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Computer-mediated communication system network data: theoretical concerns and empirical examples

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The review combines two separate foci in recent research: (1) the diffusion and use of computer-mediated communication (CMC) systems in organizations, and (2) the conceptualization of communication as a process of interaction and convergence, as represented by the network paradigm. The article discusses (1) rationales for this combined focus based upon the characteristics of CMC systems, (2) application of the network paradigm to study CMC systems, (3) the collection samples, usage data, network flows, and content by CMC systems, (4) some theoretical issues that may be illuminated through analyses of data collected by CMC systems. The article concludes by discussing issues of reliability, validity and ethics.

The proper design, management, and application of organizational information and communication systems depends to a great extent upon insights gained from appropriate and ongoing research of those systems, from technical, organizational, and social perspectives (Ellis & Nutt, 1980; Hamilton & Chervany, 1981; Kling, 1980; Rice, 1989). This article extends this body of literature in five ways. First, it discusses characteristics of computer-mediated communication (CMC) systems that may affect organizational processes. Second, it highlights the relevance of the communication network paradigm for studying such processes. Third, it identifies attributes of data collected from CMC systems that may be important for research analyses. Fourth, it provides examples of analyses of CMC network data that attempt to answer several theoretical concerns in organizational communication research. Finally, it raises some unresolved issues concerning the meaning and ethical aspects of such data.

1. Computer-mediated communication systems, interaction and networks

1.1. COMPUTER-MEDIATED COMMUNICATION SYSTEMS: CONSTRAINTS AND INTERACTIONS

Computer-mediated communication (CMC) systems bring together capabilities of both computers and telecommunication networks to facilitate the input, structuring, processing, retrieval and exchange of content. CMC systems include electronic mail, computer conferencing, computer bulletin boards, facsimile, teletex and videotex, voice messaging and related media such as electronic blackboards and desktop

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videoconferencing.† The following discussion emphasizes the analysis of *text-based* CMC systems.

Because of this combination of computers and transmission networks, CMC systems have attributes that reduce some constraints, and impose others, on human and organizational communication. This potential change in communication constraints may foster not only more efficient and effective communication, but also new kinds of interaction, data and processes (Cathart & Gumpert, 1983; Rice & Associates, 1984; Rice, 1987*a*). Three broad categories of change include (1) structures, (2) constraints, and (3) connectivity.

(1) Designers, implementors, managers and users of CMC systems may program the computer to structure communication processes. Examples include polling online groups, jointly authoring documents, broadcasting messages by means of pre-established but modifiable distribution lists, retrieving materials by keywords, and prioritizing and summarizing incoming content to reduce overload (Hiltz & Turoff, 1978, 1985).

(2) CMC systems can reduce or alter some of the temporal, physical and social constraints on communication. For example, at the place and time preferred, (a) a user can send messages or documents and apply the computer's processing capabilities to create, store, format and distribute; and (b) a receiver may scan, read, print, forward, copy, edit or delete the content. All of these activities are independent of the temporal or geographic proximity of the senders and receivers. Thus feedback can be quicker than through traditional communication channels, which either have inherent constraints (such as memos and letters which take time to be delivered) or implied constraints (such as the regular telephone, which requires both parties to be temporally proximate).

(3) Other potential changes associated with CMC systems are consequences of the capabilities of telecommunication networks to connect users in diverse locations. For example, users can expand their networks by seeking out and sending messages to other individuals who they may not know personally (such as through distribution lists or bulletin boards), who are geographically distant, or who can be identified by common keywords listed in the system's directory.

Thus CMC systems can process and structure communication activities and content, and change the kinds of constraints on communication processes. So CMC systems represent some new communication attributes, and may have different consequences for organizational communication, compared with interpersonal and traditional mass media. We return to some implications of these differences in Section 3.

The following discussion focuses on a rather different implication of CMC systems, however: CMC systems provide a fundamentally different research capability compared with interpersonal or mass media channels. They can be programmed to collect samples or censuses of the message flows, message content, and extent of usage of the system at individual, group, and organizational levels of

† For descriptions of functions, market, uses and impacts of electronic mail and computer conferencing systems, see Chesebro, 1985; Glossbrenner, 1983; Guelph University, 1987; Hiltz, 1978*b*, 1984; Hiltz & Turoff, 1978; Johansen, 1984; Johansen & DeGrasse, 1979; Johansen, Valee & Spangler, 1979; Kerr & Hiltz, 1982; Kiesler, Siegel & McGuire, 1984; Olson & Lucas, 1982; Panko, 1985; Rice, 1980*a, b*, 1987*a*; Rice & Bair, 1984; Rice & Case, 1983; Steinfield, 1986; Uhlig, Farber & Bair, 1979; and Vallee, 1984.

analysis. But the implication of this capability is more significant than simply providing another way to collect communication data. Rather, this new research capability provides an opportunity to test and extend network-based theories of organizational communication.

1.2. INTERACTION, CONVERGENCE, AND NETWORK ANALYSIS

Theories of communication have shifted from viewing communication as a linear transmission of a message by a source through a channel to a receiver (Shannon & Weaver, 1949), to conceptualizing communication as a process of interaction and convergence (Dervin, 1989; Rogers & Kincaid, 1981: ch. 2). That is, rather than an objective fact that can be transported from one person to another without considering the nature of the relationship, communication is created by interaction and leads to a convergence of meaning (not necessarily agreement, however).

Under this conceptualization, the proper units of analysis of communication processes are the communication relationship and patterns of interaction. A network is a patterned set of relationships among a set of actors. This perspective on communication, social structure, and other kinds of social processes is generally referred to as the network paradigm (Mitchell, 1969; Rice & Richards, 1985; Rogers & Kincaid, 1981; Shaw, 1978; Tichy, 1981). The network paradigm supports the concept of convergence, by refocusing attention away from individuals as independent senders and receivers of messages, toward individuals as actors in a network consisting of interdependent relationships embedded in organizational and social structures. CMC systems by definition support and affect relationships.

This paradigm emphasizes different kinds of analysis and data, than does the linear model of communication. The basic network dataset is a $N \times N$ (N being the total number of actors) matrix where the value in cell (i, j) indicates the intensity of the link from actor i to actor j. Intensity may be measured by the presence/absence, strength, frequency, importance, liking, influence, etc of a relationship. "Actors" may be individuals, groups, organizations, industrial sectors, countries, etc. A network dataset may also be a $N \times K$ matrix. That is, "actors" may also be words that occur in a common set of electronic documents, people who participate in a common set of computer conferences, bulletin boards that share individuals on their user lists, etc. A wide variety of network variables can be derived from this matrix:

(1) individual-level measures of network structure such as one's connectedness (the extent to which one is linked to other members of the network);

(2) reciprocity (the extent to which the value in the (j, i) cell of the $N \times N$ matrix is different from the (i, j) value), direction, and strength of dyadic relationships;

(3) the presence of indirect and "weak ties" in the network, allowing the transmission of new, innovative and diverse information (Granovetter, 1982);

(4) the distribution of network roles throughout the system, such as liaisons, opinion leaders, boundary-spanners;

(5) membership in clusters, groups or cliques of nodes (which distinguish participants from isolates), or positions in the organization or other social system (which distinguish similar nodes from dissimilar nodes); and

(6) patterns of organizational coordination and integration or inter-organizational imbalances in information flows.

Along with the development of network concepts since the early studies of kinship groups and decision-making in small groups, network analysis has been spurred on by the use of computers for analysing matrices (Knoke & Kuklinski, 1982; Rice & Richards, 1985; Rogers & Kincaid, 1981). Network analysis is a theoretically and practically appropriate method for the study of the organizational adoption, use, and impacts of CMC systems.

1.3. SUMMARY

Three main points, then, motivate the rest of this review:

(1) Computer-mediated communication systems combine computers and telecommunication networks, leading to potential changes in communication constraints, structures, and connectivity.

(2) Computer-monitored data about patterns of interactions (networks) among users of a CMC system provide the ability to test and extend theories of organizational communication.

(3) The computer component in CMC systems provides the potential for collecting data about how individuals and groups use the system and communicate with each other. The next section expands on this point.

2. The system as part of the research process: data and method

2.1. FOUR ASPECTS OF COMPUTER-MONITORED DATA

2.1.1. Samples

Because communication networks consist of all the interactions in a given system, network data must typically consist of the full census of system users. Thus, sampling procedures and moderate response rates characteristic of most survey research are insufficient for most kinds of network analyses. However, a CMC system's computer can be programmed to monitor all or requested portions of usage, so researchers can collect specific samples of communication behavior when appropriate, or censuses when necessary. Depending on the research goals and data-management capabilities, the sample may be of selected users, time frames, sets of commands, or content (such as messages headers or full text). For example, CMC network studies have analysed censuses of interactions within one or more selected time frames (Danowski & Edison-Swift, 1985; Eveland & Bikson, 1987; Freeman, 1980; Rice & Love, 1987; Robey, Saunders & Vavarek, 1989), or from the entire time series of network data since the initiation of the system (Rice, 1982).

2.1.2. Usage

Although infrequent, there have been studies in the past 15 years that have collected computer-monitored data to study information systems (Edelman, 1981; Gibson, 1975; Larreche, 1979; Lucas, 1978; Vanlommel & de Brabander, 1975; see also the review of many other studies by Rice & Borgman, 1983). However, the use of such data to analyse CMC systems is a recent development. The computer supporting a CMC system may be programmed to collect the number of times a user "logs on" to a system, the duration of sessions, specific messaging functions used (such as initiating a new message or replying to someone else's message, copying or forwarding a message to someone else, sending a message to a distribution list), various sequences of commands, errors made, the time of certain interactions, the fraction of day spent using the system, etc.

CMC usage data has been analysed to compute the ratio between number and time of messages sent per messages read, to identify threats of information overload to receivers in electronic messaging systems (where each message sent creates a new message for each separate receiver) *vs* computer conferencing systems (where each message sent is stored in just one conference file) (Palme, 1984). Voice messaging usage data can provide the number and length of messages sent and received, number and duration of messages archived by the user, number and length of messages rolled over from a regular outside line, aggregated by individuals, departments, telephone exchanges or the entire system (Rice & Shook, 1990*a*).

With the diffusion of personal computers accessing a CMC system through a local area network and the ability to prepare messages offline and upload them to a CMC system, it may become harder to collect such data. However, most local area network management or bulletin board software provides the ability to monitor different kinds of system usage. Further, several programs for personal computers are available that log amount and types of usage, without much RAM overhead, response degradation, or, in the case of the programs published in some computer magazines, even cost.

2.1.3. Network flows

While most communication network studies rely on questionnaire rosters to capture the who-to-whom relationships, this approach is naturally limited to a moderately-sized network (due to respondent fatigue and questionnaire formats). Information flows and network data collected by a CMC system, however, are typically limited only by the number of users, the accuracy of accounting records, and memory limitations in the network analysis program. The primary datum is a link (a message) identified by the account number of the sender and receiver, its length, its initiation date, and in some systems, the receipt date. Various network matrices or vectors can then be constructed from a set of such relational data.

2.1.4. Content

Full-text transcripts may be retrieved from CMC system files for qualitative or quantitative analyses of frequency of content (overall or within coded categories), keyword-in-context (KWIC) sets, interaction episodes, co-occurrence of concepts, or kinds of content across network roles. These transcripts themselves may be automatically content-analysed by computer (Stone, Dunphy, Smith & Ogilvie, 1986; Weber, 1984). Weber notes that computer-aided content analysis provides four immediate benefits; (1) coding rules are more explicit; (2) it is easier to replicate and extend prior analyses; (3) problems of coder reliability are reduced or eliminated; and (4) the typically large body of content data is reduced to manageable units.

Analyses of message content and networks collected by a CMC system may be combined in a variety of ways to illuminate how user's social structure both provides a context for meaning, and is affected by the content exchanged within that structure. Analysis of *content networks* conceives of relationships among the content of CMC messages as semantic networks. The number of similar words that co-occur in a sentence, or the number of words between any given pair of words, are two measures of the strength of the relationship between concepts. The weighted relationships between concepts can be network-analysed to detect patterns of meaning that develop over time (Danowski, 1982). Or, semantic networks of responses to open-ended survey questions or focus group comments can be compared with the respondents' level or type of system usage (Danowski & Rice, 1989). *Content-network comparison* analyses the relationships of the content of messages exchanged by users to the network of message flows among the users (Danowski & Edison-Swift, 1985). *Content-network mapping* analyses the content communicated by system users according to its distribution among their groups or positions (Rice & Love, 1987; Robey, Saunders & Vavarek, 1989).

2.2. CMC SYSTEMS AS MORE OR LESS OBTRUSIVE METHODS OF DATA-COLLECTION

A common threat to the validity of research conclusions is the obtrusiveness of the data collection (Webb, Campbell, Schwartz & Sechrest, 1966). A common threat to the reliability of research is the difficulty of providing exactly identical experimental conditions to multiple sets of subjects over time or across settings. CMC systems can be more or less obtrusive components of the research design, depending on whether they are used to monitor or initate data collection.

2.2.1. System as monitor

Depending on the extent and frequency of feedback to the users, and the nature of the users' consent (see the discussion below), the system may collect data unobtrusively. Most CMC systems routinely collect some basic data, which often is kept in the form of monthly or annual summaries, in paper reports or magnetic storage media, for maintenance or accounting purposes. A researcher interested in studying a particular setting should arrange to have the system begin collecting such data as soon as possible—preferably upon implementation—to provide both baseline and longitudinal measures.

2.2.2. System as initiator

A more obtrusive and reactive use of CMC systems is to initiate user activities or system structures. The resultant data are user responses that would not otherwise have occurred, collected by the computer for immediate feedback or later analysis.

A simple example is the administration of online questionnaires (Hiltz, 1979; Newsted, 1985; Kiesler & Sproull, 1986; Sproull, 1986). Advantages of online surveys include:

(1) there are fewer transformations of information between different media, such as coding and keypunching data from questionnaires, because the system can automatically format and analyse data as it is collected;

(2) built-in branching and filter questions avoid unnecessary questions or page-flipping by interviewers; and

(3) respondents can answer at their own pace or provide extended answers.

Indeed, one of the first uses of computer conferencing was to support Delphi surveys (iterative surveys of experts who are provided with the mean responses of the other anonymous experts surveyed in the prior round) (Hiltz & Turoff, 1978). However, respondents available on online systems or in subscription lists for diskette-based questionnaires at this stage in the diffusion of CMC systems are not likely to be representative of most target populations (Kiesler & Sproull, 1986).

A more complex example of using a CMC system to initiate data collection is the administration of online controlled experiments. The computer can randomly assign treatments, accurately replicate operationalizations of instructions and measures, remind or enable users to participate, determine the duration and timing of communications, collect results from periodic surveys of consensus and decisions, and maintain a complete transcript of the flow and content of the communication process. Some research has taken advantage of this capability to test hypotheses about the influence of CMC systems on accuracy, speed, consensus, leadership effects and quality of decision-making by small groups using computer conferencing systems (Finn, 1987; Hiltz, 1978*a*, 1982; Hiltz & Turoff, 1978; Kiesler, Siegel & McGuire, 1984; Rice, 1984*a*).

2.3. SUMMARY

There are, then, more aspects to computer-monitored communication data than simply measuring the amount of system usage. CMC system data augment traditional research approaches with respect to sampling, measuring usage, collecting interactions among a network of users, and collecting and analysing content. Also, CMC systems can unobtrusively monitor user behavior, or more obtrusively initiate surveys and experimental treatments.

Each of these aspects and levels, both separately and in combination, represents different ways of approaching certain research problems and even enhancing each separate approach. Finally, other information, such as individual demographics, user attitudes toward the system, departmental membership or organizational job

TABLE 1
Example studies using computer-monitored data, by aspect of data and by level of obtrusiveness

Aspect of data	Level of obtrusiveness of system in collecting data: Monitor	Initiator
Sample	Concept relations in computer bulletin boards (Danowski, 1982)	Recall versus behavior about use of messaging (Bernard *et al.*, 1982)
Usage	Access and equity in videotex (Ettema, 1985)	Group decision-making in computer conferencing (Kiesler *et al.*, 1984)
Network	Evolution of groups in computer conferencing (Rice, 1982)	Group structure, decisions in computer conferencing (Hiltz, 1982)
Content	Face-saving strategies in computer conferencing (Hiemstra, 1982)	Polls and surveys in online systems (Hiltz, 1979)

category, or other archival data, can be merged with computer-monitored usage data to support multi-method, multi-measure research (Eveland & Bikson, 1987; Rice & Shook, 1988; Williams, Rice & Rogers, 1988). As Table 1 indicates, researchers have used CMC systems to monitor as well as initiate collection of all four aspects of communication data.

3. Applying CMC network data to some organizational communication questions

This section suggests some research hypotheses about organizational communication that could be tested with computer-monitored communication data. Three areas of ongoing research are considered: (1) adoption of information systems; (2) the impact of mediated communication in organizational functioning; and (3) changes in organizational structure.

3.1. ORGANIZATIONAL ADOPTION OF CMC SYSTEMS

The adoption and implementation of innovations is a central theme in much social science research in general and in information systems research in particular (Johnson & Rice, 1987; Lucas, 1981; Rogers, 1983). Basic questions center around (1) how does adoption or usage influence the effects of such systems, and (2) what communication factors predict adoption or successful implementation of CMC systems.

3.1.1. Usage as independent variable

The amount of usage has been analysed as a predictor or correlate of changes in perceived acceptability and outcomes of CMC systems. The general convention, supported by many studies, is that usage is moderately associated with outcomes such as effectiveness and usage of other media (Rice & Case, 1983; Rice & Shook, 1988). However, usage may be associated with *lower* benefits if it means the system is poorly designed (Ettema, 1985), or users have not gained enough experience over time to understand the more significant capabilities of a system (Hiltz & Turoff, 1981). Further, users with greater system experience may begin composing their messages offline, then uploading the content through personal computers, thus appearing to use the system less if only the number of minutes online is the monitored measure (Harasim, 1987). Finally, the ways in which a system is used, independent of the overall level of usage, may be far more important in explaining adoption or success. For example, using a voice messaging system to support group collaboration and to co-ordinate work was a much stronger predictor of improvements in information handling over a six-month period than was using the system just to leave and record messages while out of the office (Rice & Shook, 1989*a*).

3.1.2. Usage as dependent variable

Amount of usage has often been analysed as a indicator of implementation success. Hiltz (1984), for example, has shown that the number of previously known colleagues on the system, along with typical variables such as accessibility of the system and relevance of the system to users' tasks, are significant predictors of levels of participation in the CMC network.

Computer-monitored usage data from an agricultural videotex system tested by 200 farmers in two counties (one grain-producing, the other livestock-producing) were acquired at the end of the evaluation project, in an attempt to verify reasons for, and the extent of, reported declines in system usage (Rice & Paisley, 1982). The system data showed a clear decline from the beginning of the demonstration, and much lower usage by farmers in the livestock county. This monitored data not only disproved claims by the system developers that the declines in usage reported by farmers were due solely to a temporary suspension of access to the Chicago market data, but also showed that usage was greater in the grain county where there was a real need due to the volatility in grain prices.

3.1.3. Usage as both independent and dependent variable; critical mass

Markus (1987), Rice (1982) and others have theorized that the value of any particular CMC system rises, and thus the relative cost of adoption decreases, as others also begin using the system. Depending on how the system is implemented, eventually a "critical mass" may be reached that is sufficient to stimulate large-scale adoption of the innovation. Because interaction among users provides the basis for the development of a critical mass, this proposition is most appropriate using network data.

Rice, Grant, Schmitz and Torobin (1990) tested this proposition using data from a small governmental agency. They found that the single best predictor of the likelihood of an individual's adoption of an electronic messaging system nine months later, was the individual's connectedness in the office communication network before implementation of the system. Further, the best predictor of some communication-related outcomes was the extent to which that individual communicated with others who had also adopted the system. As is typical, this study had to rely on self-report network data, collected at just two time periods. However, the growth and interaction among users over time is too dynamic and complex to be reliably or practically measured in retrospective self-report data.

A comprehensive study of critical mass in CMC systems would require using both traditional data (observational, archival, and survey—including online surveys) and computer-monitored longitudinal network data to test individual-level and system-level propositions such as the following:

3.1.4. Individual-level critical mass

This is that number of other potential or actual adopters of a CMC system required to (a) make using the system worthwhile and (b) enable the respondent to have sufficient access to salient (task, social, departmental, etc.) groups.

P1: The percent of each of one's important groups (task-related, social, work-units) with whom one interacts regularly before system implementation will positively influence one's adoption.

P2: Perceived system value will be positively associated with higher proportion of each of one's groups that also use the system, higher percent of reciprocated messages with other users, and with some power root of the number of other users.

P3: Centrality in the usage network will be positively associated with perceived system value.

3.1.5. *System-level critical mass*

This is the point at which the 2nd derivative of the adoption curve becomes negative, as long as the 1st derivative remains positive.

P4: Diffusion of the system will be characterized initially by clusters of densely-connected early adopters and later by isolated adopters.

P5: Strong differentiation among groups of users will enhance individual-level critical mass but delay later system-level critical mass.

P6: Critical mass will be reached more quickly under conditions of high overall network reciprocation and shorter average time between the sending and receiving of messages (see Rice, 1982).

3.1.6. *Summary*

Computer-monitored system data can be used in traditional ways to measure usage levels as independent or dependent variables. However, the greater strength of such data comes from measuring more subtle aspects of usage to explain otherwise contradictory results, and in analysing the reciprocal relations of network variables over time to explain higher-order dimension of adoption of CMC systems, such as critical mass.

3.2. MEDIA DIFFERENCES

3.2.1. *Information richness and social presence*

Daft and Lengel (1986) have developed a theoretical model of how communication channels that are more information rich may better support tasks that are more equivocal, located higher up in the organization, or occur in more organic organizations. Rice and Shook (1990*b*) provide empirical evidence for such propositions. Short, Williams and Christie (1976) have shown that media with less social presence are equally or more effective than face-to-face communication for instrumental tasks, but less effective for socio-emotional tasks.

Text-based CMC systems may reduce the amount of social presence or information richness (nonverbal communication, social cues, equivocal information, or perception of the other user's "closeness") in the content of the communication, thus limiting the applicability of CMC systems for more socio-emotional communication activities. On the other hand, the reduction of these nonverbal and social cues may improve the equality of participation and access by those otherwise constrained to interpersonal communication (such as employees with lower organizational status, who take longer to respond, have speech difficulties, or are members of minority groups) (Hiltz & Turoff, 1978; Rice, 1984*a*). The question as to the extent to which CMC systems affect the meaning of messages remains a significant issue in the implementation and application of such systems.

Some CMC researchers have analysed CMC system transcripts for evidence of socio-emotional content and interpersonal negotiating strategies. Some studies have found noticeable levels of disinhibited communication content ("flaming") due to the lack of non-verbal social regulatory cues in CMC systems (Kiesler, Siegel & McGuire, 1984), while others have found very small percentages of such content (Robey, Saunders & Vaverek, 1989). Others have found explicit use of paralinguistic cues that add context to the content (Asteroff, 1987; Hiltz & Turoff, 1978; Phillips, 1982; Spelt, 1977), substantial amounts of socio-emotional content (up to 30% of the comments in a computer bulletin board used by physicians and nurses) (Rice & Love, 1987), and face-saving strategies that are generally similar to those used in face-to-face situations (Hiemstra, 1982).

Rice and Love (1987) mapped the content network of six weeks' worth of transcripts from a public computer bulletin board used by physicians and nurses. First, network analysis was used identify members of groups (those who sent more messages to each other than to members in other groups) and isolates (those who did not belong to groups). Then their messages were categorized into socio-emotional or task-oriented content by means of Bales' Interaction Process Analysis (IPA) (Bales, 1950). Users who sent more messages sent more overall socio-emotional content, but there were few differences in socio-emotional content of messages sent by group members as compared with those sent by isolates. Thus, even if CMC systems *do* suppress socio-emotional content, such content is not necessary to maintain online groups.

Some anlayses of CMC content have focussed on the influence of agenda-setting comments, structuring strategies and leadership in group decision-making processes. Finn (1987), for example, in a content-network comparison of transcripts from a controlled experiment concerning group decision-making in a CMC system (conducted by Hiltz, Johnson & Turoff, 1982), found that organizing strategies were not particularly useful in CMC groups that did not have a strong leader or moderator. This is an important finding, because CMC systems, due to their narrow bandwidth and freedom from some communication constraints, tend to suppress the emergence of leaders in groups (Rice, 1984*a*). Thus even though structures and commands may be programmed into the CMC system to support group decision-making and intra-organizational communication, they may not sufficiently compensate for the possible decrease in leadership. This problem is probably less likely, however, in ongoing organizations than in geographically dispersed extra-organizational communication networks such as online "invisible colleges" or research groups (Hiltz, 1984). In addition, this reduced leadership can be compensated for through explicit selection and designation of leadership roles and occupants (Hiltz, Johnson & Turoff, 1982).

3.2.2. Change in constraints and resources

CMC network data can be analysed to test competing models of users' behavior over time. When individuals communicate through systems that have different kinds of constraints from traditional media (face-to-face, mass media, telephone), then the bases for social cohesion, and the criteria for evaluating communication-based relations, may change (Rice, 1984*b*; Rice, 1987*b*). Because most nonverbal, organizational and status differences are removed, the content of the information and the level of reciprocity among users may become predominant criteria for the development and maintenance of communication roles (Barnett & Rice, 1985; Rice & Barnett, 1986).

The removal of some of these constraints allows researchers to test long-held theories about the determinants of communication. For example, physical proximity has often been claimed as a primary rationale for the development of certain kinds of relationships, and it has been speculated that CMC systems may alter or re-rank these determinants and thus the nature of organizational and social structures (Rice, 1987*b*). Users in a study by Eveland and Bikson (1987) sent 45% of all their messages to others in the immediate location, and declining percentages as the distance between the sender and received increased. Users in a study by Smith, Bizot and Hill (1988) sent 22% of their messages to others in the same workgroup and 41% to others in the same section. These results indicate that task interdependency may be a greater motivation for system use than is the ability simply to cross major organizational and geographic boundaries. In other words, communication constraints are important influences on media use only if the communication is necessary.

Removing the constraint of linear sequencing of communications inherent in most traditional media may also give rise to new forms and problems of communication. Black, Levin, Mehan and Quinn (1983) and Holmes (1986) have analysed content networks using "discourse analysis" of the paths of multiple threads of conversation caused by the asynchroneity of interactions among CMC users. Multiple threads occur because, while comments are typically listed sequentially in the order in which they were entered, they may in fact be responses to items added several entries ago but just recently read by the particular respondent.

The advantage of multiple threads is that users may enter and read comments at their convenience, scanning several topics in one session. The disadvantage is that the sequential listing does not reflect the actual relationship among comments about several topics, and users may have difficulty following the threads of multiple topics. This problem suggests the need for software to help users organize the discourse, such as mechanisms to search, retrieve, index and reorganize items (Hiltz & Turoff, 1985). Interesting research topics would be the extent to which users take advantage of such capabilities, or to which confusion or misunderstandings arise as more conversational threads are present. Individual differences (such as cognitive complexity) may interact with interface design (such as the use of menus, commands, or hypertext) in affecting these outcomes. Content-network comparison would be a useful research approach to answering these questions.

3.3. ORGANIZATIONAL STRUCTURE AND CMC SYSTEMS

Organizational structure is central to a wide variety of concerns of organizational communication theorists, such as innovativeness of employees (Albrecht & Ropp, 1984), the performance of R & D units (Tushman, 1979), and organizational effectiveness in the face of changing environments (Lawrence & Lorsch, 1967). For example, Olson and Lucas (1982) hypothesized that the use of CMC systems will change interpersonal and intra-organizational communication structures, and, therefore, organizational processes. Analysing CMC communication network data—how people in fact communicate by using such systems—is necessary to test such hypotheses.

Eveland and Bikson (1987) analysed patterns of 69,000 messages sent among 800 users in a R & D organization. Smallest-space analysis of the message flows, found four departmental clusters: a cluster of research departments and a cluster of administrative departments which were close to each other, an administrativecoordinating cluster in the center between the two, and an unclustered, dispersed set of operational departments at the periphery. Analyses of 100 selected users over the 18-month period after the host CMC computers began logging usage showed that there were no differences in usage levels across departments, programs or professional categories. Seventy five per cent of the messages crossed departmental boundaries, indicating high cooperation among research disciplines within broad organizational functions. Only 40% of the messages crossed specific research project boundaries, however. The communication structures within and across research projects were generally not clustered, as were departmental network relations.

Thus, using electronic mail in the matrixed organization allowed individuals in different departments to work collaboratively on R & D projects. Indeed, communication in the organization was primarily but not exclusively focussed on those projects.

The interpretation of these results is supported by the results of a study of the use of IBM's integrated messaging and document system PROFS (Smith, Bizot & Hill, 1988). The authors selected, by stratified random sampling within divisions and job types, 188 individuals. They collected three days' worth of messaging for each individual, and asked each respondent to answer a questionnaire and comment on the messaging log, in an anonymous manner. In this traditionally hierarchical R & D organization, 83% of all messages were sent within a division. Further, 93% of messages were sent to a recipient either one job type above or below the sender, indicating little circumventing of the traditional organizational structure.

Finally, Eveland and Bikson (1987) found little evidence of changes in the departmental or project communication clusters over the 18-month period of study, indicating that the electronic mail system supported, but did not alter, the *intra*-organizational structure of the R & D organization (Eveland & Bikson, 1987). Another longitudinal study also found that electronic networks may develop to complement pre-existing task and social networks (McKenney, Doherty & Sviokla, 1986).

Inter-organizational network relationships changed, however, in an analysis of messaging behavior by approximately 800 members of 10 research groups using a nationwide computer conferencing system over a 24-month period, when new groups/organizations entered or left the system. A few months after such changes, though, the entire system tended to recover its equilibrium (Barnett & Rice, 1985; Rice, 1982; Rice & Barnett, 1986).

A content-network comparison by Danowski and Edison-Swift (1985) and Danowski (1987) analysed CMC system data before, during, and after an administrative crisis experienced by a number of offices in a statewide county extension service. Relationships among words in the CMC messages showed that crises galvanized the inter-organizational network into shared but temporary concern. The structure of the content networks was influenced by the introduction of new communication messages, sent in the prior month, relating to the budgetary source of the crisis. The network of message links restabilized several times faster than did the associated network of message content. That is, relationships among communication links were more robust or enduring than were relationships among communication content during the crisis. Rice (1982), Rice and Barnett (1986), and Robey, Saunders and Vaverek (1989) have also found that CMC networks tend to stabilze over time.

These results seem to indicate that formal and project-related organizational structures may be supported by CMC systems, but will not be significantly changed by them. Organizational communication structures may change during times of significant interaction or even crises, but will tend to revert back to the patterns of relationships established, perhaps, after a critical mass of users has begun using the system regularly. Of course, future research could illuminate such findings by measuring the usage of traditional media as well to see if they reflect such changes as quickly or are used to exchange similar crisis-oriented content. It would be difficult, however, to obtain similarly detailed content and network flow data.

A final brief comment concerns the emergence and development of technology to support group decision-making and collaboration, such as computer conferencing, group decision support systems, electronic blackboards, and voice messaging, commonly called "groupware" (Galegher, Kraut & Egido, 1990; Johansen, 1988). Clearly, proper study of the design, management, application, and effects of such systems requires appropriate data. Those data should include computer-monitored content, usage and network flows.

3.4. SUMMARY

Analysing computer-monitored content and network data can help answer some of the challenging questions about how computer-mediated communication compares with face-to-face communication, how it aids or obstructs the interpretation of content, and how it affects group formation and decision-making. Also, computer-monitored network and content data allow researchers to study some aspects of organizational change processes in a more detailed, reliable, and longitudinal fashion than most traditional data could. Rich and fruitful studies would, of course, combine all relevant and available sources of data.

4. More general issues

Beyond specific potential research opportunities presented by computer-monitored CMC content and network data, there are at least two, more fundamental, sets of issues that should be considered: reliability and validity, and privacy and equity.

4.1. BEHAVIOR OR PERCEPTION?

One of the obvious advantages of computer-monitored communication data is that the data can be accurate, reliable and provide complete records of communication behavior. From a network perspective, for example, the high reliability of such data can resolve many questions involving reciprocity. When self-reported relationships from each of two individuals disagree, it is impossible to disentangle measurement error from the extent of reciprocity. Computer-monitored network data can remove the effect of measurement error, so hypotheses involving measures of reciprocity (such as those derived from critical mass theory) can be more reliably tested.

Such traits are significant in the light of ongoing questions about self-report data. Self-reported measures of a wide range of behaviors—including responses to network questions about the number and intensity of linkages with other individuals—are often biased and misleading indicators of actual behavior (Bernard, Killworth, Kronenfeld & Sailer, 1984). Self-reported amount of system usage and other users to whom one sent or from whom one received messages are not highly correlated with comparable computer-monitored measures (typically around $r = 0{\cdot}3$ to $0{\cdot}6$; Rice & Case, 1983), even when respondents are surveyed (online or on paper) within minutes of actual system use (Bernard, Killworth & Sailer, 1982).

Further, different forms of data about the extent to which organizational members use media generally result in different conclusions (Rice & Bair, 1984: table 8.3). One study found that respondents can reliably identify which tasks they perform (92% correct; $r = 0{\cdot}8$ with observed tasks), only moderately well rank each task according to the time spent in each task ($r = 0{\cdot}7$), and are not reliably able to estimate specific amounts of time allocated to each task (mean correct for 13 respondents was 76%; $r = 0{\cdot}3$) (Hartley, Brecht, Pagerey, Weeks, Chapanis & Hoecker, 1977).

Such results imply that computer-monitored usage and network data are more reliable than corresponding self-report data. However, monitored system usage may also represent a different aspect of human communication than does perceived usage. Results from several studies support this interpretation:

(1) different demographic and information need variables differentially predict monitored usage versus self-report usage (Ettema, 1985);

(2) the two data sources differentially predict perceived benefits from a system (Rice & Shook, 1988); and

(3) computerized but voluntary questionnaires tend to have similar response rates but higher response variance than written questionnaires (Sproull, 1986), produce less socially desirable responses to close-ended questions and more disclosing responses to open-ended questions, exhibit greater completion rates and fewer item completion mistakes (Kiesler & Sproull, 1986), and attract a different subsample than equally accessible written questionnaires (Newsted, 1985).

One implication of these and other results is that while computer-monitored data are empirically more *reliable* measures of system usage than are self-reported data, diaries and observations, they are not necessarily more *valid*. They are not even as conceptually straightforward as they may appear. There is no necessary reason, for example, to expect that actual CMC usage averaged over a period of a year should be highly correlated with the reported percentage of time spent using the system in an average work day (a typical measure). Further, monitored data do not indicate the use of other media which would affect both the amount and importance of system usage. (But self-report data seldom measure the use of multiple media separately either.) Computer-monitored measures of messaging activities, unless weighted by message length or importance of the content, are treated equally, yet much interpersonal communication is insignificant and is rightfully forgotten, while in other cases a single sentence can have significant consequences. For example, some past communication activities may be more easily retrieved from memory because they occurred in a more vivid context. Such contexts might include a habitual location (near the watercooler), a higher-status individual (someone wearing a pinstripe three-piece suit), or an emotional setting (a sunny cafe). CMC systems strip away these contextual cues, perhaps removing some of the underlying salience of communication events, which helps respondents filter out what is important to remember and what is not. Note, however, that the false remembering of communication interactions that never happened is nearly as frequent of the forgetting of events that did (Bernard *et al.*, 1984), so the decontextualizing effect of CMC systems can potentially explain only in part the discrepancies between self-report and monitored data.

Computer-monitored usage and network data should be considered, then, as one addition to a multi-method, multi-trait approach to understanding how people use new organizational communication systems, rather than as a superior replacement for all self-reported measures.

4.2. ETHICS

There are potential ethical problems in collecting and analysing data about users' communication behavior, one aspect of broader ethical concerns in research on computing (Allen, 1984). To many people, such data collection is just one more instance of the invasion of privacy by a technological world: there are already far too many databanks keeping track of our personal and professional lives (Westin & Baker, 1972). While many would rightfully resist the collection and analysis of the content of their messages, knowledge of who they communicate with may be an even greater invasion, because one's network can reveal patterns of information use, and associations with specific other individuals or groups.

Some studies of communication technology networks have been explicitly experimental (Hiltz, 1982), public (Danowski, 1982) or government-sponsored (Rice & Paisley, 1982). In those situations, users typically sign consent forms or voluntarily share their communication. Other studies solve the problem by randomly re-assigning identification codes to the data so that the merged questionnaire and system data cannot be attributed to specific individuals, or using only summary measures (Eveland & Bikson, 1987). In private organizations, unfortunately, there are usually no review boards to scrutinize the use and collection of computer-monitored data.

Discussions of CMC systems often point out how they can increase access to others within or across organizations, or reduce costs of communication. However, they also tend to ignore the fact that CMC systems are, and will be for a long time, too inaccessible (physically, culturally, technically and economically) for most people. Thus CMC systems represent another potential source of social inequity. Research should consider whether the communication networks of those who do not have access to such systems are deprived even more of resources and influence (Schiller, 1982).

CMC systems can emphasize rather than reduce status differences. For example, while Robey, Saunders and Vaverek (1989) found some integration of roles over time in an analysis of a semester's worth of content and network data from an on-line course for medical professionals, they did find strong patterns of asymmetric relationships based on professional status differences. Physicians sent more message to nurses than vice-versa, while teachers occupied a unique position because they received messages similarly from all others. Even though some online courses do foster more horizontal discussion among students, some studies still find that participation is teacher-centered and teacher-dominated (Harasim, 1987).

Finally, it is not clear whether society will necessarily benefit from the rise of electronic groups. Because of the requirements of accessibility to CMC systems, ease of affiliation based solely on common interest in the message topics, reduction of social constraints, independence from personal accountability and separation from material resources, the resultant CMC system networks may also be more ephemeral, less empowering, more homogenizing and less socially cohesive than traditional personal and social networks (Rice, 1987*b*; Williams, Rice & Dordick, 1985).

Studies of inter-, intra-, and cross-national organizational CMC system networks should also consider these crucial questions of privacy, access, social stratification, control and politics (Mosco, 1982; Slack & Fejes, 1984; Schiller, 1982).

5. Summary

Because of the growing convergence of computers and telecommunications networks, organizational communication now is potentially freed of many typical constraints, while confronted with new ones. The fact that CMC systems can unobtrusively collect data on usage, flows, and content from a full census of users provides researchers with new opportunities for understanding the application, management, and consequences of such systems. A theoretically appropriate analytical approach is network analysis of CMC system data. A body of such research is growing, and it provides insights into how researchers and managers of CMC systems may extend their capabilities to better design, implement, apply, and reassess some new organizational communication systems. Such analyses may challenge previously supported findings because of the use of behavioral instead of self-report data. Evaluations should also consider ethical issues in the collection of such data and the diffusion of CMC networks.

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References

ALBRECHT, T. & ROPP, A. (1984). Communicating about innovation in networks of three U.S. organizations. *Journal of Communication*, **34**(3), 78–90.

ALLEN, R. (1984). Working paper on ethical issues for research on the use of computer services and interfaces. *SIGCHI Bulletin*, **16**(1), 12–16.

ASTEROFF, J. (1987). *Paralanguage in electronic mail: the role of user experience and expertise*. NY: Columbia University Teachers College, Department of Communication, Computing and Technology in Education.

BALES, R. F. (1950). *Interaction Process Analysis: a Method for the Study of Small Groups*. Cambridge, MA: Addison-Wesley.

BARNETT, G. & RICE, R. E. (1985). Longitudinal non-Euclidean networks: applying Galileo. *Social Networks*, **7**(4), 287–322.

BERNARD, H., KILLWORTH, P., KRONENFELD, D. & SAILER, L. (1984). The problem of informant accuracy: the validity of retrospective data. *Annual Review of Anthropology*, **13**, 495–517.

BERNARD, H., KILLWORTH, P. & SAILER, L. (1982). Informant accuracy in social network data V. *Social Science Research*, **11**, 30–66.

BLACK, S., LEVIN, J., MEHAN, H. & QUINN, C. (1983) Real and non-real time interaction: unravelling multiple threads of discourse. *Discourse Processes*, **6**, 59–75.

CATHART, R. & GUMPERT, G. (1983). Mediated interpersonal communication: toward a new typology. *Quarterly Journal of Speech*, **69**, 267–277.

CHESEBRO, J. (1985). Computer-mediated interpersonal communication. In B. RUBIN Ed. *Information and Behavior*, vol 1, 202–224. New Brunswick, NJ: Transaction Books.

DAFT, R. & LENGEL, R. (1986). Organizational information requirements, media richness and structural design. *Management Science*, **32**(5), 554–571.

DANOWSKI, J. (1982). Computer-mediated communication: a network-based content analysis using a CBBS conference. In M. BURGOON Ed. *Communication Yearbook*, vol. 6, 905–924. Beverly Hills, CA: Sage.

DANOWSKI, J. (1987). Mapping organizational cultures via word-network analysis: automated supra-communication auditing of electronic mail. In G. GOLDHABER & G. BARNETT Eds. *Handbook of Organizational Communication.* Norwood, NJ: Ablex.

DANOWSKI, J. & EDISON-SWIFT, P. (1985). Crisis effects on intraorganizational computer-based communication. *Communication Research*, **12**(2), 251–270.

DANOWSKI, J. & RICE, R. E. (1989). *Correspondence between Users' Semantic Networks and Computer-Monitored Data on Uses of Voice Mail for Messaging Versus Answering.* Paper presented to the International Communication Association, May, San Francisco, CA.

DERVIN, B. (1989). Audienced and being audienced. In R. RICE & C. ATKIN Eds. *Public Communication Campaigns*, 2nd edition. Newbury Park, CA: Sage.

EDELMAN, F. (1981). Managers, computers and productivity. *MIS Quarterly*, **5**(3), 1–20.

ELLIS, C. & NUTT, G. (1980). Office information systems and computer science. *Computing Surveys*, **12**(1), 27–60.

ETTEMA, J. (1985). Explaining information system use with system-monitored *vs* self-reported use measures. *Public Opinion Quarterly*, **49**, 381–387.

EVELAND, J. D. & BIKSON, T. E. (1987). Evolving electronic communication networks: an empirical assessment. *Office: Technology and People*, **3**, 103–128.

FINN, T. A. (1987). Process and structure in computer-mediated group communication. In B. RUBEN Ed. *Information and Behavior*. vol. 2. New Brunswick, NJ: Transaction Books.

FREEMAN, L. (1980), Q-analysis and the structure of friendship networks. *International Journal of Man–Machine Studies*, **12**, 367–378.

GALEGHER, J., KRAUT, R. & EGIDO, C. Eds. (1990). *Intellectual Teamwork: Social and Technological Foundations of Cooperative Work.* NJ: Erlbaum.

GIBSON, C. (1975). A methodology for implementation research. In R. SCHULTZ & D. SLEVIN Eds. *Implementing Operations Research/Management Science.* pp. 53–73. NY: Elsevier.

GLOSSBRENNER, A. (1983). *The Complete Handbook of Personal Computer Communications.* New York: St. Martin's Press.

GRANOVETTER, M. (1982). The strength of weak ties: a network theory revisited. In P. MARSDEN & N. LIN Eds. *Social Structure and Network Analysis*, pp. 105–130, Beverly Hills, CA: Sage.

GUELPH UNIVERSITY (1987). *The Second Guelph Symposium on Computer Conferencing.* Guelph, Ontario, Canada; University of Guelph.

HAMILTON, S. & CHERVANY, N. (1981). Evaluating information system effectiveness—Part I: comparing evaluation approaches. *MIS Quarterly*, **5**(3), 55–69.

HARASIM, L. (1987). Teaching and learning on-line: issues in computer-mediated graduate courses. *Canadian Journal of Educational Communication*, **16**(2), 117–135.

HARTLEY, C., BRECHT, M., PAGEREY, P., WEEKS, G., CHAPANIS, A. & HOECKER, D. (1977). Subjective time estimates of work tasks by office workers. *Journal of Occupational Psychology*, **50**, 23–36.

HIEMSTRA, G. (1982). Teleconferencing, concern for face, and organizational culture. In M. BURGOON Ed. *Communication Yearbook*, vol. 6, 874–904. Beverly Hills, CA: Sage.

HILTZ, S. R. (1978*a*). Controlled experiments with computerized conferencing: Results of a pilot study. *Bulletin of the American society for Information Science*, **4**(5), 11–12.

HILTZ, S. R. (1978*b*). The computer conference. *Journal of Communication*, **28**(3), 157–163.

HILTZ, S. R. (1979). Using computer conferencing to conduct opinion research. *Public Opinion Quarterly*, Winter, 562–571.
HILTZ, S. R. (1982). Experiments and experiences with computerized conferencing. In R. LANDAU, J. BAIR & J. SIEGMAN Eds. *Emerging Office Systems*, pp. 182–204. Norwood, NJ: Ablex.
HILTZ, S. R. (1984). *Online Communities: A Case Study of the Office of the Future*. Norwood, NJ: Ablex.
HILTZ, S. R., JOHNSON, C. & TUROFF, M. (1982). *The Effects of Formal Human Leadership and Computer-Generated Decision Aids on Problem Solving via Computer: A Controlled Experiment*. Research report 18. Newark, NJ: New Jersey Institute for Technology.
HILTZ, S. R. & TUROFF, M. (1978). *The Network Nation: Human Communication via Computer*. Reading, MA: Addison-Wesley Advanced Book Program.
HILTZ, S. R. & TUROFF, M. (1981). The evolution of user behavior in a computerized conferencing system. *Communications of the ACM*, **24**(11), 739–751.
HILTZ, S. R. & TUROFF, M. (1985). Structuring computer-mediated communication systems to avoid information overload. *Communications of the ACM*, **28**(7), 680–689.
HOLMES, M. (1986). A conversational analysis of computer-mediated discourse. Minneapolis, Minn: University of Minnesota Dept. of Speech Communication.
JOHANSEN, R. (1984). *Teleconferencing and Beyond: Communications in the Office of the Future*. New York: McGraw-Hill.
JOHANSEN, R. (1988). *Groupware*. NY: Free Press.
JOHANSEN, R. & DEGRASSE, R. (1979). Computer-based teleconferencing: effects on working patterns. *Journal of Communication*, **29**(3), 30–41.
JOHANSEN, R., VALLEE, J. & SPANGLER, K. (1979). *Electronic Meetings*. Reading, MA: Addison-Wesley.
JOHNSON, B. & RICE, R. E. (1987). *Managing Organizational Innovation: The Evolution from Word Processing to Office Information Systems*. NY: Columbia University Press.
KERR, E. & HILTZ, S. R. (1982). *Computer-mediated Communication Systems*. NY: Academic Press.
KIESLER, S., SIEGEL, J. & MCGUIRE, T. (1984). Social psychological aspects of computer-mediated communication. *American Psychologist*, **39**(10), 1123–1134.
KIESLER, S. & SPROULL, L. (1986). Response effects in the electronic survey. *Public Opinion Quarterly*, **50**, 402–413.
KLING, R. (1980). Social analyses of computing: theoretical perspectives in recent empirical research. *Computing Surveys*, **12**(1), 61–110.
KNOKE, D. & KUKLINSKI, J. (1982). *Network Analysis*. Beverly Hills, CA: Sage.
LAWRENCE, P. & LORSCH, J. (1967). *Organization and Environment*. Boston: Harvard Graduate School of Business Administration.
LARRECHE, J. (1979). Integrative complexity and the use of marketing models. *TIMS Studies in the Management Sciences*, **13**, 171–187.
LUCAS, H., JR. (1978). The use of an information storage and retrieval system in medical research. *Communications of the ACM*, **21**(3), 197–205.
LUÇAS, H., JR. (1981). *Implementation: The Key to Successful Information Systems*. NY: Columbia University Press.
MARKUS, M. L. (1987). Toward a critical mass theory of interactive media: universal access, interdependence and diffusion. *Communication Research*, **14**, 491–511.
MCKENNEY, J., DOHERTY, V. & SVIOKLA, J. (1986). *The Impact of Electronic Networks on Management Communication: An Information Processing Study*. Paper. Boston, MA: Harvard Graduate School of Business.
MITCHELL, J. C. (1969). The concept and use of social networks. In J. C. MITCHELL Ed. *Social Networks in Urban Situations*, pp. 1–50. Manchester, England: Manchester University Press.
MOSCO, V. (1982). *Pushbutton Fantasies: Critical Perspectives on Videotex and Information Technology*. Norwood, NJ: Ablex.
NEWSTED, P. (1985). Paper versus online presentations of subjective questionnaires. *International Journal of Man–Machine Studies*, **23**, 231–247.

OLSON, M. & LUCAS, H., JR. (1982). The impact of office automation on the organization: some implications for research and practice. *Communications of the ACM*, **25**(11), 838–847.

PALME, J. (1984). You have 134 unread mail! Do you want to read them now? In SMITH, H. T. Ed. *Computer-Based Message Services*. Amsterdam: Elsevier North-Holland.

PANKO, R. (1985). Electronic mail. In K. TAKLE-QUINN Ed. *Advances in Office Automation*, vol. 1, 191–230. NY: Wiley.

PHILLIPS, A. (1982). Computer conferencing: success or failure? *Systems, Objectives, Solutions*, **2**, 203–218.

RICE, R. E. (1980*a*). Impacts of organizational and interpersonal computer-mediated communications. In M. WILLIAMS Ed., *Annual Review of Information Science and Technology*, vol. 15, 221–249. White Plains, NY: Knowledge Industry Publications.

RICE, R. E. (1980*b*). Computer conferencing. In B. DERVIN & M. VOIGT Eds., *Progress in Communication Sciences*, vol. 2, 215–240. Norwood, NJ: Ablex.

RICE, R. E. (1982). Communication networking in computer conferencing systems: A longitudinal study of group roles and system structure. In M. BURGOON Ed., *Communication Yearbook*, vol. 6, 925–944. Beverly Hills, CA: Sage.

RICE, R. E. (1984*a*). Mediated group communication. In R. E. RICE & ASSOCIATES. *The New Media: Communication, Research and Technology*, pp. 129–154. Beverly Hills, CA: Sage.

RICE, R. E. (1984*b*). Evaluating new media systems. *New Directions in Program Evaluation*, **23**, 53–71.

RICE, R. E. (1987*a*). Computer-mediated communication systems and organizational innovation. *Journal of Communication*, **37**(4), 65–94.

RICE, R. E. (1987*b*). Communication technologies, human communication networks and social structure in the information society. In J. SCHEMENT & L. LIEVROUW Eds., *Social Aspects of the Information Society*, pp. 107–120. Norwood, NJ: Ablex.

RICE, R. E. (1989). Issues and concepts in research on computer-mediated communication systems. In J. ANDERSON Ed. *Communication Yearbook 12*. Newbury Hills, CA: Sage.

RICE, R. E. & ASSOCIATES. (1984). *The New Media: Communication, Research and Technology*. Beverly Hills, CA: Sage.

RICE, R. E. & BAIR, J. (1984). New organizaitonal media and productivity. In R. E. RICE & ASSOCIATES. *The New Media: Communication, Research and Technology*, pp. 185–216. Beverly Hills, CA: Sage.

RICE, R. E. & BARNETT, G. (1986). Group communication networks in electronic space: applying metric multidimensional scaling. In M. MCLAUGHLIN Ed. *Communication Yearbook*, vol. 9, 315–326. Beverly Hills, CA: Sage.

RICE, R. E. & BORGMAN, C. (1983). The use of computer-monitored data in information science and communication research. *Journal of the American Society for Information Science*, **34**, 247–256.

RICE, R. E. & CASE, D. (1983). Computer-based messaging in the university: a description of use and utility. *Journal of Communication*, **33**(1), 131–152.

RICE, R. E., GRANT, A., SCHMITZ, J. & TOROBIN, J. (1990). *A Network Approach to Predicting the Adoption and Outcomes of Electronic Messaging. Social Networks*, in press.

RICE, R. E. & LOVE, G. (1987). Electronic emotion: a content and network analysis of a computer-mediated communication network. *Communication Research*, **14**, 85–105.

RICE, R. E. & PAISLEY, W. (1982). The green thumb videotex experiment. *Telecommunications Policy*, **6**(3), 223–236.

RICE, R. E. & RICHARDS, W., JR. (1985). An overview of network analysis methods. In B. DERVIN & M. VOIGT Eds. *Progress in Communication Sciences*, vol. 6, 105–165. Norwood, NJ: Ablex.

RICE, R. E. & SHOOK, D. (1988). Access to, usage of, and outcomes from electronic message systems. *ACM Transactions on Office Information Systems*, **6**(3), 255–276.

RICE, R. E. & SHOOK, D. (1990*a*). Voice messaging, coordination and communication. In GALEGHER, J., KRAUT, R. & EGIDO, C. Eds. *Intellectual Teamwork: Social and Technological Foundations of Co-operative Work*, pp. 327–350. NJ: Erlbaum.

Rice, R. E. & Shook, D. (1990*b*). Relationships of job categories and organizational levels to use of communication channels, including electronic mail: a meta-analysis and extension. *Journal of Management Studies,* in press.

Richards, W., Jr. & Rice, R. E. (1981). NEGOPY network analysis program. *Social Networks,* **3**(3), 215–333.

Robey, D., Saunders, C. & Vaverek, K. (1989). *Social Structure and Electronic Communication.* Unpublished paper. Florida International University Department of Decision Sciences.

Rogers, E. M. (1983). *Diffusion of Innovations.* 3rd edition. NY: Free Press.

Rogers, E. M. & Kincaid, D. L. (1981). *Communication Networks: A New Paradigm for Research.* New York: Free Press.

Schiller, H. (1982). *Who Knows? Information in the Age of the Fortune* 500. Norwood, NJ: Ablex.

Shannon, C. & Weaver, W. (1949). *The Mathematical Theory of Communicion.* Urbana, Ill: University of Illnois Press.

Shaw, M. (1978). Communication networks. In L. Berkowitz Ed. *Group Processes,* pp. 313–349. NY: Academic Press.

Short, J., Williams, E. & Christie, B. (1976). *The Social Psychology of Telecommunications.* New York: Wiley.

Slack, J. & Fejes, F. Eds. (1984). *The Ideology of the Information Society.* Norwood, NJ: Ablex.

Smith, N., Bizot, E. & Hill, T. (1988). *Use of Electronic Mail in a Research and Development Organization.* Tulsa, OK: University of Tulsa School of Business.

Spelt, P. (1977). Evaluation of a continuing computer conference on simulation. *Behavioral Research Methods and Instrumentation,* **9**(2), 87–91.

Sproull, L. (1986). Using electronic mail for data collection in organizational research. *Academy of Management Journal,* **29**(1), 159–169.

Steinfield, C. (1986). The social dimensions of computer-mediated communications. In M. McLaughlin Ed., *Communication Yearbook,* vol. 9, 777–804. Beverly Hills, CA: Sage.

Stone, P., Dunphy, D., Smith, M. & Ogilvie, D. Eds. (1966). *The General Enquirer.* Cambridge, MA: MIT Press.

Swanson, E. (1974). Management information systems: appreciation and involvement. *Management Science,* **21**(2), 178–188.

Tichy, N. (1981). Networks in organizations. In P. Nystrom & W. Starbuck Eds., *Handbook of Organizational Design,* vol. 2, 225–249. New York: Oxford University Press.

Tushman, M. (1979). Work characteristics and subunit communication structure: a contigency analysis. *Administrative Science Quarterly,* **24**, 82–97.

Tversky & Kahneman (1974)

Uhlig, R., Farber, D. & Bair, J. (1979). *The Office of the Future: Communications and Computers.* New York: North-Holland.

Vallee, J. (1984). *Computer Message Systems.* New York: McGraw-Hill.

Vanlommel, E. & de Brabander, B. (1975). The organization of electronic data processing activities and computer use. *Journal of Business,* **48**(3), 391–410.

Webb, E., Campbell, D., Schwartz, R. & Sechrest, L. (1966). *Unobtrusive Measures: Nonreactive Research in the Social Sciences.* Chicago, IL: Rand-McNally.

Weber, R. (1984). Computer-aided content analysis. *Qualitative Sociology,* **7**(1/2), 126–147.

Westin, A. & Baker, M. (1972). *Databanks in a Free Society: Computers, Record-Keeping and Privacy.* NY: Quadrangle Books.

Williams, F., Rice, R. E. & Dordick, H. (1985). Behavioral loci of the information society. In B. Ruben Ed. *Information and Behavior,* vol. 1, 161–182. New Brunswick, NJ: Transaction Books.

Williams, F., Rice, R. E. & Rogers, E. M. (1988). *Research Methods and the New Media.* NY: Free Press.