University of Massachusetts Amherst

Group size : its effects on group performance and subsequent individual performance.

Item Type	Dissertation (Open Access)
Authors	Jorgensen, Bruce Wayne
DOI	10.7275/5v48-gn67
Download date	2026-03-12 07:29:59
Link to Item	https://hdl.handle.net/20.500.14394/11651

312066013573402

GROUP SIZE: ITS EFFECTS ON GROUP PERFORMANCE AND SUBSEQUENT INDIVIDUAL PERFORMANCE

A Dissertation Presented

by

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Submitted to the Graduate School of the
University of Massachusetts in
partial fulfillment of the requirements for the degree of

DOCTOR OF PHILOSOPHY

June (Month) 1973 (Year)

Major Subject: Social Psychology

ABSTRACT

This study was designed to test the effects of group size and leadership on group performance and on subsequent individual performance for one type of task. The subjects' task was to correctly answer a series of 8 multiple-choice questions. Performance predictions were made using Steiner's (1966, 1972) model of group productivity:

Actual productivity = Potential productivity - Process losses.

Subjects' performance on the task was to provide the following information: (1) the initial level of ability of subjects; (2) the ability of groups of differing size and leadership to utilize their resources; and (3) the ability of individuals to benefit through the acquisition and retention of information, as a function of their experience on a group task.

The main predictions of the study were: (1) Group performance on the task would be a positive function of group size. Process losses were not expected to be great within the range of sizes tested, for this performance criterion. (2) Subsequent individual performance on the task would be a curvilinear function of group size, with the best performance by individuals from groups of intermediate size. The requirements imposed by this second criterion, individual learning, implied additional process losses, primarily due to the reduced involvement of less competent members in the group process of the larger groups. It was thought that this decrement in participation would render the group decision less salient for later recall. (3) Group discussion would facilitate the acquisition of knowledge. The acquisition process was conceived of as having two steps, the selection of a correct answer by the group, and the acceptance and retention of the group answer by individual group members.

A pilot study supported the three main hypotheses. The main study

also tested hypotheses that task performance would be better, for groups and individuals, due to process loss reduction, (1) when a discussion leader was selected prior to the group effort on the task, and (2) on later questions of the task.

Subjects worked on the task on two occasions, separated by about a week. In the first session subjects initially answered the eight questions individually ($Time_{1i}$). Their performance was a measure of their initial ability level.

Immediately after completing the questions individually, subjects were assigned to groups of varying sizes to again work on the same task ($Time_{1g}$). Subjects were assigned to units of 1, 2, 3, 5, and 7 members. Persons in groups of 2 and larger were encouraged to work cooperatively with other members of their group. Half of the units were given instructions to select a leader whose responsibilities included insuring that all members participated in the task effort.

Approximately one week after the $Time_{1i}$ and $Time_{1g}$ administrations, subjects again attempted to correctly answer the same set of eight questions, all subjects working as individuals ($Time_{2i}$). Subjects were given no prior warning of the $Time_{2i}$ administration.

Results confirmed the first main hypothesis, that group performance would be a direct function of group size. At $Time_{1g}$ scores on the task were a significant direct function of group size.

The second main hypothesis, that subsequent individual performance would be a curvilinear function of discussion group size, was not confirmed. $Time_{2i}$ performance remained a positive function of size with the best scores on the task by members of groups of 7, followed by members of groups of 3.

The third main hypothesis, that group discussion would facilitate the individual acquisition of knowledge, was confirmed. Subjects who had discussed the questions in groups at $Time_{1g}$ performed significantly better than non-experimental students working on the task for the first time at $Time_{2i}$. Subjects who had worked individually at $Time_{1g}$ performed no better at $Time_{2i}$ than the non-experimental students.

Subordinate hypotheses, that performance would increase with a selected leader, and over time on the task, were not confirmed for $Time_{1g}$ or $Time_{2i}$ performance.

Key conclusions reached in the study were:

(1) Groups can be very adaptive. It appears that groups' process and structure changes can effectively postpone process losses as group size increases. The adaptive changes can be made consciously or unconsciously by group members. The apparent increase in effective process for certain "critical" group sizes suggests that group members recognize the need for procedural changes when process becomes ineffective. Subject reports indicating that motivation devrements in larger groups are greater for less competent members, suggest that an appropriate weighting of members' contributions can be reached inadvertently, postponing process losses.

(2) More must be known about how group size and task affect process losses before Steiner's (1972) group productivity model can be used effectively to predict actual group performance. For, although the model allowed an accurate prediction of group performance in this study, process losses appeared to remain fairly constant over all group sizes tested, rather than increasing with group size as was expected. Process changes seem to be greater for some critical group sizes, rather than continuous over all sizes. Perhaps these critical sizes are primarily a function of task type.

(3) The two-step conception of learning in groups, utilized to predict individual learning in this study, must be explored further. The second step of the process, individual acceptance and learning of the answer selected by the group, was expected to be facilitated by participation in the decision-making process. Although members of smaller groups, where a greater amount of individual participation was expected, tended to remember a greater percentage of correct answers from the group discussion, instructions to select a group leader had no significant effect on subjects' ability to remember correct group decisions. Subject reports indicated that participation was greater for groups instructed to select a leader, so participation per se may not be the key. It is possible that the extent one associates himself with the group's choice of a correct answer determines the extent to which that answer is internalized or accepted by the individual. Group size, as well as actual participation levels, could affect this internalization process.

(4) Groups can be effective facilitators of the individual acquisition of knowledge. Considering the many possible criteria of success for a group examination, the group size of 3 was recommended.

GROUP SIZE: ITS EFFECTS ON GROUP PERFORMANCE AND SUBSEQUENT INDIVIDUAL PERFORMANCE

A Dissertation

by

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ACKNOWLEDGMENTS

I would like to thank Dr. George Levinger for serving as committee chairman. His many valuable comments and suggestions made this project a richly rewarding educational experience.

Thanks also to Dr. Ivan Steiner for his encouragement and frequent consultation, and to Drs. Howard Gadlin and Joseph Litterer for their thoughtful criticism.

I would like to acknowledge also Drs. Alice Eagly and William Dorris for their cooperation, and Wally Smolenski for his untiring assistance on the data analysis.

Special appreciation is expressed for the patience of my wife Diane, who's sacrifice and encouragement kept me going, and to my daughter Elaine, who gave me an appreciation of education and personal development.

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CHAPTER I

INTRODUCTION

How can someone facing a task for the first time estimate what group size is best for his task, or whether a group of any size is better than an individual effort? For some tasks the choice is simple: Driving a car is seldom done better by a group than an individual, and raising money is usually easier if everyone contributes. For most tasks, however, the choice is not so simple. Discussing the complexity of the problems of group size research Bales (1958) noted "that one must determine not only what is optimum in terms of each different criterion, but also what is optimum for different types of group task (p. 129)."

In a 1963 review, Thomas and Fink reiterate this concern with the difficulty of making decisions and inferences regarding optimum group size. In attempting to assess general trends, Thomas and Fink concluded that "...considering the group performance findings as a whole, it appears that both quality of performance and group productivity were positively correlated with group size under some conditions, and under no conditions were smaller groups superior." (1963, p. 373)

Thomas and Fink acknowledge that theirs were limited conclusions, restricted not only by the small number of relevant studies in the area, but also by methodological shortcomings that are numerous in this literature. The methodological problems mentioned by Thomas and Fink fall basically into two categories; (1) Unsystematic selection of sizes used in the research; and (2) Investigators' failure to relate group size to relevant intervening variables.

The selection of a truncated series of sizes may obscure the true functional relationship between group size and group performance variables. If only two sizes are compared, for example, a curvilinear relationship between group size and performance cannot possibly be revealed. Selection of only groups of odd-numbered sizes for study would preclude the possibility of revealing characteristics unique for groups of even-numbered sizes.

A consideration of critical intervening variables is essential for studies aspiring to understand why size produces particular effects. Classes of intervening variables suggested by Thomas and Fink as worthy of greater attention included the following: (1) "Input quantity," or resource input; (2) "demand input," or socio-emotional needs of individual group members; (3) "consequences of increasing sample size;" and (4) "relational complexity," the number of possible dyadic relationships in a given group.

The Present Research Problem

This research attempts to test a model of group productivity proposed by Steiner (1966, 1972), and determine the extent to which the model permits one to predict optimal group size for two different performance criteria on a decision-making task. The main features of Steiner's model are: (1) A task typology, enabling one to generalize research findings within a task type; and (2) a plan for relating relevant intervening variables, including those mentioned by Thomas and Fink (1963), to predict actual group performance.

The model takes a fresh perspective in dealing with the relevant

dimensions of group productivity. For a particular type of task the best possible performance one can expect from a group of a given size can be estimated. The relationships of group size with group process variables then enable one to estimate how close groups are likely to come to their "best possible performance."

A more traditional approach empirically determined the performance which might be typically expected from a group of a certain size, on a given task for given criteria of success. This "shotgun" approach to optimal size was supplemented by investigations of variables which might be expected to improve or depress a group's performance.

The Model

According to Steiner, the determinants of actual productivity are three: Task demands, group resources, and group process.

Task demands include all requirements imposed on the group by the task itself. These requirements may derive from the quantity or quality of resources required for the task, from the optimal integration or use of resources, or from particular rules determining the way a task must be performed.

Group resources include all relevant knowledge and abilities of group members, and the distribution of knowledge and ability among those members. While task demands determine the nature of the resources needed and the way they can be best utilized, group resources are the capabilities actually possessed by a given group.

Together, task demands and group resources determine the potential productivity of a given group on any given task. The potential productivity of a given group is the maximum level of performance it can achieve,

assuming a perfect match-up of its resources with its task requirements.

Group process, refers to the actual behaviors of the group members. In Steiner's model, process can only detract from potential productivity. Utilization of available resources in the group will at best, with rare exceptions, provide that ideal match-up of available resources and task demands needed to equal potential productivity. Without optimal motivation, without full understanding of relevant resources, and without coordination of member behaviors, losses from a group's potential will occur. These are each aspects of "faulty process."

The effectiveness of a given group, then, may be predicted using the following formula (Steiner, 1966, p. 274):

Actual Productivity = Potential Productivity - Losses Due to Faulty Processes.

The optimum group size is that which maximizes the positive discrepancy between potential productivity and process losses.

Possible Advantages of Groups

Effective Combination of Resources

A common reason for employing collective action is to find the single best solution for a question or problem. In working toward a solution, group members discuss and assess the contributions of all the members. It is unlikely that a given solution will be either suggested or supported in the group discussion, unless at least one individual member initially favors that solution.

If at least one member of the group initially possesses the correct or best solution, it is possible, but not certain, that the group will

adopt the solution. In terms of Steiner's model,the potential of the group should exceed individual potential as a direct function of the size of the group, and actual productivity will approach potential productivity to the extent that group process permits an effective utilization of its resources.

Benefits to Individual Group Members

Some benefits of collective action on a task accrue to the individual members, as well as to the group as a unit. In many cases, an implicit goal of a group task is that participants will retain information acquired in the group setting, which may be used at a later time. One example would be the discussion of a research question with one's colleagues where one hopes to acquire useful information. Another case where retention of solutions generated in group discussion is seen as a goal is in student study groups, where members pose relevant questions to the group in preparation for an examination. To the extent that the group produces more correct responses than the individual members would produce alone, and that group members accept and retain those correct responses, the group provides an effective setting for the individual acquisition of correct responses.

Criteria of Group Performance

This study is concerned with dependent variables that pertain to these two general criteria: (1) The group's ability to combine their members' resources in order to answer questions correctly; and, (2) the individual member's ability to acquire and retain correct informa-

tion from the group discussion and decision.

Literature relating to group performance and to Steiner's model of group performance will be reviewed in the following section. The purpose of the review will be to develop two general hypotheses relative to the two criteria of group performance discussed above. Potential productivity and group process will be examined first for the criterion of effective combination of individual resources, and a general hypothesis derived. Subsequently, the criterion of individual acquisition and retention of correct responses will be discussed, and an hypothesis derived.

Type of Task

In the present study groups faced the task of correctly answering multiple-choice questions, a disjunctive task according to Steiner's (1966) task typology. Steiner defines a disjunctive task as one where: (1) The task cannot be profitably divided into smaller subtasks; and (2) potential productivity is determined by the ability of the best member of the group. If one group member can correctly answer the question, the group possesses the potential to select the correct answer. If no member can answer the question correctly as an individual, it is unlikely that the group will select the correct answer.

This research focuses on the prediction of group productivity for a disjunctive task.

Potential Productivity. Taylor (1954) and Lorge and Solomon (1955) offer similar techniques for calculating the probability that

at least one group member is capable of offering a correct solution, given the distribution of abilities in the population from which the groups are drawn. If Q equals the proportion of individuals who are not capable of producing a correct answer alone, then $100(1-Q^n)$ percent of all groups of size n should contain at least one member with the required ability.

The potential percent of groups of size n able to record a correct response also corresponds to $100(1-Q^n)$. For, if a group contains a member with the ability to correctly answer the questions, the group has the potential to select the correct answer.

The increase in potential productivity through the addition of another group member, according to this formula, can be represented by $Q^n - Q^{n+1}$. This increment indicates the increase in probability of a group of size n having a member possessing the desired ability. It can be seen that as n gets larger, the addition of another group member increases potential productivity by a progressively smaller increment. The potential of a group to arrive at a correct solution by combining individual resources should increase as a positive, but negatively accelerating function of group size.

Group Process. The advantages of larger groups' greater potential are not always realized in higher actual productivity. The ability of a group to optimally match its resources with the demands of the task is often adversely affected by an addition of new members. The greater the number of members, the less likely it is that any single member's contribution will be offered for consideration, and more likely that, if offered, the contribution will face increasing

competition for acceptance from those of other group members.

Several studies of group size indicate that the average amount of member participation tends to drop with increasing size (Hare, 1952; Bales, et. al., 1951; Bales and Borgatta, 1955). One interesting model, supported by the research of Stephan and Mishler (1952), predicts that the participation of groups' members becomes increasingly polarized as the size of the group increases. The decrement in participation for less active members is especially marked in the groups of from five to seven members.

Coordination difficulties were shown in a study by McCurdy and Lambert (1952) where subjects attempted to match patterns of switch positions in a six-switch panel. Groups of three members performed worse than individuals on this task. Steiner (1972) refers to such performance decrements as process losses.

As the organizational possibilities increase with group size, the relative merits of the various possibilities become more difficult to compare. This increase in organizational possibilities and the geometric increase of possible member interactions with increasing group size (Thomas and Fink, 1963) implies that process losses due to coordination problems are likely to increase as a positively accelerating function of group size.

Motivational decrements, would also be expected to develop rapidly with increasing group size. The effect of diffusion of responsibility, and the increasing difficulty in obtaining personal satisfaction from participation in larger groups, may contribute to a tempering of enthusiasm with increasing group size.

A study by Gibb (1951) indicated that as group size increased the

total number of contributions increased, but that the average number of contributions per subject decreased. Self-reports showed that more persons felt inhibited about participating as size increased. When all members' contributions are not made, the probability that the best member will make his contribution is reduced.

Asking subjects how much they wished to prepare for a cooperative studying task, Shaw (1960) found that motivation levels dropped with increasing group size. In larger groups subjects chose to abstract shorter articles for their group than did subjects in smaller groups.

The conclusion that motivation losses will increase with group size is probably less applicable for very small groups with few resources, or for groups dealing with extremely difficult problems. When members perceive that their group's resources are obviously insufficient to deal with their task, apathy on the part of the group members may be expected. In the study by Slater (1958), mentioned previously, subjects indicated that a group size of five was ideal, preferable over other sizes ranging from two to seven. Subjects participating in the larger groups expressed dissatisfaction primarily with group process, as might have been expected, however, participants in the smaller groups made few specific criticisms of their group. The evaluation checklist filled out by Slater's subjects asked little about group resources, a possible source of members' unspecified dissatisfaction in the smaller groups. In the present study it is not anticipated that small groups will perceive their resources as insufficient to deal with the task, and the effects of undermanning will probably be offset by the increased salience of individual contributions

in the smaller groups.

General Hypothesis 1

The ability of a group to select a correct solution to a question or problem will vary directly with the size of the group, within the range of sizes to be tested. Although process losses are expected to increase with group size, and cause larger groups to perform at a decreasing proportion of their potential, actual productivity is not expected to decrease in the 1 to 7 size range to be used in this study.

Individual Acquisition and Retention of Correct Responses

In discussing alternative solutions or answers to a problem, group members are frequently exposed to new ideas and better alternatives, in the contributions of other members. To the extent that a member can later recall other members' positive contributions to the group effort, he has benefited from the interaction, and to the extent that he acquires and retains correct responses to questions faced by the group, he has learned from the group experience. This section of the paper will focus on individual group members' acquisition and retention of correct responses, as a function of their group membership.

The group as an environment facilitating learning. Gurnee (1968) has noted that little research has been done on groups as an environment affecting learning. Despite the interest in social agents as a source of patterns of behavior in the literature on social learning, research has not focused on groups or appropriate group environments. Along with the question of optimum size, then, whether or not

groups can facilitate individual learning at all is of interest in this research.

in a review of social facilitation research, Zajonc (1966) concluded that "... the effects of coaction on learning, like the effects of audience, are negative (p. 27)." Zajonc does mention, however, that if others can provide clues regarding what are correct and incorrect responses, coaction seems to facilitate learning.

Gurnee (1937, 1939) found mixed results regarding an individual's ability to acquire a correct response in a group context. Subjects completed six trials of maze learning, either in small groups or alone. A seventh trial was completed by each subject alone. In both studies, groups performed better for the first six trials, but only in the second study were subjects who had worked in groups superior to those who had worked as individuals.

In an early study, Barton (1926) gave algebra problems to students to solve either as individuals, or in small groups. A regular course examination on the subject matter favored students who had worked in small groups.

Discussion groups, a context mentioned previously as one where benefits accruing to individual group members are expected, were favored in a study by Ryan (cf., Lorge, 1958). Participants in college level discussion groups learned more than students who studied the same material individually.

Perlmutter and de Montmollin (1952) had subjects learn two lists of nonsense syllables, one list in groups of three, and one list individually. Order of learning was reversed for half of the subjects, producing G-I

subjects, and I-G subjects. Group performance was approximately equal, regardless of the order of participation. Individuals who had previously participated in groups, however, performed better than subjects with no previous group experience on the task. The authors conclude that working in a group significantly helps individuals performing on a similar task at a later time. An appropriate control, not employed by Perlmutter and de Montmollin, would have been a group of I-I subjects, enabling one to compare the effects of group task experience with individual task experience, as a determinant of subsequent individual performance.

In a 1955 study by Yuker, subjects read a story, and were then asked to recall as much as they could remember. The individual recall was followed by recall in groups of four, and finally, by a second individual recall. As might be expected, group recall exceeded either individual recall, but important here was the fact that the second individual recall was significantly better than the initial individual recall. This improvement is presumably a result of recall of information acquired in the group setting.

Schellenberg (1959) assigned students to work on course material in discussion groups of various size, from 4 to 10. Members of smaller discussion groups were higher in academic achievement in this study.

In a 1963 study Porter found group performance on a maze task to be a positive function of group size, using groups of 2, 4, and 8 members. Subsequent individual performance on the task was a positive function of the total amount of discussion which had taken place in the group. An hypothesized positive relationship between individual talking in the

group and subsequent individual performance was not confirmed, since all individuals talked about the same in the group setting.

There seem to be ample findings indicating that the group setting can facilitate individual acquisition of a correct response, under some circumstances. The Gurnee, Barton, Ryan, and Yuker studies provide evidence of group discussion or group preparation leading to a subsequent individual performance superior to performance following an individual preparation or experience. The specific conditions under which learning in groups might be expected, and an optimal group size, is not clear from these studies. The studies by Schellenberg and by Porter provide mixed data regarding optimal size. The question of optimal size will be pursued below.

Acquisition Process

The acquisition and retention process is conceived of here as having two steps: (1) The selection of a correct answer by group members; and (2) the retention of that answer by individual group members.

Selection of a Correct Answer. The predictions regarding groups' ability to select correct responses have been discussed previously, under the heading "Effective combination of resources." Larger groups are expected to perform better within the size range to be tested.

Retention. The second step, the retention of the group response, can be treated as an additional source of process losses. If a group has the potential to select a correct response, then each member also has the potential to learn it, that is to accept it and retain it in

the future. The questions which are planned for this study are not so difficult that the correct answer cannot be understood by the participants. However, if an individual does not participate in the group discussion, he is unlikely to understand why a given solution was favored by the group, and his lack of involvement in the decision-making process is likely to render the decision less salient and less available for recall.

A decrease in participation can be a function of a drop in motivation, or an inability to coordinate all members' participation. As discussed earlier, these process losses are especially likely in larger groups.

Gurnee (1968), and Bechterev and Lange (cf., Dashiell, 1935) indicate that it is the less competent person who benefits most from group interaction. This might also be expected to be the case with this task of acquiring correct responses in group discussion, since the more competent members are going to initially know more correct responses. However, as found by Stephan and Mishler (1952) participation is likely to drop off rapidly for less active members of a group, as size increases. In group interaction the less competent members are probably less active. This constitutes a process loss interferring most with those who have the most to gain. The effect described by Stephan and Mishler probably constitutes both a coordination and a motivation loss, since in larger groups time limits the number of contributions, and those less confident of their solutions (Johnson and Torcivia, 1967) are likely to be the first to drop out of the competition for speaking time. Additionally, participation in the group decision is likely to

facilitate an internalization of that decision (cf., Kelman, 1961), rather than a more temporary compliance.

General Hypothesis 2

Acquisition and retention of correct responses in the group discussion context will be a curvilinear function of group size, with the greatest acquisition of correct responses occuring for subjects in intermediate group sizes.

For, although the ability of the group to select an appropriate response should increase with group size, the relational complexity of the group (Thomas and Fink, 1963) will increase rapidly. Those who stand to profit most will tend to drop out of the group discussion, because of the increased process problems caused by their continued participation. In the largest groups, composed of seven members, it is predicted that the decrement in average member participation will produce a corresponding decrement in individual acquisition of correct responses, compared to the performance of individuals from groups of three and five members.

CHAPTER II

PILOT STUDY

Prior to the main research a pilot study was run, primarily to test the following two general hypotheses:

(1) The ability of a group to select a correct answer to a given question is a positive function of group size, within the range of sizes tested;

(2) The ability of group members to acquire and retain correct information in the group discussion is a curvilinear function of group size, with the greatest retention for members of intermediate sized groups, of about size five.

The Group Examination

For the pilot study it was possible to take advantage of a situation in which group discussion has been used specifically to facilitate learning of course material by individuals. Since subjects participated *in situ*, the results were particularly relevant to a specific application of group facilitated learning.

Subjects were members of a large introductory psychology course at the University of Massachusetts, which has a course enrollment of about 2000 students each semester. At the time of this study two of the four examinations were taken in small groups of five to seven members. Students were encouraged to discuss each examination question with other group members, and were permitted to mark their own individual answer sheets. A primary purpose of the group examination is to facilitate the exchange of information, and promote the acquisition of

correct answers by individual students. The pilot study offered an excellent opportunity to evaluate the group examination, as well as the general hypotheses stated above.

Method of Pilot Study

Subjects

One hundred and sixty-eight introductory psychology students volunteered to participate in this study. They received additional points toward their course grade, for their participation.

Procedure

Subjects took a regularly scheduled multiple-choice group examination, being assigned to work as follows: 35 single individuals; 10 groups of three subjects each; 8 groups of five subjects each; and 9 groups of seven subjects each. During the exam, subjects in groups were permitted to discuss the questions within their own group and to mark their own answer sheets. Single individuals were not permitted to discuss the exam with anyone. This testing will subsequently be referred to as $Time_{1g}$ (first time period, group setting).

Upon completion of that exam, all subjects filled out a questionnaire regarding perceived optimum size, group resources, and motivation and coordination in their group. After responding to this questionnaire, subjects again answered the exam questions, all subjects working this time individually (called $Time_{2i}$). The $Time_{2i}$ performance of $Time_{1g}$ single individuals served as a baseline to which the $Time_{2i}$ performance of $Time_{1g}$ group subjects could be compared. Higher scores at $Time_{2i}$ by subjects who had participated in groups at $Time_{1g}$ would presumably be

the result of retention of correct responses acquired in the group discussion.

Results

Performance Measures

General Hypothesis 1. Table I shows the mean test scores as a function of $Time_{1g}$ group size. These scores were as predicted, with test score a positive function of discussion group size.

TABLE I

Mean Individual Test Scores at $Time_{1g}$ and $Time_{2i}$ As a Function of Discussion Group Size and Time of Administration

	$Time_{1g}$ Discussion Group Size			
	1	3	5	7
$Time_{1g}$ Discussion Group	7.00	8.30	8.33	10.38
$Time_{2i}$ Post-Discussion Individual Scores	7.00	8.30	8.20	9.92
"Forgetting" ($Time_{2i}$ - $Time_{1g}$)	.00	.00	-.125	-.460[a]

[a] Difference between .460 and .125, $t = 2.24$, $p < .05$

General Hypothesis 2. The $Time_{2i}$ administration of the test did not support the hypothesis that members of groups of intermediate size would be superior in the recall of correct responses. However, the "forgetting" score data do show that, for subjects in groups of size 7 at $Time_{1g}$, performance declined significantly more than for subjects in smaller groups.

Posttest Questionnaire

Perceived Optimum Size. Table II indicates subjects' responses to questionnaire items, as a function of their $Time_{lg}$ discussion group size. Answers to Question 2 indicate that subjects felt that about 4 or 5 group members would be the most appropriate size for this task. The perceived optimum size was, to a great extent, a positive function of the size of the discussion group.

Resources. Question 3 in Table II indicates that perceived group resources were a positive function of group size. Subjects' perceptions of the frequency of having a correct answer present in the group corroborated this positive relationship between resources and group size.

Process: Coordination Losses. Questions 5 through 8 in Table II consistently indicate perceptions of increasing coordination problems as group size increased. Leaders were reported in larger groups, where a greater need for a leader was perceived. Larger groups had more trouble establishing a consensus, and had more group members crowded out of the discussion.

Processes: Motivation Losses. Questions 9 through 11 indicate that more members were seen to be unmotivated to participate in the task in larger groups than in smaller groups. A comparison of Questions 10 and 11 indicates that subjects perceived the less competent members to have been those who were the less motivated in the large group sizes.

Group Atmosphere. Questions 12 and 13 show only minor differences between group sizes, with regard to inhibitions felt in the group. Question 12 indicates that subjects in smaller groups felt somewhat more free to express their own viewpoints.

TABLE II

Post-Discussion Questionnaire Responses

	Time$_1$ Discussion Group Size			
	1	3	5	7
OPTIMUM SIZE				
1. Was this group too large, too small or about right in size? (1 = too small, 9 = too large)[a]	1.74	3.73	5.35	6.54
2. The best group size is __ people (fill in the blank).	4.18	4.20	4.53	5.16
RESOURCES				
3. How large were the ability differences among members of the group? (1 = small, 9 = considerable)	1.91	3.97	4.62	5.22
4. Were the correct answers presented in the group? (1 = never, 9 = always)	5.24	6.10	6.00	6.40
PROCESS COORDINATION				
5. Did this group <u>need</u> a definite leader? (1 = no, 9 = yes)	(2.80)[b]	3.90	4.02	4.13
6. Did this group <u>have</u> a definite leader? (1 = no, 9 = yes)	(7.31)	3.43	3.70	4.51
7. Did this group have trouble establishing a consensus answer? (1 = never, 9 = always)	(3.59)	4.47	4.75	5.38
8. Were some people crowded out of the discussion? (1 = never, 9 = always)	(1.78)	1.83	3.45	3.85
PROCESS MOTIVATION				
9. Did some people in this group not seem motivated to actively participate in the task? (1 = all members motivated, 9 = many not motivated)	(2.31)	3.17	3.87	4.81

Table II continued

10. Did the competent members of this group get tired of giving all the answers? (1 = nobody got tired, 9 = definitely got tired)	(3.86)	1.80	2.79	2.57
11. Did less competent members feel a need to participate in the discussions? (1 = participated equally, 9 = felt no need)	(2.87)	2.90	4.41	4.90
GROUP ATMOSPHERE				
12. Did you feel free to express your viewpoints? (1 = never free, 9 = always free)	(8.26)	8.80	8.45	8.21
13. Was the group able to accept overt expressions of conflict? (1 = unaccepting, 9 = accepting of conflict)	(7.14)	7.47	7.54	7.10

[a] Some scales have been reversed for the convenience of the reader, and question order changed to improve organization.

[b] Individual Time$_1$ responses are in parentheses when not relevant to the question asked.

Benefits of "Ideal Size." Subjects' responses to questions regarding resources and process are classified in Table III, according to whether the subject felt his discussion group was too small, about right, or too large. Subjects who felt that their group had been too small thought that a group of ideal size would have more people with the correct answer, that is, greater resources. An interesting trend shown in Questions 2 and 3 in Table III is that subjects in both large and small groups indicated that their ideal size group would probably have fewer process problems.

TABLE III

Perceived Benefits of the Ideal Size Group

Characteristic of Ideal Group	Rated Size of Rater's Own Group		
	Too Small 1 - 3	About Right 4 - 6	Too Large 7 - 9
1. Would have been more likely to have someone in the group with correct answer (1 = agree, 9 = disagree)	2.33(46)[a]	5.04(50)	6.53(43)
2. Would have been easier to discuss issues. (1 = agree, 9 = disagree)[b]	3.00(16)	3.85(46)	2.09(44)
3. Would have been easier to reach real understandings and establish a consensus answer. (1 = agree, 9 = disagree)	2.12(17)	3.72(47)	2.07(44)

[a] Number of respondents is given in parentheses.

[b] $Time_{1g}$ individual subjects not included for questions 2 and 3.

Discussion of Pilot Results

Performance Measures

Group performance in the discussion setting was as predicted, the proportion of correct answers being a positive function of group size (Table I). The performance of groups of three and five persons was more similar than expected: Subjects' evaluations of resources (Table II, Question 4) reflected this performance similarity quite accurately.

The post-discussion individual performance was better than expected for members from groups of size seven. It had been expected that performance for members of size seven would be no better than for members of groups of size five. Perhaps extending the time between the group and individual administrations would yield the predicted curvilinearity.

Resources

The assumption that resources would be perceived by subjects to be a positive function of group size is supported by the pilot data. It is interesting to note, as mentioned above, how closely the pattern of subjects' evaluations of their relevant resources (Table II, Question 4) reflects the actual performance of the groups (Table I, Discussion group test performance). The similar performance of groups of three and of five was paralleled by subject perceptions of similar resources for these groups of three and five members.

Process: Coordination Losses

The trend in perceived coordination losses was as predicted, per-

ceived losses being a direct function of group size. In situations where the need for a leader is perceived, a leader or leaders tend to emerge (Table II, Questions 5 and 6).

Process: Motivation Losses

The posttest perceptions of subjects revealed a facilitative process in individual member motivation. As coordination problems increase with size, the less competent members were seen as those who tend to drop out of the discussion. This tendency would probably lead the group to arrive at more correct answers than if motivational decrements were equally distributed across ability levels.

Group Atmosphere

The data indicated that subjects in smaller groups tended to feel somewhat more free to express their own viewpoints than did members of larger groups (Table II, Question 12). This contradicts the findings of Bales and Borgatta (1955) regarding inhibitions as a function of group size.

Anticipated Benefits of a Group of Ideal Size

The predicted relationship between perceived group size and group resources was established (Table III, Question 1). An unexpected relationship was revealed, however, in regard to perceptions regarding process, where members of both "too small" and "too large" groups felt that they would have fewer process problems in an ideal size group. The problem experienced by smaller groups of establishing a consensus

probably related to their lack of resources. Without any member possessing confidence in his choice of a response, discussion will not be facilitated, and establishing a consensus will be difficult.

These analyses indicated that, unlike Slater's (1958) findings, members of small groups may sometimes express more dissatisfaction than members of larger groups. Where members of large groups are likely to complain only about process problems, members of small groups can suffer from lack of resources and experience process problems due to their lack of resources.

The Group Examination

It is difficult to draw conclusions relative to appropriate group size for the group examination. Members of the larger groups performed better on the $Time_{2i}$ individual exam, but their performance also showed the greatest decline from their $Time_{1g}$ individual exam scores.

The conditions of the group examination will be paralleled in the main study, and a greater intervening time between group and subsequent individual testing used, to permit more accurate inferences about the acquisition and retention of correct responses as a function of discussion group size.

Additional Considerations for the Main Study

Group Resources

The pilot study did not evaluate the abilities of group members prior to the group examination, and did not permit a calculation of group resources. Since process losses cannot be directly observed,

but must be calculated from observed potential and actual productivity it is desirable to have a measure of individual resources prior to group interaction on the task. The main study assessed individual performance on the task, prior to assigning subjects to groups.

Reduction of Expected Process Losses

Process problems in groups may be reduced if the group can organize its efforts. Groups may organize over time, as indicated by Anderson's (1961) replication of Watson's (1928) small group study. Anderson gave his *ad hoc* group more time on their anagram task, and found that their performance was better than for Watson's groups.

Group organization and process reduction may be facilitated by a group leader. Maier and Solem (1952) demonstrated that a discussion leader instructed to encourage the participation of all members tended to facilitate the acceptance of correct minority views in a group discussion.

Process problems expected to have an especially negative effect on the performance of larger groups are: (1) Relational complexity, or increasing competition between communication channels; (2) member inhibition, particularly members representing minority views; and (3) increased normative pressures from majority members.

The main study permitted analyses of process loss reduction facilitated by a leader instructed to encourage participation, and of possible performance improvement over time.

Only odd-numbered group sizes were represented in the pilot study. The following section will consider what might be expected from even-numbered group sizes, particularly from the dyad.

Even numbered sizes, particularly size 2, have characteristics which may cause their performance to vary from the pattern expected for odd numbered sizes. In groups with an even number of members there is no "natural" majority, a condition which is particularly obvious when the group is composed of only two members.

In research by Thomas and Fink (1961), groups of two appeared to be superior to other sizes in producing correct answers when no one in the group originally knew the correct answer.

Johnson and Torcivia (1967) found further positive support for the capabilities of group of size 2 using a problem solving task. In Johnson and Torcivia's groups of 2 "truth tended to triumph" when one or both members of the pair originally favored the correct answer. On an individual pretest, subjects knowing the correct answer to the problem were more confident in their chosen answers. In pairs where subjects had recorded different answers initially, the answer accepted jointly was largely a function of which subject was initially more confident of his answer. The more confident member of the dyad, then, would seem less inhibited in expressing himself.

Since the process of influencing group decisions through normative pressures is impossible when members of a dyad disagree, members are forced to influence each other as much as possible through the exchange of information.

The greater dependence upon informational pressures that probably

exists in the dyad, should result, then, in a greater realization of potential than in larger groups. In the main study, dyads were added to the group sizes considered in the pilot.

CHAPTER III

HYPOTHESES

This chapter will formulate additional hypotheses to supplement the two general hypotheses developed in Chapter I, and tested in the pilot study. The model generating the additional hypotheses will be:

Actual Productivity = Potential Productivity - Process Losses.

The literature discussed in the Introduction, the results of the pilot study, and the additional considerations discussed at the end of the pilot study chapter will be taken into account in articulating each hypothesis.

Effective Combination of Individual Resources

Hypothesis 1a

Although process losses should increase with group size, and cause larger groups to perform at a decreasing proportion of their potential, actual productivity should not decrease in the 1 to 7 size range used in this study.

1a: The ability of a group to select a correct solution to a question or problem will vary directly with the size of the group, within the range of sizes to be tested.

Hypotheses 1b and 1c

A reduction of process losses will increase the actual productivity of a group, if it is not performing at its potential. A selected leader may help reduce process losses, as may the allowance of additional time

for a group to organize.

1b: Groups will select more correct answers if instructed to select a leader to guide discussion and encourage the participation of all members, than if given no instructions regarding leadership.

1c: Groups will perform better on later questions than on earlier questions.

Hypotheses 1d and 1e

The benefit of selecting a leader, or the effect of additional interaction time should be greatest for those groups who suffer the greatest process problems. The greatest process losses are expected in larger groups, and their actual productivity might be expected to benefit most from the selection of a discussion leader, or from additional interaction time.

1d: Large groups will benefit more from the selection of a leader than will small groups.

1e: Large groups will improve their performance more over time than will small groups.

Hypothesis 1f

Members of two person groups will be restricted in their decision-making process by their inability to force a decision through normative or majority pressures. Their greater reliance on information exchange to justify a group decision should result in a more effective combination of resources for the dyad than for other group sizes.

1f: Groups of two will select correct answers at a greater proportion of their potential than will other group sizes.

Individual Acquisition and Retention of Correct Responses

Hypothesis 2a

Although the ability of the group to select a correct response will tend to increase with group size, the rapidly increasing process problems will cause those who stand to profit most from the group discussion to drop out, because of the process problems caused by their continued participation. By extending the time period between group and subsequent individual testings, the greater performance decrements shown by the larger groups in the pilot study should increase even further and reduce their actual performance to a level below that of groups of intermediate size.

2a: Acquisition and retention of correct responses in the group discussion context will be a curvilinear function of group size, with the greatest acquisition of correct responses occurring for subjects in intermediate group sizes.

Hypotheses 2b - 2f

Since the selection of correct responses by the group is conceived here as the first step in the individual acquisition process, improvements in a group's ability to select correct responses are expected to

be accompanied by a corresponding increase in individual members' acquisition of responses which are correct. Hypotheses 2b-2f reflect these assumptions.

2b: Individual group members will acquire and retain more correct answers to questions discussed in a group if the group is instructed to select a leader to direct the group discussion.

2c: Individual group members will acquire and retain more correct answers to questions discussed later by a group, than for questions discussed earlier.

2d: The benefit to the individual of selecting a leader will be greater for members of large groups than for members of small groups.

2e: The improvement in acquisition of answers to later questions, over earlier questions, will be greater for members of large groups than for members of small groups.

2f: Members of groups of two will acquire and retain correct responses from the group discussion at a greater proportion of their potential than will members of other group sizes.

CHAPTER IV

METHOD

Design and Overview

The study was designed to test the effects of group size and leadership on group performance and on subsequent individual performance. The subject's task was to correctly answer a series of 8 multiple-choice questions.

Subjects' performance on the task was to provide the following information: (1) The initial level of ability of subjects; (2) the ability of groups of differing size and leadership to utilize their resources; and (3) the ability of individuals to profit through the acquisition and retention of information, as a function of their experience on a group task.

Subjects worked on the task on two occasions, separated by about a week. In the first session (at $Time_1$) subjects initially answered the eight questions individually ($Time_{1i}$). Their performance was a measure of their initial ability level.

Immediately after completing the questions individually, subjects were assigned to groups of varying sizes to again work on the same task ($Time_{1g}$). At $Time_{1g}$ subjects were assigned to units of 1, 2, 3, 5, and 7 members: Persons in groups of 2 and larger were encouraged to work cooperatively with other members of their group.

In addition to group size, a second independent variable was manipulated in the $Time_{1g}$ session, in a 2 x 2 factorial design. Half of the groups were given instructions to select a leader whose

responsibilities included insuring that all members participated in the task. The other half of the groups received no instructions regarding leadership.

Following the $Time_{1g}$ task, subjects filled out a questionnaire dealing with their experiences on the task (see Appendix 1). The questions provided a check of the leadership manipulation, and a record of subjects' perceptions of their group's resources and process.

Approximately one week after the $Time_{1i}$ and $Time_{1g}$ administrations subjects again attempted to correctly answer the same set of eight questions, all subjects working again individually ($Time_{2i}$).

Subjects

The subjects in this study were 167 students, 72 males and 95 females, enrolled in two sections of a large undergraduate course in social psychology at the University of Massachusetts. They received credit toward their course grade for their participation in the experiment. In addition, 120 other course members who had not previously worked on the experimental task also answered the questions at $Time_{2i}$.

Fifteen other volunteer subjects pre-tested the questions used in the study as the performance measure.

The Task

A sample of 23 multiple-choice questions was prepared, relating to topics dealt with in both sections of the undergraduate social psychology course, Questions were drawn from the lectures and from a movie about Social Psychology entitled "The Social Animal." The sample of questions was reviewed by both lecturers for the two sections to

insure that the questions represented material from their course.

In order to assess the difficulty of the questions, 15 volunteer subjects answered the 23 questions two days prior to the $Time_{1i}$ and $Time_{1g}$ administrations. From the 23-question sample, 8 questions were selected, according to the following criteria:

(a) Questions were avoided that almost everyone, or almost nobody could answer;

(b) Questions were equally relevant to the topics dealt with by each section;

(c) Difficulty was not determined by a single, misleading alternative.

Questions were selected which were answered correctly by 46% to 67% of the pretest subjects, and for which performance was approximately equal across both class sections. One question found satisfactory by virtue of its difficulty was eliminated because most of its incorrect answers were identical.

The specified questions and response alternatives chosen for the task are presented in Appendix 2. The order of question presentation was varied for each of the three administrations, corresponding to the numbering of the specific question in the appendix, and the key given below:

Code Numbers for Questions

$Time_{1i}$: 5 6 7 8 1 2 3 4

$Time_{1g}$: 1 2 3 4 5 6 7 8

Or: 8 7 6 5 4 3 2 1

$Time_{2i}$: 5 6 7 8 1 2 3 4

Procedure

$Time_{1i}$

Eight multiple-choice questions were administered in two large rooms to individual subjects, who were given 10 minutes to answer the questions. Less than half the subjects who had earlier volunteered to participate did, in fact, come at the designated time, so additional subjects were contacted; they participated in similar sessions held during the two days following the initial administration.

Subjects were asked to indicate their choice of the correct answer to each question by circling the most appropriate alternative given. After choosing an answer, each subject was asked to indicate how certain he was that his answer was correct, on a six-point scale ranging from "extremely certain" to "extremely uncertain."

$Time_{1g}$

Directly following the $Time_{1i}$ administration of the task questions assigned, subjects were randomly assigned to work either alone or in groups. Assigned were 11 individuals, 12 groups of two, 12 groups of three, 8 groups of five, and 8 groups of seven members. Subjects were each given a set of directions, two sample questions, and the eight experimental questions. Instructions were similar to $Time_{1i}$, in that the subjects were asked to circle the most appropriate response alternative, and to indicate how certain they were that the chosen alternative was correct. Members of groups were to discuss each question with other members of his group, and the group was to select a single group response for each question. The certainty response

remained an individual measure of a subject's confidence in the group decision.

Half of the groups received written instructions to select a leader for the task. These subjects' instructions were as follows:

> Before starting to work on the group task, select a leader for your group. The leader's function will be to insure that:
>
> a. All members participate and make a contribution to the group effort.
>
> b. All members help determine the group answer.

Time$_{2i}$

Approximately one week later, 121 of the Time$_1$ subjects again answered the same set of eight questions. This time all subjects worked as individuals. The questions were attached to the regularly scheduled mid-term exam, and subjects were asked to complete the questions after completing the exam. Either because of time pressures or because they did not take the mid-term exam, 46 of the 167 subjects failed to answer all the Time$_{2i}$ questions. The certainty measure included in the Time$_{1i}$ and Time$_{1g}$ administrations was omitted at Time$_{2i}$.

Students who had not participated in the experiment at Time$_1$ were also asked to attempt to answer the questions at Time$_{2i}$. A total of 120 such "non-experimental" subjects completed all eight questions. The performance of the non-experimental subjects provided a baseline to which the performance of selected subsets of experimental subjects were subsequently compared.

Posttest Questionnaire

Following the $Time_{1g}$ task, all subjects individually filled out a questionnaire asking about their group experience. Questions about the following general areas of interest were included in the questionnaire:

(1) Best size for specific group activities, emphasizing aspects of process or resources;

(2) the perceived resources of the subject's own group;

(3) process problems, in terms of coordination and motivation losses;

(4) subject's own inhibition in expressing opinions in the group;

(5) ratings of participation and ability for self and all other group members.

The specific questions and the response format are included in Appendix 1.

Difference Scores

In order to account for differences in subjects' initial level of ability and confidence three new variables were created. This was accomplished by taking the difference between two original dependent variables.

A "learning" score provided an indication of the relative benefits which tended to accrue to the individual as a function of his group experience on the task, while taking into account some of the effects of his initial ability. The learning score was derived from the difference between a subject's $Time_{1i}$ score on the task from his $Time_{2i}$

score. Or: Learning = $Time_{2i}$ Score - $Time_{1i}$ Score.

A "forgetting" score provided an index of the relative ability of a subject to retain correct answers decided upon in the group. The forgetting score was derived by subtracting a subject's $Time_{2i}$ individual score from his $Time_{1g}$ group score. Or: Forgetting = $Time_{1g}$ Score - $Time_{2i}$ Score.

A "certainty change" score measured the realtive certainty of a subject in his group answers, compared to his certainty for individual answers at $Time_{1i}$. This score was derived by subtracting a subject's average certainty at $Time_{1i}$ from his average certainty at $Time_{1g}$. Or: Certainty = $Time_{1g}$ Certainty - $Time_{1i}$ Certainty.

Examination Scores

Following the mid-term examination, 121 experimental subjects and 120 non-experimental individuals completed the 8 questions of the task. In order to verify the validity of a comparison between these two groups, examination scores on the mid-term for each section were compared. Since the examination questions tested students' knowledge on the same topics as the experimental task, the mid-term score was judged to be a reasonable indication of ability on the eight questions comprising the task.

Potential Group Performance

In order to observe the relationship between group resources, actual group performance, and perceived process problems, these data were computed and compared graphically. Theoretical potential performance was calculated by the Lorge-Solomon (1955) formula.

The formula proposes that $100(1-Q^n)$ = percent of groups of size n are expected to have at least one member capable of answering the questions alone (where Q = the proportion of individuals in the population not capable of answering correctly alone). For groups of a given size the percent expected to have at least one member capable of answering the question alone was summed for the eight questions, to give an expected average total score for groups of that size.

The actual percent of groups having the potential to select the correct answer to a given question was equal to the number of groups at $Time_{lg}$ who had at least one member who had been correct at $Time_{li}$. These percentages were also summed for all eight questions to give an expected average total score.

One question was selected for a separate but similar analysis because (1) it was slightly more difficult than the other questions, and permitted a more gradual increase in potential performance as size increased; and (2) the distribution of responses indicated that the question was probably the closest to a "unitary task," a task not profitably subdivided. Incorrect responses were very evenly distributed across the four incorrect alternatives (74 subjects correct, 20, 21, 24, and 28 responses on incorrect alternatives), indicating that the difficulty had not been determined by one or two misleading alternatives. It was less likely, then, for this question, that groups could have dealt with the alternatives in a "multiple elimination" fashion, easily agreeing to eliminate some alternatives from consideration. The specific question chosen for this separate analysis is number three in Appendix 2.

CHAPTER V

RESULTS

Procedural Checks

Prior to examining data relevant to the specific hypotheses advanced and to other substantive analysis, a brief review of manipulation and other procedural checks will be made.

Questions Selected For Task

The criteria of the question selection procedure were met, as indicated by the $Time_{1i}$ performance of individual subjects. Subjects from both sections of the course averaged the same number correct answers, 4.12 out of 8 possible correct. Performance by members of the two sections did not differ significantly for any of the eight individual questions. The initial performance of subjects on the eight questions paralleled the performance of the pilot subjects, with the proportion of subjects correct on a given question varying between .44 and .66. No question had a single, very misleading incorrect alternative.

Leadership Manipulation Check

A posttest question "Did your group have a coordinator directing the group discussion?" served as a manipulation check for the leadership variable. Groups given instructions to select a leader more often reported having a coordinator ($F = 16.44$, $p < .001$), indicating that the request to select a leader was generally heeded.

Another indication that the manipulation had been effective was a significant leadership effect in an analysis of the posttest question "Were the least knowledgeable members motivated to contribute to the discussion?" Members of groups which had been assigned leaders reported their less knowledgeable members to be more motivated to participate than did members of groups not assigned to select leaders ($F = 4.66$, $p < .05$). Since the primary function explicitly assigned to selected leaders was to insure full participation by all members it appears that selected leaders did effectively follow their basic instructions.

$Time_{li}$ Performance

In order to evaluate the adequacy of the randomization procedures and the validity of analyses relative to the hypotheses, an analysis of $Time_{li}$ task scores was performed. Table I presents the mean $Time_{li}$ performance scores classified according to the size of the group in which the individual subsequently worked at $Time_{lg}$. Table II presents these data according to the leadership condition to which the subject was assigned at $Time_{lg}$.

Subjects averaged 4.61 correct answers on the 8 questions of the task. Performance did not differ significantly for subjects who subsequently served in different size groups. A significant effect of leadership condition, however, indicates that abilities were unevenly distributed with respect to the leadership variable. Subjects who subsequently received no instructions regarding leadership scored lower on the task at $Time_{li}$, but this was primarily due to a large discrepancy between subjects subsequently assigned to leader and leaderless groups

of five members. Subsequent analyses will take this initial discrepancy of abilities into account.

Hypotheses

Performance data were analyzed using an unequal cell frequency analysis of variance. Group size, Leadership, and Size X Leadership sources of variance were tested. A preliminary test of the Groups/ Size X Leadership treatment effect against the Subjects/Groups/Size X Leadership effect did not reveal significance levels exceeding a .10 level, so the two treatment effects were pooled to provide an error term.

$Time_{1g}$ Performance Hypotheses

Hypothesis 1a

This hypothesis predicted that group performance would be positively related to group size, within the range of sizes tested. Results presented in Table I and Figure 1 indicate that this hypothesis was confirmed. Performance scores were consistently greater for larger groups, for all possible comparisons.

Hypothesis 1b

It was predicted that groups would perform better if they were instructed to select a discussion leader, than if no instructions regarding leadership were given. Table II indicates that there was not a significant difference in performance as a function of leadership instructions. In fact, the initial discrepancy in abilities shown in $Time_{1i}$ performance has become non-significant, although the difference

TABLE I

Performance Scores as a Function of

$Time_{1g}$ Group Size

Performance Measure [a]	Group Size						
	1	2	3	5	7	All Sizes	
$Time_{1i}$	4.00 (11)	4.46 (24)	4.73 (36)	4.30 (40)	4.95 (56)	4.61 (167)	
$Time_{1g}$	4.36 (11)	4.92 (12)	6.59 (12)	7.00 (8)	7.38 (8)	5.90 (51)	***
$Time_{2i}$	4.63 (8)	5.42 (19)	5.93 (27)	5.80 (25)	6.42 (42)	5.90 (121)	*
Significance of difference at $Time_{2i}$ between non-experimental individuals and individuals having worked in groups	($p > .50$) [e]	($p < .03$)	($p < .001$)	($p < .001$)	($p < .001$)	Mean 4.18 (120)	
Forgetting T_{1g} to T_{2i} [b]	.25 (8)	.69 (19)	-.59 (27)	-1.24 (25)	-.96 (42)	-.60 (121)	***

TABLE I

(continued)

Learning $T_{1i} - T_{2i}$ [b]	.75 (8)	1.00 (19)	1.00 (27)	1.40 (25)	1.40 (42)	1.21 (121)

* $p < .02$.

*** $p < .001$.

a Out of 8 possible.

b A positive score indicates an improvement at $Time_{2i}$.

c Number of subjects indicated in parentheses, numbers for $Time_{1g}$ are group totals.

d Underlined figures do not differ significantly from one another.

e Figures note significance of experimental subjects' performance at $Time_{2i}$ compared to that of non-experimental controls.

TABLE II

Performance Scores as a

Function of Assigned Leadership

Performance Measure [a]	Leadership Condition			
	Appointed Leader	No Appointed Leader	All Groups	
$Time_{1i}$	4.90 (83)[c]	4.32 (84)	4.61 (167)	*
$Time_{1g}$	6.12 (25)	5.69 (26)	5.90 (51)	
$Time_{2i}$	6.10 (57)	5.73 (64)	5.90 (121)	
Forgetting T_{1g} to T_{2i} [b]	-.67 (57)	-.53 (64)	-.60 (121)	
Learning T_{1i} to T_{2i} [b]	1.26 (57)	1.16 (64)	1.21 (121)	

* $p < .05$

a out of 8 possible

b A positive score indicates an improvement at $Time_{2i}$

c Number of subjects indicated in parentheses, numbers for $Time_{1g}$ are group totals.

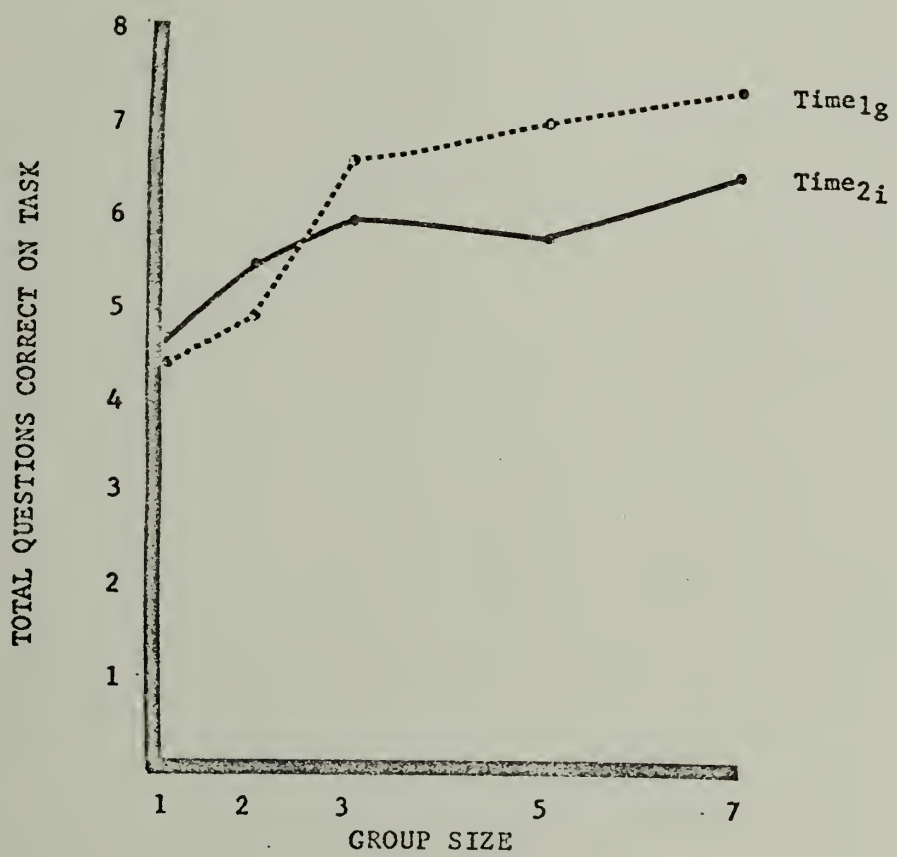

Figure 1: Actual performance as a function of group size.

is still in the same direction for the group task.

As mentioned in the Method chapter, responses to posttest questions supported the effectiveness of the leadership manipulation. Other posttest questions offer a hint why the predicted leadership effect did not appear. Members of larger groups reported that they had more difficulty coordinating their efforts on the task. In groups of five and seven, where the most difficulty was reported, members of groups given no leadership instructions tended to report that their group had a coordinator directing group discussion (interaction $p < .07$). What may have happened, then, is that where groups needed a leader and had none selected initially, a leader emerged, negating the effect of the leadership manipulation.

Hypothesis 1c

This hypothesis predicted that groups would perform better on later questions than on earlier questions. An analysis of performance on early vs. late questions failed to confirm the hypothesis, for the group sizes tested. Including all sizes, the average group was 75% correct on the first four questions and 73% correct on the second four questions. These data are presented in Table III.

Hypothesis 1d

Since larger groups were expected to suffer greater process losses, it was predicted that the selection of a leader would benefit larger groups more than it would benefit smaller groups. Operationally, the hypothesis predicts a Size by Leadership interaction, not significant in the $Time_{1g}$ analysis of variance ($F < 1$). As was the case for

TABLE III

Percent of Early and Late Questions Correct at $Time_{lg}$ as a Function of Group Size

Questions	Group Size					
	1 (N=11)	2 (N=12)	3 (N=12)	5 (N=8)	7 (N=8)	All Sizes (N=121)
First Four Questions	57[a]	56	88	91	94	75
Last Four Questions	52	67	77	84	91	73

[a] Numbers given are percent correct answers at $Time_{lg}$.

Hypothesis 1b, emerging leaders could have been an important factor negating hypothesized effects of the leadership manipulation.

Hypothesis 1e

This hypothesis predicted that larger groups would benefit more from additional interaction time, and would improve their performance more over time than would smaller groups. Table III presents group performance on early and late questions for all group sizes. Since the mean score for all of the larger groups was somewhat worse on the last four questions than on the first four questions, the hypothesis as stated was not confirmed.

Hypothesis 1f

Hypothesis 1f predicted that groups of two members would

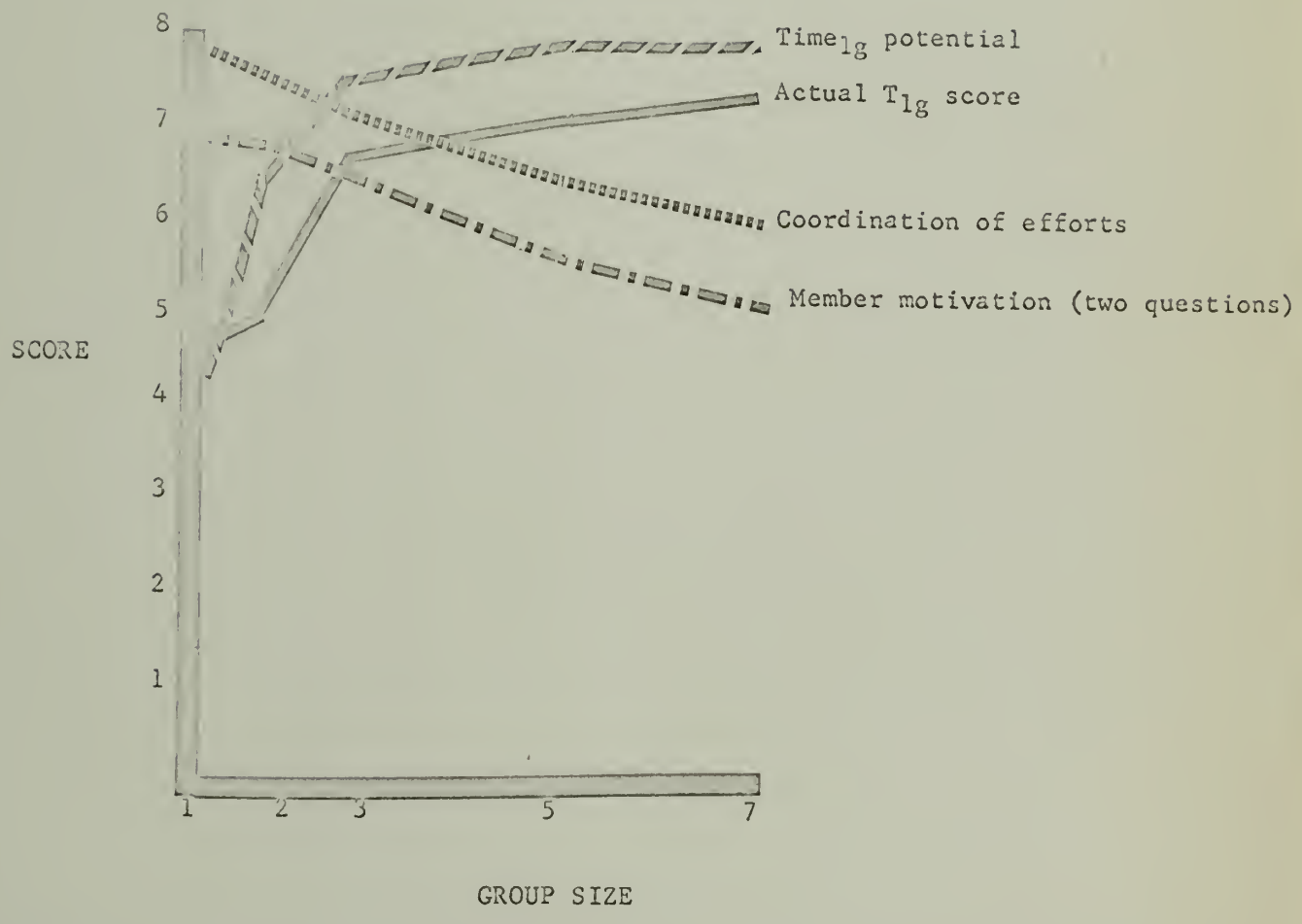

Figure 2: Actual Time$_{lg}$ scores, compared to group potential and reported member coordination and motivation, as a function of group size.

select correct answers at a greater proportion of their potential than would larger groups. The hypothesis was not confirmed, the difference between actual and potential performance for the eight questions of the task being insignificantly greater for groups of two than for larger groups. The potential of a group to answer correctly at $Time_{1g}$ was determined by the presence or absence of a member who had answered the question correctly at $Time_{1i}$. The potential and actual performance of groups and individuals at $Time_{1g}$ are presented in Figure 2.

$Time_{2i}$ Performance Hypotheses

Hypothesis 2a

This hypothesis predicted that the acquisition and retention of correct responses would be a curvilinear function of discussion group size, with the greatest acquisition and retention occurring for subjects from groups of intermediate size. Hypothesis 2a was not supported, however, as indicated by the $Time_{2i}$ performance data in Table I. $Time_{2i}$ performance was a linear function of group size, with individuals who had served in groups of 7 performing best. The only group size which had members performing significantly better than $Time_{1g}$ single individuals at $Time_{2i}$ was group size seven.

Table I also shows the relative performance of non-experimental students compared to that of experimental subjects in each group size, at $Time_{2i}$. Subjects who had twice answered the questions individually at $Time_1$ performed no better on their third attempt than did the non-experimental students answering the questions for the first time. In contrast, subjects who had worked in groups at $Time_{1g}$, performed

significantly better than the non-experimental students on the task at $Time_{2i}$.

A comparison of midterm exam grades of experimental and non-experimental respondents at $Time_{2i}$ was made to determine how valid a contrast of their performance on the experimental task might be. Since both the examination and the experimental task were based on the same body of course material, examination scores were thought to be a fair indication of ability on the task. The difference between scores on the midterm did not reach conventional levels of significance for either course section, as indicated in Table IV. The fact that this difference is non-significant adds credence to the apparent superiority of subjects with group discussion experience over non-experimental students on the $Time_{2i}$ administration of the task.

TABLE IV

Mean Percent Correct on the First Midterm Exam for Experimental and Non-Experimental Subjects Answering Task Questions at $Time_{2i}$ [a].

Section #	Experimental Subjects	Non-Experimental Subjects	
1	63% (57)[a]	58% (46)	$t=1.58, p<.20$
2	66% (58)	61% (50)	$t=1.95, p<.10$

[a] Where test scores were available, n's in parentheses.

Hypothesis 2b

This hypothesis predicted that subjects would score higher on the task at $Time_{2i}$ if their $Time_{1g}$ discussion group had been instructed to select a leader. The hypothesis was not confirmed, since there was not a significant difference between subjects from leader-appointed groups and subjects from groups where no leader had been appointed. These data are presented in Table II.

Since the $Time_{1g}$ performance of the groups was conceived of to be the first step in the individual acquisition process, and $Time_{1g}$ performance was not a significant function of Leadership, the expectation that the hypothesis would be confirmed was diminished. It was felt, however, that leaders' instructions to encourage all group members to participate might have helped the less competent members maintain their involvement, and thus may have facilitated their learning while perhaps not affecting $Time_{1g}$ group performance. Certainly the emerging leaders could have had an important effect on group performance, but the posttest indicated that subjects did not perceive that the emerging leaders kept the less knowledgeable members motivated to participate. In groups of five and seven members, where leaders were not appointed but were reported to have emerged, less knowledgeable members were reported as less motivated to participate than was the case for groups of the same size with appointed leaders. This lack of a leadership effect at $Time_{2i}$, with apparent differences in the behavior of appointed and emergent leaders, calls into question the supposition that participation of group process is necessary or helpful in the acquisition of new information in group discussion.

Hypothesis 2c

This hypothesis predicted that individual group members would acquire and retain more correct answers to later questions discussed in the group, than to later questions discussed. $Time_{1g}$ performance was conceived to be the first step in this acquisition process, and as indicated in Table III, groups did not improve their performance over time.

Hypothesis 2d

The hypothesis that the benefit of selecting a discussion leader would be greater for members of large groups than for members of small groups was not supported. The hypothesis predicted a Size by Leadership interaction for the $Time_{2i}$ performance measure, which was not significant.

Hypothesis 2e

It was predicted that the improvement in acquisition of correct answers to later questions over earlier questions would be greater for members of large groups than for members of small groups. This prediction was based upon the expectation of a similar trend in performance for groups at $Time_{1g}$. The predicted $Time_{1g}$ interaction of Size and Leadership, upon which the hypothesis was based, was not significant.

Hypothesis 2f

This hypothesis predicted that members of groups would acquire and retain correct responses from the group discussion at a

greater proportion of their potential than would members of other group sizes. Question 3 was chosen for this analysis, for a priori reasons discussed in the Method chapter. Members of groups of two did indeed appear to perform better on this question at $Time_{2i}$, not only with respect to their potential, as calculated at $Time_{1g}$, but better overall. The percentage of members of groups of two correct $Time_{2i}$ was 75, the highest percentage for members of any size group. The data for this analysis are presented in Figure 1.

This hypothesis was derived from the expectation of superior performance from groups of two at $Time_{1g}$ (Hypothesis 1f, which was not confirmed). The $Time_{2i}$ results may have been a result of different process in groups of two, which affected retention of information discussed in the group more than the group product itself. A greater dependence in groups of two upon informational exchange in the decision-making process, as discussed in the Pilot chapter, could have had such an effect.

Difference Scores

"Forgetting" Index

The difference between $Time_{1g}$ and $Time_{2i}$ performance on the task corresponds to a similar index in the pilot study, called "forgetting." This difference score provides an indication of the ability of group members to retain information from the group setting. In the main study members of larger groups showed a greater decrease in performance from $Time_{1g}$ to $Time_{2i}$ than did members of smaller groups. A similar

finding in the pilot study led to the unconfirmed prediction that, given a greater time interval between testings, groups of intermediate size would demonstrate superior performance on the $Time_{2i}$ measure. Table I presents the "forgetting" index from the main study and the $Time_{2i}$ performance data.

"Learning" Index

The difference between $Time_{1i}$ individual scores, and $Time_{2i}$ individual scores on the task gave an indication of the relative effect of the group discussion experience, taking subjects' initial level of ability into account. Data in the last row of Table I shows that this "learning" measure gives a fairly consistent advantage to members of the larger groups, although an analysis of variance indicated that the effect was nonsignificant.

Posttest Questions

Since it is impossible to observe all groups, to assess the effect of process on the group product, self-reports of subjects are a valuable input when using Steiner's (1972) model. It would be helpful to know, for example, what kind of process changes actually constitute losses from the groups' potential performance.

Questions and data from the posttest given in Tables VI and VII provide this information.

Resources

Steiner notes that for a divisible task with disjunctive subtasks, a classification into which this experimental task seems to fit, re-

sources will usually increase at a negatively accelerating rate, as a function of group size (1972, p. 78). Subject reports closely resembled the pattern described by Steiner, reported resources bearing a significant linear relationship to group size. These data are reported in Table VI and presented in Figure 3.

Figure 3 also presents two other calculations of group resources to which subject reports can be compared. "$Time_{lg}$ potential" represents the ability of a group to select a correct answer, based on having a member who was correct at $Time_{li}$. "Estimated potential" represents an estimation of the frequency a previously correct member is likely to be present in a group of a given size, based upon the distribution of individual abilities in the population and summed for the eight questions of the task. These two indices of potential have been previously discussed in this paper, in somewhat more detail.

The calculation of estimated potential was quite accurate with respect to its criterion, $Time_{lg}$ potential, as presented in Figure 3. The fact that subject estimates of group resources asymptotes somewhat sooner than the other indices of group potential is probably more of a reflection of subjects' general unwillingness to use the extremes of the scale, than a reflection of inaccurate perceptions of members' abilities.

Process: Coordination

Four questions in the posttest evaluated coordination aspects of process. They are presented in Tables VI and VII. The questions consistently indicated that process problems were a direct function of

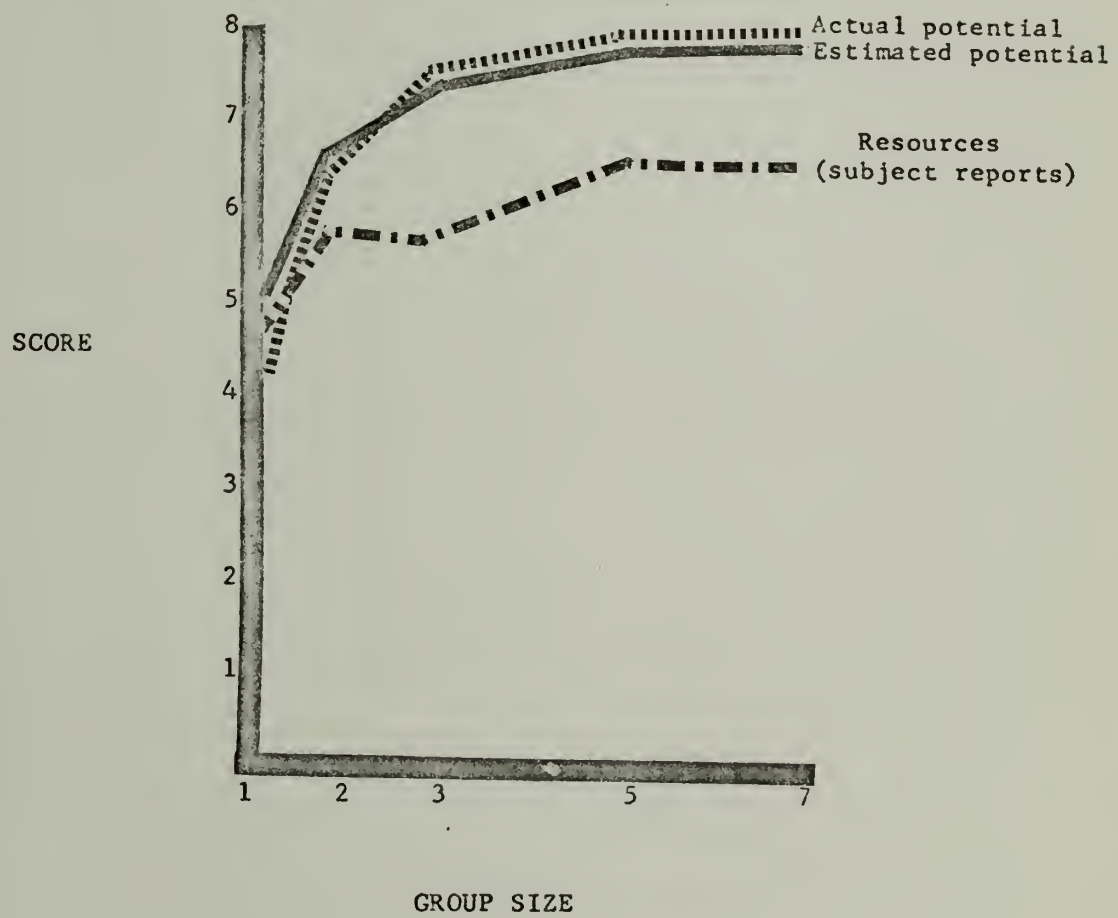

Figure 3: Actual and estimated group potential for eight questions at $Time_{1g}$, as a function of group size

TABLE VI

Members' Mean Responses to Posttest Questions

as a Function of $Time_{lg}$ Group Size

Question	Group Size						
	1(11)[a]	2(24)	3(36)	5(40)	7(56)	All Sizes (167)	
Resources							
How often do you think that at least one member of your group knew the correct answer? 1 = never, 9 = always	4.91	6.50	6.39	7.45	7.46	6.55	*** *
Process: Coordination							
How often were people crowded out of the discussion? 1 = never, 9 = always	(1.36)	1.13	1.78	2.43	3.72	2.47	*** *
Was your group able to agree on a unanimous group answer? 1 = never, 9 = always	(7.73)	8.21	7.45	7.20	6.69	7.26	** *
Were group members able to coordinate their efforts? 1 = never, 9 = always	(8.91)	8.38	8.00	7.15	6.96	7.56	*** *

TABLE VI

(continued)

Did your group have a coordinator directing the group discussion? 1 = never, 9 = always	(6.91)	2.84	4.00	6.30	5.39	5.04	*** *
Process: Motivation							
Were the most knowledgeable members motivated to contribute to your group's discussion? 1 = not at all, 9 = very motivated.	(7.82)	7.96	7.75	7.48	6.86	7.41	*
Were the least knowledgeable members motivated to contribute to your group's discussion? 1 = not at all, 9 = very motivated	(7.36)	7.34	6.67	5.23	4.56	5.76	*** *
Group Efficiency							
When during your discussion was your group most efficient? 1 = on early questions 9 = on late questions	4.54	5.55	5.48	5.38	5.34	5.36	

TABLE VI

(continued)

Group Atmosphere							
How free did you feel to express your opinions, especially if you were in the minority? 1 = felt very inhibited, 9 = felt very free	(7.54)	8.09	7.89	7.23	6.75	7.35	**

[a] n's for group size given in parentheses.

* $p < .05$.

** $p < .03$.

*** $p < .01$.

**** $p < .001$.

TABLE VII

Responses to Posttest Questions as a Function of $Time_{lg}$ Leadership Condition

Question	Leadership Condition			
	Leader Appointed (83)[a]	No Leader Appointed (84)	All Groups (167)	
Resources				
How often do you think that at least one member of your group knew the correct answer? 1 = never, 9 = always	6.45	6.65	6.55	*
Process: Coordination				
How often were people crowded out of the discussion? 1 = never, 9 = always	2.45	2.48	2.47	
Was your group able to agree on a unanimous group answer? 1 = never, 9 = always	7.08	7.44	7.26	
Were group members able to coordinate their efforts? 1 = never, 9 = always	7.74	7.39	7.56	
Did your group have a coordinator directing the group discussion? 1 = never, 9 = always	5.78	4.31	5.04	***

Process: Motivation				
Were the most knowledgeable members motivated to contribute to your group's discussion? 1 = not at all, 9 = very motivated.	7.54	7.29	7.41	
Were the least knowledgeable members motivated to contribute to the discussion? 1 = not at all, 9 = very motivated.	6.08	5.44	5.76	*
Group Efficiency				
When during your discussion was your group most efficient? 1 = on early questions, 9 = on late questions.	5.35	5.36	5.36	
Group Atmosphere				
How free did you feel to express your opinions, especially if you were in the minority? 1 = felt very inhibited, 9 = felt very free.	7.48	7.23	7.35	

[a] n's for leadership condition are in parentheses

* $p < .05$

*** $p < .001$

size, and the fourth question indicated that where the need for a coordinator was perceived, one tended to exist. For smaller groups, leaders were reported by groups when the group had been instructed to select one; for larger groups leaders were reported by groups in both leadership conditions.

The significant leadership effect for the question, "Did your group have a coordinator directing the group discussion?" supported the success of the leadership manipulation.

Process: Motivation

How motivated were the most knowledgeable and least knowledgeable group members to contribute to the group's discussion? These questions and the corresponding data are presented in Tables VI and VII.

Subjects reported that the more knowledgeable members of larger groups seemed less motivated than members of corresponding ability in the smaller group. In the pilot study subjects reported no difference in motivation for the more knowledgeable members, across group sizes.

Other data from the pilot study were replicated in the main study, members of larger groups reporting that their group's least knowledgeable members were less motivated to contribute than did members of smaller groups. The significant Leadership main effect for this question, indicated in Table VII, provided a second leadership manipulation check. Leaders had been instructed to insure that all members participated in the discussion and decision-making, and the leadership main effect on this question indicated that these instructions were perceived to have been effective.

Figure 2 illustrates changes in $Time_{1g}$ potential performance, in perceived coordination, and in perceived motivation, as a function of $Time_{1g}$ group size. Perceptions of process corresponded closely to the predictions generated by the model, with the perceived coordination of members' efforts, and motivation of members to contribute to the discussion inversely related to $Time_{1g}$ group size. Subject reports of process were made on a nine-point scale and have been multiplied by 8/9 for this figure, to correspond to the eight point maximum score on the experimental task.

Actual group performance at $Time_{1g}$, also illustrated in Figure 2, does not reflect the apparent relationship between potential and perceived process problems. Actual performance closely parallels the relationship of potential performance and size: If process became increasingly difficult as group size increased, as reports indicated, actual performance should have decreased in respect to potential performance.

Earlier, success on this task was conceived to be dependent upon the ability of the most competent member of the group. Overall motivation, and the ability of members to coordinate their joint efforts, may be less important to the functioning of the group on this task, then, than the motivation of the most competent member or members. The reported motivation of groups' most knowledgeable members is presented with potential and actual group scores at $Time_{1g}$ in Figure 4. The motivation reported for more competent group members declines only slightly with increasing group size. If subject responses are an accurate assessment of actual motivation levels, this reported decline

for the most knowledgeable members might not necessarily be reflected in a group performance decrement. For a given question, there are likely to be more members of the larger groups capable of providing a correct answer.

Group Efficiency

One posttest question asked, "When during your discussion was your group most efficient?" This question was intended to elicit perceptions of $Time_{lg}$ performance, and predictions paralleled those hypotheses dealing with $Time_{lg}$ performance. Neither the predicted Size or Leadership main effects, nor the Size by Leadership interaction were significant.

Group Atmosphere

The last posttest question asked subjects how free they felt to express their opinions, especially if in the minority. The main study replicated the results of the pilot study, and indicated that members of larger groups felt less free to express themselves than did members of smaller groups.

Subjects' Certainty of Own Correctness

In a study by Johnson and Torcivia (1967), certainty proved to have an important effect on group decision-making in the dyad. Individual subjects knowing the correct answer in a pretest of a problem-solving task were more confident in their chosen answers than subjects who were incorrect on the pretest. Later, when an individual who had

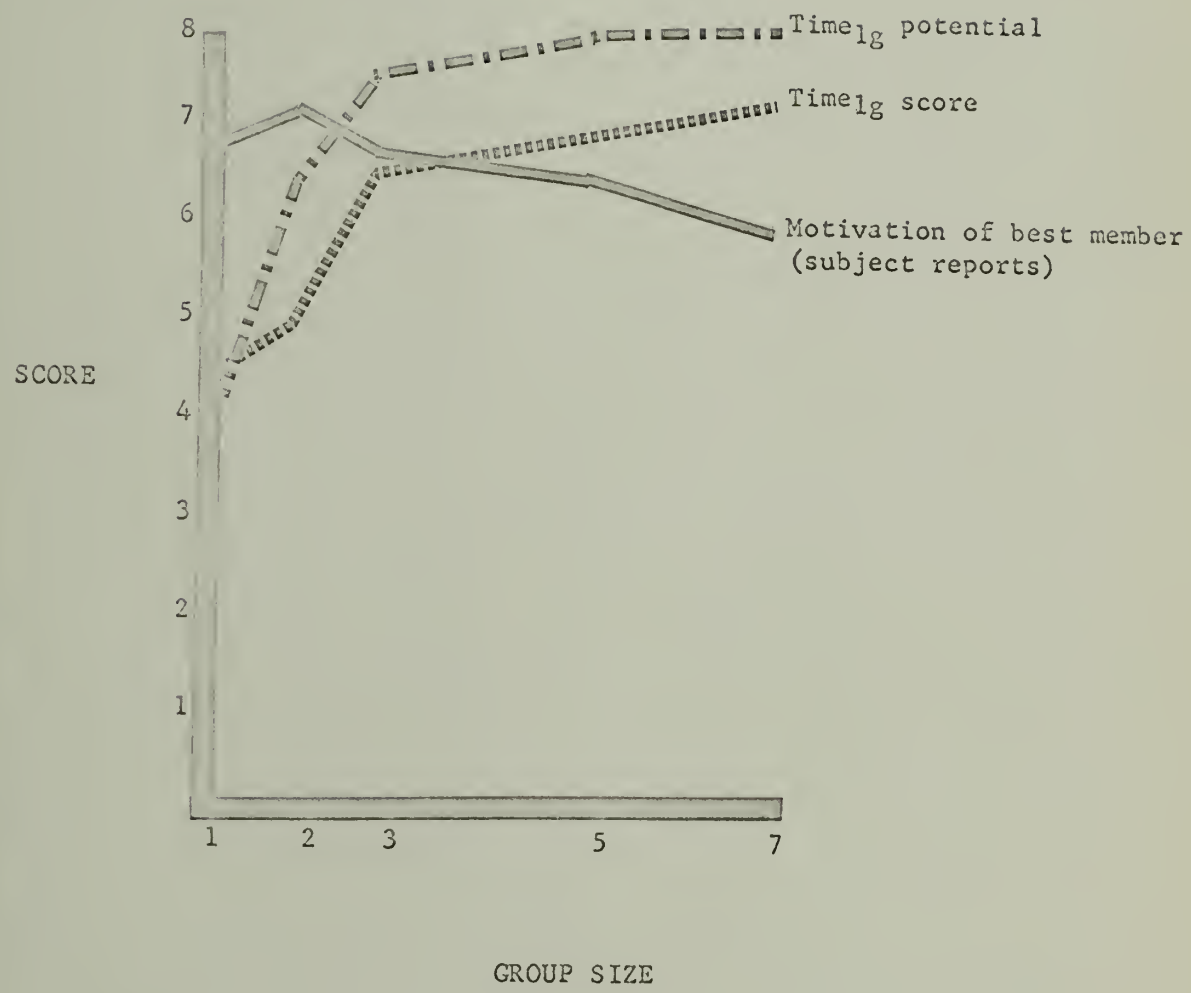

Figure 4: Actual group scores at Time$_{lg}$, compared to actual potential and best members' motivation, as a function of group size.

been correct on the pretest was paired with an individual who had been wrong initially, certainty was an accurate predictor of what answer would be selected. With the larger group sizes used in the present study it is more difficult to determine which member had the greatest influence in the decision-making process, but it is worthwhile to pursue the relationships of size, correctness and certainty in larger groups and on a different task.

Subjects were asked to indicate at $Time_{1i}$, on a six point scale, how certain they were that their chosen answer was correct, and at $Time_{1g}$ how certain they were that the answer chosen by their group was correct. The data for certainty responses are presented in Tables VIII and IX. These analyses were made with the same analysis of variance design used for the performance data.

The data indicated that subjects who were subsequently assigned to leaderless groups were less confident of their $Time_{1i}$ individual answers than were subjects subsequently assigned to groups asked to select a leader. This main effect paralleled the Leadership main effect in $Time_{1i}$ task performance analysis. The certainty totals for subjects to be assigned to leaderless groups were lower across all sizes, however, whereas the performance of these subjects was lower primarily for the group size of five.

At $Time_{1g}$, certainty was a significant positive function of group size, with members of groups of seven indicating the most certainty in their group's decision.

Changes in the average certainty indicated by subjects, from $Time_{1i}$ to $Time_{1g}$, tended to increase more when subjects made their decisions

in groups rather than alone. The increase in certainty was a significant function of group size, as shown in Table VIII, with the greatest increase shown for groups of three members.

It is not clear from Tables VIII and IX whether the increased certainty at $Time_{lg}$ reflects the degree of consensual validation (effect of group size alone), or the actual increased ability of the larger groups. Further correlational analyses examined these possibilities.

Correlational analyses. High correlations between certainty and both correctness and group size offered two possible mediators for subjects' confidence levels. The correlation between certainty and correctness was .39 at $Time_{li}$, and .40 at $Time_{lg}$. The correlation between certainty and group size was .25 at $Time_{lg}$. The correlation between the two possible mediators, group size and correctness, was .30 at $Time_{lg}$. Point-biseral coefficients were used for correlations involving correctness, and a Pearson product-moment coefficient for the group size-certainty correlation.

An analysis of partial correlations showed a partial correlation of .35 between certainty and correctness at $Time_{lg}$, with the effects of size removed, and a partial correlation of .15 between certainty and size, with the effects of correctness removed. Of the two partial correlations only the .35 correlation between certainty and correctness was significant ($p < .01$). The rather high correlation between certainty and correctness, considering the use of a point biserial correlation, indicated that subjects were quite accurate in judging whether or not their chosen answer was correct.

TABLE VIII

Mean Certainty of Correctness on Task Questions

as a Function of $Time_{lg}$ Group Size

Performance Measure	$Time_{lg}$ Group Size						
	1	2	3	5	7	All Sizes	
$Time_{li}$	3.93[a] (11)	4.04 (24)	3.79 (36)	4.01 (40)	4.23 (56)	4.03 (167)	
$Time_{lg}$	4.07 (11)	4.41 (24)	4.76 (36)	4.70 (40)	4.90 (56)	4.69 (167)	**
Average Total Change in Certainty for 8 questions ($\Sigma Time_{lg} - \Sigma Time_{li}$)	1.12 (11)	2.96 (24)	7.75 (36)	5.48 (40)	5.34 (56)	5.28 (167)	*

* $p < .02$.

** $p < .01$.

[a] A high number indicates greater certainty.

TABLE IX

Mean Certainty of Correctness on Task Questions as a Function of Leadership

Performance Measure	Leadership Condition			
	Appointed Leader	No Appointed Leader	All Groups	
$Time_{1i}$	4.20[a] (83)	3.87 (84)	4.03 (167)	*
$Time_{1g}$	4.78 (83)	4.61 (84)	4.69 (167)	
Average Total Change In Certainty For 8 Questions ($\Sigma Time_{1g} - \Sigma Time_{1i}$)	4.69 (83)	5.86 (84)	5.28 (167)	

* $p < .05$

[a] A high number indicates greater certainty.

Participation and Ability

Each subject was asked, at the end of the posttest questionnaire, to rate each member of his group on both their participation and ability on the task. The primary reason for including these ratings was to supplement the posttest questions asking about the motivation of the least and most knowledgeable group members. Additionally, the participation ratings were to provide a profile of members' participation, for each group size.

The average correlation between perceived participation and perceived ability, for the seven possible ratings, was .65. This average is for a total of 684 ratings, and is highly significant ($Z_{ave} = 20.05$, $p < .001$). The ratings were anonymous, so actual ability cannot be compared to rated ability. Since perceived resources, and certainty of the correctness of chosen answers have both been shown to be highly accurate, it is likely that subjects were fairly accurate in their appraisals of other members' ability.

That members of high ability participate more in the group discussion could not have been the whole story, however, Fifteen to twenty minutes of interaction, especially in the larger groups, is not enough time to make accurate appraisals of each member's ability on the task, especially for members who do not talk much during the session. Correlations range from a low of .55 for the first rating of participation and ability, usually a self-rating, to a high of .75 for the seventh rating, presumably for the group member about whom the rater has the least information about ability. Perceived participation,

then, appears to have played a substantial role in determining the level of perceived ability of other group members.

Small groups (1 to 3 members) usually indicated a high amount of participation for each member. Members of the larger groups (5 and 7 members) usually rated about as many members very low on participation as they rated high in participation, with varying numbers of members given intermediate ratings. Perceived participation did not drop off exponentially from the highest participator, as Stephan and Mishler's (1952) data might lead one to expect. In large groups two to four members were typically rated equally high on participation.

TABLE X

Correlations for Participation

and Ability Ratings

Rating Order	Correlation	Number of Ratings
1	.55	158
2	.73	141
3	.69	113
4	.73	90
5	.66	81
6	.69	53
7	.75	48

CHAPTER VI

DISCUSSION

This chapter reviews the successes and failures of the predictions of group, and subsequent individual success on the experimental task, using Steiner's (1972) group performance model. Where the hypotheses of the study were not confirmed, the reasons behind the failure will be pursued.

The data will be discussed under the following chapter subheadings: (1) Findings relative to the hypotheses; (2) Conclusions and recommendations regarding the group examination; and (3) The relationship between subjective certainty of correctness, and actual correctness for the experimental task.

Findings Relative to Hypotheses

Group Size

It was predicted that group performance would be positively related to group size. In terms of Steiner's model of group productivity it was expected that process losses incurred by the addition of a seventh group member would not generally exceed the resources he would add to the group. The subsequent performance of individuals was predicted to be curvilinearly related to discussion group size, with the best individual performance from subjects who had been members of groups of intermediate size. The individual learning process was conceived of as a two-step process with first, groups required to select a correct response, and second, individual group members required to internalize that answer and be able to recall it at a later time. Steiner's model

does not deal specifically with individual performance but with this conception of a two-step learning process the second step was felt by this investigator to constitute an additional process loss by restricting average individual participation in larger groups.

Predictions of group size effects were accurate for $Time_{1g}$ performance, both for the pilot study and for the main study. Performance generally rose in a positive, fairly linear fashion as a function of group size. It appears that in the size range tested in this study, process losses have little effect on group performance on this task.

The data failed to support the hypothesis that individuals from groups of intermediate size would retain more correct information than members from other size groups, and perform better individually on the task at a later testing. In both the pilot study and the main study, members of groups of five failed to perform as well as members of groups of three, at $Time_{2i}$. In both studies, subjects who had discussed the questions in groups of seven still had the highest scores on the individual administration of the task at $Time_{2i}$. It is possible that members of groups of five were affected by certain process problems which did not adversely affect the $Time_{2i}$ performance of members of the other group sizes. That groups of five may suffer process losses not experienced by members of larger groups is of special interest, and will be pursued at some length later in this chapter.

It was also predicted that members of groups of two would perform better with respect to their potential, than would members of other groups. It was felt that the reduced ability of members of dyads to employ normative pressures to determine group decision-making would lead

to a more careful consideration of relevant information and to a higher level of group performance. As Steiner (1972) and others (cf., Bales and Borgatta, 1955) have noted, feelings of responsibility toward the other member of a dyad may lead to egalitarian procedures, which, in turn, may undermine the ability of more competent group members to assign their contributions the superior weight they deserve. Groups of two performed least well at $Time_{1g}$, lending some support to Steiner's contention that, under certain circumstances, dyads should experience greater process losses than ordinarily might be expected. (1972, p. 103)

Members of dyads did perform relatively well compared to their $Time_{1g}$ group potential on the $Time_{2i}$ individual task measure. It is hard to speculate about the reasons for this difference in $Time_{1g}$ and $Time_{2i}$ performance, since both dyads and singles improved their performance from $Time_{1g}$ to $Time_{2i}$.

Leadership

It was hypothesized that leaders would act to reduce process losses at $Time_{1g}$, resulting in better group performance at $Time_{1g}$ and better subsequent individual performance at $Time_{2i}$. It was also hypothesized that the reduction of process losses resulting from the selection of a leader would be especially efficacious for larger groups, where a higher initial level of process problems was expected.

Manipulation checks in the posttest confirmed the effectiveness of the manipulation. Members of groups told to select a discussion leader more often reported that their group had a coordinator than did members of groups given no leadership instructions. Leader-led groups also

reported a higher level of motivation, for the groups' least knowledgeable members, to participate in the group discussion, complying with one of the explicit instructions given to the selected group leaders.

The request that groups appoint a discussion leader to insure full member participation did not significantly affect actual performance of groups at $Time_{1g}$, or individual performance at $Time_{2i}$. There are two explanations which might account for the lack of a leadership effect.

The first explanation does not preclude the possibility that leaders did indeed affect group process and actual group productivity. On the posttest, members of groups of five and seven reported the greatest need for a coordinator in their group. A strong trend (interaction $p < .07$) also indicated that in these group sizes members tended to report having <u>had</u> a coordinator, whether or not one had been initially selected by the group. It is possible that emerging leaders in groups of five and seven made significant contributions to the group effort, and canceled the expected advantage of groups which were initially instructed to select a leader.

The second explanation would hold that only selected leaders significantly affected group process. One of the selected leaders' primary functions was to insure the participation of all group members. Increased participation of less motivated group members, and increases in the ability of groups to better coordinate their efforts could have been offset by a corresponding increase in difficulty for the group to properly weight the contributions of its members. In the posttest subjects in larger groups reported that their more competent members were more motivated to contribute to the group effort than were their

less competent members. Since leaders had been instructed to insure total member participation their net effect could have been to interfere with the groups' natural tendency to advantageously weight member input. (cf., Steiner, 1972, p. 26.)

Motivation and Coordination

It was predicted that as group size increased, coordination problems would increase and member motivation decrease, causing actual group performance to diverge increasingly from potential performance. Since it was impossible to determine coordination and motivation problems directly by observing all the groups, subject reports provided estimates of these process variables. Figure 2 in the Results chapter indicates reported member motivation and coordination as a function of group size. In this same figure the levels of potential and actual productivity for the different group sizes are also presented.

Reported coordination and motivation were much as predicted, the level of member motivation and ability to coordinate member efforts bearing a negative relationship to group size. The expected divergence of potential and actual performance did not occur, however, despite the reported relationship between potential performance and process problems.

There are at least three possible reasons why reported process problems failed to cause actual performance to decrease in respect to potential performance:

1. Subjects perceptions of motivation and coordination in their groups may have been inaccurate. The prediction that motivation levels would tend to drop, and coordination problems increase in progressively

larger groups is probably a likely one to make, even for one not familiar with relevant experimental literature. Reports of motivation and coordination, then, might have been significantly affected by subjects' expectations.

2. It is possible that the individual items of the task were not strictly a disjunctive, unitary task, with group potential determined by the ability of the best member. To the extent that groups may have been able to eliminate incorrect alternative answers and work in a "multiple elimination" fashion, the group would have exceeded its computed potential at $Time_{lg}$ by reducing the difficulty of the questions.

It seems probable that, if groups were able to subdivide the task in this fashion, larger groups would have benefited most. Just as the potential performance of a group working on a unitary disjunctive task increases with group size, the ability to eliminate alternative answers to a multiple-choice question should be greater for larger groups. The net effect, then, if groups were able to divide the main task into sub-tasks, is one of increasing process losses in the larger groups being offset by an increasing advantage to the larger groups in their ability to lower the difficulty of the questions by eliminating incorrect alternatives from consideration.

3. Perhaps the most likely possibility, and certainly the most interesting, is that process problems reported by subjects accurately reflect the coordination and motivation decrements in their groups, but that these process problems should not be preemptorally equated with process losses. It has been noted that less competent members were

seen as less motivated in large groups than in small groups, in this study. Although the cause of the motivational decrement may have been a greater risk of embarrassment in larger groups, the functional effect of the motivation decrement may be one of advantageous weighting. (Steiner, 1972, p. 99.)

Figure 4, presented in the Results chapter, compares potential and actual performance and the reported motivation of only the members judged most competent in the groups. Group performance on the task depended most heavily on the contributions of the more competent group members, and if their motivation remained high across all group sizes little or no difference in process losses may exist between the smaller and larger groups.

Figure 4 shows that the perceived level of motivation for the more competent group members declined only slightly for larger groups compared to the smaller groups. The small motivation decrement reported may, in fact, have been an adaptive response as were the larger decrements in motivation reported for the less competent group members. For, in the larger groups we might expect to find more members competent enough to correctly answer a given question, and too high a level of motivation for the competent members might only serve to increase the coordination problems of the group.

Group Adaptation to Increasing Process Problems

As long ago as 1902, Simmel (cf., Lindsay, 1972) noted that group structures change as a function of size. Video tapes of groups working on a decision-making task provided a very relevant example of this phenomenon. The four films were made of four different groups of

introductory psychology students at the University of Massachusetts taking a group examination, much the same as the group examination investigated in the pilot study. Two of the groups were small and had three members; two were larger and had five, and six members.

Certain differences in structure and process were clear even in this very small sample. In the smaller groups, all members tended to be active and leadership tended to be shared. In one of the smaller groups a member who did not take a very active role in the decision-making process was treated as a deviant and was the target of many requests to increase his input into the task. Much information relative to the question being dealt with was usually exchanged before the small groups attempted to make a choice of an answer.

The larger groups quickly developed a centralized decision structure, with one or two group members the targets or originators of most verbal communications. The decision-making procedure was essentially a poll of the members, conducted by the leaders, taking a majority vote on alternatives given for the exam questions.

A study by Castore (1962) provides more reliable data which give a similar impression of structure and process differences. In quasi-therapeutic groups of from five to twenty members, the proportion of available communication channels actually used fell markedly as group size increased. Castore found that larger groups tended to rely on a small number of channels for conducting their affairs. In the present study, the participation profiles and reports of emerging leaders are also consistent with the structure and process differences observed on the video tapes. It is interesting to note that in the main study

large groups tended to complete the task faster than groups of two or three, probably due to the greater attempt by the smaller groups to base decision-making on information exchanged rather than a simple vote.

The data from research on communication networks is mixed regarding the effectiveness of a centralized decision structures, but have generally favored the centralized structure for larger groups. For this task in particular, being disjunctive and requiring only the input of the better members, the motivational decrements reported for less competent members in larger groups should complement the centralized decision structure, and not saturate the central members with more information than they can effectively handle. (cf., Shaw, 1964.)

The trend toward a centralized decision structure seems to be a positive, but not necessarily linear function of group size. Group sizes seem to exist where process problems become acute, and group members clearly realize that a change in procedure is called for to prevent or reduce process losses. Steiner refers to these as "critical group sizes," where noticeable changes in the trends established by smaller groups may be observed (1972, p.97).

The study by Castore (1962) mentioned previously, indicated that larger groups used a smaller proportion of the communication channels available to them than did smaller groups. The decrements were not constant across sizes on the continuum, however, Considerably larger decrements in the proportion of channels used were found when group size increased to about 9 members, and to about 17 members. Given another type of task, the critical sizes where marked change in structure and process would take place might differ from those observed by Castore.

Kelly, et. al. (1965) found groups of seven to differ from expectations in two similar studies. The studies simulated an escape situation, and found that as groups got larger, consistently fewer members "escaped" per second of elapsed time. Groups of seven deviated from this trend in both studies and tended to perform better than expected. Groups of seven apparently were a critical group size, and may have used a different process to better deal with the task.

Hackman and Vidmar (1970) had groups deal with three intellective discussion tasks. Subjects in groups of from two to six members increasingly reported that their group was too large for the tasks. Members of groups of seven, however, complained less in this regard than members of groups of six. Evidently key process changes for the groups of seven reduced perceived process problems. The Hackman and Vidmar tasks may have been similar to the Kelly, et. al. (1965) task in that groups of seven may have been a critical size.

Groups of five in the main study, and in the pilot study, performed only slightly better than groups of three. Indeed members of groups of five had lower scores than members of groups of three on the $Time_{2i}$ recall measure, although the differences were not statistically significant. Groups of seven did not seem to suffer the same problems, however, and performed best at both $Time_{1g}$ and $Time_{2i}$. Seven once again seemed to have been a critical size.

Perceived Optimal Size

Steiner has noted that "Humans have the capacity to evaluate and reorganize their collective behaviors. Perhaps the human group is

the only system in which the parts can reflect on the success of the arrangement within which they function, and can institute deliberate changes (1972, pp. 185-186)." The possibility that motivation decrements for less competent members can function advantageously to give greater weight to the contributions of competent members implies the possibility that much of man's adaptation in groups may not be deliberate. A look at the relationship between perceived and actual optimum size may provide an indication of the extent to which man does have the capacity to effectively evaluate the success of a given group arrangement.

Three studies using similar group discussion tasks (Slater, 1958; Hackman and Vidmar, 1970; Pilot Study) determined preceived optimal size by asking subjects to indicate the best size for the task, or by ascertaining the point at which complaints that the group was too large equaled complaints that the group was too small. All three studies found that groups of about five members were perceived as ideal.

The study by Hackman and Vidmar, and the present pilot study were both among the studies in which seven-member groups appeared to be a "critical size" at which performance showed an increase. Why then, did subjects perceive five member groups to be ideal when performance criteria contraindicate this conclusion?

For members of groups of a "critical size" to implicitly accept and effectively utilize procedures not used by somewhat smaller groups, the need for a different structure or process must be easily recognized. For groups only slightly smaller than the "critical size," process problems may seriously affect group performance without it being obvious

to group members that a fresh approach is called for. The group of five members, in these studies, may represent that size where resources are maximized, and process problems are just becoming annoying. Subjects probably didn't realize how well they could adapt to those process problems, although subjects in the pilot study did perceive a larger size as ideal if they had participated in a larger group, indicating some awareness of this possibility.

There are at least three ways in which groups can modify their structure or process to neutralize increasing process problems: (1) The decision-making process may be changed; (2) leaders may emerge where needed; and (3) members less capable of making positive contributions to the group effort may become inactive.

First, the decision-making process may change from one of dependence on informational exchange as a technique of influence in smaller groups, to a dependence upon majority or plurality voting procedures in larger groups. Bales and Borgatta (1955) and Slater (1958) reported evidence of differing intra-group relationships for dyads and larger groups up to seven members. An Interaction Process Analysis of members' behaviors indicated that members of dyads tended to avoid expression of hostility or disagreement. This is consistent with the supposition that smaller groups, particularly dyads, depend more on informational influence than on "jawboning" their fellow group member or members.

Second, that leaders emerge when needed was supported by data from both the pilot and the main study. Subjects reported in the posttest whether or not they felt their group needed a leader or coordinator and whether their group actually had a leader or coordinator. Members of

groups reporting that their group needed a leader, also reported having had one, even when not initially appointed.

In another study of emerging leadership, Crockett (1955) also found that leaders tended to emerge where needed. He also concluded that emerging leaders were above average in ability on his task. Since leaders appointed at $Time_{lg}$ of this study were selected prior to any task behavior it might be expected that they would be about average in ability. Emerging leaders might, then, have a more positive, though later influence on the group than appointed leaders.

Third, motivation decrements can produce process gains if the decrease in motivation affects members unable to make a positive contribution to the group. The motivation loss, in effect, saves a more harmful coordination loss. As the number of possible communication channels multiplies rapidly between groups of three and seven members (number of channels; for 3 = 6, for 7 = 42, considering directionality of communication) it becomes increasingly important to be selective in their use. For one type of task Castore (1965) demonstrated this increased selectivity as a function of group size.

Both the main study and the pilot study indicated that subjects perceived their group's less competent members to be less motivated in larger groups than in smaller groups. In both studies here, in Hackman and Vidmar (1970), and in Gibb (1951) subjects reported greater inhibitions about participating in large groups than in smaller groups. Subjects' certainty ratings in this study demonstrated a reasonable capacity to assess their own ability, and performance was best for groups of seven, so motivation decrements may have augmented process on certain occasions.

In conclusion, trends in three important areas emerge from the data and review of relevant literature, and suggest fruitful lines of research for the future.

First, groups can be very adaptive. It appears that groups' process and structure changes can effectively postpone process losses as group size increases. The adaptive changes can be made consciously or unconsciously by group members. The apparent increase in effective process for certain "critical" group sizes suggests that group members recognize the need for procedural changes when process becomes ineffective. Subject reports indicating that motivation decrements in larger groups are greater for less competent members, suggest that an appropriate weighting of members' contributions can be reached inadvertently, postponing process losses.

Second, more must be known about how group size and task affect process losses before Steiner's (1972) group productivity model can be used effectively to predict actual group performance. For, although the model allowed an accurate prediction of group performance in this study, process losses appeared to remain fairly constant over all group sizes tested, rather than increasing with group size as was expected. Process changes seem to be greater for some critical group sizes, rather than continuous over all sizes. Perhaps these critical sizes are primarily a function of task type.

Third, the two-step conception of learning in groups, utilized to predict individual learning in this study, must be explored further. The second step of the process, individual acceptance and learning of the answer selected by the group, was expected to be facilitated by

participation in the decision-making process. Although members of smaller groups, where a greater amount of individual participation was expected, tended to remember a greater percentage of correct answers from the group discussion, instructions to select a group leader had no significant effect on subjects' ability to remember correct group decisions. Subject reports indicated that participation was greater for groups instructed to select a leader, so participation per se may not be the key. It is possible that the extent one associates himself with the group's choice of a correct answer determines the extent to which that answer is internalized or accepted by the individual. Group size, as well as actual participation levels, could affect this internalization process.

The Group Examination

The goals of group examinations may be many. The acquisition of relevant course material is a primary goal, but other factors may be equally important under some circumstances. The desire to maximize active, rather than passive participation in the educational process, and give students a serious forum where their ideas can be tested in the company of peers can perhaps also be served through the use of the group examination. The data from this study give some indications of how the group examination technique might be able to best satisfy these criteria.

Acquisition of Correct Responses

The comparisons of non-experimental student performance on the

task at $Time_{2i}$ with the performance of experimental subjects offer positive support for group discussion as a facilitator of individual member acquisition of correct responses.

Individuals who had answered the questions alone twice at $Time_1$ performed no better at $Time_{2i}$ than the non-experimental students who were seeing the questions for the first time. Experimental subjects who had worked in groups at $Time_{1g}$ performed significantly better than the non-experimental students answering the questions for the first time at $Time_{2i}$. This is a strong recommendation for the group examination, and an indication that perhaps individualistic teaching devices, such as handling out study questions, are of substantially less value.

Best Group Size

A cursory inspection of the task performance data is sufficient to reveal the superiority of groups of seven among the sizes investigated. Groups of seven scored highest on the group task at $Time_{1g}$, and members of groups of seven also scored highest on the subsequent $Time_{2i}$ task administration. The superiority of groups of seven was manifested by both the pilot study and the main study.

However, as the antacid advertisement would have us believe, "The biggest is not always the best!" Other considerations may outweigh the performance figures, which so clearly seem to favor groups of seven.

Members of groups of seven retained the greatest number of correct answers, as indicated by the $Time_{2i}$ performance scores on the task. But, it is possible that the knowledge that they acquired is highly task specific, compared to a wider variety of information acquired by members of smaller groups.

The video tapes of students taking the group exam indicated that a different decision-making approach was followed by large and small groups. Small groups discussed a great deal of information before attempting to arrive at a decision; large groups tended to follow a polling procedure, and generally only considered opinions of members which were directly relevant to the alternatives offered for the specific question.

The goals of the instructor have implications for a decision based on what might be learned by members of the various group sizes. If one has specific information that he wants students to acquire or learn, groups of seven would appear to be an appropriate size to choose for a group exam. If information related to the specific question asked is also considered quite important, the possible advantage of smaller groups should be considered.

Random Assignment of Group Sizes

In these studies subjects were randomly assigned to groups, and had no prior knowledge of what size group they would be working in, aside from the range of sizes to be investigated. If they had been previously told what size group they would be working in, results might have been different. A study by Shaw (1960) found that members

of larger groups were less motivated to prepare materials for other members of their group, than were members of smaller groups. If subjects knew that they were to be assigned to a small group they might prepare or study more for the group exam, and as a result, perform as well as larger groups.

Other Reasons to Give a Group Examination

Instructors wishing to utilize the group examination may have other goals in mind. Specifically, one may wish to increase students' sense of involvement in the educational process, and generate active participation rather than passive detachment.

The present studies, as well as studies by Gibb (1951), and Hackman and Vidmar (1970) indicate that members of larger groups felt more inhibited than members of smaller groups working on a group task. If a goal of the exam is to overcome students' inhibition in the discussion of academic interests with their peers, smaller groups would be appropriate.

The video tapes indicated that inactive group members are treated as "deviants" in smaller groups of about three members and are the targets of requests to become involved in the group task. If an important criterion for the success of the group exam is maximum participation by all members, groups of three might be most appropriate.

If one is concerned with acquisition of correct answers to the specific questions asked, information related to the topics covered by the questions, and participation and involvement in the educational

process, groups of three would appear to be an appropriate size to choose. Members of groups of three were second only to members of groups of seven on $Time_{2i}$ performance on the task, average participation was higher than in the larger groups, reported inhibition was lower than in larger groups, and, with advanced knowledge of group size assignment, members of smaller groups are likely to prepare more for the exam. Above all, students should not be told to select the group that they feel would be optimal. These studies, and the Hackman and Vidmar (1970) study have indicated the lack of correspondence between subjective perceptions of optimal size and objective criteria of performance.

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