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Learning to communicate risk information in groups

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Abstract

Despite vigorous research on risk communication, little is known about the social forces that drive these choices. Erev, Wallsten, & Neal (1991) showed that forecasters learn to select verbal or numerical probability estimates as a function of which mode yields on average the larger group payoffs. We extend the result by investigating the effect of group size on the speed with which forecasters converge on the better communication mode. On the basis of social facilitation theory we hypothesized that small groups induce less arousal and anxiety among their members than do large groups when performing new tasks, and therefore that forecasters in small groups will learn the better communication mode more quickly. This result obtained in Experiment 1, which compared groups of size 3 to groups of size 5 or 6. To test whether social loafing rather than social facilitation was mediating the effects, Experiment 2 compared social to personal feedback holding group size constant at 3 members. Learning was faster in the personal feedback condition, suggesting that social facilitation rather than loafing underlay the results.

Keywords: probabilities, probability judgment, risk communication, group size.

1 Introduction

The focus of this research is to understand some of the factors that affect how forecasters choose to communicate risk information to others in their groups. Erev, Wallsten, and Neal (1991) suggested that in group contexts forecasters selected their communication modes in a manner that best served their group members as a whole, but the authors looked only at the effects of economic consequences. We build on this research to investigate the effects of some non-economic, but socially important variables on the use of probabilistic estimates, specifically the effect of group size and ease of social comparison.

Erev et al. (1991) designed an experiment inspired by the tragedy of the commons (Hardin, 1968), in which individuals acting in their own self-interest collectively hurt or destroy their society. Erev et al. (1991) asked whether forecasters would select language that induced heterogeneous or homogeneous behavior by decision makers as a function of what best served their group. For example, roads become congested when everyone drives to and from work at the same time. Conversely, traffic moves smoothly when businesses invoke flex hours. However, in some cases, homogeneous behavior may be preferable. For example, businesses in some sectors thrive when they all conform to the same standards.

To ask whether forecasters learned to choose language that induced appropriately heterogeneous or homogeneous behavior, Erev et al. (1991) designed a study with two different payoff conditions. In one, everyone in the group received a payoff when two members of the group responsible for making the decisions for the entire group made the same (correct) choice and in the other condition everyone received a payoff when at least one participant made the correct choice. In addition to possible group winnings, decision-makers won individual amounts when they were correct. The authors assumed that (1) decision-makers make choices that they believe maximize their personal chances of winning and (2) individuals differ to a greater degree in interpreting verbal than numerical probabilities. On that basis the authors predicted that forecasters would learn to give verbal judgments when heterogeneous behavior served the group's best interests (decision-makers acting in their self interest would make different choices, depending on their interpretations of the verbal terms) and numerical judgments when homogeneous behavior best served the group (all decision-makers would make the same, most likely choice). In fact, that is how the data turned out. This finding suggests that forecasters do learn to adjust their precision of communication in response to group payoffs.

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1.1 Group size and its influence on judgments

When a solution is difficult to attain or is non-existent, individuals' responses are highly influenced by previous responses from other group members, and a consensus arises over time as individuals continue to make judgments in their group (Sherif, 1935). The fact that individual are susceptible to social influences when making judgments is well documented and has been incorporated into Festinger's social comparison theory (1954), which states that the behaviors of others has a strong influence on personal judgments.

Many researchers have shown that judgment consensus emerges as a consequence of the desire to avoid negative evaluation by other group members (e.g., Diehl & Stroebe, 1987; Seta, Paulus, & Schkade, 1976; Seta, Seta, & Donaldson, 1991). However, the extent to which individuals are affected the judgments of others is positively related to the size of the group. According to Zajonc's (1965) social facilitation theory, individuals feel a higher level of arousal when engaging in a competitive task in the presence of others. The arousal can either enhance or reduce individuals' levels of performance. If the task is easy (i.e., participants' dominant responses yield the correct result), then performance will increase. Arousal will be detrimental to performance when individuals engage in a novel task in which the dominant responses yield the incorrect result.

Alternatively, it is possible that individuals may increasingly choose to use numerical estimates regardless of group size because they feel that choices that avoid ambiguity are more justifiable to other members when the decisions are wrong (Curley, Yates, & Abrams, 1986; Slovic, 1975). This account predicts that numerical estimates will be increasingly preferred with experience regardless of the payoff contingency.[1]

We hypothesize that, in a novel task requiring probabilistic forecasts, the dominant response is not immediately clear to individuals, because the results are probabilistic. Therefore, on the basis of the findings summarized above, forecasters experiencing a heightened sense of arousal will perform more poorly than those in a less aroused state in terms of selecting a forecasting mode that is best for the group.

2 Experiment 1

To manipulate the level of arousal, we had forecasters in Experiment 1 make probability forecasts in groups of three or six. According to the social impact model (Latané, 1981; Latané & Hawkins, 1976), feelings of arousal within a group of similar status people increases as a function of group size. As a consequence, Seta and his colleagues (Seta & Hassan,1980; Seta, Seta, Donaldson, & Wang, 1988) showed that performance declines with group size as the result of the evaluative arousal caused by the bystanders and co-actors. We predict similar results with forecasters.

[1] We thank one of the reviewers for suggesting this possibility.

2.1 Method

2.1.1 Participants

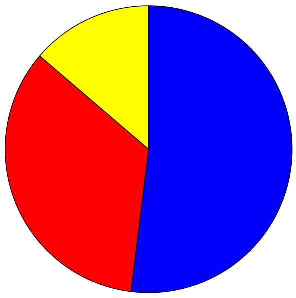
A total of 171 participants from the University of Maryland served in this study in exchange for monetary reward and course credit. Sixty participants served in three-person groups (small groups), while the remaining 111 served in five-person or six-person groups (large groups). One six-person group was excluded from the analysis when one participant verbally urged other group members to choose the numerical estimate in order for the experiment to end early, resulting in a total of 39 groups for the analysis.

2.1.2 Design

On every trial, regardless of group size, there were two decision-makers and one forecaster. Group members took turns serving as the forecaster, decision-makers, and in the large group as bystanders. Decision-makers individually won $0.15 for each correct prediction they made based on the judgments communicated by the forecaster. In addition to this first-order payoff, the decision-makers (and in the large group the bystanders), but not the forecaster, may have received second-order payoffs of $0.10 per correct prediction according to whether they were in the conjunctive or disjunctive payoff condition. In the conjunctive payoff condition the decision makers and bystanders (if any) received the second order payoff whenever the two decision-makers agreed on the correct prediction. In contrast, in the disjunctive payoff condition they received the second order payoffs as long as at least one decision-maker made the correct prediction.

A trial block was completed after everyone in the group had served as forecaster (Thus a block consisted of three trials in the small groups and of five or six trials in the large groups.). The session continued for a total of 10 blocks.

The experiment was therefore a 2 (second-order payoff condition: conjunctive v. disjunctive) x 2 (group size: small v. large) x 10 (blocks of trials) mixed design with repeated measure on the last factor.



Blue	Red	Yellow
53%	35%	14%
51%	37%	12%
54%	33%	11%
52%	36%	15%
Probable	Less often than not	Very infrequent
As often as not	Sometimes	Poor chance
Often	Less than even	Low probability
Frequent	Might happen	Once in a while

Figure 1: A sample spinner in the experimental design.

2.1.3 Stimulus, Materials, and Procedure

Participants were seated around a large table with sufficient space between them that they could not see the decision form that each had in front of him or her. Two cubicles with computers and linked monitors opened to the room that housed the table. We first distributed written instructions describing the procedure and the payoff mechanism and then demonstrated them on the computer. Then, each participant received a number for identification. These numbers were written on a whiteboard so that a public record of each forecaster's performance could be kept.

At this point we describe the procedure for the small groups only. The participant who received the number 1 (P1) started the experiment as a forecaster while P2 and P3 served as decision-makers. On the first trial, P1 entered a separate cubicle to observe stimuli on the monitor and to make forecasts on the basis of them; only the forecaster had access to the stimuli. The experimenter monitored the stimuli (and the decision-makers) from the other cubicle to make sure that forecaster followed the instructions correctly and did not intentionally mislead the decision-makers, for example by selecting terms that did not appear on the screen.

The stimuli consisted of various spinners radially divided into three colored sectors, red, blue, and yellow (see Figure 1). The three color names appeared below the spinner. Eight probability terms, four numerical and four verbal, were arrayed below each color name. All numerical values were chosen from the integers in the range of ±2 from the actual percentage of the color on the spinner. Vague descriptors were selected from a list of phrases that appeared in Mosteller and Youtz (1990), in which the authors surveyed 20 studies and tabulated the numerical averages of opinions on quantitative meanings of 52 probabilistic expressions.[2] To reflect the wide individual differences that exist in interpreting verbal phrases, the four verbal phrases describing each color were randomly sampled from all available terms that were within the range ±20 percentage points from the actual percentage of each color as found in Mosteller and Youtz (1990). The placement of verbal and numerical terms on screen was counterbalanced; half of the spinners had verbal descriptors listed before the numerical estimates, while other half had the opposite placement.

The decision forms had 30 numbered lines corresponding to the 30 trials of the session, each with RED, BLUE, and YELLOW written on it. Upon seeing the spinner on the monitor in the cubicle, the forecaster called out one estimate for each color. The decision-makers then circled the color on the appropriate line of the decision form (see Appendix A) on which they believed the spinner would most frequently land out of six spins. Then, the forecaster clicked the left bar marked "Click to spin" and told the decision-makers the color the spinner landed on, the forecaster repeated this spin procedure for a total of six times. Decision-makers then wrote down the number of times the color they selected came up in the 6 spins. Decision-makers personally accumulated $0.15 for each time the spinner landed on the color they had predicted plus the amount of second-order payoff, determined by the second-order payoff condition (conjunctive vs. disjunctive). The second-order payoff accumulated on that trial was a public record, recorded on the board next to the forecaster's assigned number. The trial ended when forecaster clicked the bar marked "Click for the next spinner" before exiting the cubicle.

The next trial started when P2 took the role of forecaster while P1 and P3 served as decision-makers. P2 repeated the same procedure as described above and then P3 took over the role of forecaster to begin the third trial. The cycle was repeated 10 times for a total of 30 trials. Every three trials made a block, for a total of 10 blocks. Similar spinners appeared in each block save for slight changes in each color's proportion on the circle (±5 percentage points).

In five-person and six-person groups, the procedure

[2] We made a few changes to their list: first, we changed adverbs to adjectives; second, we deleted the two double negatives on the list (e.g. not unreasonable); leaving 50 terms available for this study.

was identical except that, in order to keep the number of decision makers the same as in the 3-person groups, some group members had to be bystanders. Bystanders took no action but they received the same second-order payoff, as did the decision-makers. The rotation order was designed so that decision-makers were always the next two members after the forecaster, followed by the bystanders. For example, on Trial 1, P1 began the experiment serving as forecaster, P2 and P3 became decision-makers, and P4 to P6 (or P5 in groups of size 5) all took the role of bystanders. For the next trial, P2 became the forecaster and P3 and P4 were the decision-makers, etc. Each trial block here was composed of 6 (5) trials if there were 6 (5) members in the group, resulting in a total of 10 blocks.

At the end of the experiment, a true lottery was conducted using a bingo cage to determine the two trials that would count for cash payoffs. The payoff was the sum of personal winnings earned when serving as decision-maker plus the second-order payoffs on the trial selected for payment. In addition to the winnings from participation, participants in the disjunctive condition could win an additional $1 plus extra course credit if they finished first in earning.

2.2 Results

Our unit of analysis is groups, not individuals and our focus is on the proportions of numerical and verbal forecasts provided by forecasters. We hypothesized that the use of precise estimates will increase in the conjunctive payoff condition and decrease in the disjunctive, and furthermore, that the rates of change will be greater in the small than in the large group. Three groups were excluded from analysis, as group members showed no change in the proportion of numerical estimates used throughout the experiment. Figure 2 shows the mean proportion of numerical forecasts as a function of trial block in each of the four group size-payoff condition combinations. Qualitatively, the effects all appear to be as predicted.

To assess the effects statistically, we fit separate linear and quadratic functions for each group to the proportion of numerical estimates as a function of trial block. The quadratic functions did not provide significantly better fits than the linear. Further, a 2 (group size) x 2 (payoff) x 10 (trial block) mixed analysis of variance (ANOVA) using the residuals from the linear fit for each group at each trial block as the dependent variable also revealed no significant effects. Hence, we used the slopes and intercepts of the linear functions as the dependent variables for subsequent analyses. Although our main interest is in the slopes as measures of rates of change, we first checked for any initial bias in the groups' communication choices by performing a 2 x 2 between-group ANOVA on the intercepts. No factors were significant.

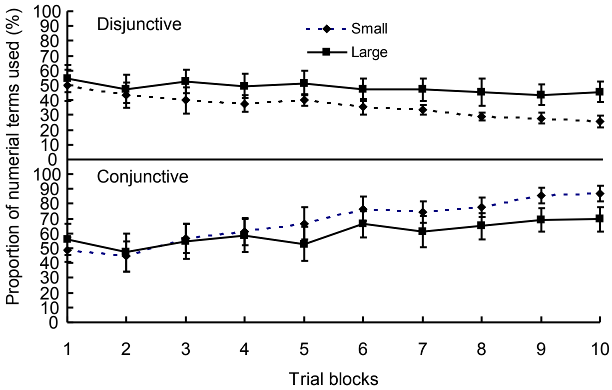


Figure 2: Top: Proportion of numerical terms used (± SE) as a function of trial blocks in the disjunctive payoff condition. Bottom: Proportion of numerical terms used (± SE) as a function of trial blocks in conjunctive payoff condition in Experiment 1.

Next, we submitted the slopes to a 2 (group size) X 2 (payoff) ANOVA. There was an expected payoff effect, $F(1, 32) = 47.81$, $p < .001$, but the effect was moderated by group size, $F(1, 32) = 9.11$, $p < .01$. The main group size effect was not significant. We followed up the interaction with simple *t*-tests comparing groups within payoff conditions. For participants in the conjunctive payoff condition, the linear increase in the use of numerical estimates as a function of time was more pronounced in the small group ($M = .17$, $SE = .03$) than in the large group ($M = .07$, $SE = .02$) and the difference was significant, $t(18) = 2.89$, $p = .01$. In the disjunctive condition, the linear decrease in the small group ($M = -.09$, $SE = .03$) was also more pronounced than in large group ($M = -.03$, $SE = .02$), although the difference was not significant, $t(17) = -1.54$, $p = .14$.

2.3 Discussion

Partly consistent with our hypothesis, smaller groups showed a faster convergence than did the larger groups toward the communication mode that conferred the most amount of money to the group during the experiment. The rate of adoption of a forecasting pattern was faster in small than in large groups, but only for conjunctive payoff conditions. The difference was not significant in the disjunctive payoff condition. This may be due to the possibility that second-order payoff for all members (except forecaster) tend to be high in the disjunctive payoff condition, which mitigates the effectiveness of feedback on forecaster's choices of probabilistic forecasts.

It can be argued that the results in Experiment 1 are caused by diffusion of responsibility where forecasters felt less responsible to members' payoffs and were less motivated to adapt to the mode of probabilistic forecast that would confer the most amount of second-order payoff in as group size increases (Forsyth, Zyzniewski, & Giammanco, 2002; Komorita & Parks, 1994; Latané, 1981). In light of this, we wish to test if the presence of co-actors can still reduce the development of a probability mode when there is no objective way for individuals to monitor the performance of others and rule out the possibility that the results in Experiment 1 cannot be due to diffusion of responsibility.

3 Experiment 2

Experiment 1 demonstrated that forecasters adopted the more favorable communication mode more slowly in larger than in smaller groups. Experiment 2 manipulated whether the second-order payoff information was social or personal. The experiment contrasted these two possibilities by holding group size constant and manipulating the availability of the second-order payoff information to group members. If the convergence to the more favorable communication mode is due to social facilitation, then the removal of payoff information from social groups should increase the proportion of precise terms used in the conjunctive payoff condition and decrease the proportion of precise terms used in the disjunctive condition. If it is due to diffusion of responsibility, then the reverse should occur. Specifically, we hypothesize that the payoff and its interaction with the availability of feedback should affect communication mode choices.

3.1 Method

3.1.1 Participants

A total of 117 participants from University of Maryland served in 39 triads in exchange for monetary rewards and partial course credit.

3.1.2 Design

The study was a 2 (payoff: conjunctive v. disjunctive) x 2 (feedback: social v. personal) x 10 (trial blocks) mixed design with repeated measure on the last factor.

3.1.3 Stimulus, Materials, and Procedure

Participants received the same stimuli and materials as those in the Experiment 1. The second-order payoff manipulation remained the same as in Experiment 1. The feedback condition manipulated the availability of information regarding the second-order payoff winnings. In the personal feedback condition, only the forecaster received information on second-order earnings whereas all participants have the information in the social feedback condition, as described in Experiment 1. We kept the second-order earnings by recording the second-order earnings personally on the forecaster's decision sheet under the column marked "Forecaster Correct" (see Appendix B). Each participant had access only to the second-order payoff on trials in which he or she served as forecaster.

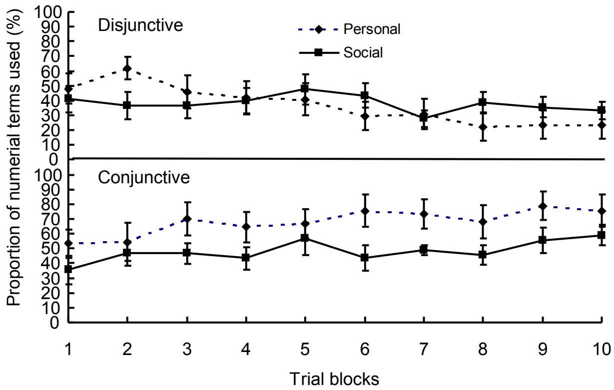


Figure 3: Top: Proportion of numerical terms used (± SE) as a function of trial blocks in the disjunctive payoff condition. Bottom: Proportion of numerical terms used (± SE) as a function of trial blocks in conjunctive payoff condition in Experiment 2.

3.2 Results

Figure 3 shows the mean proportion of precise forecasts as a function of trial block in each of the four feedback-payoff condition combinations. As before, we fitted a linear function for each group to the proportion of numerical estimates as a function of trial block to obtain the intercept and slope. Two groups were excluded from analysis as members showed no changes in the use of their probabilistic forecasts throughout the experiment. An initial ANOVA performed on the intercept found neither independent variable to be significant. Then, a separate ANOVA using slope as the dependent variable found no main effect of feedback, $F(1, 33) = 0.02$, *n.s.*, but a significant effect of payoff condition, $F(1, 33) = 19.83$, $p < .001$. There was also a significant interaction between feedback and payoff, $F(1, 33) = 5.78$, $p < .03$. We then performed simple t-tests comparing groups within payoff conditions. In the conjunctive condition, the linear increase in the use of numerical estimates was greater in the personal feedback ($M = .09$, $SE = .03$) than in social feedback ($M = .01$, $SE = .02$) and the difference was significant, $t(16) = 2.26$, $p < .04$. For participants in the disjunctive payoff condition, the linear decrease in the use of numerical estimates as a function of trial block for those in the social feedback (M = -.05, SE = .04) and those in the personal feedback (M = -.13, SE = .03) was not significantly different, $t(17) = 1.40$, p = .18.

3.3 Discussion

Experiment 2 tested whether eliminating group access to the information about second-order winnings can improve forecasters' communication. As predicted, the payoff and its interaction with feedback condition were both significant, suggesting that forecasters learned the better mode of risk communication when there was no basis for comparing their performance to that of the others. However, this pattern was significant only in the conjunctive payoff condition but not in the disjunctive payoff condition. We believe that, as in Experiment 1, because group members in the disjunctive condition tended to receive a higher second-order payoff compared to those in the conjunctive condition, feedback regarding the second-order payoffs was not indicative of performance, thereby making convergence in the probability mode more difficult.

4 General Discussion

We tested whether individuals learned to use either the numerical or verbal form of probabilistic forecast in response to payoffs in different group sizes. Experiment 1 showed that forecasters in groups of size five or six adapted to the more profitable communication mode less quickly than did those in groups of size three. Experiment 2 ruled out the possibility that the differences in group size was due to social loafing. The results are consistent with our hypothesis that social facilitation slows the rate of learning the better mode of risk communication as demanded by the payoff contingency.

How do members in the same social group adopt a pattern of probabilistic communication? An important determinant is the maximization of earnings. However, we found in two experiments factors that affect individuals' abilities to learn and adapt their communication mode. It appears that effective communication of probabilistic events may be more difficult to learn in larger groups due to decreased social facilitation in larger groups.

The results in this paper suggest that coordination is sometimes more difficult in the large than the small groups not because of social loafing but rather because members of the larger group did not develop a pattern of probabilistic communication that was shared and understood by everyone. In summary, forecasts that utilize precise numbers do not always improve the group's payoff and vague, verbal forecasts are sometimes useful.

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Appendix A: Decision sheet in Experiment 1

Trial	Role	Participant 1	Correct	Trial	Role		Correct
1	Forecaster			31	Forecaster		
2	Bystander			32	Bystander		
3	Bystander			33	Bystander		
4	Bystander			34	Bystander		
5	Decision-Maker	Blue Red Yellow		35	Decision-Maker	Blue Red Yellow	
6	Decision-Maker	Blue Red Yellow		36	Decision-Maker	Blue Red Yellow	
7	Forecaster			37	Forecaster		
8	Bystander			38	Bystander		
9	Bystander			39	Bystander		
10	Bystander			40	Bystander		
11	Decision-Maker	Blue Red Yellow		41	Decision-Maker	Blue Red Yellow	
12	Decision-Maker	Blue Red Yellow		42	Decision-Maker	Blue Red Yellow	
13	Forecaster			43	Forecaster		
14	Bystander			44	Bystander		
15	Bystander			45	Bystander		
16	Bystander			46	Bystander		
17	Decision-Maker	Blue Red Yellow		47	Decision-Maker	Blue Red Yellow	
18	Decision-Maker	Blue Red Yellow		48	Decision-Maker	Blue Red Yellow	
19	Forecaster			49	Forecaster		
20	Bystander			50	Bystander		
21	Bystander			51	Bystander		
22	Bystander			52	Bystander		
23	Decision-Maker	Blue Red Yellow		53	Decision-Maker	Blue Red Yellow	
24	Decision-Maker	Blue Red Yellow		54	Decision-Maker	Blue Red Yellow	
25	Forecaster			55	Forecaster		
26	Bystander			56	Bystander		
27	Bystander			57	Bystander		
28	Bystander			58	Bystander		
29	Decision-Maker	Blue Red Yellow		59	Decision-Maker	Blue Red Yellow	
30	Decision-Maker	Blue Red Yellow		60	Decision-Maker	Blue Red Yellow	

Appendix B: Decision sheet in Experiment 2

Trial		Individual correct	# correct?	Forecaster correct
1	1	Blue Red Yellow	Correct:	
2		Blue Red Yellow	Correct:	
3		Blue Red Yellow	Correct:	
4	2	Blue Red Yellow	Correct:	
5		Blue Red Yellow	Correct:	
6		Blue Red Yellow	Correct:	
7	3	Blue Red Yellow	Correct:	
8		Blue Red Yellow	Correct:	
9		Blue Red Yellow	Correct:	
10	4	Blue Red Yellow	Correct:	
11		Blue Red Yellow	Correct:	
12		Blue Red Yellow	Correct:	
13	5	Blue Red Yellow	Correct:	
14		Blue Red Yellow	Correct:	
15		Blue Red Yellow	Correct:	
16	6	Blue Red Yellow	Correct:	
17		Blue Red Yellow	Correct:	
18		Blue Red Yellow	Correct:	
19	7	Blue Red Yellow	Correct:	
20		Blue Red Yellow	Correct:	
21		Blue Red Yellow	Correct:	
22	8	Blue Red Yellow	Correct:	
23		Blue Red Yellow	Correct:	
24		Blue Red Yellow	Correct:	
25	9	Blue Red Yellow	Correct:	
26		Blue Red Yellow	Correct:	
27		Blue Red Yellow	Correct:	
28	10	Blue Red Yellow	Correct:	
29		Blue Red Yellow	Correct:	
30		Blue Red Yellow	Correct:	