# THE EFFECTS OF DIFFERING SPATIAL ARRANGEMENTS ON PROBLEM SOLVING GROUPS OF VARYING SIZE

---

A Thesis

Presented to

the Faculty of the Department of Psychology

University of Houston

---

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

---

By

Jeffrey S. K. Williams

September, 1978

## ACKNOWLEDGEMENTS

I would like to thank Dr. James Campion for his guidance, his support, and his enduring patience during all phases of this research.

I would also like to express my appreciation to Dr. James Baxter and Dr. Roger Blakeney for their assistance and support as committee members.

Finally, my deep appreciation goes to Janet Penner for her invaluable help and moral support when things got tough.

THE EFFECTS OF DIFFERING SPATIAL
ARRANGEMENTS ON PROBLEM SOLVING
GROUPS OF VARYING SIZE

---

An Abstract of a Thesis
Presented to
the Faculty of the Department of Psychology
University of Houston

---

In Partial Fulfillment
of the Requirements for the Degree
Master of Arts

---

By
Jeffrey S. K. Williams
September, 1978

# ABSTRACT

Group size and the spatial arrangement of group members were systematically varied for subjects working on a unitary, optimizing, disjunctive task. Group process outcomes were predicted to vary according to Steiner's (1972) predictions for tasks of this type. The outcomes that were measured included group solution quality, the time it took the group to reach a consensual decision, group member consensus, self-reported member satisfaction with the group process, and nine member reactions for which predictions were not made. The task was the 'Lost in the Desert' survival situation. Subjects were 240 undergraduate psychology students who worked in circular or rectangular groups of three, five, seven or nine.

None of the hypotheses were confirmed by the data. Member satisfaction showed a significant main effect for size ($F=3.833$, $p$ .05) and a significant interaction between size and shape ($F=3.171$, $p$ .05), but a curvilinear relationship with satisfaction peaking at group size 5 had been predicted. Five of the nine member reaction items showed significant main effects for size. To better control for error, a multivariate analysis of variance (MANOVA) was carried out on the nine member reaction items and showed a significant main effect for size ($F=3.057$, $p$ .001) over these variables. The results were therefore reported and discussed.

Possible explanations for the discrepancies between these results and earlier research were discussed. This task, although very similar to other disjunctive tasks cited in the literature, differs in the level of reality of the survival situation that is specified. The increased feeling of expertise and familiarity with the desert as opposed to the moon

(NASA Moon Exercise) apparently affects the actual group productivity and consensus curves. For this task, it was clear that, as size of the group increased, there was lower member satisfaction, more competition, and greater member heterogeneity. Members of larger groups also felt there was less chance for equal contribution of ideas and that their group was too large for best results on the task.

TABLE OF CONTENTS

LIST OF TABLES

## LIST OF FIGURES

# INTRODUCTION

Small group processes have been of interest to psychologists and others for many years. Primarily because of the many uses of small groups (i.e., decision making, training, communication, persuasion, information presentation, etc.), research has been conducted by individuals from many different fields and specialized branches of those fields. These diverse groups of researchers tend to publish in journals only read by others from the same group and rarely reference authors outside of their particular discipline. As Hoffman (1965) noted in his review of the group problem-solving literature, there has been a notable lack of a continued, consistent and additive effort in the study of small group processes. The typical experimenter does one or two studies on a single facet of the topic with a vaguely described problem no one else has used. He produces suggestive, but inconclusive results, and is never heard from again. In Hoffman's words, "this practice has left the literature on group problem-solving a large conglomeration of unrelated experiments, with only the faintest suggestion of commonality" (p. 127).

The situation is beginning to change. Two major barriers to integrating the literature on group problem-solving were identified by Hoffman in 1965. These were (1) the absence of taxonomies for problem type and subject populations, and (2) the lack of systems describing the cognitive aspects of the problem-solving process. While no progress has been reported to date on the subject population problem, and few attempts have been made to systematically describe the cognitive process (Hackman & Morris, 1975), a taxonomy of group tasks and their relationship to various group outcomes and variables has been presented by Steiner (1972) in his Group Process and Productivity.

In addition to a task taxonomy, Steiner (1972) stressed the integrative role of task demands and group processes. He also evaluated the effects of group size, heterogeneity, and various reward systems on group productivity. Recognizing that "empirical evidence concerning the effect of group size on actual productivity is highly fragmented and incomplete," Steiner indicated that "unambiguous data concerning the shape of the actual productivity curve are not available for any single task . . . . ." (p. 89). He pointed out that researchers commonly compare only two or three group sizes over a narrow range within a single study, and seldom utilize groups of eight or more members. He called for additional research to confirm or deny the conclusions he had reached utilizing the sparse and irregular data available.

Hoffman's (1965) review also noted the emphasis in small group research on identifying and studying barriers to group productivity. Acknowledging the importance of identification of obstacles, he also argued for new research efforts to find and test ways of enhancing group effectiveness. There have been few takers in the dozen years since.

The present research, while admitting to some of the pervasive errors commonly found in small group research (i.e., 'ad hoc' groups of college students), has attempted to utilize the recent developments in the field. The task was selected on the basis of Steiner's taxonomy, is one of the most commonly used types of tasks dealt with by 'real world' problem-solving groups, is objectively scored, and has been of moderate to high interest to a wide range of subjects from organizational and academic populations. Predictions as to the group process involved and the relevant outcomes expected are made on the basis of Steiner's task taxonomy and the available research evidence.

An attempt has also been made in the present research to enhance the performance of groups through manipulation of spatial arrangement. Although related empirical evidence is sparse, the theoretical framework indicates the probability of the reduction of group process losses through changes in this area.

The present study will thus attempt both to expand our knowledge of group process in a much-studied area (group size) by a careful application of Steiner's taxonomy, and to test a little-studied variable (spatial arrangement) designed to enhance the effectiveness of the group process itself.

## LITERATURE REVIEW

Psychologists and others have been concerned with the ways people interact in small groups since the 1920's. The early literature contrasted group and individual problem-solving. It focused on the quality of solutions and generally found groups to be superior. Watson (1928) used 'ad hoc,' or newly-formed, groups of college students given the task of making shorter words from the letters of a large word. He found the group product (number of smaller words) was significantly larger than the average or best individual product.

In a later study, Watson (1929) compared group and individual performances on nine tasks with three equivalent forms of each. Each subject did one form individually, one in ad hoc groups, and then another individually. On all nine tasks, the average achievement of groups was superior to that of average individuals. However, the differences ranged from small and insignificant on reading comprehension tasks to large and significant for completing sentences. This early study highlights the critical nature of the task in determining the problem-solving effectiveness of individuals and groups.

Studies by Shaw (1932), Thorndike (1938a, 1938b), Husband (1940), Timmons (1939, 1942), and Taylor and Faust (1952) further supported the by now fairly well-accepted concept of group superiority over individuals on many types of tasks. The question of what group processes were responsible for this superiority had been tangentially addressed as early as 1934. Wyatt, Frost, and Stock (1934) found that workers' rate of output varied with the output of others in the work group. The closer and more visible the other person, the stronger the effect was. When these individuals were later isolated, the correspondence between their work and others disappeared. Social facilitation, as this effect was called, was therefore identified quite early as a possible key to group superiority.

The debate over individual versus group superiority goes on today, with brainstorming studies from the late 50's and early 60's strongly supporting 'nominal' group (a mathematical combining of an identical number of individual performances into a group score as if the individuals had worked together) superiority over real interacting groups. More recent data now indicates this effect may be task-specific and only significant for certain phases of the problem-solving process (Vroom, Grant, & Cotton, 1969; Van de Ven & Delbecq, 1974; Delbecq, Van de Ven, & Gustafson, 1975; Green, 1975).

Despite this continuing controversy, most current researchers recognize that real world conditions often necessitate the use of an interacting group for problem-solving purposes. Many organizational problems require the input of information resources and/or skill that no <u>one</u> individual possesses, and this information specialization and fragmentation is increasing along with our expanding technology. The different points of view represented by a group may generate the conflict that brings new, creative solutions to problems no one individual would be able to solve (Maier & Thurber, 1969). The participation and interchange of ideas by group problem-solving members also brings about involvement in and acceptance of the solution by the group members, without the need for persuasion from above (Hoffman, Burke, & Maier, 1965). Recognizing the many organizational reasons for the use of interacting groups, many behavioral scientists have been concentrating on discovering the conditions which enhance the effectiveness of problem-solving groups. The structural characteristics of groups have received particular attention.

## GROUP SIZE

Group size has been widely studied for its impact on such group characteristics as cohesiveness (Seashore, 1954), member satisfaction (Miller, 1950), participation (Bales, Strodbeck, Mills, & Roseborough, 1951), leadership behavior (Hemphill, 1950), and productivity (Worthy, 1950). With respect to each of these dependent variables, there appears to be an optimum size beyond which measures of the dependent variable do not increase in direct proportion to the number of members added to the group. Reviewing these studies in 1954, Kelly and Thibaut concluded that as size increases, restraints against effective group interaction appear. Only a small number of members of the group are able to overcome these restraints. Groups of larger size also appear to devote a disproportionate amount of their time to leadership and procedural concerns (Blau & Scott, 1962).

### Group size and productivity

Beginning in 1927, South divided 1312 S's into groups of 3 and 6. Using criteria of accuracy and time to solution, the subjects were assigned to tasks ranging from 'concrete' to 'abstract.' The results indicated the smaller groups were more efficient with abstract problems such as judging emotion from a series of photographs. South concluded that this was due to group members arriving at a decision upon first glance and spending the bulk of the group's time and effort on compromise and persuasion. The larger groups did better with the concrete problems (one correct answer) such as solving bridge situations because of the greater amount of information available in the larger group.

Gibb (1951) used a large subject population to test relative productivity in groups of 1, 2, 3, 6, 12, 24, 48, and 96. The 1132 S's were asked to generate as many solutions as possible in thirty minutes to a series of problems requiring multiple solutions. The results indicated the number of ideas produced increased in a negatively accelerating function of size of group. One criticism of these results is that the time allowed for solution generation was not sufficient to allow the larger groups to exhaust their potential contributions. The curvilinear relationship between group size and actual productivity reported here reflects the fact that the task involved very little interpersonal coordination. Had members of Gibb's groups been required to reach consensus on each suggestion, the larger groups might have been hopelessly cumbersome and probably less effective than the smaller-sized groups. According to Steiner (1972), when tasks are essentially additive (the contributions of group members are summed) and require little interpersonal coordination, a very large number of people can contribute to the group outcome. However, member satisfaction may be threatened even if productivity is not, as Gibb reported that with increasing size an increasing proportion of group members indicated feelings of threat and inhibition.

Taylor and Faust (1952) studied productivity on a "Twenty Questions" task with groups of 1, 2, and 4. Results showed dyads significantly superior to individuals in efficiency, but four-person groups were not superior to dyads except in number of failures to reach solution, one of the three efficiency criterion. It appears the second member of the group added a larger increment of actual productivity than the third and fourth members combined, supporting the curvilinear relationship found in the Gibb (1951) study.

Ziller (1957) asked individuals and groups of from two to six persons to estimate the number of dots on a card displayed for five seconds and select the four facts from a list of fifteen that were most critical in determining the correct answer to a complex problem. The results indicated that as group size increases, the objective quality of performance on both tasks also increased. There was, however, a tendency for this positive relationship to become weaker as more and more members were added to the group. Again this is suggestive of a curvilinear relationship between group size and productivity.

In a review of the group size literature through 1962, however, Thomas and Fink (1963) found only ten experimental studies that examined the impact of size on the quality of group decisions or collective judgements. Many of these studies had severe methodological weaknesses. Unambiguous data concerning the shape of the group productivity curve was not available for any task, and comparison of such curves for different kinds of tasks or populations is a highly speculative process. They concluded that quality of performance and productivity were positively related to group size but only under highly specified conditions, namely, where mechanisms for communication and coordination were readily available or where time was allowed for the group to develop such mechanisms.

A later study by Hackman and Vidmar (1970) using groups of from 2 to 7 members found that group size had negligible effects on group performance.

Bouchard and Hare (1970) studied group productivity on a typical brainstorming task (Thumbs) for groups of 5, 7, and 9. They found no significant differences in productivity in terms of number of ideas produced between the different-sized groups of male college students.

This experiment was later replicated with a different task (the Blindness problem) and mixed-sex groups of 4 and 7 college students (Bouchard, Barsaloux, & Dravden, 1974). The results of both studies indicated that comparably-sized 'nominal' groups of individuals working apart did have significant increases in productivity as group size increased, and concluded that increasing real interacting group size adds very little to performance on brainstorming tasks because of lack of an effective system for time management within these groups.

In his book, <u>Group Process and Productivity</u>, Steiner (1972) reviewed the relationship between group size and potential/actual productivity. He concluded that:

ACTUAL PRODUCTIVITY = POTENTIAL PRODUCTIVITY minus PROCESS LOSSES

Process losses occur when the actual group processes fail to meet the demands the task imposes on the group. The shape of the potential productivity curve and the potential for process losses are a function of the task the group is engaged on, the resources possessed by group members, the appropriateness of the process employed, and the expertise with which the group applies it to the task. For example, most problem-solving or judgemental tasks used in the literature (i.e., Horse-Trading problem, Maier & Solem, 1952) are <u>unitary</u>, in that division of labor into discrete sub-tasks performed by different group members is not feasible; optimizing, in that a most preferred outcome is desired; and disjunctive, in that although different group members may reach different conclusions, the group must endorse a single solution. There is no meaningful way in which different solutions may be added, averaged, or otherwise blended into a group product that is a composite of the views of all members. For a task with these characteristics, Steiner would predict that as group size increases, potential productivity rises at a decelerating rate, while process losses increase at an accelerating rate. The resulting curve of actual productivity would then be curvilinear and parabolic in shape, with group productivity reaching a maximum at some critical level of group size and declining as size increased beyond that level. Steiner concluded that "as the group increases in size, its organizational problems become more difficult to solve in the best possible manner......large groups must discover and establish a procedure for coordinating and combining the efforts of many persons, whereas for small groups the required integrative processes are generally less complex" (p. 83).

Holloman and Hendrick (1971) studied 269 junior and senior Air Force Academy cadets in groups of 3, 6, 9, 12, and 15. The task was a judgemental decision about a film called Twelve Angry Men. This now widely-used task involved the prediction of future behavior of the film's twelve characters. Twelve Angry Men is the story of a jury in which, on a preliminary vote, all the jurors but one feel the defendent is guilty and want to render that verdict without further discussion. The one juror voting 'not guilty' influences the eleven others to his point of view until, one by one, they capitulate to a like verdict. The task is to predict the order in which the eleven jurors will change their positions to 'not guilty.' Individuals independently predicted the order and then convened into their respective groups where they were to work toward a single consensual group decision.

Group decisions were found to be significantly more accurate than averaged individual decisions, but no difference was found between the group decision and the decision of the most accurate member of the group. Analysis of the size variable showed a curvilinear relationship between size and decision quality, with groups of 3 significantly less productive than all other groups and groups of 6 significantly more accurate than groups of 3 or 9. Groups of 12 and 15 were not as accurate as groups of 6, but the difference was not significant. This curvilinear and somewhat parabolic relationship between actual productivity and group size on a unitary, optimizing, disjunctive task supports Steiner's hypothesis.

The groups of 21 and 15 performed better than would have been predicted, but observation by the experimenter may explain this. These groups actually broke up into subgroups, with one subgroup becoming actively involved in the task and the second becoming noticeably passive. This unequal participation led to the active subgroup, which tended to interact much like the groups of 6 did, being primarily responsible for the group's final decision product.

Frank and Anderson (1971) compared groups of 2, 3, 5, and 8 college students on conjunctive and disjunctive tasks in a test of Steiner's (1966) earlier model of group size and productivity relationships. The nine tasks used required no group consensus or implementation procedure, but were examples of Hackman's (1968) 'production' type task, calling for the generation of ideas, images, or arrangements. Conjunctive and disjunctive conditions were created for each task by altering the instructions to the sexually homogeneous groups. The disjunctive instructions essentially stated that the group was to work on the nine tasks in sequence, and as soon as any member had completed the task the group could move on to the next task.

Group productivity was assessed by a simple count of the number of problems completed by the group in 15 minutes (quantity) and a rating by two independent raters on a five-point scale of originality and ingenuity of response (quality). The results showed that increases in group size significantly enhanced quantitative performance on disjunctive tasks of this kind in a linear fashion. No consensus was required for this 'disjunctive' task, thereby inhibiting the effect of process losses because of coordination and communication difficulties found in group situations where a consensual decision is necessary. The raters produced a non-significant inter-rater reliability of .49 on the quality criterion, so little confidence could be placed in this measure.

Cummings, Huber, and Arendt (1974) studied the effects of size and spatial arrangements on group decision making. The 86 graduate and undergraduate business students worked in groups of 3, 4, or 5 on the NASA Moon Exercise. This unitary, optimizing, disjunctive task involves the subjects ranking fifteen survival items in terms of importance. Individuals independently ranked the items, convened into groups operating under consensual group decision rules, and finally, following the group ranking, re-ranked the items as individuals. Results indicated that the quality of group solutions increased with group size over the limited range that was studied.

A later study by Manners (1975) using the same task but a wider range of group size found that group solution quality increased with group size up to a point (N=11) and then began to decrease. This parabolic relationship between group size and productivity is in accord with Steiner's (1972) prediction. Group sizes in this experiment ranged from 2 to 18 in one-member steps, with the 38 groups of high school students averaging slightly over two groups per cell. Time was not measured in this experiment, unlike the three just previously cited. There is also no mention of the sexual breakdown of the sample, and no decision making instructions were given the subjects. Despite these difficulties, the curvilinear, parabolic relationship between size and actual productivity was quite clear (p=.0003) and "knowledge of only two variables, group size and performance of the best member of the group working alone, accounted for 42 percent of the total variance in group problem solving performance" (p. 723).

Thomas and Fink found inconsistent relationships between group size and productivity in 1963, but advances in task definition and taxonomy since that time (Steiner, 1972) and recent research on a particular type of task similar to those most 'real world' interacting groups attempt to solve (Holloman & Hendrick, 1971; Cummings et al., 1974; Manners, 1975) have yielded some hypotheses. For unitary, optimizing, disjunctive tasks, <u>potential</u> productivity should increase along with group size, but at a decelerating rate, while process losses start low but increase at an increasing rate. The resulting parabolic relationship indicates <u>actual</u> productivity reaching a maximum at some group size and then declining as size increases beyond that level due to increasing process losses and smaller proportional increases in productivity. Where the optimum point is and the shape of productivity curves for different tasks and populations is an empirical question only further study can determine.

Group size and member satisfaction

Several studies have focused on the interaction between group size and the satisfaction of the individual group member with the group process itself. Slater (1958) found the optimum group size for high member satisfaction was five. Members of five-person groups of college students made significantly fewer 'too large' complaints than members of six and seven-person groups, and significantly fewer 'too small' complaints than members of two, three, or four-person groups. Large groups were seen by members as lacking effective leadership and communication mechanisms and were prone to extensive conflict. Even though members of small groups expressed no overt dissatisfactions with their groups, behavioral observations indicated a higher level of tension, passivity, and constraint than was seen in members of larger groups.

Carter, Haythorn, Lanzetta, and Mairowitz (1951) reported a study using groups of varying sizes which concluded that in groups of four, individuals have sufficient 'space' in which to express their views, but in larger groups only the forceful are heard.

Hare (1952) and Golembiewski (1962) found that, as group size increases, there is a tendency for groups to form subgroups or cliques. This is an indication of greater potential conflict and possible communication difficulties. Golembiewski (1962) concluded that the smaller the group, the more a member will be satisfied with the group discussion and his part in it.

Shaw (1960) compared the willingness of members of groups of college students to work on "cooperative studying." Members of 'small' groups (2, 3, 4, 5) chose significantly longer articles to abstract than did members of 'large' groups (6, 7, 8). Shaw interpreted this as indicating that the greater the individual's weight in determining the quality of the group outcome, the greater is his incentive to function effectively and the more satisfied he will be with the group product.

However, the group may also be too small. Bales and Borgatta (1955) and O'Dell (1968) found that members of smaller groups tend to feel more tension because of the 'intimate' nature of a small group which inhibits the expression of disagreement. In both studies groups of size two were characterized by high tension and low expressions of hostility.

Thelan (1949) also pointed out that nonparticipation and below average individual effort and performance are especially visible in small groups. This could easily lead to decreased member satisfaction for the below-average group member (dissatisfied with his own performance) and have a disproportionately negative effect on how other group members view the performance of the group as a whole.

Hackman and Vidmar (1970) studied groups of 2, 3, 4, 5, 6, and 7 and found the highest member satisfaction in groups of <u>four</u> and <u>five</u>. Both smaller and larger groups were found to generate less member satisfaction. These results held up in samples from two different populations. The authors speculate that the increased satisfaction associated with intermediate-sized groups may be due to (a) the fact that members of smaller groups (e.g., dyads and triads) feel unusually exposed and, therefore, generally uncomfortable because of their high individual or personal visibility; and (b) the fact that members of larger groups (e.g., six and seven members) are unhappy because of the serious problems of communications and coordination that size generates.

A related area of study concerns odd versus even-sized groups. Maier (1972) found four-member groups working on a human relations problem were inclined to divide into factions, and persuasion rather than cooperation or compromise was usually necessary in the decision-making process.

Frank and Anderson (1971) studied groups of 2, 3, 5, and 8 working on conjunctive and disjunctive tasks. They found significantly higher levels of conflict and greater perceived unpleasantness and alienation in even-sized groups as opposed to odd-sized groups.

The studies reviewed here indicate a curvilinear relationship between group size and member satisfaction with the group process. Currently available evidence indicates the most satisfactory group size to be five or six, with a higher probability for five-member groups because of the lessened conflict generally found in odd-sized groups.

### Group size and member consensus

There is little research evidence on the relationship between group size and the agreement of the individual group member with the group decision (member consensus or acceptance). This could be due to the measurement difficulties encountered in attempting reliable measurement of covert reservations about an overt activity.

Hare (1952) found the degree of member consensus regarding the group decision decreased as his groups of Boy Scouts increased in size from five to twelve.

Cummings et al. (1974) studied groups of 3, 4, and 5 on the NASA Moon Exercise and found no significant differences in member acceptance of the group decision over the admittedly small range of group sizes studied. According to the researchers, the small range of sizes studied, the small number of groups per cell (3 or 4), the unique nature of groups of size 4 (high in conflict, low in consensus), and the interaction of odd versus even-sized groups may have contributed to their lack of a significant size effect.

Manners (1975) studied groups of high school students on the NASA Moon Exercise over a wide range of sizes (2 to 18 members in one-member steps). Despite a small cell size (2+), group size had a significant nonlinear effect on member consensus. This hyperbolic relationship is interpreted by the author to mean that "as a small group adds new members, postdiscussion consensus drops off sharply at first but is soon virtually unaffected or affected only slightly by the addition of new members."

The few studies reviewed here indicate a curvilinear, inverse relationship between group size and member consensus. Recent research suggests a hyperbolic function will best describe this relationship.

SPATIAL ARRANGEMENTS

There is relatively little data available on the effect of spatial arrangements of members within problem-solving groups. The studies that have been conducted, however, provide some fairly consistent evidence that spatial arrangements in groups exert a significant influence on the pattern of member participation and satisfaction with the group process. With one recent exception, little is known about the impact of spatial arrangement upon the efficiency and quality of group problem-solving.

Steinzor (1950) conducted the first major effort to investigate the impact of spatial arrangement on group interaction. He found that people in ten-member discussion groups displayed a strong tendency to communicate with persons across the table facing them rather than with persons directly adjacent to them. This effect, now called the 'Steinzor Effect,' was statistically significant in eleven of fifteen half-hour observations. He concluded that the way individuals are arranged in a small face-to-face group can exert a strong influence on the patterns of communications that develop between individuals within the group.

Hearn (1957) replicated this finding in his three "self-motivated" groups. These groups were assigned a passive leader who acted primarily as a resource agent and never imposed his will on the group. However, there was a reverse tendency to the Steinzor Effect in Hearn's three "trainer-induced" groups. These groups were assigned active participant leaders who critiqued member's performance and urged modification of certain group behavior. In these groups with a strong 'directive' leader, members tended to interact more with their adjacent neighbors than with those sitting across from them. Hearn concluded that leadership style has a significant influence on the interpersonal communication patterns in a group. The greater the formal designation of leadership, the less the tendency for the Steinzor Effect to appear.

Studies by Bass and Klubeck (1952) and Strodtbeck and Hook (1961) support Steinzor's tentative conclusion that mean seating distance is a determinant of leadership emergence in a group.

A major study by Howells and Becker (1962) extended Steinzor's conclusions and provided strong additional evidence that spatial position within a group is an important determinant of leadership emergence. Groups of five were seated at a rectangular table with three persons on one side and two on the opposite side. Seating positions were randomized across subjects. The Steinzor Effect predicted that, in the absence of a strong directive leader, communication would flow across rather than around the table. It was therefore predicted that the two persons on one side of the table would influence the three on the opposite side, whereas the three persons would effectively be able to influence only two. The hypothesis was that spatial position determines the flow of communication which, in turn, determines leadership emergence. The experimental data supported their prediction, as 14 persons from the two-person side emerged as leaders as compared to 6 leaders from the three-person side.

The relationship between individual acceptance of a decision and the amount of individual participation in the decision is supported by several studies. Thibaut and Kelly (1961) conclude that a member's participation in the group decision is the key factor in gaining a member's acceptance of that decision. Barnlund and Haiman (1960) found the amount of <u>actual</u> participation in the decision exhibited by the group member is positively related to acceptance of the decision. French, Israel, and As (1960) found that the amount of perceived participation was positively related to member acceptance, and Hoffman and Maier (1959, 1961) found that member acceptance is related to a feeling of satisfaction with the amount of influence exerted on the group decision. Extension of these findings to Howells and Becker's (1962) work would predict greater member acceptance of and satisfaction with the group decision from the group members on the less populated side of the table. These members would exhibit proportionately greater influence on the group decision because of their seating position and would therefore tend to have a higher acceptance of that decision.

Norum, Russo, and Sommer (1967) examined the interaction between group task and preferred seating arrangement of group members. Under conditions calling for individual work or cooperative effort, group members preferred side-by-side or corner locations. Under conditions calling for competitive effort, however, the subjects preferred to sit across from one another.

Sommer (1965) found similar results with college students acting under similar conditions.

Cummings et al. (1974) arranged their three, four, and five-person groups in 'leader centered' and 'neutral' spatial arrangements. Leader centered groups were arranged such that one position was physically separated from the remaining positions with the latter being equidistant from their neighbors. In the neutral groups all positions were equidistant from their neighbors. Subjects were randomly assigned to their seats. The quality of solutions, group efficiency as measured by time to solution, and member consensus were significantly higher in the neutrally structured groups than the leader centered groups. This study showed that spatial arrangement has a powerful effect on important group problem-solving outcomes for a unitary, optimizing, and disjunctive task, i.e., the most common type of problem addressed by real world interacting groups.

The studies reviewed here support the hypothesis that spatial arrangement has a significant effect on interpersonal communication patterns in a group situation. It also appears that the communication pattern in a group has an effect on the kind and amount of individual member participation in the group decision-making, which is directly tied to individual acceptance of that decision. It is therefore hypothesized that a spatial arrangement designed to yield an interpersonal communication pattern equalizing member participation in the group process would lead to higher member acceptance of the group decision.

Additional evidence concerning member's preferred seating arrangement for different types of personal interaction (cooperative versus competitive) indicate a possible relationship between side-by-side or circular seating versus face-to-face or rectangular seating and group member satisfaction with the group process and product. A rectangular seating arrangement with subjects seated in a face-to-face, across the table configuration may actually generate more competition and conflict than a circular, side-by-side seating arrangement. It is therefore hypothesized that the circular seating arrangement will tend to equalize member participation in the group process and lead to higher member acceptance of the group decision (consensus) and higher member satisfaction with the group process than the rectangular seating arragement.

Interaction between spatial arrangement and group size

According to Steiner (1972), by chance alone large groups tend to be more heterogeneous than small ones in terms of member ability and task-relevant knowledge. This "heterogeneity of task-relevant abilities tends to establish high levels of potential productivity when the task is disjunctive" (p. 130). So, for the type of task to be studied here, as group size increases so does the level of potential productivity because of the greater amount of diverse information new members may bring with them.

However, the larger the group the more similar the most competent and the next most competent group members will be. The range of abilities between best and worst group members increases as group size increases, but in a negatively accelerating fashion. As the group gets larger and more heterogeneous the member-to-member differences in ability and knowledge decrease. The most competent person is then likely to be less unique in large groups, thereby generating more competition for dominance and status. This combination of heterogeneity and homogeneity should expose large groups to the danger of splintering or clique formation (Hare, 1952; Holloman & Hendrick, 1971). Steiner (1972) points out that "similarity in the midst of diversity sometimes permits a high level of potential productivity, but it is likely to be responsible for large process losses" (p. 129).

Certain spatial arrangements tend to inhibit competitive group processes and are used more for cooperative enterprises (Sommer, 1965; Norum et. al., 1967). These spatial arrangements should minimize competition for dominance or status in large groups, thereby minimizing a major source of process loss and enabling the group's actual productivity to more closely approximate its potential productivity. Therefore it is hypothesized that the relationship between group size and productivity will be curvilinear for rectangular, face-to-face spatial arrangements, and linear for conflict-reducing spatial arrangements such as circular, side-by-side seating.

## METHOD

### Research design

Group size and spatial arrangement were manipulated in a 4 X 2 ANOVA design with four levels of group size (three, five, seven, and nine members) and two spatial arrangements (circle, rectangle). The design is depicted in Figure 1. There were 5 replications per cell.

### Task design and selection

The experimental exercise used in this research is, in Steiner's (1972) taxonomy, a unitary, optimizing, and disjunctive task called 'Lost in the Desert.' This task involved the subjects, in the role of survivors of a plane crash in a desert area, individually ranking fifteen items in terms of their relative importance to survival. The subjects are then assigned to a group where they are asked to work together and reach agreement about a group decision on how to rank the survival items. Following the group decision, subjects are asked to rank the items again on an individual basis.

This task was selected because it is representative of the type of problem (Steiner, 1972) most real world interacting groups are called upon to solve. It is a task with a 'most correct' solution (drawn up by desert survival expert Alonzo W. Pond) which the group decision should approximate in order to be effective in terms of quality ('optimizing task'). It is a task where group members are heterogeneous in terms of quality and amount of relevant information possessed. It is a task involving organizational skills (i.e., an overall survival plan must be created out of the situation), synthesis of information, and choice

| SPATIAL ARRANGEMENT | SIZE | | | |
|---|---|---|---|---|
| | 3 Members | 5 Members | 7 Members | 9 Members |
| Circular | | | | |
| Rectangular | | | | |

FIGURE 1

Spatial Arrangement and Size Manipulations behavior (i.e., a 'unitary, disjunctive' task). Finally, the task involves individual's acceptance of the group decision for it to be effective, another common reason for group decision making in organizations.

'Lost in the Desert' was also selected because there is a small but fairly uniform amount of experimental evidence describing similar tasks and the interaction of variables of interest to this study (Holloman & Hendrick, 1971; Steiner, 1972; Cummings et al., 1974; Manners, 1975). This task has also been used extensively in organizational settings, primarily as a training device, with indications of high interest in the problem from a variety of subject populations. A crucial aspect of task performance is the motivational level of the subject, and experience by the experimenter with this particular task both in an academic setting and a training situation in industry has shown evidence of this task's ability to induce high motivation levels in the average subject.

The task is found in Appendix A, together with an analysis of the expert's rankings and the survival strategy to be employed.

## Subjects

Subjects were 240 male and female undergraduate psychology students. They were randomly assigned to treatments, with the provision that all groups should consist of males *and* females. The ratio of males and females was held as closely as possible to one-to-one and counterbalanced within and across treatments. There were 136 females and 104 males in the study.

All of the subjects participated in the experiment during one five day period. This was to minimize possible history, maturation, and practice effects due to dessemination of task information by subjects who had already been through the experiment. The size of the group and the spatial arrangement were randomly distributed through the five days of the study.

## Procedure

Subjects reported to a 'staging area' where they were randomly assigned to a particular group and treatment. Several groups were usually run simultaneously in isolated rooms of appropriate size and arrangement. The number and size of the groups being run depended on room availability and the number of subjects reporting to the 'staging area' at that particular time.

As subjects reported in, name cards were made for them. These cards were shuffled and used to randomly assign seating positions within the groups. After all subjects had reported in, the doors were closed and a taped introductory message was played. The script for this message and the six that follow are in Appendix B. All critical instructions to the subjects were taped to insure equal exposure and minimize the effect of the experimenter.

Subjects were then conducted to the experimental room to which they had been assigned. Here they were instructed to be seated as indicated by the placement of their name tags. The second taped message - an introduction to the survival task - was then played and the task was distributed.

Following the four-minute period in which the subjects familiarized themselves with the task, the subjects received their third taped message. This message described the procedure they were to follow in their individual rankings. They had five minutes for this task.

The fourth taped message was then played. The subjects were instructed to reach a consensual group decision on the rankings of the 15 survival items. The quality of the solution and the speed of arriving at that decision were stressed. It was also indicated that the group should stick together and agree on a survival plan. No time limit was announced. The group was timed from when the first group member started talking to when consensus was reached by all group members on the task.

After a group decision was reached, the subjects were instructed by a fifth taped message to individually re-rank all the survival items. They were given four minutes for this task. The survival task was then collected.

A sixth taped message was now played to ask them for their opinions of and reactions to the group process they had just been through. The member reaction questionnaire was then distributed. The subjects were instructed to raise their hands if they had any questions. They had also been given this opportunity twice before. Only a small percentage (well under 10%) actually asked any questions during these periods. There was no time limit on the questionnaire. Most subjects finished within four minutes and none took longer than seven minutes.

After the questionnaire was completed and collected, the seventh and final taped message was played. This was a debriefing message designed to thank them for participating and to inform them about the complete debriefing they would receive later. The experimental credit slips were then distributed and the subjects dismissed.

Dependent variables

Four dependent variables were examined. Two focused directly upon the group's actual productivity, one focused upon the amount of consensus achieved among the members of the group, and one is self-report of member satisfaction with the group process.

A. Performance Measures

(1) Quality of solution: the degree to which a given group's ranking of survival items corresponds with the 'correct' item ranking generated by a desert survival expert. This is a summation of the absolute differences between each item's group rank and the correct rank assigned to that item by the expert. The lower the score the higher the solution quality.

(2) Time to solution: the amount of time (in minutes) for a given group to reach consensus concerning the appropriate solution to the assigned ranking task.

B. Member Consensus and Satisfaction

(1) Member consensus: the degree to which group members final individual rankings coincide with the ranking agreed on by the group. This is a summation of the absolute differences between each item's group rank and the individual's re-rank of that item. The individual consensus scores were also averaged to obtain a group consensus score. The lower the score the higher the consensus.

(2) Member satisfaction: the degree to which the individual group member is satisfied with the actual group process. This was assessed immediately following the final individual re-rank by means of a brief questionnaire. This instrument, together with an explanation of the scoring system used, is found in Appendix C.

Individual satisfaction scores were also averaged to obtain a group satisfaction score. The higher the score the higher the member satisfaction.

Hypotheses

The hyopstheses that were investigated explored the effects of varying size and spatial arrangements on group process outcomes. Specifically, it was predicted that:

Hypothesis Ia: The quality of solutions generated by a group is a positive, linear funcion of the group's size for groups in a circular arrangement.

Hypothesis Ib: The quality of solutions generated by a group is a positive, but negatively accelerating (curvilinear) function of the group's size for groups in a rectangular arrangement.

Hypothesis II: The problem-solving speed of a group is a negative function of a group's size.

Hypothesis IIIa: Member consensus is a negative function of the group's size.

Hypothesis IIIb: Member consensus is higher for groups in a circular arrangement than for groups in a rectangular arrangement.

Hypothesis IVa: Member satisfaction is higher for groups in a circular arrangement than for groups in a rectangular arrangement.

Hypothesis IVb: Member satisfaction has a positive parabolic relationship with group size, with groups of 5 significantly higher in member satisfaction than groups of 3 or 9.

Hypothesis V: Acceptance of the group decision (individual consensus scores) is higher for those subjects sitting on the less populated side of the rectangular table as compared to those on the opposite side of the table.

Data Analysis

All hypotheses were examined with a 4 X 2 analysis of variance model, with each appropriate dependent variable in turn serving as the criterion variable. In assessing the significance of the F-ratio, the .05 level of significance was employed. With the exception of Hypothesis IVb, which involved planned comparisons, post hoc analysis of mean differences employed the S-method of multiple comparisons (Scheffe, 1959). This method is quite conservative, as any number of comparisons made will retain the same level of significance. It is also exact for groups of unequal sizes and the recommended method (Myers, 1972) for complex, non-pairwise comparisons. Scheffe (1959) suggest the adoption of the .10 level of significance when employing his method. His suggestion was followed in this study.

# RESULTS

## Solution Quality

Hypotheses Ia and Ib predicted that solution quality of the group decision would increase as a function of group size, with a linear function describing the groups in a circular arrangement and a curvilinear and negatively accelerating function describing the groups in a rectangular arrangement. The results are presented in Table 1. There were no significant main effects due to size or shape and the interaction was not significant. Differences between the group means were not significant nor were they in the predicted direction. Therefore, Hypothesis Ia and Hypothesis Ib were not supported.

## Time to Solution

Hypothesis II predicted that the time it takes to arrive at a group solution would be a positive function of the group's size. The results are presented in Table 2. There were no significant effects due to size, shape, or interaction between the two variables. Therefore, Hypothesis II was not supported.

## Member Consensus

Hypothesis IIIa predicted that member consensus is a negative function of the group's size. The results are presented in Table 3. There was no significant main effect for size. Therefore, Hypothesis IIIa was not supported.

Hypothesis IIIb predicted that groups in a circular arrangement would be higher in member consensus than groups in a rectangular arrangement.

TABLE 1

Analysis of Variance and Means for Solution Quality

| Source of variance | df | MS | F |
|---|---|---|---|
| Size | 3 | 14.025 | .098 |
| Shape | 1 | 11.025 | .077 |
| Size X Shape | 3 | 319.158 | 2.225 |
| Within cells | 32 | 143.450 | |

| Shape | Size | | | | Across Size |
|---|---|---|---|---|---|
| | 3 members | 5 members | 7 members | 9 members | |
| Circular | 68.6 | 66.8 | 55.6 | 58.0 | 62.3 |
| Rectangular | 60.4 | 58.0 | 69.2 | 65.6 | 63.3 |
| Across Shape | 64.5 | 62.4 | 62.4 | 61.8 | 62.8 |

TABLE 2

Analysis of Variance and Means for Time to Solution in Minutes

| Source of variance | df | MS | F |
|---|---|---|---|
| Size | 3 | 59.366 | 1.006 |
| Shape | 1 | 140.813 | 2.387 |
| Size X Shape | 3 | 84.000 | 1.424 |
| Within cells | 32 | 58.991 | |

| Shape | Size | | | | Across Size |
|---|---|---|---|---|---|
| | 3 members | 5 members | 7 members | 9 members | |
| Circular | 15.65 | 20.40 | 26.39 | 15.50 | 19.50 |
| Rectangular | 14.35 | 17.05 | 14.48 | 17.04 | 15.73 |
| Across Shape | 15.00 | 18.72 | 20.43 | 16.27 | 17.84 |

TABLE 3

Analysis of Variance and Means for Member Consensus

| Source of variance | df | MS | F |
|---|---|---|---|
| Size | 3 | 252.159 | 1.335 |
| Shape | 1 | 1.838 | .010 |
| Size X Shape | 3 | 200.484 | 1.061 |
| Within cells | 232 | 188.931 | |

| Shape | Size | | | | Across Size |
|---|---|---|---|---|---|
| | 3 members | 5 members | 7 members | 9 members | |
| Circular | 11.87 | 20.64 | 19.46 | 21.24 | 19.42 |
| Rectangular | 18.40 | 22.24 | 19.20 | 17.91 | 19.25 |
| Across Shape | 15.13 | 21.40 | 19.33 | 19.58 | 19.34 |

The results are presented in Table 3. There was no significant main effect for shape. Therefore, Hypothesis IIIb was not supported.

Hypothesis V was not analyzed due to difficulties during the data collection phase of the experiment. Subjects were not accurately coded as to their seating postions, thereby rendering the data useless for any further analysis.

Member Satisfaction

Hypothesis IVa predicted higher satisfaction for individuals in a circular arrangement than for individuals in a rectangular arrangement. The results are presented in Table 4. There was no significant main effect for shape and differences between group means were not in the predicted direction. Therefore, Hypothesis IVa was not supported.

Hypothesis IVb predicted a positive, parabolic relationship with group size, with member satisfaction being highest for groups of 5 and lowest for groups of 3 and 9. The results are presented in Table 4. There was a significant main effect for group size ($F=3.833$, $p<.01$) and a significant interaction between group size and spatial arrangement ($F=3.171$, $p<.05$). However, the planned comparisons between the group means for sizes 3 and 9 versus size 5 were not significant, nor were they in the predicted direction. Therefore, Hypothesis IVb was not supported.

Inspection of the means in Table 4 indicates that satisfaction with the group process generally declines as group size increases (main effect), except for a substantial drop for groups of size 7. Average satisfaction is actually higher for groups of 9 than for groups of 7. Examination of the appropriate means, however, indicates that the cause

TABLE 4

Analysis of Variance and Means for Member Satisfaction

| Source of variance | df | MS | F |
|---|---|---|---|
| Size | 3 | 4.301 | 3.833** |
| Shape | 1 | 1.067 | .951 |
| Size X Shape | 3 | 3.558 | 3.171* |
| Within cells | 232 | 1.122 | |

*p<.05 , **p<.01

| Shape | Size | | | | Across Size |
|---|---|---|---|---|---|
| | 3 members | 5 members | 7 members | 9 members | |
| Circular | 5.20 | 5.20 | 4.31 | 5.00 | 4.87 |
| Rectangular | 5.60 | 5.00 | 5.03 | 4.78 | 5.00 |
| Across Shape | 5.40 | 5.10 | 4.67 | 4.89 | 4.93 |

of this drop is due to the circular groups alone. The S-method of multiple comparisons (Scheffe, 1959) was applied to this data, and showed significant differences between the 7-person circular groups and all other groups combined ($p<.05$) and the 7-person circular groups and all other circular groups ($p<.10$). This unusual satisfaction score for the 7-person circular groups probably accounts for the significant size by shape interaction found in the overall F-test.

Additional Analyses: Member Reactions

In addition to an overall evaluative measure of member satisfaction with the group process, nine additional questions were asked to assess member reactions to other group process phenomena. These questions, together with an explanation of the scoring system, are in Appendix A. The member reaction items were derived from previous research (Hackman & Vidmar, 1970) and a priori speculation. No specific predictions were made as to the expected member reaction outcomes.

To better control for the error that could be introduced by treating each member reaction as an independent criterion measure, a multivariate analysis of variance (MANOVA) was carried out on the nine member reaction items plus the overall satisfaction item from the questionnaire. The results of the MANOVA showed that there is a significant main effect for group size ($F=3.057$, $p<.001$) over these ten dependent variables.

Five of the member reaction items and the overall satisfaction item had significant univariate F-tests for group size. Member reaction 7 ("This group is too small...") and member reaction 8 ("Everyone got an equal chance to contribute their ideas...") were significant at the $p<.001$

level. Member reaction 1 ("This group is too large...") was significant at the $p<.005$ level. Member reaction 2 ("...more cooperation than competition...") and member reaction 3 ("...differences in ability and competence...") were significantly affected by group size at the $p<.05$ level.

The results of the MANOVA for spatial arrangement showed that although one member reaction item showed a significant main effect for shape, the overall main effect for the ten items was not significant ($p<.18$).

The same analysis for the interaction of size and spatial arrangement yielded a nonsignificant but suggestive interaction effect ($p<.08$). Two of the three significant univariate interactions found were marginal ($p<.05$) and are not reported. The third significant interaction was reported for the following reasons. First, the variable in question is the overall satisfaction item, for which predictions concerning both size and spatial arrangement were made. No predictions were made for the nine member reaction items. Secondly, post hoc analysis with the S-method yielded significant results which supported the interaction. Finally, the univariate interaction was better than marginally significant ($p<.025$).

Member reaction 1 ("This group is too large...") and member reaction 7 ("This group is too small...") reflect opposing types of general disatisfaction with group size. Table 5 presents the analysis of variance results for both variables. For member reaction 1 there was a significant main effect for group size ($F=5.115$, $p<.005$). For member reaction 7 there was a significant main effect for group size ($F=9.789$, $p<.001$). The appropriate group means for the two variables are presented in Table 6. A low score indicates agreement with the item (too small or too large) and low satisfaction with the size. Inspection of the means in Table 6 shows

TABLE 5

Analysis of Variance for Member Reactions 1 and 7

| Source of variance | df | MS | F |
|---|---|---|---|
| Size | 3 | 4.528 | 5.115*** |
| Shape | 1 | .038 | .042 |
| Size X Shape | 3 | 2.361 | 2.667 |
| Within cells | 232 | .885 | |

***$p < .005$

MR #1
(too large)

| Source of variance | df | MS | F |
|---|---|---|---|
| Size | 3 | 8.078 | 9.789**** |
| Shape | 1 | .004 | .005 |
| Size X Shape | 3 | 1.039 | 1.259 |
| Within cells | 232 | .825 | |

****$p < .001$

MR #7
(too small)

TABLE 6

Means for Member Reactions 1 and 7

MR #1 (too large)

| Shape | Size 3 members | 5 members | 7 members | 9 members | Total Size |
|---|---|---|---|---|---|
| Circular | 5.60 | 5.04 | 4.97 | 4.93 | 5.05 |
| Rectangular | 5.33 | 5.12 | 5.49 | 4.64 | 5.08 |
| Total Shape | 5.47 | 5.08 | 5.23 | 4.79 | 5.06 |

MR #7 (too small)

| Shape | Size 3 members | 5 members | 7 members | 9 members | Total Size |
|---|---|---|---|---|---|
| Circular | 4.40 | 5.28 | 4.94 | 5.18 | 5.03 |
| Rectangular | 4.00 | 5.04 | 5.20 | 5.22 | 5.03 |
| Total Shape | 4.20 | 5.16 | 5.07 | 5.20 | 5.03 |

an increase in "too large" agreement as size increases and an increase in "too small" agreement as the size of the group decreases.

A method proposed by Hackman and Vidmar (1970) for determining the optimal group size is to plot both scores, in standardized form, with group size on the abscissa and satisfaction on the ordinate. The intersection of the plots indicates the point of optimal reported satisfaction with the size of the group. This plot is presented in Figure 2. According to this method, the optimal group size for this task would be between 5 and 7 members.

Member reaction 8 ("Everyone got an equal chance to contribute their ideas...") showed a significant main effect for group size ($F=10.189$, $p<.001$). The means in Table 7 show a reported decline in "chance to contribute ideas" as group size increases.

The results for member reaction 2 ("...more cooperation than competition...") are presented in Table 8. There was a significant main effect for group size ($F=3.069$, $p<.05$). Examination of the means indicates a reported decline in cooperation and/or a rise in competition as group size increases.

Table 9 contains the analysis of variance and means for member reaction 3 ("...differences in ability and competence..."). There was a significant main effect for group size ($F=2.885$, $p<.05$), indicating that as groups increase in size they are perceived as more heterogeneous by their members.

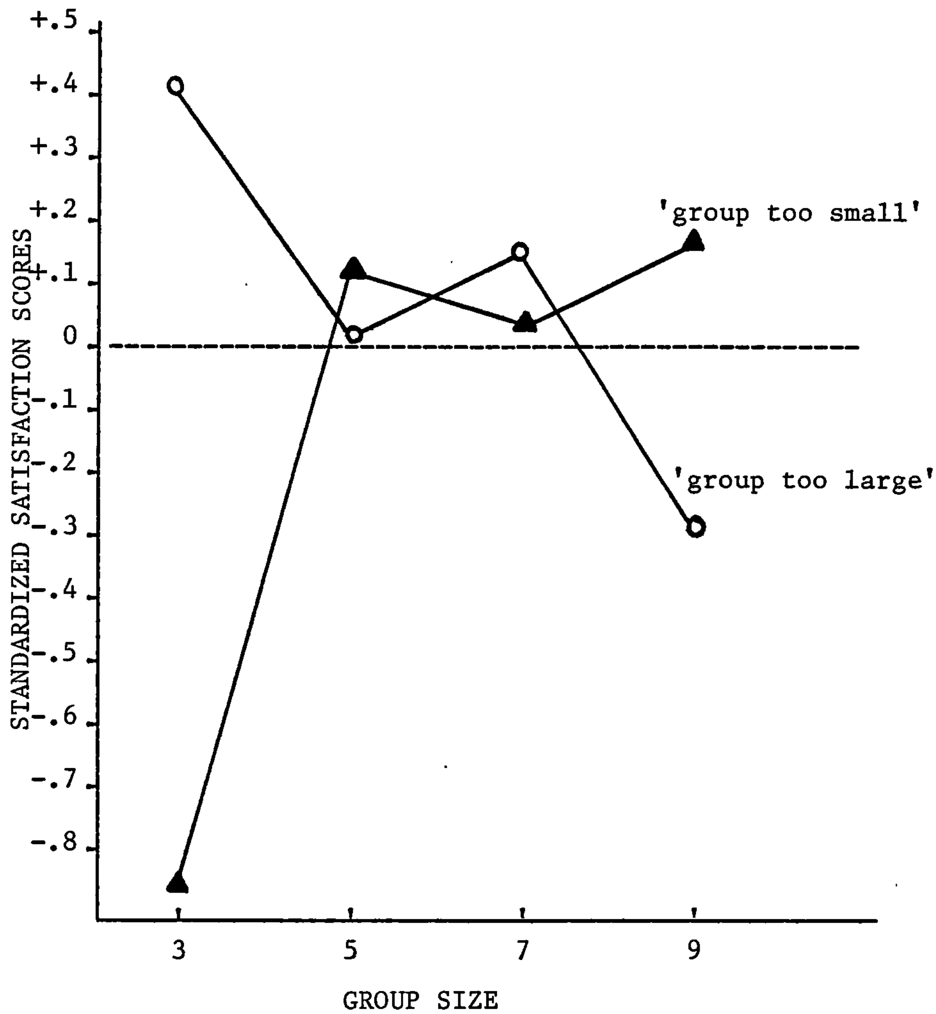


FIGURE 2

Reported Satisfaction with Group Size

TABLE 7

Analysis of Variance and Means for Member Reaction 8
"equal chance to contribute ideas"

| Source of variance | df | MS | F |
|---|---|---|---|
| Size | 3 | 16.447 | 10.189**** |
| Shape | 1 | .817 | .506 |
| Size X Shape | 3 | 2.846 | 1.763 |
| Within cells | 232 | 1.614 | |

****p<.001

| Shape | Size<br>3 members | <br>5 members | <br>7 members | <br>9 members | Total Size |
|---|---|---|---|---|---|
| Circular | 5.40 | 4.68 | 4.71 | 4.47 | 4.70 |
| Rectangular | 5.87 | 4.92 | 4.66 | 3.91 | 4.58 |
| Total Shape | 5.63 | 4.80 | 4.69 | 4.19 | 4.64 |

TABLE 8

Analysis of Variance and Means for Member Reaction 2
"more cooperation than competition"

| Source of variance | df | MS | F |
|---|---|---|---|
| Size | 3 | 4.154 | 3.069* |
| Shape | 1 | .600 | .443 |
| Size X Shape | 3 | 3.629 | 2.681 |
| Within cells | 232 | 1.353 | |

*p<.05

| Shape | Size<br>3 members | <br>5 members | <br>7 members | <br>9 members | Total<br>Size |
|---|---|---|---|---|---|
| Circular | 5.13 | 4.60 | 4.37 | 4.96 | 4.73 |
| Rectangular | 5.40 | 4.72 | 4.66 | 4.31 | 4.63 |
| Total Shape | 5.27 | 4.66 | 4.51 | 4.63 | 4.68 |

TABLE 9

Analysis of Variance and Means for Member Reaction 3
"homogeneity of group members"

| Source of variance | df | MS | F |
|---|---|---|---|
| Size | 3 | 5.765 | 2.885* |
| Shape | 1 | .338 | .169 |
| Size X Shape | 3 | 2.161 | 1.081 |
| Within cells | 232 | 1.998 | |

*p<.05

| Shape | Size 3 members | 5 members | 7 members | 9 members | Total Size |
|---|---|---|---|---|---|
| Circular | 3.80 | 3.76 | 2.89 | 3.40 | 3.38 |
| Rectangular | 4.07 | 3.32 | 3.46 | 2.91 | 3.30 |
| Total Shape | 3.93 | 3.54 | 3.17 | 3.16 | 3.34 |

# DISCUSSION

## Group Size and Solution Quality

Contrary to expectations, changes in group size had no significant effect on overall productivity on this task. Productivity was measured by the quality of the group's decision. Although the research evidence linking group size with group productivity is somewhat inconsistent (Thomas & Fink, 1963), recent research utilizing a task that is very similar to the task used in this study found significant relationships between the two variables (Cummings et. al., 1974; Manners, 1975). Examination of Figure 3 may help to clarify the conflict.

The Cummings et. al. study used groups of 3, 4, and 5, and found that solution quality increased as group size increased from 3 to 5. Figure 3 indicates that there is a similar but nonsignificant trend in this study, with both circular and rectangular groups showing an improvement in solution quality as size increases from 3 to 5. Beyond this point, however, average solution quality increases only slightly.

An explanation for the relative insensitivity of the group's decision quality score to changes in the group size may lie in the nature of the task. Both the NASA Moon Exercise used in the Manners and Cummings et. al. studies and the Lost in the Desert task used in this study are unitary, optimizing, and disjunctive tasks. They both ask the subject to rank fifteen items in terms of their relative importance for survival. The steps in the task are identical to each other and occur in the same order. They should be as nearly comparable as tasks are. There is one crucial difference, however. In one task they are placed on the moon; in the other they are placed on a desert area in the southwest U.S.

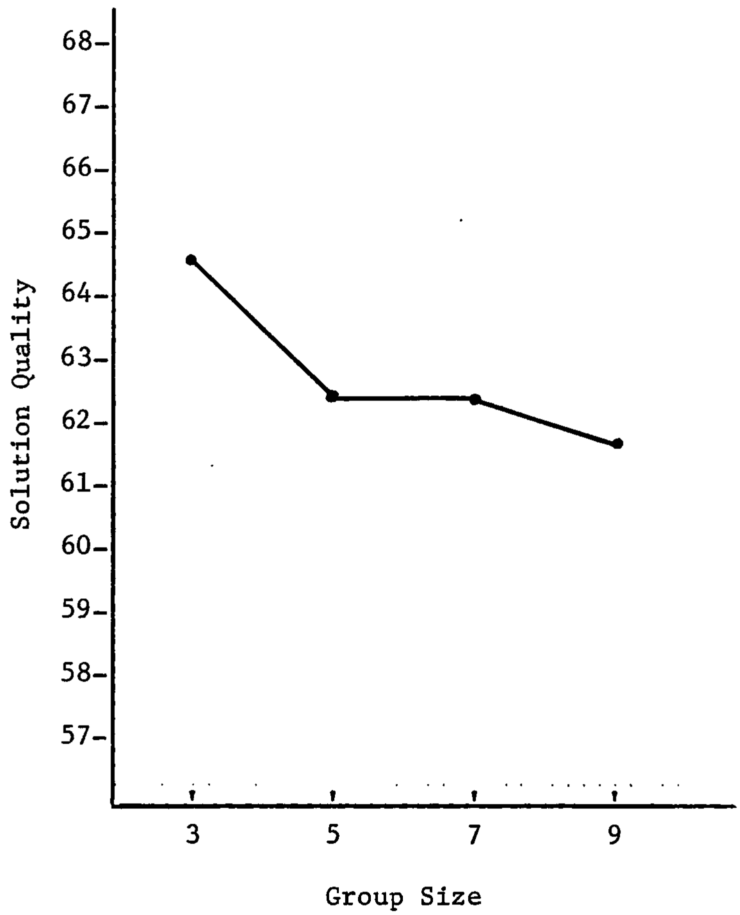


FIGURE 3

Group Size and Solution Quality

According to Cummings et. al., the NASA task requires remembering specific science-related information. There is "a higher probability that someone in a large group will remember essential pieces of information than will someone in a small group." The key word here is 'remember.' Observation by the experimenter during prior work with the NASA task indicates a general willingness on the part of the subjects dealing with this situation to accept without question whatever 'science-related information' is put forward by other group members. The principal work of the group involves (1) remembering relevant information about the items and (2) deciding how to best utilize the items in this situation. The conflict that occurs during this task almost always involves (2). The subjects do not often promote themselves as experts in this situation, and in general tend to adopt a detached, objective viewpoint. Being on the moon is a somewhat alien, unreal situation to them.

The desert survival situation, on the other hand, is much more realistic and possible for the subjects. A group member's information about a survival item is often hotly debated with other group members, who may also consider themselves 'experts' on the item or the overall situation. Group acceptance of the information about an item's survival value is often difficult to achieve. The contrast between the two tasks is analagous to a group of people being presented with a general question concerning physics and a general question about psychology. For the answer to the physics question, the group draws on the memories of its most knowledgeable members and presents the answer it obtains. This search for information is sharply contrasted with the same group's behavior in response to the psychology question. Here everyone considers himself, if not an expert, at least well-informed. The mode of operation now becomes persuasion; and the search for consensus is now the goal.

This line of reasoning would predict the sort of results for this task that were obtained. As size increases, the potential amount of relevant information about the survival task increases. However, the difficulties involved in reaching consensus about that information also multiply. As Steiner (1972) would put it, process losses on the desert survival task accelerate more rapidly than on the NASA Moon task. The potential productivity curves should be similar, but the actual productivity curves are different because of the differences in the rate of the process losses.

## Group Size and Speed

Prior research suggests that the time it takes a group to reach a consensual decision will increase as the size of the group increases. The data in this study did not confirm this hypothesis. Examination of Figure 4, however, indicates that, as group size increased from 3 to 7, time to solution tended to increase. Then, as group size increased from 7 to 9, the time to solution decreased somewhat.

A possible explanation for this could be the increased likelihood of larger groups to form sub-groups (Hare, 1952; Holloman & Hendrick, 1971). This would result in a group of 9 functioning as if it were a much smaller active group with another group of essentially passive members. This sort of group would then reach consensus in less time than was predicted.

## Group Size and Member Consensus

Figure 5 shows average member consensus plotted against group size, with a low score indicating high consensus. It can be seen that consensus

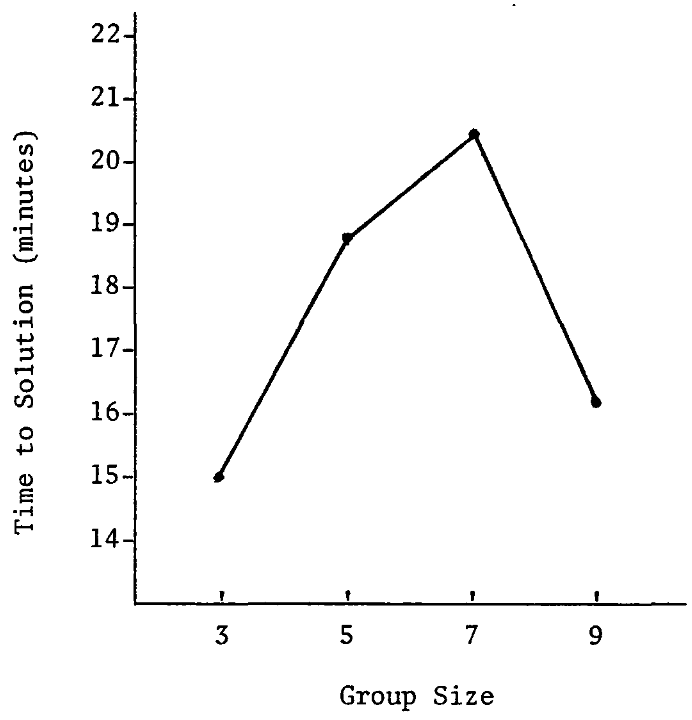


FIGURE 4

Group Size and Speed

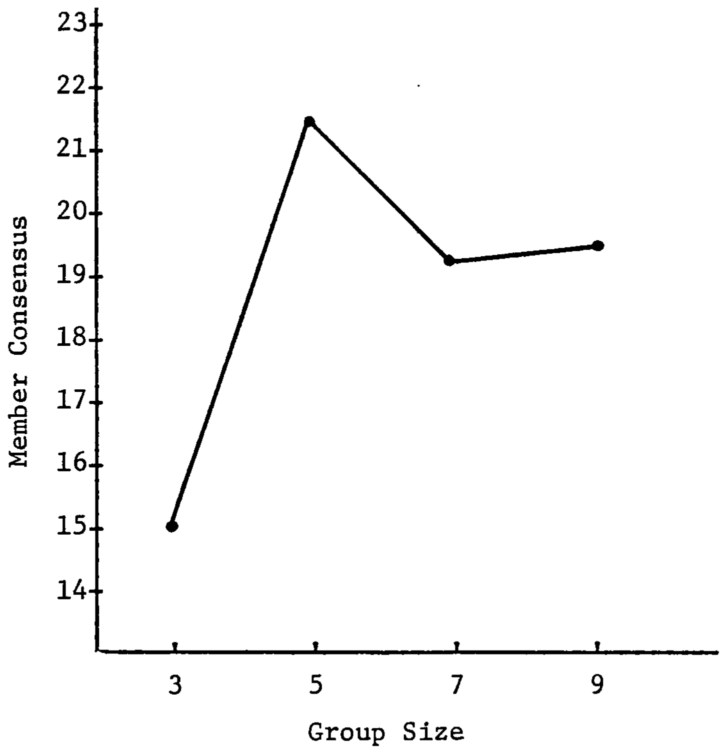


FIGURE 5

Group Size and Member Consensus

drops when group size is increased from 3 to 5, and then increases slightly and remains relatively constant for groups of 7 and 9. Post hoc analysis of mean differences showed groups of 3 to be different from the larger groups in terms of consensus, but not quite significantly so (Scheffē, $p < .11$).

According to Manners (1975), "as a small group adds new members, postdiscussion consensus drops off sharply at first but is soon virtually unaffected or affected only slightly by the addition of new members." In that study, however, the group size where consensus reached a low and leveled off appeared to be around 11 or 12, and the predictions for this study were based on that evidence. Actual consensus score comparisons cannot be made between the two studies due to a lack of consensus data reported in the Manners study.

The discrepancy between the consensus plots for larger groups of 7 or more can be examined in light of the task and subject differences between the Manners (1975) study and this study. First, Manners used high school students as subjects. High school students are more likely to be naive and easily persuaded than the more skeptical, 'show me' college students used in the present study. It would follow that, for the same size group, consensus would be higher for a high school student group than for a college student group. The leveling off of consensus at a low level at some larger group size that was predicted by the Manners study would then occur sooner and at a smaller group size for the more skeptical college student group. This quicker drop in consensus scores coupled with a lower consensus score to begin with could result in a curve similar to the one in Figure 5.

Secondly, differences in the task would also predict a lower initial consensus for a given group size and a faster drop to the leveling-off point. The NASA Moon Exercise used in the Manners study is more unreal and requires remembering science-related information that other group members are likely to accept. The desert survival task, on the other hand, is a more familiar situation. Much information about this situation advanced by group members is hotly contested by other members. The higher conflict levels then expected from the desert survival task, coupled with the more skeptical, less-accepting college student population, could predict results similar to those found in this study.

## Group Size and Member Satisfaction

Self-reported member satisfaction with the group process was higher in small groups than in large groups. This relationship is pictured in Figure 6. Average satisfaction declines fairly consistently as group size increases, except for a more substantial drop in satisfaction for groups of size 7 than was expected.

Figure 7 shows the satisfaction scores for circular and rectangular groups separately. The cause of the drop in satisfaction for 7-person groups is clearly indicated. The 7-person circular groups are significantly lower in member satisfaction than all other groups (Scheffé, $p < .05$).

A possible explanation for this data is that the members of 7-person circular groups were somehow different from the average member of the other groups. There may have been a greater proportion of aggressive or argumentative persons among the 35 subjects who were randomly assigned to this condition than among the other conditions.

If it can be assumed that the overall satisfaction level for groups of 7 persons is lower in this study than others because of the unique

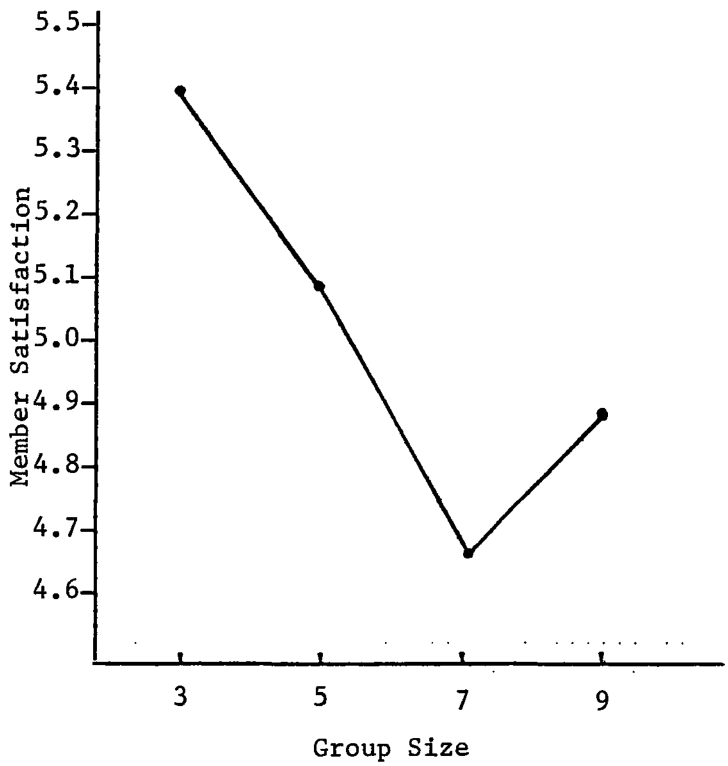


FIGURE 6

Group Size and Member Satisfaction

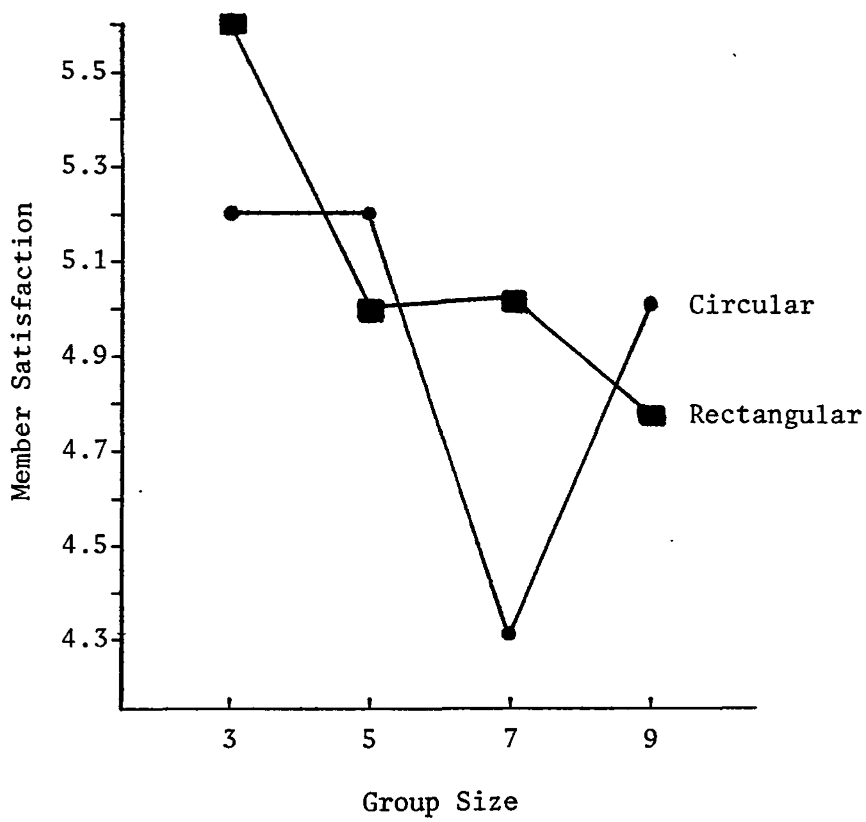


FIGURE 7

Interaction of Size and Spatial Arrangement for Member Satisfaction circular spatial arrangement used here, it can then be said that self-reported mamber satisfaction with the group process declines continuously as group size increases.

Group Size and Member Reactions

The nine member reaction items were designed to sample a variety of possible reactions to the group experience. It is therefore noteworthy that five of the nine items were significantly affected by group size and three of the other four items showed nonsignificant trends in the same direction for group size. Only one member reaction item, item #5 ("Our group was efficient in its use of time..."), showed no general trend in ratings over size.

Member reaction 7 ("This group was too small . . . for best results on the task") was significantly affected by group size and supported the curvilinear relationship between group size and member satisfaction predicted by hypothesis IVb ($F=6.640$, $p<.005$ for nonlinearity). There were more "too small" comments in groups of 3 than in the larger groups. The other member reaction items and the overall satisfaction item, however, tended to indicate highest satisfaction with small groups (size 3) and increasing disatisfaction with the group process as the group size increased.

An explanation for this discrepancy is that item #7 is really more of a task-oriented rather than a satisfaction-with-the-group-process item. It is logical to assume that many members of the 3-person groups who were very satisfied with the group process (as ahown on the other items) still were aware that they had only three members and thought perhaps they could perform better on the task if they had more members. Also, the traditional concept of a 'group' usually connotes more than three people to the layman.

Consistent with certain of the studies cited previously, then, there were more self-reports of disatisfaction with the group process as the size of the groups increased from 3 to 9. Members of larger groups felt they did not have an equal chance to contribute their ideas during the group discussion (member reaction 8) and that there was less cooperation and more competition (member reaction 2) as the group size increased (Carter et. al., 1951; Hackman & Vidmar, 1970). As groups became larger in size, group members felt they were too large (member reaction 1) for the best results on the task (Slater, 1958) and that the group members themselves were more heterogeneous (member reaction 3) in terms of ability and task competence (Hemphill, 1949; Steiner, 1972).

Three member reaction items showed nonsignificant trends in the same direction for group size. There was a tendency for more subgrouping or individual work (member reaction 6) as group size increased (Golembiewski, 1962; Hare, 1952). Members of larger groups tended to feel more inhibited from expressing their opinions (member reaction 4) during the group discussion (Carter et. al., 1951). Finally, group members tended to feel more tense and uncomfortable during the group discussion as group size increased (member reaction 9).

## Spatial Arrangement

Although research on the physical arrangement of group members has been sparse, the studies reviewed earlier (Steinzor, 1950; Hearn, 1957; Bass & Klubeck, 1952; Strodtbeck & Hook, 1961; Howells & Becker, 1962; Norum et. al., 1967; Sommer, 1965; Cummings et. al., 1974) support the hypothesis that spatial arrangment affects some important group process variables. It appears that interpersonal communication patterns in a group are affected by the way in which group members are physically situated, and that the communication patterns affect the kind and amount of individual member participation in the group decision-making. Member participation in group decision-making is tied to member acceptance of the decision (consensus) and satisfaction with the group process (Thibaut & Kelley, 1961; Barnlund & Haiman, 1960; French et. al., 1960; Hoffman & Maier, 1959; Hoffman & Maier, 1961). The circular spatial arrangement was designed to yield an interpersonal communication pattern equalizing member participation in the group process, thereby leading to higher member acceptance of the group decision and higher levels of satisfaction with the group process itself.

In the present study, however, manipulation of the spatial arrangement of the groups had very little effect on major group process outcomes. There were no significant main effects of shape for solution quality, group consensus, group efficiency, or satisfaction with the group process. The expected benefits of the circular seating arrangement for groups of 3, 5, 7, and 9 persons were not found in this experiment. The one variable that was significantly affected by group shape, member reaction 9, was in the opposite direction to that predicted. Groups in a circular spatial arrangement felt more "tense and uncomfortable during the group discussion." This was not reported in the Results section because the MANOVA analysis indicated that the overall main effect for shape was not significant ($p < .18$).

The Cummings et. al. (1974) study showed that one particular spatial manipulation, their "leader-centered" arrangement, could have powerful effects on group process outcomes for a task similar to the task used in this study. Their "neutrally structured" groups of 3, 4, and 5 persons were significantly higher in solution quality, efficiency, and member consensus (satisfaction variables were not measured). The lack of significance in the present study is therefore likely to have been a function of the kind of spatial manipulation that was used. For the particular type of task used in this study, it can be concluded that a circular seating arrangement has no significant benefits over the standard side-by-side rectangular seating arrangement for the range of group sizes studied.

## CONCLUSIONS

This study was designed to apply and test predictions made by Steiner (1972) and extend other recent research involving similar tasks (Cummings et. al., 1974; Manners, 1975). Group size and spatial arrangement of the group members were systematically varied for college students working on the 'Lost in the Desert' survival task. The outcomes that were measured included group decision quality, the time it took a group to reach a consensual decision, group member acceptance of the decision, self-reported member satisfaction with the group process, and nine member reaction items designed to sample a variety of possible reactions to the group process. Predictions were not made for the member reaction items.

None of the hypotheses were confirmed by the data. Member satisfaction showed a significant main effect for size and a significant interaction between size and shape, but a curvilinear relationship with the satisfaction peaking at group size 5 had been predicted. Five of the nine member reaction items showed significant main effects for size. There were no significant effects for spatial arrangement.

Practical application of the results of this study and related research suggest that for tasks that require group consensus and group input of information for a solution, an important factor determining the optimum composition of the group is the particular group process outcome desired.

If high member consensus is desired, Manners (1975) found that small groups were better. The results of this study, although not significant, suggest that 3-person groups produce higher consensus levels than the larger 5 to 9-person groups studied (Scheffé, $p<.11$). In addition, other related research indicates these small groups should be "neutrally structured" (i.e., circular for 3, square for 4), rather than "leader-centered"

(Cummings et. al., 1974).

If high solution quality is required, however, the findings are somewhat ambiguous. Recent research has found that the larger the group the better the quality of the group decision for disjunctive tasks. This is true up to the point where additional group members provide little new information and/or the information processing that is required becomes too cumbersome for whatever system the group is using to process its data (Holloman & Hendrick, 1971; Cummings et. al., 1974; Manners, 1975). The present study found no significant relationships between decision quality and group size or spatial arrangement,and, coupled with earlier reports of inconsistent and nonsignificant relationships between group size and productivity (Thomas & Fink, 1963; Hackman & Vidmar, 1970; Bouchard & Hare, 1970; Bouchard et. al., 1974), cast doubt on a simple group size/productivity relationship. Significant relationships, where found, are probably very specific to the task and situation employed.

It is probable that the task taxonomy developed by Steiner, while useful, is not specific enough to clearly predict group process outcomes for some tasks. For example, the task used in this study was identical in format and scoring procedure, dealt with the same basic situation (survival), and required the same group process procedures as the NASA Moon Exercise. The only difference was in the specific survival situation they were asked to consider. As discussed earlier, however, this small task difference may be the major reason for the difference in the experimental results of this study and the Cummings et. al. (1974) and Manners (1975) studies.

Another major barrier to our understanding of group process is the lack of an accurate taxonomy of subject populations (Hoffman, 1965). As discussed earlier, subject population differences between this study and the Manners (1975) study could explain some of the differences in results.

Suggested directions for future research in this area would lie along the course that interviewing research took in the 60's. At that time there had been large numbers of articles dealing with the selection interview published in many different journals over the past 30 years or so, yet there was little real generalized knowledge about what the interview could and could not do nor how well it functioned (Webster, 1964). Searching for an explanation for this dilemma, Mayfield and Carlson (1966) concluded that "many of the studies that have been reported are not comparable due to the lack of controls and the fact that different interviewing methods were used in the different studies" (p. 41). This is the <u>current</u> situation for the literature on group problem-solving.

The shift in the interview research that took place was toward a study of the decision-making process in the interview. Researchers became interested in increased experimental control and understanding of the 'microanalytical' aspects of the interview situation, and all but abandoned study of the interview in a real-life setting. The use of a written description of a 'hypothetical applicant' to simulate an interview situation became commonplace and research on actual interview validity decreased. It was understood that until the relationships between item and applicant variables and the resulting interviewer decisions were better understood, attempts to empirically determine interview validity would not generalize beyond the actual information and situation employed in a particular study. According to Mayfield and Carlson (1966), it had become "obvious that a complex, extensive, and coordinated research project is necessary to evaluate the effects of all the variables operating in any real interview situation" (p. 52). This approach has yielded much more reliable research results and a better understanding of the interview process itself (Wright, 1969).

Several suggestions utilizing the experiences of researchers on the interviewing process follow. First, there should be a common, coordinated research effort focusing on the decision-making processes in group problem-solving. This common effort could be based initially on Steiner's (1972) work and conducted by major universities or research groups such as AIR or LOMA. Next, a tightly controlled method of studying this process should be developed. This method must be fully replicable by others. There should also be a set of tasks developed for the use of researchers in this area, with standardized procedures for scoring and administration. Last, some schema of subject variables should be developed so that they may be more tightly measured, controlled, and understood. Application of these research suggestions to the study of group problem-solving would provide more systematic and reliable empirical evidence on which to base future prescriptions for action in applied settings.

# REFERENCES

Bales, R. F., and Borgatta, E. F. Size of group as a factor in the interaction profile. In A. P. Hare, E. F. Borgatta, and R. F. Bales (Eds.), Small groups: Studies in social interaction. New York: Knopf, 1955, 396-413.

Bales, R. F., Strodbeck, F. L., Mills, T. M., & Roseborough, M. Channels of communications in small groups. American Sociological Review, 1951, 16, 461-468.

Barnlund, D. C., & Haiman, F. S. The dynamics of discussion. Boston: Houghton-Mifflin, 1960.

Bass, B. M., & Klubeck, S. Effects of seating arrangements on leaderless group discussions. Journal of Abnormal and Social Psychology, 1952, 47, 724-727.

Blau, P. M., & Scott, W. R. Formal organizations. San Francisco: Chandler, 1962.

Bouchard, T. J., Jr., Barsaloux, J., & Drauden, G. Brainstorming procedure, group size, and sex as determinants of the problem-solving effectiveness of groups and individuals. Journal of Applied Psychology, 1974, 59, 135-138.

Bouchard, T. J., Jr., & Hare, M. Size, performance, and potential in brainstorming groups. Journal of Applied Psychology, 1970, 54, 51-55.

Carter, L., Haythorn, W., Lanzetta, J., & Mairowitz, B. The relation of categorizations and ratings in the observation of group behavior. Human Relations, 1951, 4, 239-254.

Cummings, L. L., Huber, G. P., & Arendt, E. Effects of size and spatial arrangement on group decision making. Academy of Management Journal, 1974, 17, 460-475.

Delbecq, A. L., Van de Ven, A. H., & Gustafson, D. H. Group techniques for program planning: A guide to nominal and delphi processes. Glenview: Scott, Foresman and Company, 1975.

Frank, F., & Anderson, L. Effects of task and group size upon group productivity and member satisfaction. Sociometry, 1971, 34, 135-149.

French, J. R. P., Israel, J., & As, D. An experiment on participation in a Norwegian factory: Interpersonal dimensions of decision-making. Human Relations, 1960, 13, 3-19.

Gibb, J. R. The effects of group size and threat reduction upon creativity in a problem solving situation. American Psychologist, 1951, 5, 324.

Golembiewski, R. T. The small group: An analysis of research concepts and operations. Chicago: University of Chicago Press, 1962.

Green, T. B. An empirical analysis of nominal and interacting groups. Academy of Management Journal, 1975, 18, 63-73.

Hackman, J. R. Effects of task characteristics on group products. Journal of Experimental Social Psychology, 1968, 4, 162-187

Hackman, R., & Vidmar, N. Effects of size and task type on group performance and member reactions. Sociometry, 1970, 33, 37-54

Hare, A. P. Interaction and consensus in different sized groups. American Sociological Review, 1952, 17, 261-267.

Hare, A. P. Handbook of small group research. Glencoe, Illinois: Free Press, 1962.

Hearn, G. Leadership and the spatial factor in small groups. Journal of Abnormal and Social Psychology, 1957, 54, 269-272.

Hemphill, J. K. The leader and his group. Education Research Bulletin, 1949, 28, 225-229.

Hemphill, J. K. Relations between the size of the group and the behavior of "superior" leaders. Journal of Social Psychology, 1950, 32, 11-22.

Hoffman, L. R. Group problem solving. In L. Berkowitz (Ed.), Advances in Experimental Social Psychology, Vol. 2. New York: Academic Press, 1965.

Hoffman, L. R., Burke, R. J., and Maier, N. R. F. Participation, influence, and satisfaction among members of problem-solving groups. Psychological Reports, 1965, 16, 661-667.

Hoffman, L. R., & Maier, N. R. F. The use of group decision to resolve a problem of fairness. Personnel Psychology, 1959, 12, 545-559.

Hoffman, L. R., & Maier, N. R. F. Quality and acceptance of problem solutions by members of homogeneous and heterogeneous groups. Journal of Abnormal and Social Psychology, 1961, 62, 401-407.

Holloman, C. R., & Hendrick, H. W. Problem solving in different sized groups. Personnel Psychology, 1971, 24, 489-500.

Howells, L. T., & Becker, S. W. Seating arrangement and leadership emergence. Journal of Abnormal and Social Psychology, 1962, 64, 148-150

Husband, R. W. Cooperative versus solitary problem solution. Journal of Social Psychology, 1940, 11, 405-409.

Kelley, H. H., & Thibaut, J. W. Experimental studies of group problem solving and process. In G. Lindzey (Ed.), Handbook of Social Psychology. Reading: Addison-Wesley, 1954.

Maier, N. R. F. Decision-making in three- vs. four-person groups. Personnel Psychology, 1972, 25, 531-534.

Maier, N. R. F., & Solem, A. R. The contribution of a discussion leader to the quality of group thinking: The effective use of minority opinion. Human Relations, 1952, 5, 277-288.

Maier, N. R. F., & Thurber, J. A. Innovative problem-solving by outsiders: A study of individuals and groups. Personnel Psychology, 1969, 22, 237-249.

Manners, G. E., Jr. Another look at group size, group problem solving, and member consensus. Academy of Management Journal, 1975, 18, 715-724.

Mayfield, E. C., and Carlson, R. E. Selection interview decisions: First results from a long-term research project. Personnel Psychology, 1966, 18, 41-55.

Miller, N. E. Effects of group size on group process and member satisfaction. Ann Arbor: University of Michigan, 1950.

Myers, J. L. Fundamentals of experimental design. Boston: Allyn and Bacon, 1972.

Norum, G. A., Russo, N. J., & Sommer, R. Seating patterns and group task. Psychology in the Schools, 1967, 3, 276-280

O'Dell, J. W. Group size and emotional interaction. Journal of Personality and Social Psychology, 1978, 8, 75-78.

Scheffe, H. The analysis of variance. New York: Wiley, 1959.

Seashore, S. E. Group cohesiveness in the industrial work group. Ann Arbor: Institute for Social Research, University of Michigan, 1954.

Shaw, D. M. Size of share in task and motivation in work groups. Sociometry, 1960, 23, 203-208.

Shaw, M. E. Comparison of individuals and small groups in the rational solution of small problems. American Journal of Psychology, 1932, 44, 491-504

Slater, P. E. Contrasting correlates of group size. Sociometry, 1958, 21, 129-139.

Sommer, R. Further studies in small group ecology. Sociometry, 1965, 28, 337-348.

South, E. B. Some psychological aspects of committee work. Journal of Applied Psychology, 1927, 11, 348-368.

Steiner, I. D. Group process and productivity. New York: Academic Press, 1972.

Steinzor, B. The spatial factor in face-to-face discussion groups. Journal of Abnormal and Social Psychology, 1950, 45, 552-555.

Strodtbeck, F. L., & Hook, H. L. The social dimensions of a twelve man jury. Sociometry, 1961, 24, 397-415.

Taylor, D. W., & Faust, W. L. Twenty questions: Efficiency in problem solving as a function of size of group. Journal of Experimental Psychology, 1952, 44, 360-368.

Thelan, H. A. Group dynamics in instruction: Principles of least group size. School Review, 1949, 57, 139-148.

Thibaut, J. W., & Kelley, H. H. The social psychology of groups. New York: Wiley, 1961.

Thomas, E. J., & Fink, C. F. Effects of group size. Psychological Bulletin, 1963, 60, 371-384.

Thorndike, R. L. On what type of task will a group do well? Journal of Abnormal and Social Psychology, 1938, 33, 408-412.

Thorndike, R. L. The effects of discussion upon the correctness of group decision when the factor of majority interest is allowed for. Journal of Social Psychology, 1938, 9, 343-362.

Timmons, W. M. Decisions and attitudes as outcomes of the discussion of a social problem. Teachers College, Contributing Education, 77, Columbia University, Bureau of Publications, 1939.

Timmons, W. M. Can the product superiority of discussers be attributed to averaging and majority influences? Journal of Social Psychology, 1942, 15, 23-32.

Van de Ven, A. H., & Delbecq, A. L. The effectiveness of nominal, delphi, and interacting group decision making processes. Academy of Management Journal, 1974, 17, 605-621.

Vroom, V. H., Grant, L. D., & Cotton, T. S. The consequences of social interaction in group problem-solving. Organizational Behavior and Human Performance, 1969, 4, 77-95.

Watson, G. B. Do groups think more efficiently than individuals? Journal of Abnormal and Social Psychology, 1928, 23, 328-336.

Webster, E. C. Decision-making in the employment interview. Montreal: Industrial Relations Centre, McGill University, 1964.

Worthy, J. C. Organizational structure and employee morale. American Sociological Review, 1950, 15, 169-179.

Wright, O. R. Summary of research on the selection interview since 1964. Personnel Psychology, 1969, 22, 391-414.

Wyatt, S., Frost, L., & Stock, F. G. L. Incentives in repetitive work. Medical Research County Report No. 69. London: H. M. Stationery Office, 1934.

Ziller, R. C. Group size: A determinant of the quality and stability of group decisions. Sociometry, 1957, 20, 165-173

# APPENDIX A

## DESERT SURVIVAL TASK

## DESERT SURVIVAL -- ANSWERS

| | |
|---|---|
| 1. A COSMETIC MIRROR<br>2. ONE TOP COAT PER PERSON<br>3. ONE QUART OF WATER PER PERSON<br>4. A FLASHLIGHT (4 battery size)<br>5. A PARACHUTE (red and white) | CRITICAL<br>items for survival<br>in this situation |
| 6. A JACK KNIFE<br>7. A PLASTIC RAINCOAT (large size)<br>8. A .45 CALIBER PISTOL (loaded)<br>9. ONE PAIR OF SUNGLASSES PER PERSON<br>10. A COMPRESS KIT WITH GAUZE | USEFUL<br>to relatively useful<br>in this situation |
| 11. A MAGNETIC COMPASS<br>12. A SECTIONAL AIR MAP OF THE AREA<br>13. A BOOK "EDIBLE ANIMALS OF THE DESERT"<br>14. 2 QUARTS OF 180 PROOF VODKA<br>15. A BOTTLE OF SALT TABLETS (1000) | USELESS<br>to relatively dangerous<br>in this situation |

## DESERT SURVIVAL -- GENERAL STRATEGY

The general strategy is to survive by staying with the wrecked plane and making the best use of the available items. The principle uses of the items salvaged from the plane are (1) to protect against dehydration and (2) to signal to search aircraft.

The first decision is whether to walk out - usually to the mining camp - or to stay at the crash site. There are two principal reasons the experts are against attempts to walk out.

(1) The available navigation equipment is poor. You may not even be able to find the mining camp. A sectional air map is virtually worthless when your point of view is at ground level rather than 20,000 feet up. Think too of the terrible heat haze in the desert that distorts distance and size perception. Even without the mirages and errors of judgement a few days in the desert will bring, your present perception will mislead you into believing a distant mountain is a nearby hill or vice-versa. The compass is really all you have, and maintaining a perfect heading north-northeast for 70 miles over the desert at night (the only possible time to walk for survival reasons) without variation is impossible. How will you know when you've walked 70 miles? You will probably have to walk 10% to 20% more because of detours around cactus, canyons, mesas, hills, etc. Remember that a mine is mostly underground, too.

(2) Your chance of surviving an 80 to 85 mile hike in the desert with the available equipment is very low. This is the worst time of the year in the Sonora, and only the hardiest, best trained, knowledgeable individuals could walk this distance before they died. The experts

estimate that the average individuals who decide to walk will probably not live beyond the second day - after walking less than 33 miles - assuming they walked only at night. If they decided to walk during the day they would probably be dead sometime the next day after having walked less than 12 miles.

When the odds for survival and finding the mining camp are put together, the experts say stay with the wreck, prolong your survival, and properly use your equipment to stay alive and signal. If you follow this procedure, the probability of rescue within 24 hours of the crash is 80%.

## DESERT SURVIVAL -- DETAILED ANSWERS

(1) COSMETIC MIRROR...Of all the items the mirror is absolutely critical. It is the most powerful tool you have for communicating your presence. In sunlight a simple mirror can generate 5 to 7 million candlepower of light. The reflected sunbeam can even be seen beyond the horizon. Best signalling device available.

(2) ONE TOP COAT PER PERSON...The biggest enemy in the desert is dehydration, or the loss of body fluids from within your cells. The biggest source of water in the desert in this situation is within your own body - more than 60% of your body weight is water. Conserving that water is far more important to survival than any quart canteen or water is surrounding cacti. Think of what desert-dwelling folk wear: long, heavy robes, turbans, face cloths, etc. They know that every square inch of skin exposed to the desert air means water loss. Every unfiltered breath of air they take means moist air out, dry air in. The top coat then is the best survival tool you have. You should also tie strips of cloth at your wrists and ankles to seal off the ends of the top coat's sleeves and pants legs from the air and create a moist atmosphere under the clothes so your body water is reabsorbed.

(3) ONE QUART OF WATER PER PERSON...Although this item is not nearly as crucial as the first two (it would not significantly extend your survival time or help you signal) it would help to hold off the effects of dehydration. Do not ration the water, drink it as you become thirsty. Once dehydration begins, it is impossible to reverse with the amount of water available in this situation. This readily available water is also a nice psychological boost in this situation.

(4) FLASHLIGHT (4 battery size)...The only quick, reliable night signalling device is the flashlight. In the desert there is little competing light and the beam would probably be visible to searching aircraft. It is also useful to illuminate any activity such as erecting a better shelter, constructing a solar still, etc. Any physical activity except for erection of the first sun shelter should be performed at night. Also provides psychological security (like the water).

(5) A PARACHUTE (red and white)...The parachute provides your second best daytime signalling device and your second best protection from dehydration. Use the cacti as tent poles and erect the parachute as a shelter. The temperature underneath the parachute would be reduced by as much as $20^{o}$ to $25^{o}$, especially if the chute is double or triple folded.

(6) A JACK KNIFE...Although not crucial like the first five items, the knife can be used to get water from the barrel cacti (not much this time of year), cut strips of parachute or cloth for turbans or Eskimo-style sunglasses, help in rigging the shelter, and innumerable other uses.

(7) PLASTIC RAINCOAT (large size)...The raincoat can be turned into a solar still, although the maximum daily yield of 1 quart is not a significant amount for a large group of people, and the physical activity required to construct the still and extract the water would very likely use up as much or more body water than would be gained. A person skilled in solar still use and construction who dug it out only at night and conserved his energy carefully could benefit from this. Details of construction will be found in the Air Force Survival Manual.

(8) A .45 CALIBER PISTOL (loaded)...By the end of the second day speech would be impaired and you might be unable to walk (6% to 10% dehydration).

The pistol would then be useful as a sound signalling device during the day and a possible visual signal at night (muzzle flash). The butt of the pistol could be used as a hammer. You could also shoot the others and take all their water (a joke, but this highlights the danger of the pistol once dehydration is advanced and irrational behavior and irratibility commonplace). Don't worry about killing animals for food with it, because even if you lucked out and hit one, eating the meat would increase dehydration enormously, as the body uses its water to process the food.

(9) ONE PAIR OF SUNGLASSES PER PERSON...In the intense sunlight of the desert photothalmia and solar retinitis (similar to snow blindness) could be serious problems especially by the second day. However, the dark shade of the parachute shelter would reduce the problem, as would darkening the area around the eyes with soot from the wreckage. Using a handkerchief or compress material as a veil with eye slits cut into it (Eskimo-style sunglasses) would eliminate the vision problem. But sunglasses would make daytime vision much more comfortable.

(10) A COMPRESS KIT WITH GAUZE...This kit is useful for the cloth material in it, not for first-aid purposes. The desert is one of the healthiest and germ-free environments in the world, and your blood will thicken considerably with the onset of dehydration. The cloth can be used for turbans, rope, etc.

(11) A MAGNETIC COMPASS...You could possibly use its reflective surface as an auxiliary signalling device. The compass could be dangerous to have around once the effects of dehydration begin. It might give someone the notion of walking out.

(12) A SECTIONAL MAP OF THE AREA...Might be helpful for starting a fire or for toilet paper. One person might use it for a head cover or eye shade. It might have entertainment value. It is dangerous for the same reason as the compass.

(13) A BOOK "EDIBLE ANIMALS OF THE DESERT"...General rule of thumb in survival situations - if you have lots of water, eat, otherwise, don't consume anything.

(14) 2 QUARTS OF 180 PROOF VODKA...Alcohol absorbs water (remember the dread "cotton mouth" the morning after). Could be lethal in this situation. The bottle could be useful, but the vodka represents more dangers than help.

(15) A BOTTLE OF SALT TABLETS (1000)...Wide spread myths about salt tablets exist. In a humid environment like Houston, physical activity leads to loss of body fluids through perspiration. Salt is also lost as the perspiration drips or is rubbed off our skin. When the body fluids are replaced by drinking water, some of this water will not be absorbed and will merely pass through the body unless the salt that was lost is also replaced. In this desert situation, however, you will lose much body fluid and little salt. You do not have a large amount of water available to replace what you lose. Taking salt will only further the effects of dehydration, as water is drawn out of your cells to dilute the salt you are taking in. The effect would be like drinking seawater - the concentration of salt in seawater further dehydrates your body each time you drink it. Even the man who developed salt tablets now maintains they are of questionable value except in geographical areas where there are salt deficiencies. A common side effect is stomach cramps. Most

professional athletic teams now use an artificial mixture of liquids the body can readily absorb.

# APPENDIX B

# INSTRUCTIONS TO SUBJECTS

## Experimental Instructions to Subjects

"Welcome to this research study on human problem solving. I am investigating the effect of individual and group composition on problem-solving behavior in a stressful situation. You will be in no actual danger, but will be asked to place yourself mentally in a certain dangerous situation. I ask you to use all your available talents and knowledge to best resolve the problem that will be presented to you.

In just a minute a research assistant will take you to the experimental area. You will receive more instructions there.

In the meantime, there is some information I would like to give you. Number one, this is an anonymous experiment - I do not want your name on anything but your name tag and your experimental credit slip. Number two, you will not be videotaped or otherwise recorded; and number three, there is no deception in this experiment. I want all of you to do your best. Thank you for your participation."

"Your research assistant will now hand out a complete description of the situation you are to imagine yourself in. You will have four minutes to read this description thoroughly. You will then receive more instructions as to what to do. Remember, you will have four minutes to thoroughly familiarize yourself with this situation. Please begin now."

"Your overall objective in this situation will be to make the best use of your relevant knowledge, skills, and the available equipment to survive. Your first task is to make an assessment as an individual of the items you have salvaged from the plane and rank them as to their importance for your survival, with a ranking of '1' being the most important and '15' being the least important item you have salvaged. Put your rankings in the column headed by the word 'Rank.' There can be no ties -- every rank from 1 to 15 must be used and only used once. To repeat, give a ranking of '1' to the most important item, '2' to the next most important, and so on. Remember, this first task is to be done individually, so no talking will be allowed. If you do not understand the task, raise your hand now. (10-second pause) You will have five minutes to complete your individual rankings. Your research assistant will warn you when you have only one minute left. Please begin now."

"Now that you as individuals have indicated how you would rank these 15 items, I am going to turn this problem over to you as a group of passengers who are stranded together. In a survival situation like this one, it is important for a group to stick together and agree on a survival plan. This survival plan should be of high quality - making the best use of the skills and equipment available - and should be arrived at as quickly as possible to protect against panic and focus the group on working toward survival and avoiding worry about their situation.

Your task is to reach a group consensus on the ranking of these 15 items, taking into account the strengths, weaknesses, and knowledge in your group. Use the column headed by 'GR' to record your group rankings. It is suggested that simple voting as a means of decision-making be avoided if possible. Discussion of opposing or conflicting views to bring out more facts and ideas is very desireable. If you do not understand the task, raise your hand now. (5-second pause) Please begin now."

"Now that you have listened to the information and opinions presented by the other survivors, I want you to consider yourself as the absolute, unquestioned leader of this same group of people. With that in mind, you are to indicate in the column headed by 'RR' your final ranking of the 15 items. This will be done individually - no discussion please. You will have four minutes for this task. Please begin now."

"Now that you have completed this desert survival task, I would like your individual opinion of the way your group went about solving this problem. Your research assistant will pass out a brief opinion questionnaire now. Please read the instructions thoroughly and answer all ten items. Raise your hand if you have a question and the research assistant will help you. Do not put your name on the questionnaire. Please begin now."

"Thank you for participating in this experiment. I am examining group of different sizes arranged in different ways and trying to determine what effects these differences have on group efficiency, the quality of group and individual solutions, and the satisfaction with the group process and the group decision. I am interested in group data - that is why your responses were anonymous. There was no deception involved in the experimental instructions or the experiment itself.

A few words are necessary about the survival situation you were placed in. There is a best ranking of the 15 items as determined by desert survival experts. For your own information and knowledge, this best set of rankings and all the reasons behind it will be presented to you sometime during the first two weeks of November. Members of Kasschau's TV class will find a full typed explanation posted in their TV room, and other classes will either have a personal visit from me - their instructor permitting - or a full explanation posted in their classrooms. I cannot release the answers until all groups have attempted to solve the problem - even my research assistants don't know the proper ranking. If people came into this experiment knowing the survival situation they were to face, my research results would be jeopardized. I therefore ask you to please keep this experiment completely to yourself until after 4:00 pm this Friday, October 28. Even the words 'desert survival' could give someone an unfair advantage. Give everyone else the same chance to struggle with the situation as you did. Thank you for your cooperation."

# APPENDIX C

## MEMBER REACTIONS QUESTIONNAIRE

## OPINION QUESTIONNAIRE

**I am interested in your reactions to the group discussion you have just participated in. Please answer the following questions with care. Your frank opinions are needed to help improve group discussion as a decision-making technique.**

Directions: Please CIRCLE the one response for each statement that is closest to how you feel about the statement.

KEY

SA . . . . . . STRONGLY AGREE with the statement

A . . . . . . AGREE with the statement

SLA . . . . . SLIGHTLY AGREE with the statement

SLD . . . . . SLIGHTLY DISAGREE with the statement

D . . . . . . DISAGREE with the statement

SD . . . . . . STRONGLY DISAGREE with the statement

SA A SLA SLD D SD 1. This group was too large (in number of members) for best results on the task it was trying to do.

SA A SLA SLD D SD 2. There was more cooperation than competition between the group members during the group discussion.

SA A SLA SLD D SD 3. There were considerable differences in ability and competence on this task among the members of the group.

SA A SLA SLD D SD 4. I felt inhibited from expressing my opinions during the group discussion.

SA A SLA SLD D SD 5. Our group was efficient in its use of time during the group discussion.

SA A SLA SLD D SD 6. Rather than one unified group, it seemed our group worked in sub-groups or as individuals on this problem.

SA A SLA SLD D SD 7. This group was too small (in number of members) for best results on the task.

SA A SLA SLD D SD 8. Everyone got an equal chance to contribute their ideas during the group discussion.

SA A SLA SLD D SD 9. I felt tense and uncomfortable during the group discussion.

SA A SLA SLD D SD 10. In general, I was satisfied with the way our group worked together in reaching a group decision.

SCORING PROCEDURE: MEMBER REACTIONS QUESTIONNAIRE

To avoid response set, items were worded so that 'agree' responses were socially desireable on some items and undesireable on others. The scoring key was set up so that the most positive answers possible received 6 points, the next most positive 5 points, and so on. The most negative answer possible was worth 1 point. The item-by-item scoring was as follows:

| Member Reaction | SA | A | SLA | SLD | D | SD |
|---|---|---|---|---|---|---|
| 1. | 1 | 2 | 3 | 4 | 5 | 6 |
| 2. | 6 | 5 | 4 | 3 | 2 | 1 |
| 3. | 1 | 2 | 3 | 4 | 5 | 6 |
| 4. | 1 | 2 | 3 | 4 | 5 | 6 |
| 5. | 6 | 5 | 4 | 3 | 2 | 1 |
| 6. | 1 | 2 | 3 | 4 | 5 | 6 |
| 7. | 1 | 2 | 3 | 4 | 5 | 6 |
| 8. | 6 | 5 | 4 | 3 | 2 | 1 |
| 9. | 1 | 2 | 3 | 4 | 5 | 6 |
| Overall Satisfaction | 6 | 5 | 4 | 3 | 2 | 1 |