Pergamon

Telematics and Informatics, Vol 11, No 2, pp. 97–109, 1994

0736-5853/94 $6.00 + .00

0736-5853(94)E0005-D

THE IMPACT OF FOUR CONFERENCING FORMATS ON THE EFFICIENCY AND QUALITY OF SMALL GROUP DECISION MAKING IN A LABORATORY EXPERIMENT SETTING

Gary P. Radford
Barry F. Morganstern
Charles W. McMickle
Jennifer K. Lehr

Abstract—This study reports the results of a laboratory experiment which compares the efficiency and quality of small group decision making in four conferencing and teleconferencing formats. 204 subjects randomly assigned to 51 small decision making groups were asked to reach a group consensus on an information exchange task with a criterion solution. These groups were randomly assigned to one of four conference format conditions: Communication via face-to-face, audio, video, or computer channels. Conferencing format was found to be related to the efficiency and quality of group decision making when the four types of conferencing formats were compared. However, when the Tukey studentized range test is considered, this main effect is seen to be generated by the difference of the computer condition from all other conditions. No significant differences were found on either measure between the face-to-face, audio, and video conditions.

INTRODUCTION

With the development and use of communication technologies to handle many information and communication needs, the comparison of face-to-face and mediated communication is becoming an increasingly relevant research problem (Hiltz, Johnson, & Turoff, 1986). Face-to-face communication, both in dyads and small

Gary P. Radford is the Research Director of The Interpersonal-Telecommunication Research Group, Department of Communication, The William Paterson College of New Jersey, Wayne, NJ 07470, radford@pilot.njin.net. Barry F. Morganstern is the Director of The Interpersonal-Telecommunication Research Group, Department of Communication, The William Paterson College of New Jersey, Wayne, NJ 07470. Charles W. McMickle is the Technical Coordinator of The Interpersonal-Telecommunication Research Group, Department of Communication, The William Paterson College of New Jersey, Wayne, NJ 07470. Jennifer K. Lehr is a doctoral student at the School of Communication, Information, and Library Studies, Rutgers University, 4 Huntington Street, New Brunswick, NJ 08903 and a member of The Interpersonal-Telecommunication Research Group.

groups, has, until recently, been considered the interpersonally "richest" form of communication (Burleson, Levine, & Samter, 1984). It allows the greatest amount of social presence (Rice, 1993) and facilitates the formation of personal relationships.

An increasingly important factor to be considered in evaluating the desirability of the face-to-face communication in the organizational setting is cost. Hiltz (1988, p. 1438) states that management communications is the largest single cost factor for U.S. businesses today, exceeding the costs for direct labor and capital. Face-to-face communication requires getting people together which has significant consequences in terms of travel time and cost (see Pye & Williams, 1977, pp. 238–240). Teleconferencing systems offer an alternative to travel by enabling people to participate in meetings without the necessity of actual physical presence. Such systems have the potential to significantly reduce economic, environmental, and psychological costs incurred by travel (Grayson, 1983; Hellweg, Berman, Stuart, & Smith, 1985; Hiltz & Turoff, 1978).

The potential savings of the virtual meeting, coupled with its face-to-face feel, has stimulated the adoption of electronic conferencing systems in many settings including trade association meetings (Meeting face to face—at a lower cost, 1993), local area networks (Kirvan, 1993), training (Emery & Schubert, 1993), education (Cooper and Selfe, 1990), academic conferences (Borman, 1993a, 1993b), and universities (Watkins, 1992). Sales of videoconferencing systems are expected to rise from $660 million in 1993 to $10.8 billion in 1997 (LaPlante, 1993, p. 111). Feldman (1993) reports that the market for videoconferencing equipment is expected to increase to $4.77 billion in 1996.

In the rush to develop, promote, and adopt new teleconferencing technologies, the implications for small group communication and group decision making have not yet been fully explored (see Huber, 1990; Steinfield & Fulk, 1990). Despite the self-interested rhetoric and competing claims of the communication technology industry, the question still remains: does a virtual meeting via some teleconferencing technology retain the desirable attributes of the face-to-face encounter? More specifically, do teleconferencing groups maintain or exceed acceptable levels of efficiency and decision quality when compared to face-to-face groups? This study reports the results of a laboratory experiment which compares the efficiency and quality of small group decision making in four conferencing and teleconferencing formats: Face-to-face, audio, video, and computer. Since decision making groups are major users of teleconferencing, the investigation of their performance in a teleconferencing situation along these dimensions is of practical, as well as scholarly, significance.

Research approach

Many variables are used to assess small group decision making in conferencing and teleconferencing settings. Hiltz, Johnson, & Turoff (1986) utilized two broad categories of variables: (a) group process variables, and (b) outcome variables. The first category, group process, is defined as, "a set of intervening variables that includes amount of communication, functional type of communication, and the distribution of participation among members" (Hiltz, Johnson, & Turoff, 1986, p. 227). Hirokawa & Johnston (1989) describe group process as an evolutionary procedure characterized by circularity rather than linearity. Decisional elements are continuously presented and represented, examined and reexamined, developed and redeveloped as the group moves toward a final decision. Hiltz, Johnson, & Turoff (1986) found strong evidence that communication mode (in this case face-to-face and computer conferencing) was related

to group process and this, in turn, was reflected in terms of the second category, outcomes.

Group outcomes are measures of the end result of the group decision making process and include such variables as quality of decision, degree of agreement on a decision, and group efficiency (time taken to reach the decision). The study reported here considers the second of Hiltz, Johnson, & Turoff's (1986) categories and builds on their claim that differential group process produced as a result of different conferencing formats will lead to differential group outcomes. The specific outcome measures considered here are: (a) group decision making efficiency, or how long the group takes to reach consensus on a final decision, and (b) the quality of the decision made by the group, defined as, "how close a group came to the solution provided by recognized . . . experts" (Finn, 1988, p. 179). The research questions addressed in this study are:

- RQ1: Is small group decision making in a teleconference format (audio, video, or computer) more or less efficient than decision making in a face-to-face conference format?
- RQ2: Are the decisions produced by small groups in a teleconference format (audio, video, or computer) of better, equal, or worse quality than decisions produced by small groups in a face-to-face conferencing format?
- RQ3: How does decision making efficiency and decision making quality compare among the three teleconferencing formats?

LITERATURE REVIEW

The following review focuses upon the extant literature which addresses the issues of small group decision making efficiency and quality in video, audio, and computer conferencing formats.

Video conferencing

Video conferencing typically utilizes two-way full motion video with two-way audio and, of the three formats, most closely simulates a face-to-face meeting (Rosetti & Surynt, 1984). Video conferences differ from face-to-face meetings in at least four ways: (a) they place geographic distance between participants, (b) they do not allow for the effects of the environment or setting, (c) the status differences around the conference table do not exist to the extent they do in face-to-face settings, and (d) they do not transmit olfactory information (Morganstern, McMickle, & Radford, 1993, p. 11).

Research comparing video and face-to-face conferencing in terms of efficiency and decision quality is extremely limited and suggests little or no difference between the two formats (Champness, 1972; Champness & Reid, 1970; Williams & Holloway, 1974). The dearth of research may be explained by the equipment demands of video conferencing technology, or the fact that video conferencing is significantly more expensive than computer conferencing or audio conferencing (Rice, 1984, p. 130) although these costs are now rapidly falling (Francis, 1993; Hutsko, 1993; Kirvan, 1993). Recent trends strongly suggest that video may be the teleconferencing format of choice in the near future (Fish, Kraut, Root, & Rice, 1993; Kupfer, 1992). Clearly, more systematic research is needed in this area.

Audio conferencing

Audio conferencing can be defined as a way for several individuals in different locations to meet via voice-to-voice interaction over a period of time (Morganstern, McMickle, & Radford, 1993, p. 9). Audio conferences admit paralinguistic modes of information into the group communication process such as tone, volume, and rate, but filters out visual nonverbal communication channels such as posture, appearance, eye gaze, and facial expression. The most common audio conferencing device is the telephone. Fielding & Hartley (1987) rightly point out that the telephone is the "neglected medium" (p. 110) when it comes to research on communication technology. Similarly, a notable characteristic of the audio conferencing literature is the paucity of studies conducted in the area of small group decision making. This lack can be considered unusual especially given Fielding & Hartley's (1987, p. 110) claim that the telephone is the most basic, the most common, and possibly the most powerful telecommunications device.

Like videoconferencing, the available literature generally suggests that no significant differences exist between audio and face-to-face conferencing on measures of efficiency and quality (Champness, 1975; Chapanis, 1975; Fowler & Wackerbarth, 1980; Short, 1971). Fielding & Hartley (1987) suggest a possible explanation for these findings. They argue that decision making is a task in which social relationships are relatively unimportant. Nonverbal research, such as that of Argyle (1983), suggests that visual nonverbal cues function primarily to transmit socio-emotional information and, therefore, nonverbal cues are of less importance in determining the outcome of task-oriented encounters. Again, systematic investigation of claims such as these are needed.

Computer conferencing

Computer conferencing is defined as, "a way for several computer users in different locations and at different times to hold an electronic 'conference call' on a particular topic, contributing to a group discussion without the restrictions of time and space" (Piturro, 1989, p. 43). There are two main types of computer conferencing; synchronous and asynchronous. Synchronous computer conferencing involves small group members communicating in real time using the computer keyboard to enter and send messages and a screen and/or printer to read the messages of others. Asynchronous computer conferencing, exemplified by e-mail systems, involves a message produced by one person being stored in the system which others can then retrieve and respond to at a different time. In both synchronous and asynchronous formats, participants do not share a physical setting, are not visible to one another, and have no access to the nonverbal signals that are available in face-to-face (all channels), video (facial expression, paralanguage) and audio (paralanguage) formats. A third and significant use of computer technology in small group decision making is the deployment of Group Decision Support Systems (DeSanctis & Gallupe, 1987; McGrath & Hollingshead, 1993; Poole & DeSanctis, 1992) and Electronic Meeting Systems [EMS] (see Dennis, Nunamaker, & Vogel, 1991; Finley, 1991; Nunamaker, Dennis, Valacich, Vogel, & George, 1991) which combine communication, computer, and decision technologies to support decision-making and related activities of work groups.

Since the present study compares face-to-face, audio, and video formats in a laboratory experiment setting, only the synchronous computer conferencing literature is appropriate here because, as Hiltz, Turoff, & Johnson (1989) point out, "a 'controlled'

experiment, in which asynchronous conferencing is used, is . . . a contradiction in terms" (p. 224). There is no sense of control in the asynchronous situation. Users may sign on at any time it is convenient for them and may spend a total of five minutes on the discussion, whereas others might spend five hours or more (Hiltz, Turoff, & Johnson, 1989, p. 224). Thus it is impossible to usefully compare the efficiency of computer conferencing with other formats in a laboratory design using the asynchronous mode.

Decision efficiency research in synchronous computer conferencing is characterized by several conflicting findings. In some cases, computer conferencing may be slower to reach a decision than face-to-face settings (Hiltz, 1986; Hiltz, Johnson, & Turoff, 1986; Olaniran, Friedrich, & VanGundy, 1992; Phillips, 1983). These findings were based on results indicating that typing is slower than speaking, thereby increasing the amount of time in the computer conferencing format. Yet in computer conferencing studies employing no time limitations there were no differences between the computer and face-to-face formats (Walther & Burgoon, 1992). Lea (1991) states that computer conferencing can be viewed as an efficient channel of communication and Adrianson & Hjelmquist (1991) suggest that there are no differences in problem solving efficiency across face-to-face and computer conferencing formats. According to Dennis, George, Jessup, Nunamaker, & Vogel (1988), perhaps the only generalization possible for synchronous computer conferencing studies of decision efficiency is that of inconsistent findings.

The literature which examines decision quality in computer conferences appears to be reasonably consistent. While perfect agreement does not exist (Kerr & Hiltz, 1982), the data available clearly suggests that group decisions are equally good in both face-to-face and computer conferencing formats (Archer, 1990; Hiltz, Johnson, & Turoff, 1986). Findings such as these lead Adrianson & Hjelmquist (1991) to question whether group process differences as an effect of mode have a direct effect on final outcomes, as claimed by Hiltz, Johnson, & Turoff (1986). However, Adrianson & Hjelmquist (1991) qualify this when they note that, "only a few studies have been conducted, implying a restricted range of problems used, and a limited number of methods for analysis of the outcome" (p. 282). As with video and audio conferencing, more research is needed in this area.

Summary

This literature review suggests that, since the 1970s, research into the effects of conferencing formats on the outcome measures of group decision making efficiency and quality is scarce. Where it does exist, the focus has been primarily on comparisons of face-to-face with one other conferencing format. Except for the work of Morganstern, McMickle, & Radford (1993), no research has been reported that compares the four group interaction formats in the same design. One reason for this is that many reported studies are case studies and address particular systems within the idiosyncracies of real world organizations and users. As Steinfield & Fulk (1990) have argued, there is a lot of accumulated empirical findings with no basis to generalize across them. Because of this demonstrated lack of generalizability across research, and the paucity of experimental studies in this area, this study addresses research questions rather than directional hypotheses and systematically manipulates four conferencing formats (face-to-face, video, audio, and computer) within a single experimental design. This is described in the following sections.

METHOD

A laboratory experiment utilizing an undergraduate student population was conducted to address the research questions stated above in order to achieve a high degree of control through (a) the manipulation of the independent variable (conference format), (b) the random assignment of subjects to experimental conditions, and (c) accounting for the influence of extraneous variables. While field studies have revealed much about the use and performance of conferencing technologies with particular groups of users in particular settings (e.g., Dennis, Nunamaker, & Vogel, 1991; Finholt & Sproull, 1990), the experimental situation can focus on the impact of the communication mode in the absence of such variables as organizational setting, experience with the technology, relationships between users, and gender. It may also reveal general trends which may throw light on the teleconferencing behavior that is observed in any particular field setting. In the laboratory experiment internal validity is enhanced by controlling, to the greatest extent possible, characteristics of context and users through random assignment of subjects to zero-history groups and conferencing format conditions. In this way effects on efficiency and decision quality can be observed when *only* the communication mode is systematically manipulated.

Sample

Subjects in this study were 204 undergraduate students enrolled at a Northeastern 4-year state college. 46% were male, 54% were female, and the average age was 21.9 years. Subjects were enrolled in a wide cross section of majors, although the majority (145) were currently enrolled in communication courses. Subjects were recruited through announcements made in their classes. All subjects who took part in this study were volunteers and did not receive extra credit for their participation.

Task and procedure

The study used the NASA Moon Survival Problem (Hall & Watson, 1970), an information exchange task resulting in a rank-ordering of 15 items required for survival on the moon. The task had a criterion solution plus a measure of how "correct" a group's answer was. This task was selected because (a) it resulted in a group product that can be objectively and quantitatively evaluated, and (b) its successful completion required an identifiable and finite body of task-relevant information.

Each subject was given a problem answer sheet which contained a subject number, a group number, and a code number specifying the conference format through which the group would conduct its discussion. These sheets were shuffled and distributed in random order assuring that each subject was randomly assigned to both group and conference format condition. Any subjects who had knowledge of this task previous to the experiment, as determined by a pre-test interview, were excluded from the study. Subjects completed the rank ordering of the 15 items individually and in silence. This was done under the supervision of the experimenter to ensure no interaction among the subjects. The individual solution to the problem was recorded on the problem sheet in a column called "Individual Ranking." No verbal instructions were given to subjects other than that of telling the subjects to read the instructions on the problem sheet, to carry them out, and to work in silence. From this point, the experimenter did not answer any questions regarding the task.

The 204 subjects were randomly assigned to 51 groups of four. Subjects were told

that they would be asked to compare and contrast their individual responses with those of three other subjects to derive a group ranking of the 15 items. No instructions regarding decision making strategies such as consensus decision making (see Hall & Watson, 1970) or voting were given. All of the groups were considered unstructured (i.e., with no pre-established patterns of leadership or role structure) and with zero-history at the time they began the group interaction. Subjects consulted the problem sheet and located their assigned group number and the three other people with the same number. The experimenter then consulted the condition number assigned to that group, and took them to the appropriate experimental setting (face-to-face, audio, video, or computer conferencing). Once in the assigned condition, subjects were instructed to complete the problem as a group by sharing and discussing the rankings generated individually. 12 groups participated in the face-to-face condition, 13 in the audio, 12 in the video, and 14 in the computer.

Independent variable

The independent variable, the channel through which small group communication was to take place, had four levels: face-to-face, audio, video, and computer conferencing. These are described below.

Face-to-face condition. In the face-to-face condition, subjects communicated around a small table with full access to the nonverbal information of the other participants. The discussion was recorded by a video camera placed unobtrusively behind a screen. Subjects were notified that the recording was taking place.

Video condition. In the video condition, groups of four were assigned to stations in four separate rooms. Each subject was seated before a video screen on which other subjects in the group could be seen simultaneously. Each group member appeared in one quadrant of the screen. Group members could freely speak to one another through the audio-conferencing devices on a single shared line.

Audio condition. As in the video condition, groups of four were individually seated before the isolated teleconferencing stations. However, in this condition video screens were turned-off, allowing intragroup communication by voice only.

Computer condition. In the computer condition, individuals, in groups of four, were individually seated before computer terminals in separate rooms so that subjects were unable to see or hear each other. The only means of communication available was through the terminals in "real time," or synchronously. Subjects entered their messages in the lower portion of the computer screen. After depressing the "Enter" key, these messages would then be sent to the conference, and would appear in the upper portion of the screen so that subjects could read the group's conference transcript as the discussion transpired. Transcripts were saved and printed.

Technical specifications

To meet the unique demands of the experiment, a special conferencing system was created. The video portion consisted of a four-node network, laid out in a "star" topology with a Panasonic WJ450 video multiplexor at the center. Placed at each subject position (node), was a Panasonic WV-D5110 remotely controllable, low light

camera and a color monitor. The multiplexor allowed all four subjects to appear simultaneously in separate quadrants of each screen, and a VHS videorecorder was used to record the multiplexed output.

The audio for both the video and audio conditions was provided by NEC "VoicePoint," echo-cancelling, audio-conferencing devices placed at each subject position. Each unit has a self-contained speaker and microphone. To accomplish communication across all four nodes, each was connected to an AT&T System 75 PBX, and a "party line" was created by means of a conference call. The computer portion of the experiment was conducted on an AT&T "Starlan" through UNIX-based "Xchange" conferencing software.

Dependent variables

Efficiency. The efficiency of the group was operationalized as the time taken for the group to complete the task, measured in minutes. In all four conditions, groups were allowed as much time as needed to reach a group decision.

Decision quality. The NASA Moon Survival Problem used in this study has a correct solution, or criterion, obtained from the Crew Equipment Research Section of the NASA Manned Spacecraft Center at Houston, Texas (see Hall & Watson, 1970, p. 303). Decision quality was operationalized in terms of the group's summed deviations from the criterion rank order. This score represents a measure of error, thus magnitude is inversely related to decision quality. The score is free to vary from 0 to 112 points away from absolute accuracy. A score of zero indicates total agreement (i.e., no difference) with the NASA ranking. Rank order estimates of quality of decision have been used in other studies, including Finn (1988), Hall & Watson (1970), Hiltz, Johnson, & Turoff (1986), and Hirokawa (1987).

Statistical analysis. A single factor analysis of variance (ANOVA) using a general linear model procedure for unbalanced cells was conducted to examine the influence of the four communication channels on the measures of efficiency and decision quality. Tukey's studentized range test, controlling for type I experimentwise error rate, alpha = .05, was conducted to compare, post hoc, the mean of each condition relative to the means of all other conditions.

RESULTS

A significant result was found for the effect of conference format on decision efficiency (time taken to complete the task), $F(3,47) = 51$, $p < .0001$. The mean scores for the four conditions are presented in Table 1. The Tukey studentized range test ($p < .05$) showed that the computer condition was significantly less efficient than all other conditions. The face-to-face, audio, and video conditions were not significantly different from each other.

A significant result was found for the effect of conference format on group decision quality, $F(3,47) = 4.36$, $p < .01$. The mean scores for the four conditions are presented in Table 2. The Tukey studentized range test ($p < .05$) showed that the computer condition produced decisions of significantly lower quality than all other conditions. The face-to-face, audio, and video conditions were not significantly different from each other.

Table 1. Decision efficiency: Mean time taken to complete task by conferencing condition

Condition	Mean Time (min)
Face-to-face (N = 12)	9.417*
Audio (N = 13)	12.538*
Video (N = 12)	14.333*
Computer (N = 14)	35.357

Conditions marked with an asterisk are not significantly different ($p < .05$). Lower mean scores reflect lower times to group decision.

DISCUSSION

This study compared the efficiency and quality of small group decision making in four conferencing formats: Face-to-face, audio, video, and computer. Conferencing format was found to be significantly related to efficiency and decision quality when the four types were considered together in a one-way analysis of variance. However, when the post hoc Tukey studentized range test is considered, it becomes clear that the main effect is generated by the difference of the computer conferencing condition from all other conditions. No significant differences were found on either dependent measure between the face-to-face, audio, and video conferencing conditions.

The lack of significant differences between face-to-face, audio, and video conferencing suggests that any diminishment of verbal and nonverbal cues that may be due to these two technological conditions had no significant effect on groups' ability to reach a decision in a timely manner, when compared to the face-to-face condition. These results suggest that groups did not let the presence of the mediated channels interfere with the task focus required to address the problem and reach a consensus. This may be a function of the highly structured nature of the task used in this study. The NASA task requires only that the group agree on a ranking, and it is possible that this can be done with little discussion if certain group members either dominate the group and/or if other members agree to conform to the wishes of others without significant input and discussion. However, this also suggests that communicating via the audio and

Table 2. Decision quality: Mean summed deviation from NASA experts' criterion by conferencing condition

Condition	Mean Summed Deviation
Face-to-face (N = 12)	32.5*
Video (N = 12)	32.667*
Audio (N = 13)	33.769*
Computer (N = 14)	43.214

Conditions marked with an asterisk are not significantly different ($p < .05$). Lower mean scores reflect greater agreement with NASA ranking.

video conferencing formats had no impact on the emergence of dominance or conformity behaviors as evidenced in the efficiency and quality measures.

This claim is supported when the decision quality indexes reported in this study are compared to Hall & Watson's (1970) original estimates of decision quality in small group decision making. Hall & Watson found a mean decision quality index of 34.19 (summed deviations from the criterion) for unstructured groups comparable to the groups used here. When compared with the mean decision quality indexes of 32.5, SD = 11.25 (face-to-face), 32.66, SD = 5.93 (video), and 33.7, SD = 8.72 (audio) reported here, it can be claimed that the performance of the small groups in this experiment was not unusual, thus strengthening the validity of the finding that audio and video groups performed with statistically equal efficiency and quality as the face-to-face groups. This finding is also consistent with those of Morganstern, McMickle, & Radford (1993) who found no significant differences between the face-to-face, audio, and video conferencing conditions when subjects were engaged in solving an information exchange task with a criterion solution, this time on measures of satisfaction and group consensus.

Limitations and directions for future research

The finding that decisions produced in the computer conferencing condition were of significantly less quality than all other conditions runs counter to many previous studies reviewed in the literature. Such studies have reported that computer conferencing groups perform as well or better than face-to-face groups. It must be noted that the subjects in the computer conferencing condition had little experience with computer conferencing systems of this type, unlike some other studies which used experienced users in corporate situations (e.g., Finholt & Sproull, 1990). An important direction for future research is to investigate whether or not these findings can be generalized to samples drawn from a population of managers within organizations. Another factor to be considered is that the medium was being used synchronously and with a fairly small group whereas, according to Hiltz, Johnson, & Turoff (1986), "its strengths lie in asynchronous communication among larger groups" (p. 247). The use of synchronous conferencing ensured experimental control for the demands of the study, but in doing so sacrificed organizational realism, a shortcoming of this particular paradigm noted by Finn (1988). The synchronous mode essentially forces participants to act as if they were in a face-to-face setting without any of the cues that are available to face-to-face groups. It is possible that these users had to communicate a large amount of adaptation metacommunication in which strategies of turn-taking, participant identification, and so on are decided upon. Although these tasks may be resolved relatively quickly in the face-to-face, audio, and video conditions, in the computer conferencing condition this activity may be time consuming and, ultimately, dysfunctional. In the asynchronous mode, computer conferencing may not be like face-to-face communication at all. It may have structures and dynamics that make it a different kind of communication experience altogether. Therefore, the comparison of synchronous computer conferencing with the face-to-face may not be appropriate as a test of the capabilities of the computer channel. While these results suggest that computer conferencing does not perform as well as the small face-to-face group in a synchronous mode, it may do much better at other tasks in large asynchronous groups. This is an important direction for further study.

Overall, with the exception of the computer conferencing medium, these results are very positive for those who are in a position to adopt teleconferencing technologies.

They suggest that the costs associated with face-to-face small group decision making can be reduced without any significant loss in the efficiency and decision quality of unstructured small problem solving groups, addressing information exchange tasks, using audio or video teleconferencing technologies. More controlled experimentation is needed to explore the effects of variables which are either confounded or left untreated in this study. For example, the impact of task type in the face-to-face and teleconferencing situations is an important variable for further study. The task is a specific goal that the decision making group intends to achieve. Socioemotional tasks emphasize the more social interpersonal skills and outcomes, such as negotiations or getting new members to join, while a technical task involves more factual or cognitive skills and outcomes, such as arriving at a decision based on information gathered and/or evaluated by the group (Rice, 1984). Studies using task type as an independent variable along with conferencing format suggest that different conferencing formats are better suited for different types of task (e.g., Hiltz, Johnson, & Turoff, 1986).

Another untreated variable is the presence or absence of some kind of pre-established structure in which the group discussion takes place. In this study, no instructions were given to subjects concerning specific discussion or decision making procedures. It would be useful to investigate whether or not the findings presented here can be generalized to small groups employing other group discussion formats, such as delphi or nominal group techniques (Delbecq, Van de Ven, & Gustafson, 1975; Van de Ven & Delbecq, 1974).

Variables such as task type and structure have the potential to reveal differences between the conferencing formats that were not found in this study; differences which may prove to be more costly in the long run than the money and time that is saved through reduced travel. The findings presented here do not suggest this. However, in a time where development, availability, and affordability promise to make teleconferencing a commonplace feature in modern organizations of all sizes, these possibilities need to be systematically investigated so a thorough understanding of behavior in teleconferencing settings can be developed. At the present time, it is clear that more research is needed in this area before definitive conclusions can be reached.

REFERENCES

Adrianson, L., & Hjelmquist, E. (1991). Group process in face-to-face and computer mediated communication. *Behavior & Information Technology, 10*(4), 281–296.

Archer, N. (1990). A comparison of computer conferences with face-to-face meetings for small group business decision making. *Behavior and Information Technology, 9*(4), 307–317.

Argyle, M. (1983). *The psychology of interpersonal behavior.* New York: Penguin.

Borman, S. (1993a, February 15). On-line chemical education meeting may be harbinger of the future. *Chemical & Engineering News, 71*(7), 25–26.

Borman, S. (1993b, October 11). Benefits of electronic conferences cited by on-line meeting "attendees." *Chemical & Engineering News, 71*(41), 26–27.

Burleson, B. R., Levine, B. J., & Samter, W. (1984). Decision making procedure and decision quality. *Human Communication Research, 10*, 557–574.

Champness, B. (1972). *The assessment of user's reactions to Confravision* (Report No. E/73250/CH). London, England: Communication Studies Group.

Champness, B. (1975). Attitudes toward person-person communication media. *Human Factors, 15*, 437–448.

Champness, B. & Reid, A. (1970). *The efficiency of information transmission: A preliminary comparison between face-to-face meetings and the telephone.* London, England: The Communications Study Group.

Chapanis, A. (1975). Interactive human communication. *Scientific American, 232*(3), 36–42.

Cooper, M. M. & Selfe, C. L. (1990). Computer conferences and learning: Authority, resistance, and internally persuasive discourse. *College English, 52*(8), 847–871.

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

Dennis, A. R., George, J. F., Jessup, L. M., Nunamaker, J. F., & Vogel, D. R. (1988). Information technology to support electronic meetings. *MIS Quarterly, 12*, 591–619.

Dennis, A. R., Nunamaker, J. F., & Vogel, D. R. (1991). A comparison of laboratory and field research in the study of electronic meeting systems. *Journal of Management Information Systems, 7*, 107–135.

DeSanctis, G. & Gallupe, B. (1987). A foundation for the study of group decision support systems. *Management Science, 33*(5), 589–609.

Emery, M. & Schubert, M. (1993, June). A trainer's guide to videoconferencing. *Training, 30*(6), 59–63.

Feldman, J. M. (1993, September). Bane of business travel? *Air Transport World, 30*(9), 44–49.

Fielding, G. & Hartley, P. (1987). The telephone: A neglected medium. In A. Cashdan & M. Jordin (Eds.), *Studies in communication* (pp. 110–124). New York: Basil Blackwell.

Finholt, T. & Sproull, L. S. (1990). Electronic groups at work. *Organization Science, 1*(1), 41–64.

Finley, M. (1991, September). The best of all possible meetings? *Across the Board, 28*(9), 40–45.

Finn, T. A. (1988). Process and structure in computer-mediated group communication. In B. D. Ruben (Ed.), *Information and Behavior* (Vol. 2, pp. 167–193). New Brunswick, NJ: Transaction.

Fish, R. S., Kraut, R. E., Root, R. W., & Rice, R. E. (1993). Video as a technology for informal communication. *Communications of the ACM, 36*(1), 48–61.

Fowler, G. D., & Wackerbarth, M. E. (1980). Audio teleconferencing versus face-to-face conferencing: A synthesis of the literature. *Western Journal of Speech Communication, 44*, 236–252.

Francis, R. (1993, October 1). Tune in to cheaper videoconferencing. *Datamation, 39*(19), 48–50.

Grayson, C. J., Jr. (1983). *Computer conferences on productivity: A final report for the White House conference on productivity*. Houston, TX: American Productivity Center.

Hall, J., & Watson, W. (1970). The effects of a normative intervention on group decision-making performance. *Human Relations, 23*(4), 299–317.

Hellweg, S. A., Berman, S. J., Stuart, J., & Smith, A. F. (1985, November). *Emerging organizational electronic communication technologies: A selected review of the literature*. Paper presented at the meeting of the Speech Communication Association Convention, Denver, CO.

Hiltz, S. R. (1986). The virtual classroom: Using computer mediated communication for university teaching. *Journal of Communication, 36*, 95–104.

Hiltz, S. R. (1988). Productivity enhancement from computer-mediated communication: A systems contingency approach. *Communications of the ACM, 31*(12), 1438–1454.

Hiltz, S. R., Johnson, K., & Turoff, M. (1986). Experiments in group decision making: Communication process and outcome in face-to-face versus computerized conferences. *Human Communication Research, 13*(2), 225–252.

Hiltz, S. R., & Turoff, M. (1978). *The network nation: Human communication via computer*. Reading, MA: Addison-Wesley Publishing Company.

Hiltz, S. R., Turoff, M., & Johnson, K. (1989). Experiments in group decision making 3: Disinhibition, Deindividuation, and group process in pen name and real name computer conferences. *Decision Support Systems, 5*, 217–232.

Hirokawa, R. Y. (1987). Why informed groups make faulty decisions: An investigation of possible interaction-based explanations. *Small Group Behavior, 18*(1), 3–29.

Hirokawa, R. Y. & Johnston, D. D. (1989). Toward a general theory of group decision making: Development of an integrated model. *Small Group Behavior, 20*(4), 500–523.

Huber, G. P. (1990). A theory of the effects of advanced information technologies on organizational design, intelligence, and decision making. In J. Fulk and C. Steinfield (Eds.), *Organization and communication technology* (pp. 237–274). Newbury Park, CA: Sage.

Hutsko, J. (1993, November). Face-to-face phones: Video conferencing comes to the desktop. *PC World, 11*(11), M72–76.

Kerr, E. B. & Hiltz, S. R. (1982). *Computer-mediated communication systems: Status and evaluation*. New York, NY: Academic Press.

Kirvan, P. (1993, October). Teleconferencing in the 1990s: Videoconferencing. *Communications News, 30*(10), 57.

Kupfer, A. (1992, December 28). Prime time for videoconferences? *Fortune, 126*(14), 90–94.

LaPlante, A. (1993, September 13). TeleConfrontation: Enter the era of virtual meetings. *Forbes ASAP* (A Technology Supplement), *152*(6), 110–118.

Lea, M. (1991). Rationalist assumptions in cross-media comparisons of computer-mediated communications. *Behavioral Information Technology, 10*(2), 153–172.

McGrath, J. E. & Hollingshead, A. B. (1993). *Groups interacting with technology*. Newbury Park, CA: Sage.

Meeting face to face—at a lower cost (1993, October 6). *Journal of Commerce and Commercial, 398*(28077), S4.

Morganstern, B. F., McMickle, C. W., & Radford, G. P. (1993, May). *Small group decision making in four conferencing formats: Effects of communication channels on group consensus and satisfaction*. Paper presented at the meeting of the International Communication Association, Washington, DC.

Nunamaker, J. F., Dennis, A. R., Valacich, J. S., Vogel, D. R., & George, J. F. (1991). Electronic meeting systems to support group work. *Communications of the ACM, 34*(7), 40–61.

Olaniran, B. A., Friedrich, G. W., & VanGundy, A. B. (1992, May). *Computer-mediated communication in small group decisional stages*. Paper presented at the meeting of the International Communication Association, Miami, FL.

Phillips, A. F. (1983). Computer conferences: Success or failure? In R. N. Bostrom (Ed.), *Communication Yearbook 7* (pp. 200–224). Beverly Hills, CA: Sage Publications.

Piturro, M. C. (1989). Computer conferencing: Brainstorming across time and space. *Management Review, 78*, 43–46.

Poole, M. S. & DeSanctis, G. (1992). Microlevel structuration in computer-supported group decision making. *Human Communication Research, 19*(1), 5–49.

Pye, R. & Williams, E. (1977, June). Teleconferencing: Is video valuable or is audio adequate? *Telecommunications Policy*, pp. 230–241.

Rice, R. E. (1984). Mediated group communication. In R. E. Rice and Associates, *The new media: Communication, research, and technology* (pp. 129–154). Beverly Hills, CA: Sage.

Rice, R. E. (1993). Media appropriateness: Using social presence theory to compare traditional and new organizational media. *Human Communication Research, 19*(4), 451–484.

Rosetti, D. K. & Surynt, T. J. (1984). Video teleconferencing and performance. *Journal of Business Communication, 22*(4), 25–31.

Short, J. (1971). *Cooperation and competition in an experimental bargaining game conducted over two media.* Communications Studies Group, Joint Unit for Planning Research, University College, London.

Steinfield, C. W. & Fulk, J. (1990). The theory imperative. In J. Fulk & C. Steinfield (Eds.), *Organizations and communication technology* (pp. 13–26). Newbury Park, CA: Sage.

Van de Ven, A., & Delbecq, A. L. (1974). The effectiveness of nominal, delphi and interacting group decision making processes. *Academy of Management Journal, 17*(4), 605–621.

Walther, J. B., & Burgoon, J. K. (1992). Relational communication in computer-mediated interaction. *Human Communication Research, 19*(1), 50–88.

Watkins, B. T. (1992, September 16). Universities try electronic format to make meetings more productive. *Chronicle of Higher Education, 39*(4), A22.

Williams, E. & Holloway, T. (1974). *The evaluation of teleconferencing: Report of a questionnaire study of users' attitudes to the Bell Canada Conference Television System* (Report No. P/74224/WI). London, England: Communication Studies Group.

Acknowledgments—The researchers are extremely grateful to: Mr. Harold Dunn for his expertise and efforts in developing the technology necessary for this and future studies; Dr. Marie Radford, Jennifer King, Ralph Malachowski, and Dr. Ruby Roy Dholakia, for their help in the preparation of the manuscript; and three anonymous *Telematics and Informatics* reviewers. A version of this paper was presented at the 79th Annual Meeting of the Speech Communication Association, Miami Beach, Florida, November 18–21, 1993.