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Verbal versus Numerical Probabilities: Efficiency, Biases, and the Preference Paradox

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Experts (sportswriters and broadcasters) were asked to assess the probabilities of upcoming basketball game events. Based on these predictions, decision makers (students) had to rate the attractiveness of gambles. Half of the students could win real stakes based on the quality of their decisions and the outcomes of the events, while the other half were paid a flat rate. The gambles were also constructed so as to elicit the conjunction fallacy and wishful thinking biases. While most conveyors of information used verbal terms when expressing their opinions spontaneously, most decision makers preferred to receive numerical probabilities. However, no difference between the efficiency of the verbal and the numerical assessments was found. The occurrence of judgmental biases was unrelated to communication mode, but the conjunction fallacy was marginally related to the monetary payoff condition of the students. Two possible explanations for the communication mode preference inconsistency were examined, one of which seems to be supported by the results. A theoretical framework is suggested that accounts for the present data and former results.

INTRODUCTION

According to most decision models (e.g., Savage, 1954), people behave as if they assign numerical probabilities to their opinions about the chances that future events will occur. Based in part on this notion, and on the assumption that people can express these probabilities up to some degree of accuracy, it is often claimed (e.g., Behm & Vaupel, 1982) that people communicate best by stating their uncertain opinions only with numerical expressions (e.g., 60% chance).

Still, most people do not use numerical expressions to convey their opinions about the chances of uncertain events. Wallsten, Zwick, Kemp, and Budescu (in preparation) have suggested, on the basis of question-

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naire data, that while most people prefer to receive information about the probabilities of chance events numerically, they prefer to express such information verbally (e.g., *doubtful, likely*). This behavior is inconsistent with Behm and Vaupel's (1982) suggestion above and is paradoxical if it occurs when both the receivers and conveyors of information want efficient communication and both parties know that the information is vague. The following example illustrates the paradoxical nature of this behavior. Suppose there are three Army Intelligence officers of different ranks, who share the goal of giving the best possible information to the ultimate decision makers so that they can make the best decisions. According to the results of Wallsten *et al.* the middle ranking officer would prefer to receive information from the subordinate officer in numerical terms, but would prefer to give it to the superior officer in verbal terms. Clearly, however, if this middle ranking officer wants to do the best job of understanding what is communicated and being understood when communicating, then the same mode should be used in both cases. Thus, this possible phenomenon will be referred to here as the communication mode preference (CMP) paradox.

Possible Explanations for the CMP Paradox

The above preference structure is paradoxical only under the assumption that both the conveyors and receivers of information want efficient communication (i.e., communication that is as clear and understandable as possible). Thus, knowledge of which mode of communication best achieves this goal should be the basis of any possible explanation of the CMP paradox. Previous experimental results have not provided a clear answer to this question, however. While Zimmer (1983) suggested that people are less likely to make judgmental biases using verbal rather than numerical expressions, Budescu, Weinberg, and Wallsten (1988) found that numerical expressions were the better. Of course, it is possible that the more efficient mode depends on the particular situation of interest. Two tentative explanations for the possible paradoxical preferences will be considered, each based on a different answer to the efficiency question.

The spontaneous vs controlled behavior explanation. When people express uncertain opinions naturally they are not aware of a decision about which mode to use. Since their spontaneous behavior is likely to be shaped by past reinforcements, and the probability of being positively reinforced (being understood) is higher when the better mode is used, people come to use spontaneously the mode which leads to better understanding. This mode may be different for different people and for a single person in different situations. Thus, the results of Wallsten *et al.* (in preparation) suggest that verbal communication is the better mode for being understood for most people who attempt to express the probabilities of chance events.

On the other hand, when asked in which mode they prefer to get information, people are aware of the decision they are making. In this case, the decision is a controlled cognitive process, and the mode that is considered to be the most accurate will be preferred. Since the numerical mode is usually used when it is possible to give precise estimation (Wallsten *et al.*, in preparation), it better represents "accuracy" and therefore is considered to be the more accurate. Hence, it will be preferred by most people.

The "cover" explanation. Even if the goal of communication is to be understood, it is possible that there are other significant utility sources in the process that affect people's preferences. For example, the information conveyor may be punished, not necessarily monetarily, for being wrong (e.g., one's reputation as an expert decreases). Clearly one can be found to be wrong by comparing one's assessments to a post hoc relative frequency analysis, which can be conducted with numerical terms only. Hence, even if the more efficient communication mode is known to be numerical, people will still prefer verbal terms in most cases.

Experimental Questions

We will first examine whether the general preferences suggested by Wallsten *et al.* (in preparation) for unspecified types and sources of information describe people's behavior under the conditions for which such preferences are paradoxical. A better understanding of the CMP paradox (if it exists) can be useful for suggesting the conditions under which verbal or numerical communication of uncertain opinions may be preferred or more efficient.

The decision-making situation that was examined experimentally in the present study utilized events pertaining to future basketball games. The experiment was designed to examine the following five major experimental questions:

(1) Do people generally prefer to convey vague opinions about the chances of future events in verbal terms, but prefer to receive such opinions in numerical terms?

(2) Which is the more efficient mode for communicating opinions about the chances of events: verbal of numerical? This question was asked in the following two ways:

(a) Which of the two modes of communication produces fewer biases? Two well-known judgmental biases were investigated—the conjunction fallacy (Tversky & Kahneman, 1982) and wishful thinking (Irwin, 1953; Irwin & Snodgrass, 1966).

(b) Under which mode of communication will people make decisions that maximize their profits?

Assuming that the paradoxical preference structure would be observed, two questions were asked in order to examine the *spontaneous vs controlled behavior* explanation:

(3) Do people spontaneously use their more efficient mode of communication to express their opinions about the chances of events?

(4) Which mode do people consider to be the best mode of communication?

The final question relates to the "*cover*" explanation for the possible paradox:

(5) Are people more likely to use numerical terms when the results of the decisions based on their advice are important to them?

METHOD

The experiment consisted of two phases, each using a distinct group of subjects. First, four sports experts were asked to assess probabilities that various events will obtain in upcoming area college (ACC) basketball games. Then, 36 decision makers used the experts' assessments to rank gambles concerning these events.

Subjects

Experts. Two sportswriters and two well-known radio announcers from the Chapel Hill/Durham area were asked and agreed to serve as basketball experts for pay in this experiment.

Decision makers. Thirty-six people were recruited to serve for pay. They were primarily undergraduates at the University of North Carolina at Chapel Hill.

Materials Used with Experts

Uncertain event list. A list of 27 different events that could occur in a set of ACC basketball games was prepared by the experimenters. Eight of these events are listed on the left of Table 1.

Materials Used with Decision Makers

Gambling sets. Based on these 27 events, five sets of eight gambles each were constructed. One set, based on the uncertain events listed in Table 1, is shown on the right side of the same table. As can be seen from the table, each gamble pays a certain number of chips (ranging from 10 to 60) if a specific event actually occurs and pays nothing otherwise. The

TABLE 1
EIGHT OF THE 27 UNCERTAIN EVENTS AND AN ASSOCIATED GAMBLING SET

Uncertain event list	Gambling set		
		Number of chips	
(1) UNC will win.	(1)	30	if UNC wins.
		0	otherwise.
(2) J. Wolf will take more rebounds than Q. Snyder.	(2)	40	if player B12 (UNC) will take more rebounds and score more than player C19 (Duke).
(3) J. Wolf will score more than Q. Snyder.		0	otherwise.
(4) D. Popson will take more rebounds than D. Lewis.	(3)	60	if player T21 will take more rebounds than player U26.
		0	otherwise.
(5) J. R. Reid will score more than K. Drummond.	(4)	15	if player Z81 (UNC) will score more than player D20 (NCSU).
		0	otherwise.
(6) K. Smith will score more than 26 points.	(5)	30	if player A30 (UNC) will score more than 26 points.
		0	otherwise.
(7) H. Grant will take more rebounds than C. Hunter.	(6)	15	if player V22 will take more rebounds than player W27.
		0	otherwise.
	(7)	30	if UNC wins and player A30 will score more than 26 points.
		0	otherwise.
(8) B. Bolton will score more than J. Lebo.	(8)	50	if player E5 (NCSU) will score more than player F60 (UNC).
		0	otherwise.

names of the players were coded, so that the decision makers would rely more on the experts' assessments and less on their own opinions. For example, gamble (3) on the right side of Table 1 is based on event (4) on the left side of Table 1. These five sets of gambles were duplicated, with modifications in the order of the gambles and the player codes, to make a total of 10 sets of gambles.

The gambling sets and the decision-makers' ranking task were designed to achieve two goals. One was to examine the efficiency with which the decision makers considered both the probabilities of the different events and the outcomes (number of chips) associated with them in order to rate the worth (attractiveness) of the gambles. The second goal was to elicit two well-known decision biases: the conjunction fallacy (Tversky & Kahneman, 1982) and wishful thinking (Irwin & Snodgrass, 1966; Marks, 1951).

To elicit the conjunction fallacy, among each set of eight gambles there were two simple gambles (such as gambles (1) and (5) in Table 1) and one gamble consisting of the conjunction of the events in the two simple gambles (such as gamble (7) in Table 1), all with the same number of chips. The laws of probability maintain that the probability of a conjoint event cannot exceed the probabilities of either of the component events. That is, $P(A \cap B) \leq Min[P(A), P(B)]$. Thus, if the conjoint gamble is given a higher rating than either of the simple gambles then the conjunction fallacy will have occurred.

Our attempt to elicit the wishful thinking bias rested upon the assumption that the subjects thought more favorably of the UNC basketball players than of the players for other ACC basketball teams. To elicit this bias, we manipulated the presentation of the team name following the player code on some gambles. In each gambling set, there were two gambles (call them 1 and 2) which stated that one player would outperform another player. Gamble (1) included the team names, whereas gamble (2) did not. Another set contained two gambles (1′ and 2′), where gamble (1′) was identical to gamble (1), except that the team names were not included, and gamble (2′) was identical to gamble (2), except that the team names *were* included. If gamble (1) were rated higher than gamble (2), while gamble (2′) were rated higher than gamble (1′), then one can claim that the reversal of the ratings was due to the presence of the team names in gambles (1) and (2′). If rating reversals occur, such that UNC players are favored over players from other teams, then one may argue that a wishful thinking bias has occurred.

Expert assessments. For each expert and each of the five gambling sets, two sets of expert assessments of the simple events were prepared, based on the interviews with the experts. One set consisted of verbal probability expressions, whereas the other set consisted of numerical probability expressions.

Procedure and Design

Phase 1: Expert interviews. The four experts were interviewed individually in their offices and asked to give their best probability assessment of each of the 27 events. For roughly half of these event assessments, the experts were paid a flat fee. For the other half of the event assessments the experts were told that they would be paid 80% of the winnings of the decision makers that used their advice to gamble for real money. The order of the two payoff conditions and the events considered under each of them were balanced over the four experts. Furthermore, the set of games under consideration differed from expert to expert.

The experts' responses were recorded in the manner in which they spontaneously chose to communicate. Thus, for the event "K. Smith will score more than 12 points," if an expert said, "I'm sure of it" then the word "sure" was recorded as the expert's best assessment of the chances of that particular event occurring. After going through the entire list of 27 events in this way, the experts were then asked to reassess the chances of the same events using the alternative mode of communication (i.e., if they spontaneously responded by using verbal communication, they were now asked to give numerical responses, and vice versa). The experts were shown their earlier responses while making these reassessments. Additionally, they were asked whether they thought the subjects would make more money using their verbal advice or their numerical advice. A correct answer to this question was worth $10 to the expert.

For the experts, the independent variable was type of payoff condition (flat rate or incentive payments) and the main dependent variable was mode of communication (verbal or numerical). An additional dependent variable was the amount of profits that the decision makers were able to make using each expert's assessments.

Phase II: Decision making. After recording an expert's assessments, but before the relevant basketball games were played, a group of either 8 or 10 decision-making subjects was brought together. The first and third experts had 10 decision makers using their advice, whereas the second and fourth experts had only 8 subjects using their advice.

These decision makers were randomly assigned into one of two groups, differing only in the payoff conditions:

1. A bonus group paid according to their converted ratings on a single randomly selected set of gambles.
2. A nonbonus group paid a fixed amount of money ($5.00) for their participation in the study.

All subjects were seated in a classroom and received written instructions, which explained that their task was to assign a unique rating from 1 to 8 to each of the eight gambles within each of the 10 sets presented to them, one by one, by the experimenters. It was emphasized that these ratings would serve as conversion factors from chips into cents (imaginary cents for the nonbonus group, but potentially real cents for the bonus group). For example, if gamble (1) in Table 1 were given the rating 8, then it would be worth $30 \times 0.08 = \$2.40$ if the event obtained (i.e., if UNC won). The best gamble was to receive a rating of 8, the second best a rating of 7, and so on. At the end of the experiment, 1 of the 10 sets of gambles was randomly selected. Subjects in the bonus group were informed that they could win an amount of money equal to their conversion rates multiplied by the number of chips for each gamble on that randomly selected set that turned out to be true.

Subjects were informed that the gambles pertained to real upcoming basketball games, that all gambles on a given set concerning a particular player or team referred to only one game, and that there was a one to one match between players and codes in each set. The subjects were told that they would have to rely on the expert advice to decide how to rate the gambles since the player names were coded and team names were not always presented. Subjects were informed that the expert advice would be in either numerical or linguistic form and that they could request which type of advice (numerical or linguistic) they wanted to use on two of the sets. The presentation of numerical or linguistic advice was balanced for the remaining eight sets.

At the end of the experiment all subjects were asked the following question: "For which type of advice (verbal or numerical) do you think you made the most money?" (This question was phrased in terms of hypothetical money for the nonbonus group.) If a subject chose to answer this question, a correct answer paid an extra dollar to the subject.

After performing the experimental task, all the subjects were informed of the real basketball games for which their experts were giving advice and were given one randomly selected set of gambles with the player names and teams decoded. As an additional test, when the subjects came to pick up their winnings following the real basketball games, they were asked to serve as "experts" for an upcoming basketball game. The purpose of this procedure was to see what type of advice (verbal or numerical) the subjects would spontaneously use to convey probabilistic information. A total of 21 subjects performed this task.

As stated above, the entire procedure was performed for each of four groups of decision makers, one group for each expert. It took about 1 hr for each subject to complete all 10 sets of gambles and answer the final question.

For the decision makers, the independent variables were payoff condition (bonus or nonbonus) and mode of expert communication (verbal or numerical). The dependent variables of main interest were hypothetical profits, incidence rates of judgmental biases, and the answers to the questions posed during the experiment.

RESULTS

Preferred Modes of Communication

Table 2 presents the number of decision makers preferring each mode of communication for receiving and conveying information about uncertainty. The preferred mode for receiving information was determined by noting in which mode each decision maker requested the expert assessments. Out of the 36 decision makers, 27 preferred to receive information

TABLE 2
NUMBER OF DECISION MAKERS PREFERRING VERBAL (V) OR NUMERICAL (N) MODES OF COMMUNICATION

To convey information	To receive information: V	N	V & N	Total
V	3	8	3	14
N	1	5	1	7
—[a]	0	14	1	15
Total	4	27	5	36

[a] Did not take part in this session.

numerically on both opportunities, 4 preferred verbal communication both times, and 5 subjects requested each mode once. The proportion of subjects showing a preference for the numerical mode (ignoring the five inconsistent subjects) is 87%, which is significantly greater than 50% (Sign test, $p < .001$).

The preferred mode for conveying information was determined by noting the mode in which each subject assessed uncertainty when acting as an expert. Three of the four experts used verbal expressions spontaneously for at least 26 of the 27 assessments they made. The fourth expert used numerical expressions spontaneously on 25 of the 27 assessments. Combining the four experts with the 21 decision makers who gave expert advice upon receiving their payment, 17 of the 25 (68%) used verbal terms, and 8 of the 25 (32%) used numerical terms. In this case, the proportion using verbal communication is significantly greater than 50% (Sign test, $p < .04$).

Judgmental Biases

The conjunction fallacy. Each of the 36 subjects could exhibit the conjunction fallacy up to 10 times, once in each of the 10 sets of gambles. Table 3 shows the proportion of conjunction errors over all decision makers by mode of communication and payoff condition. It is of interest that the conjunction fallacy occurred at least half of the time under all conditions. Although the conjunction fallacy is more frequent in the numerical mode (62%) than the verbal mode (59%), the difference is nonsignificant (repeated measures ANOVA, $F[1,34] = 0.51, p < .48$). The overall effect of payoff condition was marginally significant ($F[1,34] = 3.85, p < .06$ using ANOVA, and chi-square[1] $= 3.89, p < .05$ using a nonparametric median analysis), with the bonus group committing fewer conjunction errors (52%) than the nonbonus group (69%). The interaction between payoff condition and mode was nonsignificant ($F[1,34] = 0.23, p < .64$).

Wishful thinking. Each subject could commit this fallacy up to 10 times,

TABLE 3
PERCENTAGE OF CONJUNCTION FALLACIES BY COMMUNICATION MODE AND PAYOFF CONDITION

	Communication mode		
Payoff condition	Verbal	Numerical	Total
Bonus	51.1	52.3	51.7
Nonbonus	66.6	72.2	69.4
Total	58.8	62.2	60.5

once in each gambling set. However, the fallacy occurred only 45 of the 360 possible times (12.5% incidence rate). Neither communication mode nor payoff condition had a significant effect, although incidence is greater in the verbal mode (14%) than in the numerical mode (11%).

Profit Analysis

After the basketball games had been played, the hypothetical profit of each decision maker was calculated as the total amount of money earned had all 10 sets of gambles actually been played. In order to test the validity of this measure of the quality of the decisions, the decision-makers' profits were compared to the expected profit from a random rating. Since the decision makers had to assign a unique exchange rate between 1 and 8 to each of the eight gambles in a set, the expected random rate of exchange is 4.5. The expected profit of random rating was therefore calculated as the hypothetical profit of an equal rating of 4.5 to all the gambles. The average decision-makers' profit on the two communication modes, grouped by expert and payoff condition, as well as the random rating profit is presented in Table 4. Over all subjects, the average profit is $3.66 higher than the profit under random rating. This difference, which is highly significant ($t[35] = 8.95$, $p < .0001$), suggests that the "profit" variable is sensitive to the quality of the decisions.

On the other hand, the average difference between the decision-makers' profits using the verbal and numerical assessments, over the four experts and the two payoff conditions, is less than $0.06. This difference favors the numerical mode, but is far from being significant ($t[35] = 0.04$).

As an alternative way of examining decision-making efficiency, the proportion of hypothetical to maximum possible profit was analyzed. That is, each subject's profit was divided by a profit measure based on a post hoc optimal rating. These proportions, grouped by expert, mode of communication, and payoff condition, are presented in Table 4. It can be seen that there were only very slight differences as a function of payoff condition or mode of communication (payoff condition, $F[1,31] = 0.02$, $p < .90$; communication mode, $F[1,31] = 0.07$, $p < .80$; repeated-measures

TABLE 4
RANDOM RATING EXPECTED PROFITS, AVERAGE HYPOTHETICAL PROFITS, DIFFERENCES BETWEEN THE PROFITS GIVEN THE EXPERTS' PREFERRED MODE AND THE FORCED MODE, AND THE PROPORTION OF THE MAXIMUM POSSIBLE PROFITS EARNED BY EXPERT AND PAYOFF CONDITION

Measure	Forecast type	Expert 1	Expert 2	Expert 3	Expert 4
Preferred mode		Verbal	Verbal	Numerical	Verbal
			Random rating		
Expected profit		2947.5	1417.5	2317.5	1620.0
			Bonus		
n		5	4	5	4
Hypothetical	Verbal	3243.0	1760.0	2603.0	2228.75
profits	Numerical	3098.0	1696.25	2780.0	2171.25
Preferred-forced		145.0	63.75	177.0	57.5
Proportion of	Verbal	.72	.77	.71	.85
maximum profit	Numerical	.68	.75	.76	.83
			Nonbonus		
n		5	4	5	4
Hypothetical	Verbal	2988.0	1848.75	2633.0	2195.5
profits	Numerical	2986.0	1863.75	2593.0	2267.5
Preferred-forced		2.0	−15.0	40.0	−72.5
Proportion of	Verbal	.66	.81	.71	.83
maximum profit	Numerical	.66	.82	.72	.86

ANOVA). Differences between the experts were large ($F[3,31] = 16.68$, $p < .0001$). However, this effect will not be considered further, since it may be confounded with the different games considered by each expert.

The Spontaneous vs Controlled Behavior Explanation

The first question concerning this explanation of the CMP paradox is whether or not people use the more efficient mode of communication to express their opinions. It can be answered only with data from the four experts. For each expert, we calculated the difference in the decision-makers' profits between decisions based on the expert's spontaneously given advice and those based on his reassessment of the events in the opposite (forced) mode of communication. These differences are shown in Table 4, as a function of expert and payoff condition. For Experts 1, 2, and 4, the preferred mode was verbal, while for Expert 3 it was numerical.

The interaction between the expert's mode of communication and the decision-makers' payoff condition was significant (repeated-measures ANOVA, $F[1,31] = 4.26$, $p < .05$; and chi-square[1] $= 6.91$, $p < .01$, using a nonparametric analysis of medians). The nature of this interaction was that decision makers in the bonus condition achieved a greater hypothetical profit when they were using the advice given in the spontaneous mode of communication than in the alternative mode of communication, whereas, decision makers in the nonbonus condition achieved about the same hypothetical profit under both communication modes. The simple effect of communication mode was significant for the bonus group ($t[17] = 3.73$, $p < .03$), but nonsignificant for the nonbonus group ($t[17] = 0.49$, $p < .66$).

Table 5 addresses the second question about the spontaneous vs controlled behavior explanation, namely, whether or not people have a tendency to believe that numerical information is more efficient than verbal information. Of the 27 decision makers willing to bet about the best mode, 22 guessed that they would make greater profit using the numerical mode. This proportion, 81.5%, is significantly higher than 50% (Sign test, $p < .001$).

In actuality, about half of the decision makers made greater profit using the numerical mode, and only 12 out of the 27 decision makers (44%) were correct about the mode with which they would do better. Similarly, three of the four experts guessed that the decision makers would perform better with their numerical advice. Two of these experts had spontaneously used verbal terms, but incorrectly guessed that numerical terms would be better.

The "Cover" Explanation

The number of verbal and numerical expressions used by the four experts was not at all affected by the payoff conditions. One expert used verbal terms spontaneously for all 27 event assessments, two experts used verbal terms for 26 of the 27 assessments, and the fourth expert spontaneously used numerical terms to assess the chances of 25 of the 27 events. Thus, these results do not support the "cover" explanation.

TABLE 5
THE MODE CONSIDERED MORE EFFICIENT AND THE MODE FOUND MORE EFFICIENT FOR THE 27 DECISION MAKERS WHO WERE WILLING TO BET ON THE BEST MODE (V = VERBAL, N = Numerical)

The mode considered better	The better mode (higher profit)			
	V	N	Same	Total
V	2	3	0	5
N	11	10	1	22
Total	13	13	1	27

Additional Analyses

The nature of the experts' assessments. Table 6 presents the number of probability terms used by the four experts in the two modes of communication in order to assess the 27 events. Note that they used an average of only 11.75 numerical terms to describe the 27 events, while they used even more unique verbal terms (mean 13.25) to describe the same events.

The proportion of obtained events by 10 intervals of the experts' numerical assessments is presented in Table 7. It can be seen that events that were assessed with probabilities between 0 and .29 were almost as likely to occur as events assessed with probabilities between .30 and .59. Thus, it seems that the experts were sensitive to fewer than 10 levels of probability. Still, because of the small number of events per expert, these results are only suggestive.

Comparison with expected value ratings. Rating the gambles according to their expected value (EV) should yield the optimal decision strategy, assuming that the experts know something about the chances of the events and can express this knowledge in an unbiased fashion. The decision-makers' profits were compared with EV rating profits for the 32 gambles for which one numerical expression was given by each of the experts. In Table 8 it can be seen that only for two of the experts are the EV rating's profits higher than the decision-makers' profits.

DISCUSSION

The results presented above have implications for three distinct issues in the psychology of decision making. Two of these issues—effects of decision-makers' monetary motivation and conditions under which judgmental biases occur—were not the focus of the present study and will be discussed only briefly at the beginning of this section. Then, the answers to our five main experimental questions about decision making using verbal versus numerical assessments will be considered. A theoretical

TABLE 6
NUMBER OF UNIQUE EXPRESSIONS USED BY THE FOUR EXPERTS

Expert	Number of verbal terms	Number of numerical terms
1	12	10
2	10	16
3	17	10
4	14	11
Mean	13.25	11.75

TABLE 7
PROPORTIONS OF OBTAINED EVENTS BY THE INTERVALS OF NUMERICAL ASSESSMENTS GIVEN BY THE FOUR EXPERTS

Intervals of numerical assessments	Proportion of obtained events	Number of events
.00–.09	.11	9
.10–.19	.10	10
.20–.29	.43	7
.30–.39	.00	6
.40–.49	.13	8
.50–.59	.43	7
.60–.69	.63	16
.70–.79	.64	11
.80–.89	.75	8
.90–1.00	1.00	25

framework will be suggested to account for these answers and the results of other, related studies.

Decision-Makers' Motivation

Our results suggest that the decision makers who were financially motivated to make good decisions made fewer judgmental biases and were able to earn more money using the experts' spontaneous, rather than forced, mode of communication. The low motivation group showed no effect of the experts' communication mode. Thus, there was an experts' communication mode by decision-makers' payoff condition interaction. However, no effect of the decision-makers' payoff condition on the overall profit was found.

An explanation of these results can be based on the existence of two contradicting effects of motivation on the decision makers. A positive effect of higher motivation is an increased concentration on the probabilities of winning the gambles (Feather, 1959; Slovic, 1969). This would make the conjunction fallacy more transparent to the subjects and allow them to avoid making an error. However, this increased concentration

TABLE 8
ACTUAL PROFITS USING NUMERICAL ADVANCE AND PROFITS USING EXPECTED VALUE RATINGS FOR 32 GAMBLES BY EXPERT

	Expert			
	1	2	3	4
Actual profits	2,091.0	1,259.4	1,748.0	1,418.1
Expected value ranking profits	2,407.5	1,230.0	1,910.0	1,279.0

also produces a negative effect on profits. It is inefficient to weight the probability to win more heavily than the payoff for winning in the decision-making process, particularly when the given probabilities—the experts' assessments—are not entirely trustworthy.

Judgmental Biases

The decision makers violated the conjunction rule more than 50% of the time. However, no tendency for wishful thinking was found.

We believe that the lack of significant results for the wishful thinking bias may be due to either a difference in the degree of the bias, or perhaps a more fundamental difference between our work and former studies that have found the wishful thinking bias to be a significant factor in the decision process (e.g., Cohen, 1986; Irwin, 1953; Irwin & Snodgrass, 1966). The difference in degree could be created by a possible weaker manipulation in the present work. That is, the decision-makers' wishful thinking (their wish that UNC's players will do better than other teams' players) was not strong enough to reverse their ratings of the gambles.

The more basic difference may be due to the fact that in all former studies the wishful thinking was generated on the same dimension that the decision makers were attempting to maximize (money, or points convertible into money). This was not the case in the present study. This interpretation of our results suggests that the wishful thinking phenomenon may be limited to misunderstanding the independence of outcomes and probabilities only in a single dimension.

There is strong support for the presence of the conjunction fallacy in the decision-makers' data. These results are consistent with previous findings (Slovic, Fischhoff, & Lichtenstein, 1976; Tversky & Kahneman, 1982, 1983; Wolford, Taylor, & Beck, in preparation). The present results suggest that the bias occurs even when the purpose of the decision is to make money, and real future events are considered. However, it is possible that the rate of occurrence of the bias is affected by the decision-makers' motivation. Subjects who were paid for their decisions exhibited the bias about 52% of the time. Without this monetary motivation, the rate of the conjunction fallacy was much higher, at about 69%.

Verbal and Numerical Expressed Uncertainties

The existence of the CMP paradox, as suggested by Wallsten *et al.* (in preparation), is strongly supported by the results. Most of the experts and the nonexperts who were asked to assess the vaguely specified probability of chance events used verbal terms to do so. Still, most of the decision makers wanted to receive numerical assessments.

On the other hand, we failed in the attempt to extend to our study Zimmer's (1983) results about verbal communication as less biased than numerical communication, and the results of Budescu *et al.* (1988) concerning higher efficiency in numerical communication. No significant differences in the numbers of biases of thinking or in the overall profit made under the two communication modes were found. Note, however, that only two biases, the conjunction fallacy and the wishful thinking bias, were actually studied. It is possible that other results would be obtained for different biases.

The difference between our results and those of Budescu *et al.* (1988) may be due to the nature of the experimental situation under study. In the present study vague opinions were communicated about the chances of events in basketball games, while Budescu, *et al.* had their "forecasters" express the chances that a visible red and white spinner would stop spinning with the pointer over the white portion of the spinner.

Only one of the two hypothetical explanations suggested for the CMP paradox—the spontaneous vs controlled behavior explanation—was supported by the results. That is, most of the subjects thought that they would do better with the numerical assessments, while this was true only for half of them. Still, the mode that was used spontaneously by the four experts was the most efficient one. It is important to remember that the latter results, which are statistically significant, are based only on four experts' behavior. A larger sample size is needed to make these results generalizable. The "cover" explanation prediction about more numerical expressions for contingent payoffs was not sustained. This result may be due to insufficient payoff differences, however. Thus, we cannot exclude the possibility that under some conditions this explanation holds.

We believe that our findings as well as Zimmer's and Wallsten's and his associates' results, discussed above, can be better understood under the following framework.

First, as Ellsberg (1961) has argued, uncertain events differ in the amount of ambiguity (vagueness) associated with them. Thus, the precision of the assessed chances of these events is heavily dependent on this characteristic. For this reason there is a negative correlation between the number of probability levels that people can distinctively express and the amount of ambiguity. For example, suppose that we would have asked our experts in North Carolina to assess the probabilities of some events pertaining to Israeli basketball games. Clearly they could not distinguish between more than one or two levels of probability (e.g., they may think that the home team will always perform better than the visiting team). They could distinguish between more levels of probability when assessing the chances of ACC basketball game events because they have more knowledge about these teams. They have even more distinct levels of probability for assessing the chances that visible spinners will stop with the pointer over the white portion. Consistent with this argument, our experts used about 12 distinct numerical terms to describe the chances of 27 different events, whereas the forecasters in the Budescu *et al.* (1988) study used 18 distinct numerical terms to assess the probabilities that 20 different spinners will land on white.

Note, however, that this result does not necessarily contradict Savage's (1954) notion of personal probability. It is possible that people will choose between alternatives as if they have continuous subjective probabilities, but are not able to express these probabilities in more than a certain level of resolution.

Second, the more distinct probability levels that one wishes to express, the harder it is to do so using verbal terms. One may express the opinion that there are higher chances that the home team will win a game and lower chances that the visiting team will win by using verbal terms without the loss of important information. However, it is hard to use verbal terms without losing information when expressing the chances that spinners will stop on white, as Budescu *et al.* (1988) have found.

Finally, forcing people to give numerical expressions for vague situations where they can only distinguish between a few levels of probability may result in misleading assessments. This could be a result of the attempts made by most people not to use the same phrases repeatedly in communication. For example, suppose an expert could not express more than one level of probability of low chance events. Still, because of the social norm to avoid repeating oneself, this expert would not want to use only one term to express opinions. This is easy to do with verbal expressions—one can use synonymous phrases to describe similar opinions. However, this is not possible with numerical terms. For that reason, we believe, our experts used some probability assessments that were not in accord with their true beliefs when we forced them to communicate their opinions in this mode. Hence, using our experts' assessments as numerical probabilities in order to rank the gambles according to their expected values yielded no better outcome than the decision-makers' actual ranking, for two out of the four experts.

This explanation is also consistent with the Wallsten *et al.* finding that most people prefer to assess the imprecise probabilities of chance events with verbal terms and with Zimmer's ideas about the verbal mode as the better one in some situations.

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