneous auctions. Shapira (1993) discussed ambiguity in organizations. van Dijk and Zeelenberg (2003) examined the impact of ambiguous information on costs and benefits of individual's decisions. Carnes (1996) compared individual and group tax accounting judgments in the face of ambiguous tax scenarios. Here ambiguity lies in the uncertainty of how the Internal Revenue Service would react to an accountant's judgment. When there was a high probability of taking a position favorable to a client, groups made a higher (risky) tax judgment (more favorable to the client). When there was a low probability, group decisions were lower (more conservative, less favorable to the client) than were individual judgments. This is consistent with group polarization from choice shift research.

3 Method

3.1 Participants

A total of 70 graduate business students volunteered for and completed the experiment at the University of Wisconsin-Parkside (in the Midwestern US) and the University of California, Irvine (in the Western US).[1] The 26 students at Parkside and the 44 Irvine students were randomly paired into 13 and 22 dyads, respectively. Subjects made hypothetical judgments and did not receive payment based on their responses. However, since they knew they would be paired with another participant, this could have increased their motivation to take the hypothetical questions seriously.

3.2 Procedures

In part 1, each individual responded to three cases. Each case presented two scenario options and participants provided a judgment of a willingness-to-pay (WTP) amount for each scenario. They also responded to questions on gender, graduate status, major, age, and familiarity with men's baseball and women's soccer. Upon turning in their part 1 responses, they were randomly paired with another participant to complete part 2 of the survey. When completing part 1, students did not yet know who their partner would be, but they were aware that there would be a second part in which they would be paired up with another person. In this part, they responded to

[1] UC Irvine students received $5 each for participation in the experiment.

the same cases as in part 1, except they had to decide together in a face-to-face meeting on a WTP amount for each scenario option. Upon completing the three cases, the dyad wrote down the general approach they took in making their decision.

3.3 Survey

The appendix contains the texts for the three cases in part 1 (involving scenarios with known vs. unknown numbers of red vs. white balls, distances between cities in the U.S. vs. China and outcomes of a men's baseball game vs. a women's soccer match). The cases dealt with gambles that could pay off \$100 or \$0. They were assumedly similar gambles except that in each case one scenario option had presumably less ambiguous probabilities than the other. We designed the scenarios to vary in ambiguity so we could examine shifts in the dyad's prices for the scenarios across varied levels of ambiguity. Following each case were the following questions:

1. Suppose you are to be given the choice of one game ticket.

Which ticket will you choose? (Ticket A, Ticket B, or Indifferent)

2. What is the most that you would pay for Ticket A?

3. What is the most that you would pay for Ticket B?

For example, in Case 1, we present Ellsberg's two-color problem: a participant could choose Ticket A, which allowed him/her to draw from Bag A with 50 white balls and 50 red balls. The participant would guess a color (white or red), then draw a ball out of the bag. If the ball matched the guessed color, the participant would win (hypothetically) \$100; if not, nothing was won.

With Ticket A the probability of winning \$100 is 0.5, so the expected value is \$50. Or, the participant could choose Ticket B, which allowed a draw from a 100-ball bag B with unknown numbers of red balls and white balls. Again, if the guessed color matches that drawn, \$100 is won; if not, nothing is won. With Ticket B, there is an ambiguous probability p of a white ball and $(1 - p)$ of a red ball. If a person thinks $p > 0.5$, then the white color should be guessed and the expected value is $\$100p > \$50$. If p is thought to be less than 0.5, the red color should be guessed and the EV = \$100 $(1 - p)$ > \$50. If p is seen as 0.5, EV = \$50. Thus, with Ticket B, in all cases, EV > \$50. By construction, the probability in B is more ambiguous than the probability in A, and a "good guess" for each probability would be 0.5.

Cases 2 and 3 are constructed similarly, except in each of the two scenarios in each case all probabilities are ambiguous. Case 2 dealt with distances in the US (assumed to be more familiar and therefore have less ambiguous probabilities because the subjects were in the US) and in China (conversely, assumed to be more ambiguous). By construction, a good guess for the probabilities would again be .5, since participants were to specify if a distance was less than or greater than 680 miles, when the true distances were within 10 miles of that number. Case 3 dealt with professional men's baseball (assumed to be more familiar and therefore have less ambiguous probabilities) vs. women's soccer.[2]

For part 2, the texts were the same except the participants had to specify how much the team would be willing to pay for an option, when a correct prediction would yield each person \$100 and an incorrect prediction would yield each \$0. Each person had to pay exactly half of the total the team would pay. Thus, they faced the same monetary outcomes for each person as in part 1, except the pair had to decide together.

Table 1: Mean prices for individuals and dyads.

Scenario	Individual (n=70)	Dyad (n=35)
1. Balls, unambiguous	\$23.94	\$20.27
2. Balls, ambiguous	\$11.21	\$10.79
3. Distance, U.S. cities	\$31.23	\$22.63
4. Distance, Chinese cities	\$20.96	\$11.58
5. Men's baseball outcome	\$19.66	\$19.23
6. Women's soccer outcome	\$13.23	\$12.46

4 Results

Table 1 reports the observed average prices for individuals and dyads in each of the six scenarios. Note that scenario 1 represents a decision under risk (with known probabilities) and the remaining scenarios 2 through 6 represent decisions under ambiguity (risky decisions with ambiguous probabilities).

The participants' willingness to pay when deciding as an individual confirms the results reported in previous literature that people pay less under ambiguous situations when compared to a corresponding unambiguous situation (scenario 2 vs. scenario 1). Similarly, they pay less for more ambiguous situations as compared to less ambiguous situations (scenarios 4 vs. 3 and 6 vs. 5).

Examining the average price for dyads in Scenario 1 (with a precise probability 0.5 of winning \$100), we see that dyads display risk aversion with an average risk premium of \$50-\$20.27 = \$29.73. This result is not surpris-

[2] Based on participants' responses, women's soccer was more familiar than baseball for only 3 out of 70 subjects. Women's soccer was more familiar to none of the Wisconsin subjects (21 were more familiar with baseball and 5 were equally familiar with both) and to 3 of the California subjects (23 were more familiar with baseball and 18 were equally familiar).

Table 2: Observed price shifts when individuals join a dyad.

	Number of each type of shift:		
Scenario	Cautious	No shift	Risky
1. Balls, unambiguous	23	8	4
2. Balls, ambiguous	18	6	11
3. Distance, U.S. cities	23	7	5
4. Distance, Chinese cities	25	5	5
5. Men's baseball	18	5	12
6. Women's soccer	18	2	15
Aggregate count of shifts	125	33	52

ing since risk aversion seems to be quite robust across a variety of situations. The size of the risk premium suggests that expected value reasoning does not appear to be persuasive (even if it is considered) even when two individuals jointly make a decision.

We used the unambiguous (Scenario 1) and ambiguous (Scenario 2) "balls in bag" gambles to examine ambiguity aversion. We calculated a dyad's ambiguity premium as: willingness-to-pay for the unambiguous gamble minus the willingness-to-pay for the ambiguous gamble. The average ambiguity premium was \$20.27-\$10.79 = \$9.48, well above zero. Thus, on average, the dyads implicitly are willing to pay a risk premium of \$29.73 and an extra \$9.48 on top of that as an ambiguity premium. This result is somewhat surprising because the attribution of blame (or self blame) should be moderated in a group setting. Further, since the subjects are choosing the color of the ball, a joint decision might have led to a realization that the probability of winning is (at least) 0.5. Apparently it does not.

We note that the price difference between a pair of less ambiguous and more ambiguous situations remains approximately the same in judgments by individual and by dyads. The individual price differences for the distance scenarios is \$31.23- \$20.96 = \$10.27 and for dyads it is \$22.63 - \$11.58 = \$11.05. Similarly, in the sports scenarios, the individual price difference is \$6.43 and in dyads it is \$6.77. It is somewhat surprising that information exchange between two people does not reduce ambiguity aversion.

We now examine whether dyads make a cautious or a risky shift (or do not shift, called "no shift") while making decisions under risk. When the jointly agreed upon amount D that each dyad member will pay is less than the average of individual 1's price and individual 2's price, the dyad is willing to pay less than what they paid individually, we call such an evaluation a cautious shift. When D is more than the average, it is a risky shift. And, when D equals the average, we shall say there is no shift. Our experiment focuses on the question of which shift is more likely. Across 6 scenarios, for the 35 dyads, there were 125 cautious shifts, 33 cases with no shift, and 52 risky shifts.

The frequencies of prices changing in a risky or cautious shift, or not shifting, in each of the 6 scenarios is shown in Table 2. While cautious shifts predominate overall, in some specific scenarios (*i.e.*, women's soccer in our study), cautious and risky shifts may be equally likely. A predominance of cautious shifts suggests that, even with the benefit of face-to-face discussion with another person, dyads do not bring to mind the realization that the probability of winning is at least 0.5. If dyads were to realize (more than when they made individual judgments) that the probability of winning is at least 0.5, and conclude that 0.5 (or higher) would be a good guess for the probability, then one would see a greater number of risky shifts. Our results are consistent with the supposition that the person with the lower original price (when judged as an individual) receives a higher weight in the determination of the dyad's joint price.

5 Conclusion

We examined willingness to pay for gambles involving risk and ambiguity made by individuals and dyads. We found that dyads display risk aversion and ambiguity aversion, and they are more likely to display a cautious shift than a risky shift under both risk and ambiguity.

Risk aversion seems to be robust across situations and, therefore, it is not surprising that we find it in dyads as well. Expected value reasoning is apparently not employed when two individuals are brought together in joint decision making.

It is somewhat surprising that ambiguity aversion persists in dyads in approximately the same degree as it does in individuals. Again, there are two reasons for an *a priori* expectation of lower ambiguity aversion in dyads. One is that individual blame or regret should be moderated in a group situation. The other is that an exchange of information may lead the dyad to realize that the probability of winning regardless of the degree of ambiguity is at least 0.5. Thus, the expected value is at least \$50, and so dyads' prices might be higher (which would be interpreted as less ambiguity aversion.) In an unaided decision context, ambiguity aversion persists even when two individuals have an opportunity to share information in a face-to-face meeting. Further, the predominance of cautious shifts in our data suggest that it is as if the individual with a lower price carries more weight in the determination of the joint price.

Our study was restricted in at least three important aspects. First, the group size was limited to dyads. Many decisions are made by dyads, such as marriage partners, business partners, etc., though larger groups are common and might exhibit more complex attitudes toward risk and ambiguity. Second, a dyad's willingness-to-pay amount was required to be equally shared by the two individuals, as was the group payoff. Sharing the same decision outcome among the whole group is common in organizational settings. Examples include joint decisions of a household, acquisition decisions by a team of managers, and committee decisions such as choice of a conference venue. Differential sharing of the cash flows with side payments and further randomization is possible. Such sharing might affect risky and cautious shift patterns. Third, the underlying gamble was winning a prize with an ambiguous probability p. More complex gambles with many different outcomes can also affect the behavior of groups. Future research may take up the case of larger group sizes, unrestricted risk/ambiguity sharing among individuals, and other types of underlying gambles.

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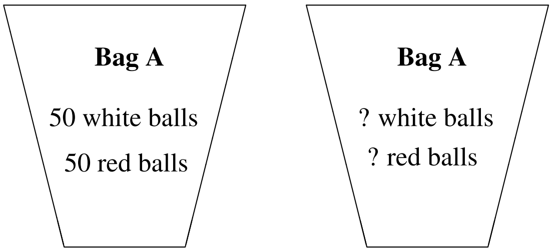
Appendix: Texts for three cases

Case 1

Imagine that there is a bag on the table (**Bag A**) filled with exactly 50 white balls and 50 red balls, and a second bag (**Bag B**) filled with 100 balls with some that are white and some that are red, but you do not know their relative proportion.

Suppose that you are offered a ticket to a game that is to be played as follows: First, you are to guess a color (white or red). Next, without looking, you are told to draw a ball out of one of the bags. If you draw the ball matching the color you predicted, then you will win $100; otherwise you win nothing.



Ticket A: You will draw from Bag A with 100 total balls (with 50 red and 50 white balls.)

Ticket B: You will draw from Bag B with 100 total balls (with an unknown number of white and red balls.)

Case 2

Imagine that there are two game tickets.

Ticket A: You guess whether the air distance between San Francisco and Seattle is less than 680 miles (1094 km) or more than 680 miles (1094 km). If you are right, you win $100.

Ticket B: You guess whether the air distance between Shanghai and Beijing is less than 680 miles (1094 km) or more than 680 miles (1094 km.). If you are right, you win $100.

Case 3

Imagine that there are two game tickets.[3]

Ticket A: You guess the winner of the August 23, 1999 professional baseball game between the Los Angeles Dodgers and the Milwaukee Brewers. You have to make your guess now. If you are right, you win $100. (If the other team wins or there is a tie, you get nothing.)

Ticket B: You guess the winner of the June 20, 1999 Women's World Cup soccer match between North Korea and Nigeria. If you are right, you win $100. You have to make your guess now. (If the other team wins or there is a tie, you get nothing.)

[3] The experiments were conducted April 13, 1999 in Wisconsin and April 21, 1999 in California. Nigeria beat North Korea, 2–1, in the Rose Bowl in Pasadena, California on June 20, 1999. The USA Women eventually won the World Cup. The Los Angeles Dodgers professional men's baseball team beat the Milwaukee Brewers by 8 to 4 on August 23, 1999. The distance between San Francisco and Seattle is 679 miles (via United Air flight 2106) and between Beijing and Shanghai is 670 miles (via China Eastern Airline flight 5162). Chow and Sarin (2001) used scenario 1 in an experiment on ambiguity; they found an ambiguity premium for individuals (UCLA undergraduates) of $15.07 when participants compared two gambles, as did our participants, and an implicit premium of $9.45 when different people judged the two gambles.