08901-2-T

HUMAN PERFORMANCE CENTER
DEPARTMENT OF PSYCHOLOGY
The University of Michigan, Ann Arbor

Risky Decisions by Individuals and Groups

BARBARA C. GOODMAN

Technical Report No. 21

June 1970

THE HUMAN PERFORMANCE CENTER

DEPARTMENT OF PSYCHOLOGY

The Human Performance Center is a federation of research programs whose emphasis is on man as a processor of information. Topics under study include perception, attention, verbal learning and behavior, short- and long-term memory, choice and decision processes, and learning and performance in simple and complex skills. The integrating concept is the quantitative description, and theory, of man's performance capabilities and limitations and the ways in which these may be modified by learning, by instruction, and by task design.

The Center issues two series of reports. A Technical Report series includes original reports of experimental or theoretical studies, and integrative reviews of the scientific literature. A Memorandum Report series includes printed versions of papers presented orally at scientific or professional meetings or symposia, methodological notes and documentary materials, apparatus notes, and exploratory studies.

T H E   U N I V E R S I T Y   O F   M I C H I G A N

COLLEGE OF LITERATURE, SCIENCE AND THE ARTS

DEPARTMENT OF PSYCHOLOGY

RISKY DECISIONS BY INDIVIDUALS AND GROUPS

Barbara Cora Ettinger Goodman

HUMAN PERFORMANCE CENTER--TECHNICAL REPORT NO. 21

June, 1970

This research was supported by the National Aeronautics and Space Administration under Grant NGL 23-005-171 to the Engineering Psychology Laboratory, University of Michigan, monitored by the Ames Research Center, NASA.

PREFACE

This report is an independent contribution to the program of research of the Engineering Psychology Laboratory. It was supported by the National Aeronautics and Space Administration under Grant NGL 23-005-171 to the Engineering Psychology Laboratory, University of Michigan, monitored by the Ames Research Center, NASA.

This report was also a dissertation submitted by the author in partial fulfillment of the degree of Doctor of Philosophy (Psychology) in the University of Michigan, 1970. The doctoral dissertation committee was: Professor Ward Edwards, Chairman; Professor Clyde H. Coombs; Professor Walton M. Hancock; Associate Professor David H. Krantz; and Professor Robert B. Zajonc. This research also profited from the advice of Dr. Cameron R. Peterson.

TABLE OF CONTENTS

ABSTRACT

RISKY DECISIONS BY INDIVIDUALS AND GROUPS

by

Barbara Cora Ettinger Goodman

Chairman: Ward Edwards

This study investigates the shifts between individual and group performance in two action selection tasks (a choice dilemma task in which subjects equate a risky option with a sure thing and a gambling task in which subjects wager their own money) and in one Bayesian diagnosis task (likelihood ratio estimation). 27 male subjects performed each task alone. Then 24 of these subjects were formed into 6 four-man leaderless groups and repeated each task. Three subjects, serving as individual controls, performed each task alone a second time. Finally, all 27 subjects repeated each task again alone.

The group decisions in the choice dilemma task reproduced previously found patterns of shifts (compared with mean pregroup performance) toward the risky option or toward the sure thing. In the gambling task groups tended to prefer higher variance gambles than did the average group member on his pregroup performance. A striking conformity effect occurred in the likelihood ratio estimation task: the estimates of 22 of the 24 test subjects more closely resembled their group's values than their own pregroup estimates. However, no conclusion can be drawn about whether groups or individuals make more extreme likelihood ratio estimates.

Both group and individual correlations between measures of performance in all three tasks were low. Thus proclivity for a risky option in the choice dilemma, preference for higher variance in gambling, and tendency to extreme likelihood ratio estimates seem to be unrelated.

INTRODUCTION

Decision theory offers a framework for describing one of man's primary activities. Within decision theory, a decision under risk is formally defined as the selection of a course of action of uncertain outcome depending upon states of nature whose probabilities are assessable. The components of such a decision are as follows:

(1) alternative courses of action ≡ a set of mutually exclusive actions available to the decision maker. The selection of one of a set of alternative courses of action is called action selection.

(2) states of nature ≡ an exhaustive set of mutually exclusive events, not under control of the decision maker, which affect the consequences of the different courses of action being considered.

(3) probabilities of states of nature ≡ numerical estimates of the likelihood of occurrence of the specific chance events under consideration. The process of determining these numerical estimates will here be called diagnosis.

(4) outcome ≡ the consequences that accrue to the decision maker resulting from his selected course of action when a specific state of nature obtains.

Action Selection

Some investigators have shown that groups may make riskier decisions than individuals. This phenomenon was observed by Stoner (1961) and called "the risky shift". Specifically, the "risky shift" is the phenomenon occurring when unanimous group decisions are more risky than the average of the initial individual decisions. Reviews on this subject appear in Brown (1965), Burnstein (1969), and Kogan and Wallach (1967). Most experiments have used an individual-group-individual (I-G-I) design wherein the task is initially performed alone, repeated in a group, and then repeated again alone. A consistent finding in the studies of the risky shift that used the I-G-I design is that final (postgroup) individual decisions conformed more closely to the decisions of the group than to the initial (pregroup) individual decisions.

The choice dilemma paradigm was the usual task. In this paradigm, the individual or group acts as advisor in hypothetical situations. Subjects rarely have experienced the consequences of their decisions (e.g., monetary wins or losses) with the exception of studies by Lonergan and McClintock (1961), Rettig (1966), and Wallach, Kogan, and Bem (1964). It is still an open question whether risky shifts will occur in real life situations.

Thus far differences between individuals and groups in decision making have been studied only in action selection. This study investigates the hypothesis that individuals and groups differ also in diagnosis.

Diagnosis via Bayesian Inference Techniques

Hypotheses are states of nature. The diagnostic process consists of revising the probabilities of the various hypotheses on the basis of new information. The estimate before the revision is the prior probability. The revised estimate is the posterior probability. In Bayesian inference, diagnosis is done by means of a mathematical rule called Bayes's theorem. The odds-likelihood ratio form of Bayes's theorem is written as follows:

$$\frac{P(H_A|D)}{P(H_B|D)} = \frac{P(D|H_A)}{P(D|H_B)} \cdot \frac{P(H_A)}{P(H_B)} . \qquad (1)$$

H_A and H_B are mutually exclusive hypotheses. $P(H_A)$ and $P(H_B)$ are the probabilities of H_A and H_B before receiving additional information. These are the prior probabilities. $P(H_A|D)$ and $P(H_B|D)$ are the probabilities of H_A and H_B, respectively, given datum D. These are the posterior probabilities. $P(D|H_A)$ and $P(D|H_B)$ are the probabilities of observing datum D assuming the truth of H_A and H_B, respectively. The ratios of probabilities of hypotheses are odds. $\frac{P(H_A)}{P(H_B)}$ is the prior odds of hypothesis H_A relative to H_B. $\frac{P(H_A|D)}{P(H_B|D)}$ is the posterior odds of hypothesis H_A relative to H_B. $\frac{P(D|H_A)}{P(D|H_B)}$ is the likelihood ratio (LR). In other words, Bayes's theorem states that the posterior odds equals the prior odds times the likelihood ratio. The likelihood ratio (LR) is a measure of the diagnostic impact of datum D on H_A compared to H_B. For example, a LR of 2 in favor of H_A implies that, whatever the estimate of $P(D|H_A)$, it is twice the size of the estimate of $P(D|H_B)$. The value of the LR is that it is a numerical estimate of the impact of only those features of the datum which are affected by the two hypotheses unequally. Numerical evaluations of those features of the datum which are affected by each hypothesis equally are unnecessary since whatever their value, they occur as a product in both the numerator and denominator, and hence are cancelled by the ratio.

The use of Bayes's theorem in the form of odds permits revision of prior opinion through estimation of LRs. An information processor is a conservative diagnostician when his posterior probabilities differ from his prior ones less than Bayes's theorem prescribes. A great deal of research has shown that in certain situations people are conservative diagnosticians. Reviews of this literature can be found in DuCharme (1969), Edwards (1968), and Peterson and Beach (1967). Would groups be more or less conservative than individuals in an inference task?

Purpose of this Study

This study considers three questions. One, will a risky shift occur in an action selection task in which the participants wager their own money? Two, does individual or group behavior in several tasks that might all be supposed to require responses to "risk" show the kind of coherence that would permit the assumption of a general risk-seeking or risk-avoiding trait? Three, are individuals more or less conservative diagnosticians than are groups?

METHOD

Subjects

Ss were 27 male volunteers, 17 graduate students and 10 undergraduates from several disciplines, but none were psychology majors. Ss were paid $30 plus their winnings or minus their losses from the gambling task.

Tasks

Three tasks were used in order to contrast decisions of individuals and groups in action selection and diagnosis, and to search for a possible underlying phenomenon of risk preference.

1. Choice dilemma task. I selected the same twelve choice dilemma situations used by Stoner (1968) to determine a S's (or group's) preferences in hypothetical situations. Problem 9 illustrates the total format; I present the others only in Stoner's summary form.

> "1. A dentist with a family must decide whether to undergo an operation which would remove a severe pain if successful but would prevent his continuing his dental practice if unsuccessful. (Nordhøy)
>
> 2. A man about to embark on a vacation trip experiences severe abdominal pains and must choose between disrupting his vacation plans in order to see a doctor or boarding an airplane for an overseas flight. (Stoner)
>
> 3. A chess player must decide whether to take a manuever that might bring victory if successful or a defeat if unsuccessful. (Wallach and Kogan)

4. An electrical engineer is faced with an opportunity of joining a new company with an uncertain future which, if it is successful, could offer greater chance for advancement than his present, more secure, position offers. (Wallach and Kogan)

5. A recent medical-school graduate is choosing between two long-term projects. One is almost certain to be a success and will help his career but will not be of major importance. The other will be either a complete success or a complete failure; if successful it will lead to a cure for a "crippling disease which leaves children blind and mentally retarded." (Stoner [modified Wallach and Kogan])

6. A father, who has recently received a promotion, is considering spending some savings originally set aside for his sons' college education on a family trip to Europe. (Stoner)

7. A college senior is choosing between attending a high-prestige university, which may be too rigorous for him to receive his Ph.D., and a lower-prestige university from which he is certain to obtain his degree. (Wallach and Kogan)

8. A couple must choose between allowing a complicated pregnancy to continue, with danger to the mother's life, or having the pregnancy terminated. (Stoner)

10. A person (sex of the decision-maker was purposely ambiguous) involved in an airplane accident must choose between rescuing only his child or attempting to rescue both his spouse and child with the realization that both would be lost if the attempt is unsuccessful. (Stoner)

11. A recently married young man with a pregnant wife is deciding whether or not to give up his hobby of sports car racing. (Stoner)

12. A man of moderate means is considering borrowing on his life insurance to invest in a stock which may grow substantially in value. (Nordhøy)

9. Mr. I is the captain of College X's football team. College X is playing its traditional rival, College Y, in the final game of the season. The game is in its final seconds, and Mr. I's team, College X, is behind in the score. College X has time to run one more play. Mr. I, the captain, must decide whether it would be best to settle for a tie score with a play which would be almost certain to work; or, on the other hand, should he try a more complicated and risky play which would bring victory if it succeeded, but defeat if not.

Imagine that you are advising Mr. I. Listed below are several probabilities or odds that the risky play will work. PLEASE CHECK THE LOWEST PROBABILITY THAT YOU WOULD CONSIDER ACCEPTABLE FOR THE PLAY TO BE ATTEMPTED.

______The chances are 0 in 10 that the risky play will work (i.e., the risky play is certain to fail).
______The chances are 1 in 10 that the risky play will work.
______The chances are 2 in 10 that the risky play will work.
______The chances are 3 in 10 that the risky play will work.
______The chances are 4 in 10 that the risky play will work.
______The chances are 5 in 10 that the risky play will work.
______The chances are 6 in 10 that the risky play will work.
______The chances are 7 in 10 that the risky play will work.
______The chances are 8 in 10 that the risky play will work.
______The chances are 9 in 10 that the risky play will work.
______The chances are 10 in 10 that the risky play will work (i.e., the risky play is certain to succeed.)"

The S checks the line indicating the lowest probability for which he would advise taking the risk.

2. Likelihood ratio estimation task. I used a task devised by Ward Edwards to compare Ss' and groups' diagnostic judgments. This task uses seven-inch sticks colored blue and yellow in various proportions. The Ss are shown two blue and yellow colored drawings each of a sample of approximately 100 sticks from one of the populations being considered. Populations A and B have Gaussian (normal) distributions with mean lengths of blue of 4.5 inches and 2.5 inches respectively. Each population has a standard deviation of 1.25 inches of blue. To prepare the drawings the cumulative normal distribution for each population was divided into 100 equally likely parts. 1/100 of the population falls between every two division or boundary points. The mean lengths of blue at the boundary points comprise the sample. Three lengths are missing because it was too difficult to produce the very small amounts of color required to represent the boundary points at the tails of the distribution. The order of the 97 sticks pictured in each chart was random. Thus each chart is a picture of a random arrangement of what looks like a sample from a normal distribution but in fact has been chosen so that the "sample" precisely depicts the population. A line is drawn across each chart showing the population mean. The Ss are told that each chart shows a random sample of sticks from its population, even though this was not the case.

The S is presented a stimulus of a partly blue-partly yellow stick. With the charts as guides, he is asked to state from which population (A or B) this stick is more likely to have been sampled and, in a ratio form, how much more likely. This is the likelihood ratio estimation process. It is repeated with 80 different sticks.

In mathematical terms, the task requires the S to infer either the quantity $\frac{P(D|H_A)}{P(D|H_B)}$ or $\frac{P(D|H_B)}{P(D|H_A)}$ where D is the stimulus, H_A is the hypothesis that the stick is a sample from population A, and H_B is the hypothesis that it is a sample from population B.

3. Gambling task. I selected the gambles designed by Coombs and Huang (in press) to determine a S's (or group's) preference in a gaming situation. Ss or groups are shown, one at a time, the five sets of seven gambles displayed in Table 1. They are asked to rank

TABLE 1

THE GAMBLES COMPRISING THE GAMBLING GAME*

S(5)	S(10)	S(15)	S(20)	S(25)
($1,-90¢)	($1,-80¢)	($1.50,-$1.20)	($2,-$1.60)	($2.50,-$2)
(50¢,-40¢)	(60¢,-40¢)	($1,-70¢)	($1,-60¢)	($1.50,-$1)
(30¢,-20¢	(50¢-30¢)	(70¢,-40¢)	(80¢,-40¢)	($1,-50¢)
(25¢,-15¢)	(40¢,-20¢)	(50¢,-20¢)	(60¢,-20¢)	(80¢,-30¢)
(20¢,-10¢)	(30¢,-10¢)	(40¢,-10¢)	(50¢,-10¢)	(65¢,-15¢)
(15¢,-5¢)	(25¢,-5¢)	(35¢,-5¢)	(45¢,-5¢)	(55¢,-5¢)
(5¢,5¢)	(10¢,10¢)	(15¢,15¢)	(20¢,20¢)	(25¢,25¢)

*The flip of a coin determines the outcome of a gamble (heads wins, tails loses). The first number of each pair is the amount to be won if that gamble is played and a head comes up. The second number of each pair is the amount to be lost.

order from most to least preferred the seven gambles within each set. Following this, the most preferred choice from one of the sets is randomly selected and played. The flip of a coin determines the outcome. The _S_s are given money to wager, but they could lose more than they are given.

Procedure

The first three of the nine sessions of the experiment were individual; the second three were group; the last three were individual again. In sessions 1, 4, and 7, _S_s performed the choice dilemma task. In sessions 2, 5, and 8, they performed the likelihood ratio task. And in sessions 3, 6, and 9, they performed the gambling task. _S_s worked at their own pace, and were not given prior information about the I-G-I design.

There were 24 test _S_s who did the tasks alone and in groups. These test _S_s were randomly assigned into four-man, leaderless groups. Three _S_s were individual controls, performing each task three times alone. There were no group controls.

The groups were formed after the initial individual sessions and remained unchanged. Each group sat around a desk. There was no fixed seating arrangement. Group sessions were tape recorded with _S_s' knowledge. _E_ remained present and answered only procedural questions. Unanimous decisions were required in each case.

For the choice dilemma task, the pre- and postgroup individual performances were done outside the laboratory. _S_s were given the problems with instruction not to discuss the material. The three control Ss performed the first and third sets of problems at leisure. The second performance was done in the laboratory. For each problem, S checked the lowest probability for which he would advise taking the higher risk alternative. During the group session, each of the men was given a booklet containing the choice dilemma problems. They discussed each problem until they reached an unanimous decision. Each man recorded the group decisions in his booklet. There was a three week interval between successive choice dilemma sessions.

For the LR estimation task, each S was individually trained to express inferential judgments in the form of LRs. This instruction generally took 30 minutes to an hour. The training consisted of a written explanation, with examples, of the inferential process. Actual example tasks, with feedback of the correct values, were then performed. In the last example task the S estimated LRs for five data which were sampled from two Gaussian (normal) distributions. One distribution was the heights, in stocking feet, of an empirical sample of American men between the ages of 18 and 79; the other was the same for American women. For each datum the S first estimated whether that height was more likely to have been sampled from the population of men, or the population of women. Then he estimated how much more likely in a ratio sense. E presented all five data before giving any feedback. The five heights were presented in the following order: 5'2", 6'1", 5'6", 5'8", and 4'10". The corresponding correct LRs are 1:10, 725:1, 1.3:1, 7.5:1, and 1:120.

After E was satisfied that LR estimation was understood, the specific task using blue and yellow sticks was explained to the S.

The procedure of the LR estimation was as follows. The S was shown 80 sticks, one at a time, in a special holder that presented the entire length of blue and yellow against a white background. S decided whether a stick was more likely to have been sampled from the predominantly blue or the predominantly yellow population. Then he decided how much more likely in a ratio sense. S recorded both responses (qualitative and quantitative) on a sheet of paper. When S turned the paper over, E removed that stick from the holder, placed it out of sight, and put the next stick into the holder. The order in which the sticks were presented never changed. The individual and group sessions were performed in the same manner. The groups discussed each stimulus. When an unanimous decision was reached, each person recorded these values on a sheet of paper. There was a three week period between the pregroup individual sessions and the group session and a two week period between the group session and the postgroup individual sessions. The same relative spacing occurred for the individual sessions of the control Ss.

For the gambling task, a brief explanation of the format was given before the initial individual sessions. All the individual gambling sessions followed the same procedure. Each S was given $1.50 when he first arrived. He was told that one gamble would be played at the end of the session, and that this would be selected at random from his most preferred choices among the different sets of gambles. He was given, however, the option of selecting his second most preferred choice, if the possible loss from his first choice was greater than $1.50. Then S was handed five decks of IBM cards, with one gamble printed on each card. The random order within a deck was held constant throughout the experiment. The decks were given, one at a time in order of increasing wager. Within each deck, S was asked to rank order the gambles from most to least preferred. When S finished the rank orderings, the gamble was randomly selected, played, and the appropriate payoff was made.

At the beginning of the group sessions each member was given $1.50. The E explained that the one gamble to be played at the end of the experiment would be selected in the same manner as it had been in the individual sessions. Each person stood to win or lose the full amounts of the gamble finally selected. The sets of gambles were given one at a time to each person. When the group arrived at an unanimous preference ranking, each member arranged his cards according to the group decision and then turned these cards over to E, who handed out the next deck of cards. When groups finished the rank orderings, a gamble was randomly selected, played, and the appropriate payoffs made. Three weeks intervened between the pregroup individual and group sessions. There was a two week interval between the group and postgroup individual sessions. This same spacing was maintained for the control Ss.

RESULTS

Shifts-Changes Between Pregroup Individual Performance and Group Performance

The Choice Dilemma Task

Both risky and cautious shifts were found. A risky shift is a positive difference resulting from the subtraction of the group Risk Score from the pregroup average individual Risk Score. A negative difference in the same subtraction defines a cautious shift. Table 2 summarizes the mean shifts in performance of the 6, four-man groups compared to pregroup individual performance.

Stoner (1968) found for the same task with a larger sample, 30-33 groups of 4-7 members, statistically significant risky shifts in problems 3, 4, 5, 7, 9, and 10 and statistically significant cautious shifts in problems 2 and 8. The mean Risk Scores obtained in this study resembled those found by Stoner. Moreover, the direction of the shifts coincided with Stoner's findings, even though most of the shifts in this study were not significant. The Pearson product-moment correlation coefficients for the mean Risk Scores and mean shifts of Stoner's and the present study were .95 and .84, respectively. Thus there is excellent qualitative agreement between these two sets of results.

TABLE 2

SUMMARY OF THE GROUP SHIFTS ON THE CHOICE DILEMMA PROBLEMS

Problem Number	Mean [of the Pregroup Average Individual] Risk Scores[α]	Mean Group Risk Score	Mean Shift	t	Number of Groups Showing Risky Shift	Number of Groups Showing Cautious Shift
1	6.41	5.50	.91	1.22	4	2
2	5.62	6.00	- .38	.34	3	3
3	3.17	1.67	1.50	2.51	5	1
4	3.67	3.17	.50	.69	3	3
5	2.83	2.67	.16	.33	3	3
6	4.54	3.83	.71	.85	3	3
7	4.12	3.67	.45	.86	4	2
8	8.29	9.33	-1.04	2.87*	1	5
9	2.67	1.17	1.50	3.05*	5	1
10	3.33	3.00	.33	.39	2	3
11	6.08	5.83	.25	.37	3	3
12	6.00	5.83	.17	.20	3	3
				TOTAL	39	32

[α] Risk Score equals probability of success multiplied by 10.0

* $p < .05$, two-tail t test

The Gambling Task

The riskiest gamble, the one with the greatest possible loss within each set, is scored 1, the next 2 etc., until 7. The number corresponding to the S's most preferred choice in a set is called the Level of Risk Score (LOR) for that set. A risky shift is a positive difference resulting from the subtraction of the group LOR from the pre-group average individual LOR. A negative difference in the same subtraction defines a cautious shift. Table 3 summarizes the mean shifts in performance of the groups. Although both risky and cautious shifts were found in all sets of gambles, the mean shift was risky. Considering only the four-member groups, there were 18 instances of risky shift, one instance of a cautious shift, and one instance without shift.

The Likelihood Ratio Estimation Task[1]

The Group Conservatism Score (GCS) is the slope of the regression line relating the group log likelihood ratios (LLR) to the pregroup average individual LLRs. This value is a quantitative measure of conservatism between groups and individuals. If it is greater than 1, the group is less conservative than the individual; and if it is less than 1, the group is more conservative than the individual.

Although each individual or group estimated 80 LRs per session, 79 are shown in all the data analyses. The one response which was

---
1 See Reference Section- p. 51

TABLE 3

SUMMARY OF THE MEAN LEVEL OF RISK SCORES AND THE

GROUP SHIFTS FOR THE GAMBLING TASK

Set	Mean [of the Pregroup Average Individual] Level of Risk Score[α]	Mean Group Level of Risk Score	Mean Shift	*t*	Number of Groups Showing Risky Shift	Number of Groups Showing Cautious Shift
S(5)	4.08	2.83	1.25	1.29	5	1
S(10)	3.92	3.17	.75	.69	3	2
S(15)	3.95	2.50	1.45	1.68	4	2
S(20)	4.03	2.00	2.03	3.02*	5	1
S(25)	4.36	2.67	1.69	2.91*	5	1

[α]Two of the six groups have 3 members each, the other four groups have four members each

* $p < .05$, two-tail *t* test

eliminated was for a nearly all blue stick which frequently generated an extreme LR far out of the range of the other 79.

The GCSs and corresponding correlations between the average pregroup estimates and group estimates for this task are shown in Table 4.

TABLE 4

GROUP CONSERVATISM SCORES AND CORRESPONDING CORRELATION COEFFICIENTS FOR THE LR ESTIMATION TASK

Group	Correlations Between Average Pregroup LLRs and Group LLRs	Group Conservatism Scores	*t*[1]
1	.986	.922	4.460***
2	.945	.882	3.394***
3	.890	.673	8.322***
4	.952	.470	30.966***
5	.983	1.071	3.147**
6	.975	1.320	9.283***

[1]Test of the null hypothesis that the regression slope equals 1.000.
** $p < .01$, two-tail *t* test
*** $p < .002$, two-tail *t* test

Since the correlation coefficients were high, the relation between group values and the average pregroup individual values can be represented by a linear approximation. The GCSs indicate the difference between group and individual performance. Four of the six groups were more conservative than the average of the individuals within those groups.

Conformity

Diagnosis Task

There is much response ambiguity built into this task since Ss have insufficient information to permit calculation of the Bayesian values. The SLLR-BLLR scatterplot represents subjective performance with respect to the calculated values. This plot was made for each individual and group session. These graphs are shown in Figures 1-6. Each figure contains the graphs for one group of Ss. (a) - (d) are the pregroup individual graphs, (e) the group graph, and (f) - (i) the post-group graphs.

The postgroup individual estimates showed striking conformity to those of the group regardless of the individual's pregroup performance or that of the group itself.

The graphs in Figure 7 are the scatterplots for the three control Ss. Graph sets (a) - (c), (d) - (f), and (g) - (i) are the SLLR-BLLR plots for the 1st, 2nd, and 3rd individual sessions respectively. Graph sets (a), (d), and (g); (b), (e), and (h); (c), (f), and (i) each represent one S.

The shape of the functions for each control S was similar from session to session.

The degree of this conformity is further illustrated by the Sum of the Squares of the Difference (SSD) between the postgroup individual and the group LLRs and also between the postgroup individual and the pregroup individual LLRs across the 79 sticks. The SSDs between the

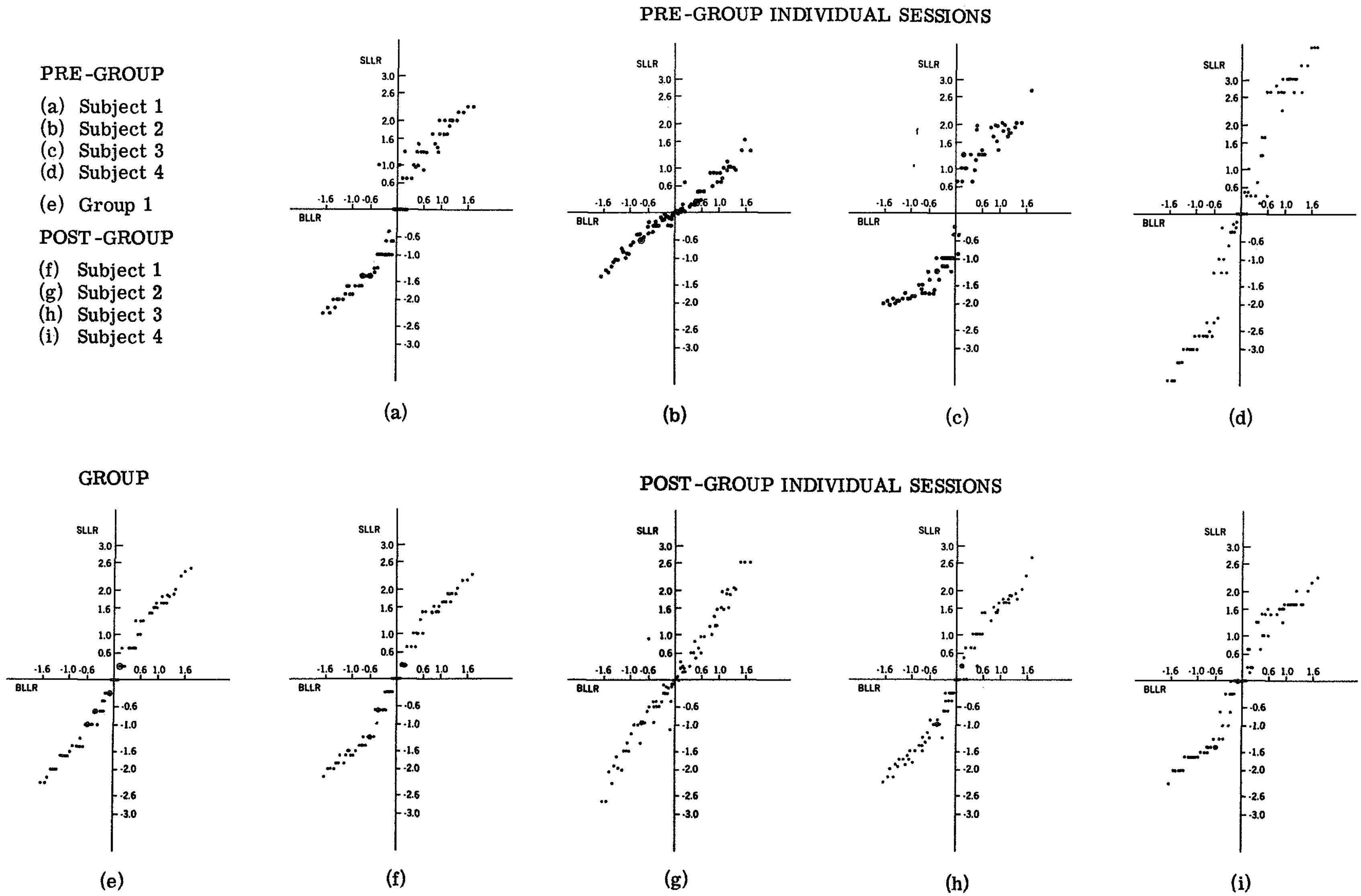


FIGURE 1. LOG LIKELIHOOD RATIO SCATTERPLOTS. Logarithms of the estimated likelihood ratios as a function of the logarithms of the Bayesian likelihood ratios for Group 1 subjects. In the top row are the plots for the pre-group individual sessions. In the bottom row are the group consensus plot and the post-group individual session plots.

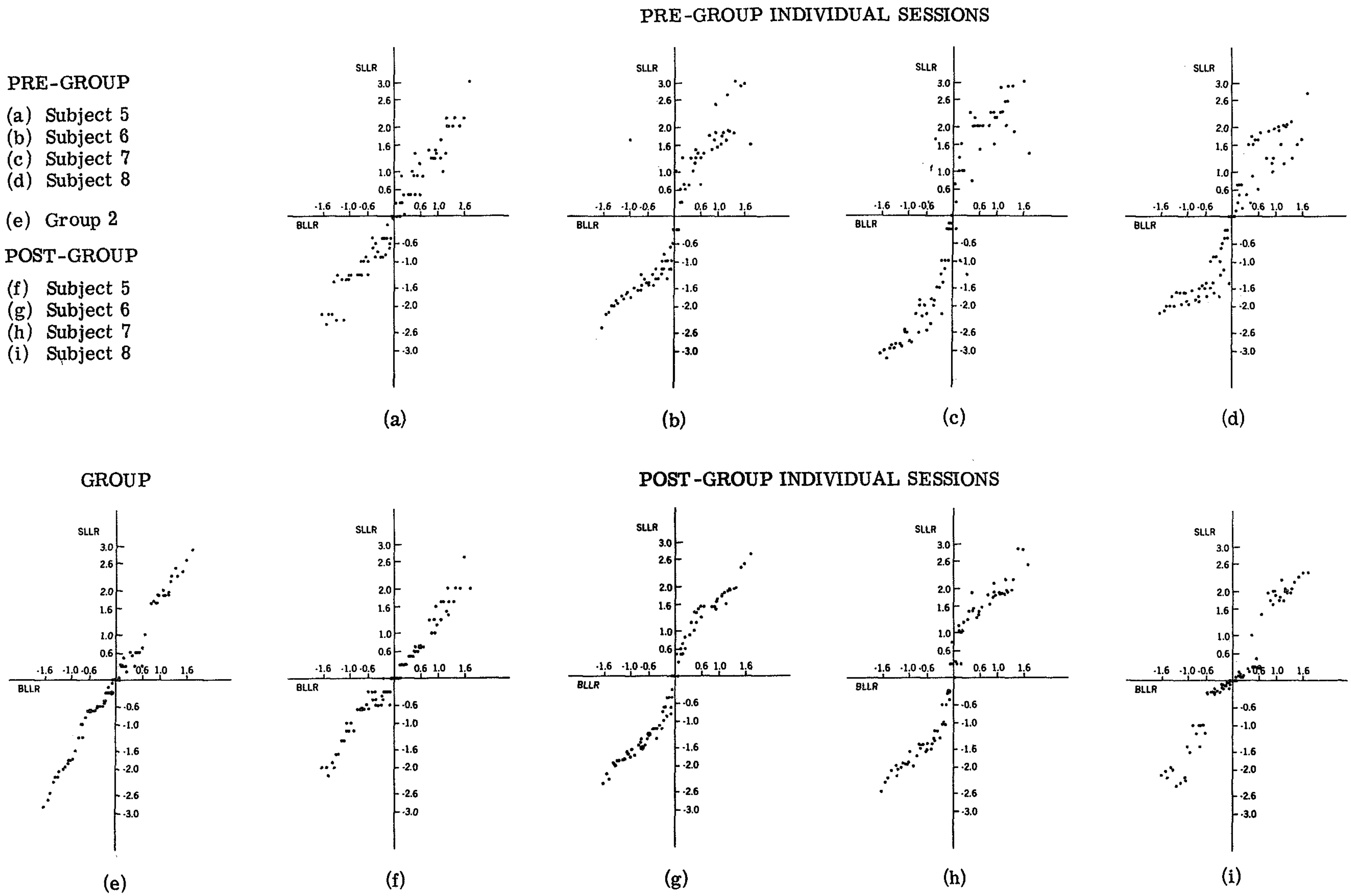


FIGURE 2. LOG LIKELIHOOD RATIO SCATTERPLOTS. Logarithms of the estimated likelihood ratios as a function of the logarithms of the Bayesian likelihood ratios for Group 2 subjects. In the top row are the plots for the pre-group individual sessions. In the bottom row are the group consensus plot and the post-group individual sesson plots.

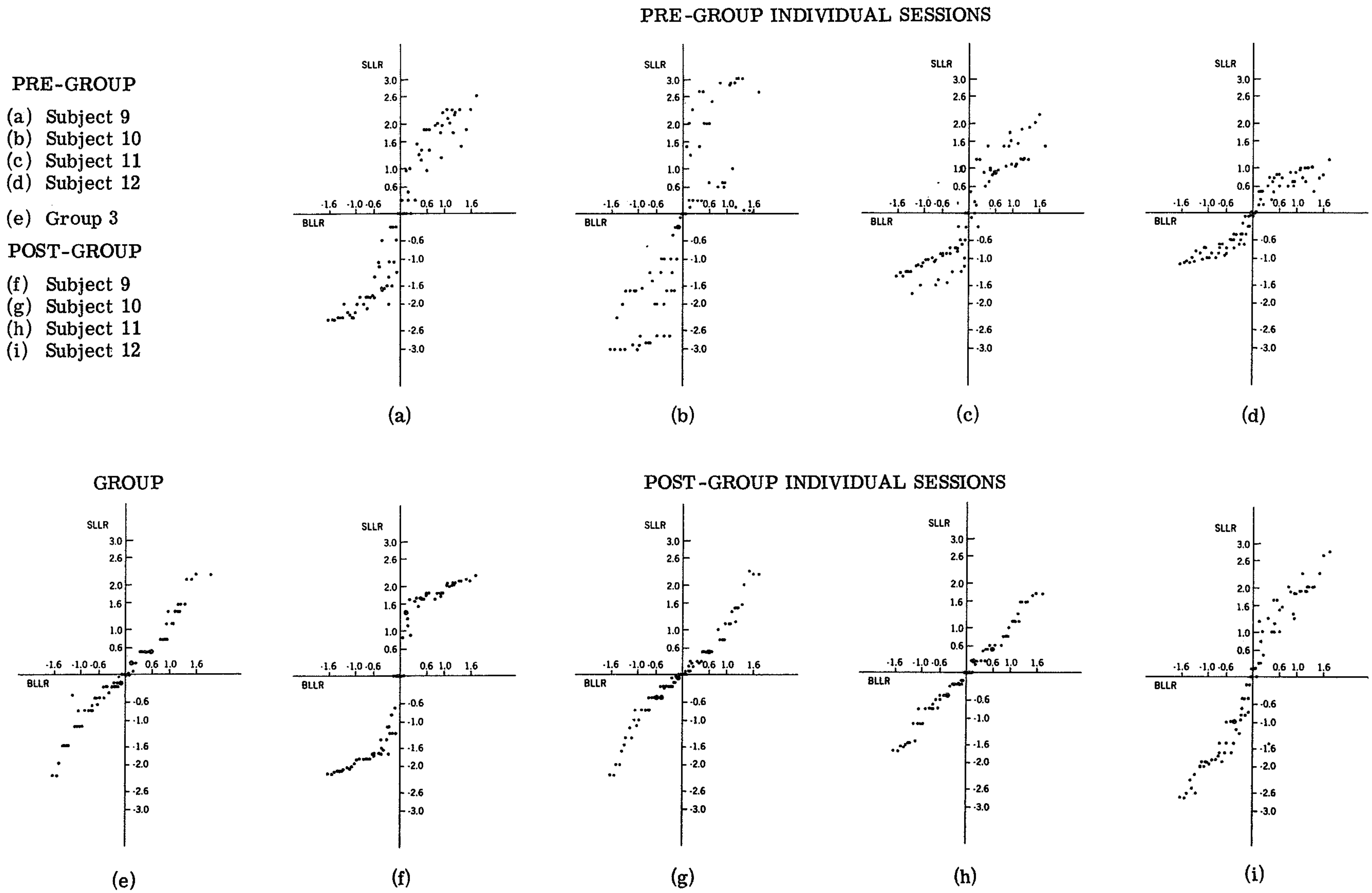


FIGURE 3. LOG LIKELIHOOD RATIO SCATTERPLOTS. Logarithms of the estimated likelihood ratios as a function of the logarithms of the Bayesian likelihood ratios for Group 3 subjects. In the top row are the plots for the pre-group individual sessions. In the bottom row are the group consensus plot and the post-group individual session plots.

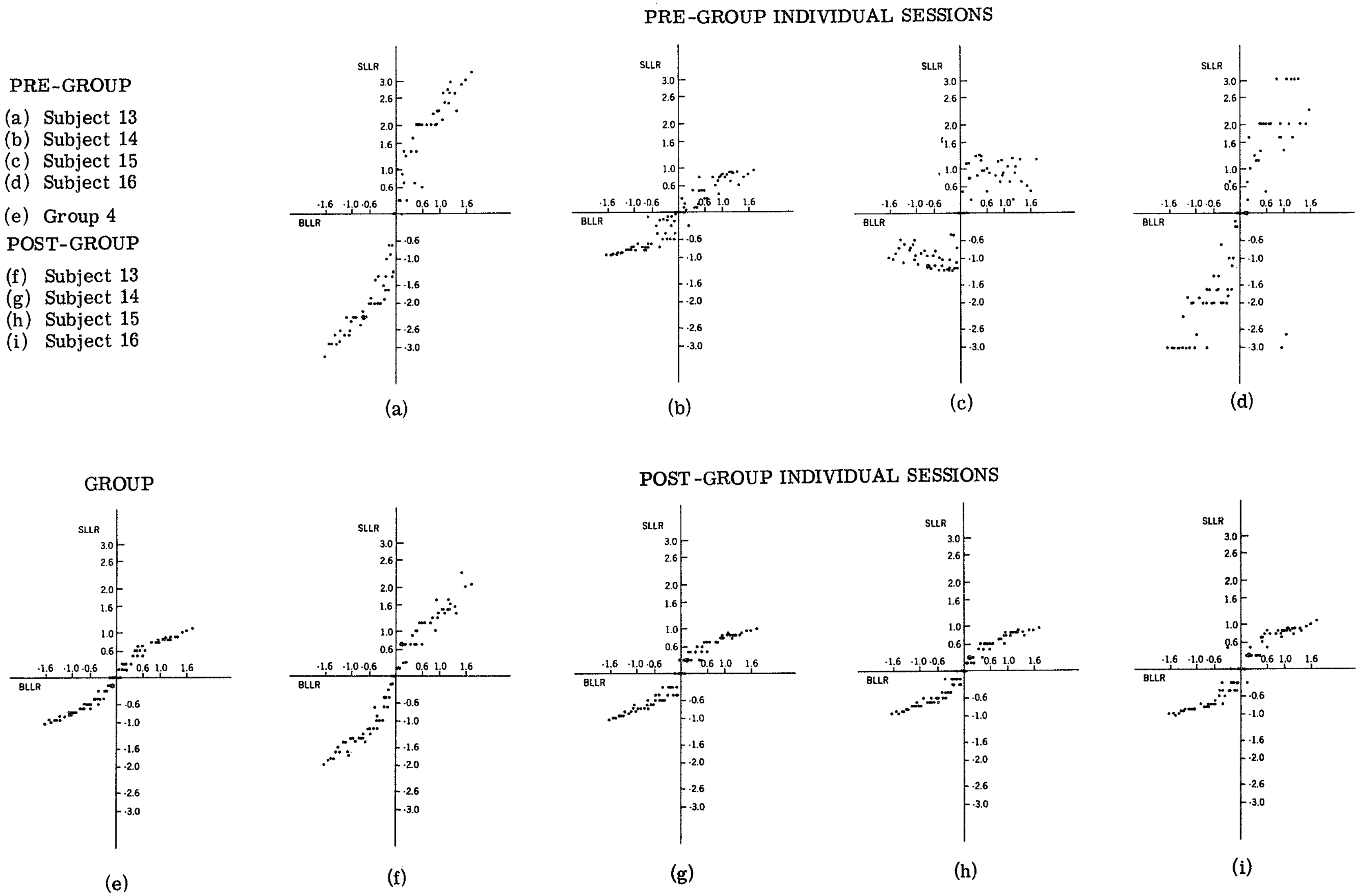


FIGURE 4. LOG LIKELIHOOD RATIO SCATTERPLOTS. Logarithms of the estimated likelihood ratios as a function of the logarithms of the Bayesian likelihood ratios for Group 4 subjects. In the top row are the plots for the pre-group individual sessions. In the bottom row are the group consensus plot and the post-group individual session plots.

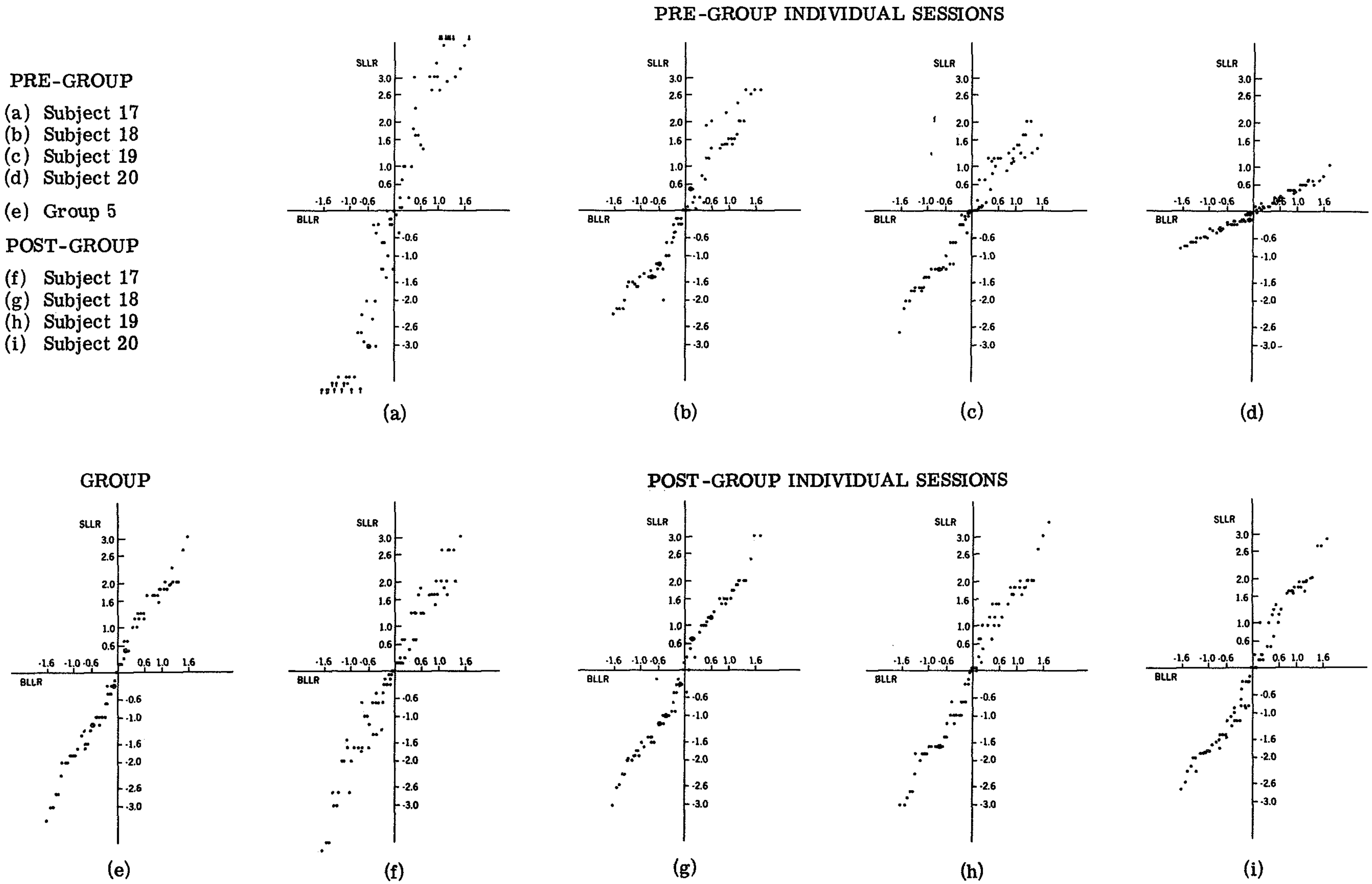


FIGURE 5. LOG LIKELIHOOD RATIO SCATTERPLOTS. Logarithms of the estimated likelihood ratios as a function of the logarithms of the Bayesian likelihood ratios for Group 5 subjects. In the top row are the plots for the pre-group individual sessions. In the bottom row are the group consensus plot and the post-group individual session plots.

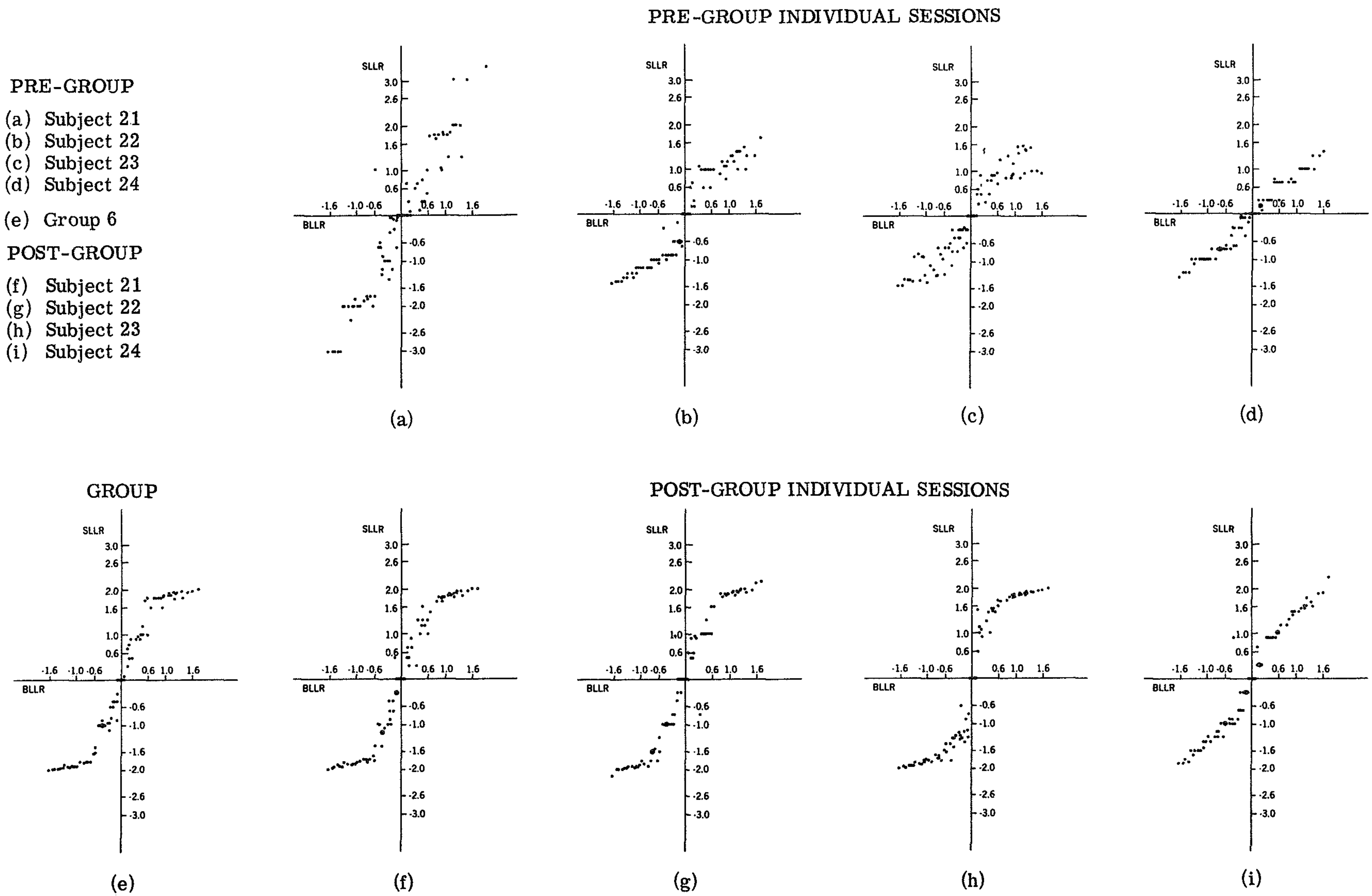


FIGURE 6. LOG LIKELIHOOD RATIO SCATTERPLOTS. Logarithms of the estimated likelihood ratios as a function of the logarithms of the Bayesian likelihood ratios for Group 6 subjects. In the top row are the plots for the pre-group individual sessions. In the bottom row are the group consensus plot and the post-group individual session plots.

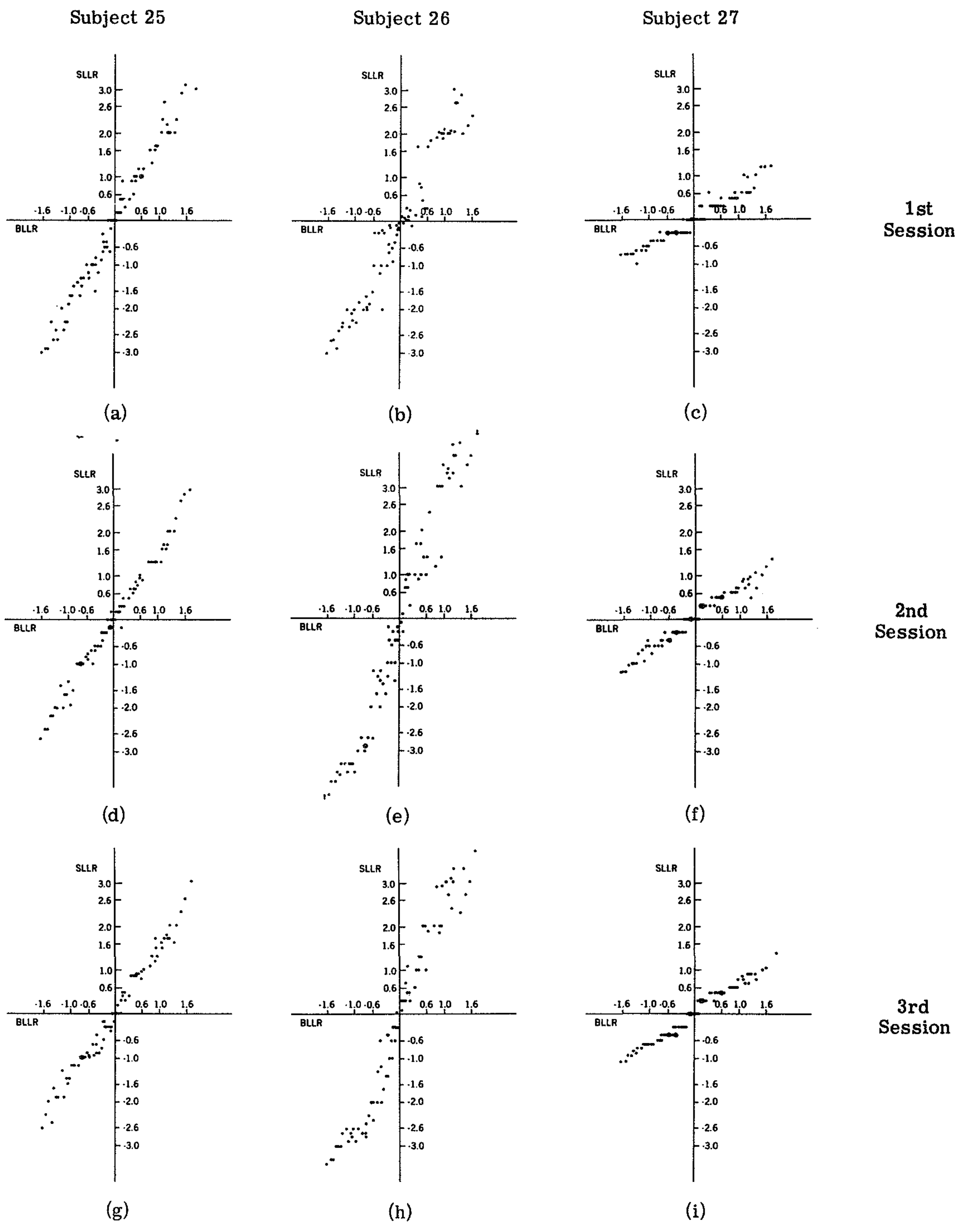


FIGURE 7. LOG LIKELIHOOD RATIO SCATTERPLOTS. Logarithms of the estimated likelihood ratios as a function of the logarithms of the Bayesian likelihood ratios for the three control Ss. In the top row is the plot for each S's first session. In the middle row are the plots for the second sessions. The last row contains the third session plot for each control S.

1st Session	2nd Session	3rd Session
(a) Subject 25	(d) Subject 25	(g) Subject 25
(b) Subject 26	(e) Subject 26	(h) Subject 26
(c) Subject 27	(f) Subject 27	(i) Subject 27

final and initial session LLRs, and between the final and group (or 2nd) session LLRs, as well as the ratios of the two values are shown in Table 5. The greater the value of the ratios shown in Table 5 for the test Ss, the greater the conformity. This ratio was larger than one for 22 of the 24 individuals, and was larger than two for 18. The ratios for the three control Ss indicate that their estimates converged on their own standard in the absence of an external source of information or group norm. The SSDs between the final and initial LLRs clarify the picture even more. These SSDs for the two control Ss with high ratios (#25, #27) are smaller than the corresponding SSDs for almost all of the test Ss.

Action Selection Tasks

Table 6 summarizes the absolute differences between the final and initial session RSTs and between the final and group (or 2nd) session RSTs for the choice dilemma task. Seventeen of the 24 test Ss showed conformity in this task, whereas 22 of the 24 Ss showed conformity in the LR task. Therefore, conformity was greater in the LR task than it was in the choice dilemma task. Similar to the findings in the LR estimation task, the third session individual values for the three control Ss resembled the second session values more closely than they did the first session values.

TABLE 5

SUMS OF SQUARES OF THE DIFFERENCES BETWEEN FINAL AND INITIAL LLRs, AND BETWEEN FINAL AND GROUP (or 2nd Session) LLRs ACROSS THE 79 STICKS; AND THE RATIOS OF THESE TWO SUMS OF SQUARES

Group Number	Subject Number	SSD Between Final and Initial LLRs	SSD Between Final and Group (or 2nd Session)	Ratio of Final, Initial SSD to Final, 2nd Session) SSD
1	1	12.02	2.60	4.63
1	2	31.79	10.72	2.97
1	3	37.08	4.02	9.22
1	4	91.70	17.62	5.20
2	5	10.76	12.45	0.87
2	6	22.18	14.78	1.50
2	7	81.88	24.61	3.33
2	8	40.41	7.63	5.30
3	9	19.20	69.47	0.28
3	10	136.82	1.65	82.96
3	11	23.08	4.44	5.19
3	12	80.36	71.12	1.13
4	13	59.36	27.18	2.18
4	14	3.06	1.34	2.28
4	15	20.52	0.81	25.20
4	16	205.62	6.13	33.53
5	17	143.03	10.84	13.20
5	18	9.67	5.21	1.86
5	19	17.49	3.00	5.84
5	20	89.97	6.86	13.12
6	21	32.26	4.19	7.70
6	22	28.98	8.88	3.27
6	23	37.48	7.24	5.18
6	24	20.08	13.46	1.49
Control	25	12.89	3.57	3.59
Control	26	38.68	25.51	1.52
Control	27	2.81	0.94	2.98

TABLE 6

BETWEEN SESSION ABSOLUTE DIFFERENCES OF

THE RISK SCORE SUM FOR TOTAL PROBLEM SET (RST)

Subject Number	Absolute Difference Between Final and Initial RST	Absolute Difference Between Final and Group (or 2nd Session) RST	Subject Number	Absolute Difference Between Final and Initial RST	Absolute Difference Between Final and Group (or 2nd Session) RST
1	.9#	.1	15	.6	1.2
2	2.3#	1.6	16	2.8#	.5
3	.8#	.6	17	3.1#	.7
4	1.0#	.2	18	.5#	.4
5	1.4#	.7	19	.6#	.2
6	.8#	.7	20	1.7#	1.3
7	.7	1.4	21	.7	1.0
8	.8#	.1	22	.4	.9
9	.8#	.4	23	.9#	.1
10	1.4#	.6	24	.8#	.1
11	1.4#	.9		Control Ss	
12	.2	1.5	25	2.0@	0
13	.6	1.4	26	1.1@	.5
14	.2	1.4	27	1.4@	.8

signifies that the Postgroup minus Pregroup absolute difference is the larger difference, i.e., instances showing conformity

@ signifies that the 3rd Session minus 1st Session absolute difference is the larger difference

Table 7 presents the absolute differences between the final and initial session Average Level of Risk Scores and between the final and group (or 2nd) session ALORs for the gambling task. Eleven of the 22 test Ss showed conformity in this task. Therefore, conformity was least in the gambling task. For four of the five control Ss their third session performance more closely resembled their second than their first performance.

Correlations Between Tasks Within Individual and Groups

Action Selection Tasks (Choice Dilemma and Gambling Tasks)

Many dependent variables are possible when scoring an individual or group performance of choice dilemma problems. Five nonorthogonal dependent variables were studied.

1. Risk Score Sum for Risk Problems (RSR) is the sum of the Risk Scores the individual (or group) selected across the six problems (3-5,7,9,10) for which Stoner (1968) predicted a risky shift.

2. Risk Score Sum for Cautious Problems (RSC) is the sum of the Risk Scores the individual (or group) selected across the six problems (1,2,6,8,11,12) for which Stoner (1968) predicted a cautious shift.

3. Risk Score Sum for Total Problem Set (RST) is the sum of the Risk Scores across all 12 choice dilemma problems. The smaller the value for the above three variables, the riskier is the response.

TABLE 7

BETWEEN SESSION ABSOLUTE DIFFERENCES OF THE AVERAGE LEVEL OF RISK (ALOR)

Subject Number	Absolute Difference Between Final and Initial ALOR	Absolute Difference Between Final and Group (or 2nd Session) ALOR	Subject Number	Absolute Difference Between Final and Initial ALOR	Absolute Difference Between Final and Group (or 2nd Session) ALOR
1	0	1.2	16	4.6#	.4
2	2.4	4.0	17	.4#	.2
3	2.8#	.6	18	5.6#	.2
4	2.6#	0	19	4.4#	.2
5	4.4#	2.2	20	0	.2
6	0	2.2	21	3.6	5.0
8	.4	.8	22	.8#	.4
9	0	1.2	23	.2#	0
10	0	4.8	Control Ss		
11	3.8#	0	7[a]	5.2@	0
12	0	1.2	23[a]	.2@	0
13	4.8#	.2	25	.4	.4
14	0	5.0	26	2.4@	.6
15	.4	.4	27	1.2@	.4

signifies that the Postgroup minus Pregroup absolute difference is the larger difference, i.e., instances showing conformity

@ signifies that the 3rd Session minus 1st Session absolute difference is the larger difference

[a] This _S_ did NOT participate in the group session for this task. _S_ served as an additional control _S_ for this task.

4. Sum of Middle Score Differences (SMD) is the sum of the absolute differences between the individual (or group) Risk Score and 5 across all 12 choice dilemma problems. Considering risk to increase as a function of the dispersion the lesser the value of SMD, the riskier the response.

5. Risk Frequency Score (RFS) is the number of problems in which an individual (or group) response is riskier than those of another individual (or group) summed across all other individuals (or groups). The greater the RFS, the riskier is that individual (or group) relative to others.

In reference to all of the above variables except the SMD, a riskier choice is one in which the probability selected is lower. Individuals and groups were rank ordered on each of the above five variables with respect to risk.

One dependent variable was examined from the scores of individual (or group) performance of the gambling task. This variable is the Average Level of Risk (ALOR) which is the average of the five LORs. Table 8 presents the Spearman Rank Order Correlations between the different measures of risk in the action selection tasks. Since there is little correlation between performance in the two action selection tasks, this line of inquiry has not been fruitful.

Diagnosis Task (LR Estimation Task)

Two nonorthogonal dependent variables were studied.

1. Likelihood Accuracy Ratio (LAR) is the slope of the

TABLE 8

SPEARMAN RANK ORDER CORRELATIONS BETWEEN DIFFERENT MEASURES OF RISK IN THE ACTION SELECTION TASKS

Between Task Comparisons	Pregroup Individuals (27)	Groups (6)
RSR, ALOR	.300	.464
RSC, ALOR	.097	-.522
RST, ALOR	.173	.232
SMD, ALOR	-.203	.058
RFS, ALOR	.267	-.116
Within Task Comparisons		
RSR, RSC	.353	-.086
RSR, RST	.800	.371
RSR, SMD	-.389	-.543
RSR, RFS	.776	.086
RSC, RST	.828	.600
RSC, SMD	-.116	.086
RSC, RFS	.828	.829
RST, SMD	-.322	.371
RST, RFS	.975	.600
SMD, RFS	-.278	-.086

regression line relating subjective log likelihood ratios (SLLR) to the corresponding Bayesian log likelihood ratios (BLLR). The SLLR is estimated and the BLLR calculated. The scatterplot relating SLLR and BLLR contains 79 points, each corresponding to the estimated and Bayesian value for a single blue and yellow stick. The greater the LAR, the less conservative are the subjective estimates.

2. Difference of Final Odds Score (DFO) is the absolute difference of the sum across the 79 sticks of the SLLR values and the sum across the 79 sticks of the BLLRs. It is the difference of the final cumulative odds for the estimated and calculated values resulting from the total sample.

$$DFO = \left| \sum_{j=1}^{79} (SLLR)_j - \sum_{j=1}^{79} (BLLR)_j \right| . \qquad (2)$$

The DFO is a measure of the deviance of individuals (or groups) from the Bayesian value.

Individuals and groups were rank ordered on both of the above variables, with respect to conservatism in the case of the LAR and with respect to the extent of deviation from the Bayesian value in the case of the DFO. Table 9 lists the Spearman Rank Order Correlations between the variables in the diagnosis task and those of the action selection tasks. There is no evidence for a substantive relationship between performance of the diagnosis and action selection tasks. The four

TABLE 9

SPEARMAN RANK ORDER CORRELATIONS BETWEEN MEASURES OF RISK IN THE ACTION SELECTION TASKS AND MEASURES OF PERFORMANCE IN THE DIAGNOSIS TASK

Between Task Comparisons	Pregroup Individuals (27)	Groups (6)
LAR, RSR	-.077	-.314
LAR, RSC	-.207	.086
LAR, RST	-.144	.143
LAR, SMD	-.198	.543
LAR, RFS	-.202	-.086
LAR, ALOR	-.177	-.349
DFO, RSR	.054	.029
DFO, RSC	-.061	.771
DFO, RST	.014	.143
DFO, SMD	-.205	-.371
DFO, RFS	.005	.486
DFO, ALOR	-.060	-.696
Within Task Comparison		
LAR, DFO	.595	-.257

group correlations whose absolute values were greater than .4 are not evidence of a relationship, since the corresponding individual correlations were either opposite in sign or approach zero.

Comparison-Individual And Group Subjective LR Estimates Compared to Bayesian Values

It is possible to grade performance when a task has objective criteria. The LR estimation task is such a task. Behavior is conservative when people do not extract as much certainty from new information as is available within the data. The LAR is the dependent variable used to measure conservatism. Behavior is conservative when the LAR is less than 1, and radical when LAR exceeds 1.

Table 10 presents the means, standard deviations, and ranges of the LARs, correlation coefficients, and intercepts of the SLLR-BLLR analyses for the pregroup individual, group, and postgroup individual sessions of the 24 test Ss.

Table 11 presents the LARs, correlation coefficients, and intercepts of the SLLR-BLLR scatterplots for the 1st, 2nd, and 3rd individual sessions of the three control Ss.

TABLE 10

THE MEANS, STANDARD DEVIATIONS, AND RANGES OF THE REGRESSION ANALYSIS STATISTICS FOR THE PREGROUP INDIVIDUAL, GROUP, AND POST-GROUP INDIVIDUAL SLLR-BLLR SCATTERPLOTS

Analyses	Mean	Standard Deviation	Range
Pregroup Individual			
Correlations	.930	.061	from .744 to .991
LARs	1.546	.640	from .519 to 3.364
Intercepts	- .089	.083	from -.345 to .028
Group			
Correlations	.982	.010	from .963 to .992
LARs	1.457	.383	from .761 to 1.895
Intercepts	.010	.031	from -.042 to .061
Post Group Individual			
Correlations	.963	.026	from .891 to .986
LARs	1.488	.358	from .720 to 2.072
Intercepts	- .010	.050	from -.168 to .081

TABLE 11

REGRESSION ANALYSIS STATISTICS FOR THE SLLR-BLLR SCATTERPLOTS FOR THE THREE CONTROL Ss

Analyses	Subject 25	Subject 26	Subject 27
1st Session			
Correlations	.990	.959	.967
LARs	1.878	2.006	.599
Intercepts	- .039	- .016	.012
2nd Session			
Correlations	.993	.979	.871
LARs	1.563	2.890	.714
Intercepts	.009	- .096	.071
3rd Session			
Correlations	.990	.976	.985
LARs	1.498	2.434	.707
Intercepts	.021	- .107	.026

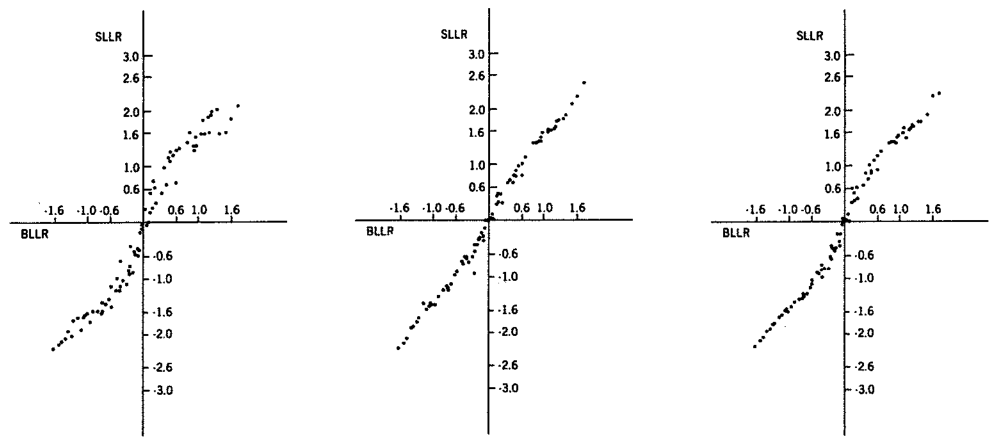
Figure 8 displays the SLLR-BLLR scatterplots for the average pregroup individual, the average group, and the average postgroup individual sessions.

Several conclusions can be drawn from the analyses presented in Tables 10 and 11 and Fig. 8. First of all, the high correlations in all the tables show good qualitative agreement between the estimated LRs and the Bayesian values, i.e, the individuals and groups performed the task well. Secondly, most groups and individuals were not conservative, since most LARs exceeded 1. They tended to err in the radical direction, extracting too much certainty from data presented.

DISCUSSION

Although the results of this administration of the choice dilemma task are not statistically significant, perhaps because a small number of groups were used, they agree with those of Stoner (1968). The repetition of Stoner's findings confirmed the reproducibility of the risky shift under conditions of this study.

The gambling task used in this investigation is the only experiment I know of which includes all of the following conditions: an I-G-I design, unanimous group decisions, and Ss experiencing the consequences of their decisions in all sessions. Although a risky shift was found in each set of gambles, there were, as in the choice dilemma problems, groups showing less risk than the average pregroup individual. In any event, this study demonstrates that a risky shift can occur in an action selection task in



(a) AVERAGE PRE-GROUP INDIVIDUAL

(b) AVERAGE GROUP

(c) AVERAGE POST-GROUP INDIVIDUAL

FIGURE 8. LOG LIKELIHOOD RATIO SCATTERPLOTS. Average of the logarithms of the estimated likelihood ratios as a function of the logarithms of the Bayesian likelihood ratios across the 24 experimental Ss on their pre- and post-group individual session and across the six groups into which these Ss were placed for the group session.

which Ss wager their own money.

The "cultural value" hypotheses offer an explanation for the findings of both the risky and cautious shifts in these action selection tasks. According to Nordhøy (1962) and Marquis, the group discussion influences each person toward those widely held social values that the particular problems evokes within that group. Brown (1965) proposed that there are two ways in which this can occur. First, the flow of information will be influenced by the value under discussion. Once the value is introduced, information in its support is pooled. This makes the total support available to the group for that value greater than the support that was available to any individual. Secondly, in the group setting the individual can compare his position with that of the others. If he believes that he is relatively risk-seeking and he is exposed to opinions that are riskier than his, then he must increase his own risk in order to maintain his conception of himself as being relatively risk-seeking. The converse is true, when the individual believes that he is relatively risk-averse and he is exposed to opinions that are less risky than his own. A third mechanism which may explain particular shifts was proposed by Stoner (1968). He hypothesizes that an individual, when making decisions for himself, is guided by his own values even when they differ from the cultural norms. However, when this same individual takes part in group decisions, he may accept the widely held cultural norms.

Since this study was not designed to test which one, if any, of these mechanisms can account for particular shifts, no specific conclusions can be drawn. However, there was nothing within the group interaction inconsistent with the cultural value explanations.

Instances of risky and cautious shifts were observed in both action selection tasks. Can we really understand or explain these findings without a clear conception of risk itself? Are we measuring shifts on the same dimension?

There are several operational definitions of greater risk. In the choice dilemma problems greater risk is defined as advising the hypothetical person to prefer, with a lower probability of success, a course of action offering a very attractive or poor outcome over a guaranteed intermediate outcome. Lonergan and McClintock (1961) have defined greater risk as choosing to wager a greater stake for a higher possible reward in a gambling game having constant probabilities and an expected value of zero. In Coombs' Portfolio Theory (Coombs & Huang, in press; Coombs & Meyer, 1968) various operations which increase the risk of a bet are specified. These include increasing its range, increasing its variance, decreasing the amount to be won, and increasing the amount to be lost.

A conceptual definition of risk was proposed by Pollatsek and Tversky (1969). They showed that when a set of gambles satisfies a particular set of seven axioms, then the risk of a gamble within this system is a linear combination of the expectation and the variance of the gamble under consideration.

Do these various operational and conceptual usages define and measure the same thing? Has risk been defined exclusive of the conditions under study? If persons who are risk-seekers on one action selection task are also risk-seekers on another such task, there is evidence that both tasks are measuring the same variable. If risk-seeking (or avoidance) does not generalize from task to task, we cannot assume that these tasks are measuring the same value dimensions. Slovic (1962) found low intercorrelations within individuals between different risk taking measures. Similarly, the present study also found small rank order correlations within individuals (or groups) between two action selection tasks, each with a nonambiguous definition of greater risk. Therefore, we must assume that these two tasks were measuring different behavioral characteristics.

At the present time there is no single, generally acceptable definition of risk. Moreover, there is no experimental evidence of a general risk-seeking or risk-averse behavioral trait. Consequently, there cannot exist a general risky shift phenomenon. Each instance of a risky shift must be qualified by the particular operational definition of risk implied by the task under study.

Diagnosis and action selection are two different processes and produce unrelated behavior within the same individuals and groups. The low correlations between performance in the inference task and performance in the action selection tasks support the hypothesis that different processes and different individual and group characteristics might be involved in the performance of the two kinds of tasks.

A striking result of this study was the extent of the conformity in the diagnosis task. This conformity, two weeks after the group session, occurred irrespective of the group performance and of the S's pregroup individual estimates. What caused it? I believe there were two main factors. First of all, the group had to evolve and specify a modus operandi in order to generate unanimous estimates for the 80 sticks. Having established an explicit rule, they remembered it. Secondly, Ss accepted the group rule and were satisfied with it. The informational social influence defined by Deutsch and Gerard (1955) as "an influence to accept information obtained from another as evidence about reality" appears to have been a major influence towards conformity.

Different strategies were used to arrive at a LR estimation rule. Common to all of these strategies was first a sequential appraisal of individual opinion. Then relevant information was discussed. For all groups, but one, there was the realization that it was not possible to calculate the true scale with only the information available to them. Finally, all groups determined that consistency was the primary task requirement. All rules reflected this; so that if a second stick was more blue than the first, then it was more likely for the second stick to have come from the predominantly blue population.

In addition to the group evolving a specific procedure, it enforced the rules to different degrees in different groups. If a member of the group proposed an estimate clearly contrary to the rules, the other members questioned his evaluation of the amount of blue on the stick and/or his selection of the appropriate LR for that amount of blue.

Conformity was greater in the LR estimation task than in either the choice dilemma or the gambling task. This finding supports the hypothesis that Ss were more uncertain about their own responses in this task than in the other tasks, since the most critical task variable influencing the extent of conformity behavior seems to be S's uncertainty about the correctness of his own response (Boomer, 1959; Kelley & Lamb, 1957; Seaborne, 1962; Sherif, 1935; Suppes & Schlag-Rey, 1962; Wiener, 1958; Zajonc & Morrissette, 1960).

The implication of these results for studies in LR estimation is that if you want a task which requires that Ss have confidence in the accuracy of their estimates, then don't use this data generating process with the present displays.

The Ss did a good job of performing the inference task. They understood the nature of the process. They were consistent. Most Ss were also nonconservative. Most groups were nonconservative. This nonconservatism may have resulted from feedback given in the training procedure, or there might be something about this data generating process which encourages people to extract more certainty from information than they should.

Four groups were more conservative than was the average individual within that group on the pregroup session; the other two groups were not. Therefore, it is not possible to conclude from this study whether groups are more or less conservative than individuals.

This study, like many, answers some questions, while raising new questions. If Ss were very uncertain about the correctness of their own responses in a LR estimation task, would it be possible to get a conformity effect without the necessity of the group interaction? A testable hypothesis is that the conformity behavior found in the particular inference task used in this study is due solely to cognitive factors. Suppose one makes available to a S, after he has performed the task alone, a rule which has some authoritative basis and which is consistent with his intuitions about the nature of the task. Then S used this rule in a repetition of the task. Two weeks later, the S repeats the task again. Will he have internalized the rule given to him?

How should we train subjects to translate their intuitions about LRs onto a numerical scale so that they understand the units of measurement, and consequently have confidence in their transformations of subjective judgments into numbers? What training methods, displays and response modes will be useful?

CONCLUSIONS

Individuals and groups differed in performance on two action selection tasks, a choice dilemma task and a gambling task, and one diagnosis task, a likelihood ratio estimation task. Risky and cautious shifts similar to those of Stoner (1968) occurred in the choice dilemma task. Risky shifts occurred for all sets of gambles in the gambling task. The intercorrelations of measures of risk preference between the choice dilemma and the gambling tasks were low. Either there is no general risk-seeking or risk-averse trait, or else either or both of these two tasks did not measure risk preference. There may be no general risk dimension or risk space such that all options involving uncertain outcomes can be ordered within it. The intercorrelations between the measures of performance in the action selection tasks and the measures of performance in the diagnosis task were low. Presumably the two kinds of tasks measure different cognitive processes or behavioral traits. In the likelihood ratio estimation task four groups were more conservative and two groups were less conservative than was the average individual within that group. Thus no conclusions can be drawn regarding the relative conservatism of groups and individuals. A striking conformity effect occurred in the likelihood ratio estimation task. Postgroup performance of most Ss more closely resembled the group's performance than it resembled that S's pregroup estimates. This conformity effect occurred two weeks after the group session with Ss who, during the group session, were not aware that there would be another likelihood ratio estimation session. This conformity is caused by the large amount of response uncertainty inherent in the task.

REFERENCES

Boomer, D. S. Subjective certainty and resistance to change. _Journal of Abnormal and Social Psychology_, 1959, 58, 323-328.

Brown, R. _Social psychology_. New York: Free Press, 1965.

Burnstein, E. An analysis of group decisions involving risk (the "risky shift"). _Human Relations_, 1969, 22, 381-395.

Cartwright, D. & Zander, A. (Eds.) _Group dynamics_. New York: Harper & Row, 1960.

Collins, B. E. & Guetzkow, H. _A social psychology of group processes for decision-making_. New York: Wiley, 1964.

Coombs, C. H. & Huang, L. C. A portfolio theory of risk preference. _Journal of Experimental Psychology_, in press.

Coombs, C. H. & Meyer, D. E. Risk preference in coin-toss games. _Michigan Mathematical Psychology Program Technical Report MMPP 68-1_, 1968, University of Michigan.

Deutsch, M. & Gerard, H. B. A study of normative and informational social influences upon individual judgment. _Journal of Abnormal and Social Psychology_, 1955, 51, 629-636.

DuCharme, W. M. A review and analysis of the phenomenon of conservatism in human inference. _Applied Mathematics and Systems Theory Technical Report_ #46-15, 1969, Rice University.

Edwards, W. Conservatism in human information processing. In B. Kleinmuntz (Ed.) _Formal representation of human judgment_. New York: Wiley, 1968, 17-52.

Edwards, W., Phillips, L. D., Hays, W. L., & Goodman, B. C. Probabilistic information processing systems: Design and evaluation. IEEE Transactions on Systems Science and Cybernetics, 1968, SSC-4, 248-265.

Kelley, H. H. & Lamb, T. W. Certainty of judgment and resistance to social influence. Journal of Abnormal and Social Psychology, 1957, 55, 137-139.

Kogan, N. & Wallach, M. A. Risk taking: A study in cognition and personality. New York: Holt, Rinehart, and Winston, 1964.

Kogan, N. & Wallach, M. A. Risk taking as a function of the situation, the person, and the group. In New directions in psychology III. New York: Holt, Rinehart, and Winston, 1967, 111-278.

Lonergan, B. G. & McClintock, C. G. Effects of group membership on risk-taking behavior. Psychological Reports, 1961, 8, 447-455.

Lorge, I., Fox, D., Davitz, J., & Brenner, M. A survey of studies contrasting the quality of group performance and individual performance, 1920-1957. Psychological Bulletin, 1958, 55, 337-372.

Nordhøy, F. Group interaction in decision-making under risk. Unpublished Masters thesis, Massachusetts Institute of Technology, School of Industrial Management, 1962.

Peterson, C. R. & Beach, L. R. Man as an intuitive statistician. Psychological Bulletin, 1967, 68, 29-46.

Pollatsek, A. & Tversky, A. A theory of risk. *Michigan Mathematical Psychology Program Technical Report MMPP* 69-6, 1969, University of Michigan.

Rettig, S. Ethical risk taking in group and individual conditions. *Journal of Personality and Social Psychology*, 1966, 3, 648-654.

Seaborne, A. E. M. Group influence on the perception of ambiguous stimuli. *British Journal of Psychology*, 1962, 53, 287-298.

Sherif, M. A study of some social factors in perception. *Archives of Psychology*, 1935, 27, No. 187.

Slovic, P. Convergent validation of risk taking measures. *Journal of Abnormal and Social Psychology*, 1962, 65, 68-71.

Slovic, P. The assessment of risk taking behavior. *Psychological Bulletin*, 1964, 61, 220-223.

Stoner, J. A. F. A comparison of individual and group decisions involving risk. Unpublished Masters thesis, Massachusetts Institute of Technology, School of Industrial Management, 1961.

Stoner, J. A. F. Risky and cautious shifts in group decisions: The influence of widely held values. *Journal of Experimental Social Psychology*, 1968, 4, 442-459.

Suppes, P. & Schlag-Rey, M. Analysis of social conformity in terms of generalized conditioning models. In J. Criswell, H. Solomon, & P. Suppes (Eds.) *Mathematical methods in small group processes*. Stanford, Calif.: Stanford University Press, 1962, 334-361.

Wallach, M. A. & Kogan, N., & Bem, D. J. Diffusion of responsibility and level of risk taking in groups. Journal of Abnormal and Social Psychology, 1964, 68, 263-274.

Wiener, M. Certainty of judgment as a variable in conformity behavior. Journal of Social Psychology, 1958, 48, 257-263.

Zajonc, R. B. Conformity. In International Encyclopedia of the Social Sciences. New York: Crowell-Collier, 1968, 253-260.

Zajonc, R. B. & Morrissette, J. The role of uncertainty in cognitive change. Journal of Abnormal and Social Psychology, 1960, 61, 168-175.

---

[1] Analyses for LR and odds responses use logarithmic transformations of the data because the logarithmic transformation of Bayes's theorem results in an equation in which the log likelihood ratio (LLR) is added to the logarithm of the prior odds to obtain the logarithm of the posterior odds. Thus information of a given diagnosticity, LR, on a log scale changes the log of the prior odds a constant amount, irrespective of what the log of the prior odds may be. Neither the LR scale, nor the odds scale, nor the probability scale has this property. Therefore, analyses using untransformed odds and LR scales would result in changes in prior odds, from an application of Bayes's theorem, being dependent upon the size of the prior odds.

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)* University of Michigan, Human Performance Center Department of Psychology, Ann Arbor, Michigan	2a. REPORT SECURITY CLASSIFICATION Unclassified 2b. GROUP

3. REPORT TITLE

Risky Decisions By Individuals and Groups

4. DESCRIPTIVE NOTES *(Type of report and inclusive dates)*

Technical Report, 1970.

5. AUTHOR(S) *(First name, middle initial, last name)*

Barbara C. Goodman

6. REPORT DATE June 1970	7a. TOTAL NO. OF PAGES 51 + viii	7b. NO. OF REFS 31
8a. CONTRACT OR GRANT NO. NGL 23-005-171 b. PROJECT NO. 08901 c. d.	9a. ORIGINATOR'S REPORT NUMBER(S) Technical Report No. 21 9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*	

10. DISTRIBUTION STATEMENT

Qualified requesters may obtain copies of this report from DDC. Others may obtain copies of this report from Office of Technical Services, Department of Commerce.

11. SUPPLEMENTARY NOTES	12. SPONSORING MILITARY ACTIVITY

13. ABSTRACT

This study investigates the shifts between individual and group performance in two action selection tasks and in one Bayesian diagnosis task. 27 male subjects performed each task alone; then were formed into four-man leaderless groups or served as an individual control and repeated each task; and finally performed each task again alone. In all three tasks there were differences in performance between the average individual within a group in the pregroup individual session and the group. A striking conformity effect occurred in the Bayesian diagnosis task. Moreover, both group and individual correlations between measures of performance in all three tasks were low.

Unclassified

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
1. risky shift						
2. decision theory						
3. Bayesian inference						
4. conformity						
5. group decision theory						
6. gambling						

Unclassified

Security Classification

TECHNICAL REPORTS

1. Phillips, L. D. Some components of probabilistic inference. January 1966.
2. Egeth, H. E. Parallel versus serial processes in multidimensional stimulus discrimination. January 1966.
3. Biederman, I. Human performance in contingent information processing tasks. October 1966.
4. Peterson, C. R. & Beach, L. R. Man as an intuitive statistician. November 1966.
5. Martin, E. & Melton, A. W. Recognition memory for CCC and CVC trigrams of various association values. January 1967.
6. Smith, E. E. Choice reaction time: An analysis of the major theoretical positions. January 1967.
7. Reicher, G. M. Perceptual recognition as a function of meaningfulness of stimulus material. February 1968.
8. Ligon, E. The effects of similarity on very-short-term memory under conditions of maximal information processing demands. May 1968.
9. Triggs, T. J. Capacity sharing and speeded reactions to successive signals. August 1968.
10. Tversky, B. G. Pictorial and verbal encoding in short-term memory. October 1968.
11. Lively, B. L. The Von Restorff effect in very-short-term memory. December 1968.
12. Greeno, J. G. How associations are memorized. December 1968.
13. Swensson, R. G. The elusive tradeoff: Speed versus accuracy in choice reaction tasks with continuous cost for time. December 1968.
14. Bjork, R. A. Repetition and rehearsal mechanisms in models for short-term memory. May 1969.
15. Kamlet, A. S. Processing of sequentially presented signals in information-combining tasks. June 1969.
16. Pollatsek, A. W. Rehearsal, interference, and spacing of practice in short-term memory. July 1969.
17. Garskof, M. H. The effect of spacing and variation of repetition in short-term memory. August 1969.
18. Shulman, H. G. Presentation rate, retention interval, and encoding in short-term memory for homonyms, synonyms, and identical words. September 1969.
19. Du Charme, W. M. A responsive bias explanation of conservative human inference. December 1969.
20. McCormack, P. D. Monitoring eye movements during the learning of paired-associate lists. March 1970.

MEMORANDUM REPORTS

1. Fitts, P. M. Cognitive factors in information processing. February 1967.
2. Melton, A. W., Sameroff, A., & Schubot, E. D. Short-term recognition memory. May 1967.
3. Martin, E. Responses to stimuli in verbal learning. October 1967.
4. Melton, A. W. First annual report: Human information handling processes. June 1968.
5. Jahnke, J. C. The Ranschburg paradox. July 1968.
6. Greeno, J. G. Theory of graphs on sets with applications to problem solving and understanding. October 1968.
7. Edwards, W. A bibliography of research on behavioral decision processes to 1968. January 1969.
8. Melton, A. W. Second annual report: Human information handling processes. June 1969.
9. Greeno, J. G. A cognitive interpretation of negative transfer and forgetting of paired associates. November 1969.
10. Martin, E. Associative interference theory and spontaneous recovery. November 1969.