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INDIVIDUAL AND NETWORK INFLUENCES ON THE ADOPTION AND PERCEIVED OUTCOMES OF ELECTRONIC MESSAGING *

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Theories of organizational information processing and social influence are applied, using network analytical methods, to longitudinal data from a small government office surveyed immediately before, and nine months after, the implementation of an electronic messaging system. The results provide strong support for the role of a critical mass in influencing adoption and for the role of pre-usage expectations in forming enduring evaluations of some outcomes of an EMS. They also show slight support for the roles of social information processing and certain organizational information processing variables. Implications for theories and research designs concerning the use and impacts of computer-mediated organizational media are discussed.

1. Introduction

One of the many paradigmatic debates in current social science and organizational research is the relative influence of individual dif-

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ferences and network factors on attitudes and behaviors (Rogers and Kincaid 1981; Tichy 1981; Wellman 1983). In the study of new communication media, rarely have these approaches been combined to provide either a critical test or a more integrated model, even though they have been suggested (Fulk, Steinfield, Schmitz and Power 1987; Rice 1982, 1984; Williams, Rice and Rogers 1988). Yet, theories of organizational communication and characteristics of these new media imply that both paradigms should be relevant. The present research tests hypotheses derived from both paradigms that may be expected to influence potential users' adoption of, and outcomes associated with, electronic messaging systems (EMS).

Specifically, we propose and test hypotheses that adoption and usage of EMS are influenced by (1) perceptions of the fit between media characteristics and information processing needs, (2) a critical mass of other potential adopters and other users, and (3) social information processing as operationalized through network variables at the individual, dyadic, and group levels of analysis.

2. Electronic messaging

Electronic messaging systems (EMS) are defined as the entry, storage, processing, distribution and reception, from one account to one or more other accounts, of digitized text by means of a central computer and remote terminals connected by a telecommunications network (see Hiltz and Turoff 1978; Licklider and Vezza 1978; Panko 1984; Rice 1980b; Rice and Bair 1984; and Uhlig, Farber and Bair 1979 for discussions of EMS). The computer processing and network capabilities allow the sending and receiving of messages independently of when or where users access their accounts. In 1987, over 1.3 million commercial mailboxes were used to exchange 14 million messages per month (*PC Magazine* 1987). The diffusion of EMS provides fertile opportunities for understanding appropriate strategies for facilitating the adoption, management and application of new organizational media (Huber 1984; Kling 1980; Lucas 1981; Rice 1980a; Rice and Associates 1984).

Because communication and information processing are fundamental components of organizing, EMS have the potential to alter the structure, effectiveness and survivability of organizations. Research has identified these (as well as other) categories of possible outcomes of using EMS: (1) reductions in synchronous communication activities such as telephone calls, memos and letters sent and received and increases in document output; (2) increases in the frequency of communication through a widening of professional and social connections and increases in horizontal, vertical and inter-organizational communication; (3) decreases in the time required to handle information, by reducing the number of media transformations (such as copying a telephone message to a desk calendar) and shadow functions (such as waiting for all participants in a meeting to show up); and (4) improvements in the quality of work, in terms of greater control, improved communication and greater access to information (Rice 1980b, 1987). These outcomes may be summarized as (1) changes in media use and (2) changes in task effectiveness.

3. Theoretical foundations

Two competing theoretical approaches are used to derive our hypotheses: (1) organizational information processing, to test the importance of individual-level assessments and task requirements; and (2) social information processing, to test the effect of social network context, on the adoption and perceived outcomes of EMS. Throughout the paper, hypotheses concerning the *adoption* of EMS will be identified by -A, and those concerning *outcomes* will be identified by -O.

3.1. Organizational information processing

The first approach, organizational information processing theory (Daft and Lengel 1984), is an extension of contingency theory. Contingency theory argues that organizational information processing must match the complexity of environmental inputs in order for the organization to endure and prosper (Perrow 1967; Thompson 1967; Woodward 1965). Organizations may respond to a complex external environment by increasing their internal interdependence, but this response entails increased coordination and communication (Galbraith 1977; Lawrence and Lorsch 1967; March and Simon 1958).

Some studies have applied this contingency perspective to relationships of individuals' task environments with their use of communication channels and outcomes such as performance (Daft, Lengel and

Trevino 1987; Tushman 1979). Because different media have different capacities to convey social cues, contextual meaning, detailed numeric information and nonverbal communication, they are not all equally effective in supporting specific communication tasks (Daft and Lengel 1986).

Two highly similar or parallel constructs represent important ways in which these capacities vary: social presence and information richness. Short, Williams and Christie (1976) defined *social presence* as the extent to which a communication medium is perceived to convey the actual presence of another communicator, or the appropriateness of a medium for supporting a variety of communication tasks. Daft and Lengel (1984, 1986) defined *information richness* as the extent to which a medium allows interpretation, feedback and learning in a given situation.

Organizational information processing theory suggests at least three categories of influences on an individual's adoption and reported outcomes of an EMS: (1) task requirements; (2) existing patterns of media use; and (3) perceived appropriateness of a medium for a variety of communication tasks.

3.1.1. Task requirements

Perrow (1967) argued that organizational tasks may be characterized by the extent to which they are routine or are analyzable. Others have linked such task requirements to the use of organizational media (Randolph and Finch 1977; Tushman 1979; Van de Ven, Delbecq and Koenig 1976). *Routineness* is the extent to which a task has little variation, involves repeated actions, and does not involve new problems or solutions. *Analyzability* is the extent to which a task can be documented, described by rules or regulations, and can be solved by following known procedures (Hall and Lawler 1970; Mintzberg 1973; Ruchinskas 1982; Wright 1974). Daft and colleagues argued that while nonroutine tasks may require more communication in general, tasks with low analyzability require richer media (such as face-to-face interaction or telephone calls) in order to integrate situations, interpret the meaning of a situation, negotiate and regulate that meaning (Daft and Lengel 1984, 1986).

Hypothesis 1a-A. Higher task analyzability is positively associated with adoption of an EMS.

Hypothesis 1a-O: Higher task analyzability is positively associated with positive perceived outcomes from an EMS.

3.1.2. Existing patterns of media usage

Because of its lower level of information richness and social presence, EMS is more likely to be substituted for communication channels with similarly low social presence (such as memos, letters and short reports, rather than face-to-face communication) due to its ability to convey analyzable information such as facts or questions (Rice and Bair 1984).[1] EMS is thus also more likely to be perceived as beneficial by those who use such communication channels more frequently.

Hypothesis 1b-A. Greater prior use of communication channels with low social presence (i.e. written media) is positively associated with adoption of an EMS.

Hypothesis 1b-O. Greater prior use of communication channels with low social presence (i.e. written media) is positively associated with positive perceived outcomes from an EMS.

3.1.3. Perceived appropriateness of EMS

Because many characteristics of media, especially new media, are subjective, the perceived congruence of media with communication tasks (i.e. the appropriateness of the medium) should influence the adoption and reported outcomes of EMS (Rice and Love 1987; Rice 1987). While there is no necessary assumption that the hypothesized influence of perceived appropriateness is due solely to rational choice processes, Daft, Lengel and Trevino (1987) argued that users who *are* aware of the potential congruence of certain media with certain tasks are likely to perform more effectively than those who do not.

Hypothesis 1c-A. Perceived appropriateness of an EMS is positively associated with adoption of an EMS.

Hypothesis 1c-O. Perceived appropriateness of an EMS is positively associated with positive outcomes from an EMS.

[1] EMS may also complement other organizational media, but we test only the hypothesized substitution effect.

Many perceived attributes of media are based upon individuals' prior experiences, their associations with other media and upon their own attempts to reduce uncertainty about an unfamiliar innovation. These perceived attributes lead to expectations about gratifications to be derived from use of particular media (Palmgreen and Rayburn 1985; Torobin 1987) and about how well media meet information processing requirements (Daft, Lengel and Trevino 1987). Thus, expectations about the outcomes of EMS may endure and influence later evaluations of that medium over and above the influence of actual adoption (Hiltz 1983; Rice and Case 1983; Rogers 1983; Torobin 1987). Certainly, values on post-implementation measures of attitudes should be controlled for values on pre-implementation measures.

Hypothesis 1d-O. One's expectations about the outcomes of an EMS before adoption will be positively associated with one's later perceived outcomes, independently of level of adoption.

3.2. Network influence

As Becker (1970), Burt (1973), Erickson (1988), Rogers and Kincaid (1981), Tichy and Fombrun (1979) and others have argued, social structure is crucial. It is the mechanism through which social influence concerning an innovation operates, where information is exchanged about an innovation, where individuals can vicariously experience others' trial adoption and where others legitimate changes associated with and reduce uncertainty about, an innovation.

A network perspective is theoretically appropriate for studying the use of new communication systems because such systems facilitate interactions among users (Rice 1984). The concept of *critical mass*, defined as the number of adopters sufficient to generate a marked increase in subsequent adoption, and necessary to provide benefits from using the system, is an important factor in explaining adoption and determining the worth of an interactive medium such as EMS (Markus 1987). Organizational tasks that require interdependence among individuals will be more easy to accomplish if the co-workers can communicate easily. Thus, the greater the number of direct communication links an individual has with a set of potential users (i.e. network connectedness) before adopting the EMS, the greater the potential value of the system and the more likely that the individual

will adopt the system (Hiltz 1983). Note that this aspect of critical mass makes no prediction about the *level* of EMS usage, only about its adoption. Once the user has adopted, other factors should take precedence (Rice 1982).

Hypothesis 2a-A. Connectedness before implementation of an EMS is positively associated with adoption of an EMS.

The potential value of an interactive communication system increases with each subsequent adopter, particularly those with whom the adopter needs or wishes to communicate (Markus 1987; Rice 1982; Rice and Shook 1988). That is to say, interactive communication systems such as a telephone network or an EMS have little value to one or two individuals, but have significant value when a large portion of a social community has access to and uses, the system. Thus, one measure of the value of an interactive communication system is *critical mass adoption*, the extent to which others with whom one has frequent direct links also adopt the EMS.

Hypothesis 2a-O. Critical mass adoption of an EMS is positively associated with positive perceived outcomes of an EMS.

The sources of one's evaluations and expectations regarding an innovation, where an individual may not have prior experience or when the referent object is ambiguous, are not solely dependent upon the particular individual's own decision processes or upon objective characteristics of the innovative medium used. Eiser (1987) argues that attitudes are both one's own subjective experience and the product of social influence. Evaluations of an innovation may also be affected by social influence processes such as diffusion, attribution, social comparison, reasoned action and social learning (Ajzen and Fishbein 1973; Bandura 1977; Bem 1972; Festinger 1954; Rogers 1983). Early (Asch 1956) and more recent (Saltiel and Woelfel 1975) studies of attitude change conclude that group norms, especially in ongoing social structures such as groups of organizational coworkers, represent strong influences on information, values, perceptions, norms and behaviors, such as adopting an innovation (Zaltman and Duncan 1977). Frequent interaction and similar tasks, job positions, or social roles provide shared contexts for interpreting prior behaviors and attitudes that

influence subsequent attitudes (Dean and Brass 1985; Hackman 1983; Pfeffer 1982; Salancik and Pfeffer 1978). As Erickson (1988) concluded in her discussion of the relational bases of attitudes, "People are most likely to compare with and come to agree with others to whom they are more strongly tied" (p. 115).

One extension of social influence theories to the organizational setting is social information processing theory (Salancik and Pfeffer 1978). Socially constructed meaning about tasks, individuals' past experiences and objective characteristics of the work environment, all influence perceptions, assessments, attitude formation and behaviors, particularly in situations where objective reality is indeterminant, as may be the case for innovations such as new media (Fulk, Steinfield, Schmitz and Power 1987). Empirical tests of the influence of social information processing on adoption to and attitudes toward new media provide contradictory results. For example, Steinfield, Jin and Ku (1988) found that others' perceptions of media attributes and communication tasks influenced respondents' perceptions as well as their use of an EMS. Svenning (1982) found that the attitudes of one's supervisors, peers, and subordinates influenced one's intentions to use a proposed videoconferencing system, although Pease (1988) found no significant influence of these referent groups on individuals' actual use of the teleconferencing system after it had been implemented.

Each of these (and other) theories of social influence imply different mechanisms whereby members of one's social network influence one's attitudes. However, few of these take an explicitly network perspective. Friedkin and Johnsen (1989) have derived a general model of social influence through networks which can be specified for over-time effects and particular mechanisms. We assume a variant of the simple "peer effects" mechanism where a focal actor's attitudes are partially influenced by the attitudes and behaviors of one's peers as weighted by the extent of interaction between the actor and each peer and partially influenced by individual-level organizational information processing factors. That is, $SIP_i' = P_{ij}A_j' + O_{xi}' + e$, where SIP_i' is the vector of i's attitudes, P_{ij} is the proximity matrix, A_j' is the vector of j's attitudes, and O_{xi} is the vector of i's values on x organizational information processing variables.

Further, we propose that influence occurs through network patterns of direct interaction (the "cohesion" network model). Such interactions are hypothesized to facilitate processes of social information processing whereby those who interact develop shared or similar attitudes. The alternative "positional" model of network influence would argue that influence occurs through patterns of similar interactions with the same or similar others (Burt 1987). We return to this alternative model in the conclusion section. Given this simple model of network influence, social influence may operate at three levels of network relations.

(1) *Individual relations*. One's perceived outcomes associated with a particular new medium may be affected by the average social influence in one's personal communication network.

Hypothesis 2b-O. An individual's perceived outcomes of an EMS are positively associated with the average social influence concerning those outcomes.

(2) *Dyadic relations*. If social influence plays a significant role in one's adoption of an innovation, adoption behavior should be similar, but not necessarily resulting in adoption, for coworkers who communicate frequently. This viewpoint expands upon and refines traditional innovation theory, which typically posits that those who communicate more with each other are more likely to adopt, because of increased opportunities for communication about the innovation. Analyzing the similarity of adoption both avoids this possible pro-innovation bias and shifts the proposed influence of dyadic relations from a strictly information transfer process to a social influence process (Erickson 1988).

Hypothesis 2c-A. Pairs of individuals who frequently communicate with each other before the implementation of an EMS will similarly adopt, or not adopt, the EMS after its implementation in an organization.

(3) *Group relations*. Group membership should influence one's attitudes and behaviors due to shared social realities (Berger and Luckmann 1966), social comparisons within formal and informal social boundaries (Festinger 1954) and because organizational and group norms affect the use and distribution of information (Dewhirst 1971).

Hypothesis 2d-A. Group membership is related to an individual's adoption of an EMS independent of the influence of individual-level variables.

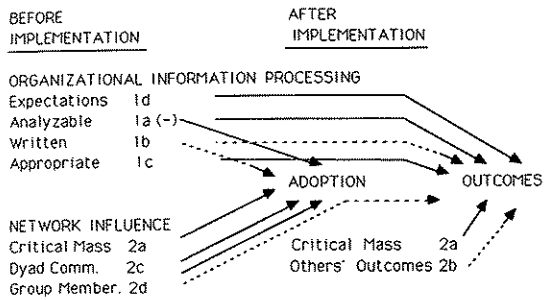

Fig. 1. Hypothesized relationships among organizational information processing variables, critical mass, social information processing, adoption of an EMS, and reported outcomes from using an EMS, with summary results. *Note*: Solid arrows represent significant relationships in the multivariate analyses, and dotted arrows represent nonsignificant relationships. A negative sign indicates a significant relationship but in the opposite direction from that predicted.

Hypothesis 2d-O. Group membership is related to an individual's perceived outcomes from using an EMS independent of the influence of individual-level variables.

Figure 1 summarizes the hypothesized relationships and the results of each hypothesis test.

4. Method

4.1. Subjects

A small, decentralized Federal office in a major Western city was surveyed just before it implemented an system of networked microcomputers (T1) and approximately nine months later (T2). The system provided software support for a variety of office tasks as well as EMS; terminals were available for each employee. Most of the employees were white-collar professionals, although some were clerical workers. The office processes requests for material and services by other government agencies in the region. A representative of the organization personally sent the questionnaire to each employee, who then returned it in a sealed envelope. At T1, 81% of the employees (50 of 62) returned their questionnaires. At T2, 78% (67 of 86) returned their questionnaires. Our sample for the present analysis includes the 36 individuals

who were employed in the office at both time periods and who returned both the T1 and T2 questionnaires. [2]

4.2. Measures

All of the organizational information processing variables in the T1 and T2 questionnaires replicate items from prior surveys of new organizational media (Kerr and Hiltz 1982; Rice and Bair 1984; Rice and Case 1983; Ruchinskas 1982; Svenning 1982; Steinfield 1986). The survey items also include some of the outcomes of EMS found in the studies reviewed at the beginning of this paper. [3] Table 1 shows scale items, item ranges, descriptive statistics and factor loadings for the variables of study. Factor analyses used varimax-iterated principal components; factor scores were created using the regression method.

Usage of organizational media (both traditional and EMS) was measured by the reported percent of the day spent using that medium. Adoption of EMS was computed as 1 if there was any reported usage of EMS and 0 otherwise. The biserial correlation between the percent of day spent using EMS and the computed measure of adoption was $r = 0.88$. Appropriateness was calculated as the total of individual items measuring the appropriateness of EMS for 11 communication activities to which respondents answered 0 = no or 1 = yes. Percent of the day spent reading journals and books and reading and writing letters and memos, loaded on a "written" media usage factor; face-to-face communication and meetings loaded on a "face-to-face" factor. Task analyzability and routineness items were coded from 1 = not at

[2] At T1, the only significant differences (t-tests at $p < 0.05$) between the 36 respondents used in the analyses and the other respondents were: (1) higher expected effect on number of letters sent; (2) greater appropriateness of EMS for bargaining; and (3) greater appropriateness of EMS for getting to know someone. At T2, the only significant differences were: (1) greater reported impact on number of contacts initiated; (2) lower appropriateness of EMS for getting to know someone; and (3) greater appropriateness of EMS for exchanging time-sensitive information. Neither the total appropriateness nor outcome scales involving these items were significantly different. Thus, for the purposes of the present study, the 36 cases in common between T1 and T2 are representative of the remaining respondents at each time period.

[3] Other variables relevant to organizational information processing theory at the individual level —such as organizational level and communicator style—were also measured and analyzed, but are not reported here because (1) they required more space for review and operationalization than space limitations permit, and (2) they were not significantly associated with any of the dependent variables. Information about these variables, and the zero-order correlation matrix of the variables reported in this study, is available.

Table 1
Summary Statistics, Factor Loadings and Scale Reliabilities

Variables	Time 1				Time 2		
	M	SD	Factors		*M*	SD	Factors
Media style [a]			*Written*	*Face*			
Journal/book reading	6.46	9.62	*0.85*	−0.21	–	–	
Long report write/read	18.29	26.95	−0.30	−0.54	–	–	
Letter & memo write/read	9.66	7.70	*0.83*	0.25	–	–	
Telephone	19.31	15.97	−0.03	−0.13	–	–	
Face-to-face (not meetings)	19.29	16.90	−0.18	*0.74*	–	–	
Meetings	6.71	7.65	0.16	*0.73*	–	–	
Eigenvalue			1.86	1.36			
Percent variance			30.9	22.7			
Task requirements [b]			*Analyzability*				
Standard procedures	4.69	1.53	*0.82*		–	–	
Well-defined subject	4.29	1.60	*0.84*		–	–	
Clear outcomes	4.71	1.91	*0.75*		–	–	
Rules and regulations	5.92	1.18	*0.63*		–	–	
Routine repetitive tasks	4.67	1.87	0.42		–	–	
Many different tasks	5.77	1.22	0.09		–	–	
Work with strangers	3.46	1.51	−0.18		–	–	
Innovation/problem-solving	4.17	1.99	−0.45		–	–	
Unexpected events	5.03	1.48	0.01		–	–	
Eigenvalue			3.29				
Percent variance			36.5				
Appropriateness [c]	4.95	2.64			–	–	
Exchanging information	0.87	0.35			–	–	
Exch. time-sensitive info.	0.75	0.44			–	–	
Generating ideas	0.72	0.45			–	–	
Decision-making	0.55	0.51			–	–	
Staying in touch	0.43	0.50			–	–	
Exchanging opinions	0.41	0.50			–	–	
Asking questions	0.36	0.49			–	–	
Exch. confidential info.	0.28	0.45			–	–	
Bargaining/negotiating	0.24	0.44			–	–	
Resolving disagreements	0.24	0.43			–	–	
Getting to know someone	0.14	0.36			–	–	
Cronach's alpha reliability	0.74				–	–	
Use of the electronic messaging system							
Percent of day using EMS	–	–			12.05	12.86	
Adoption of EMS d	–	–			61%		

Expectations and Outcomes [e]	Expected		*Effective*	*Media*	Reported		*Effective*	*Media*
Rate information handled	4.03	1.13	*0.87*	0.13	3.93	0.94	*0.86*	0.27
Quality of work	4.23	0.90	*0.85*	0.13	4.17	0.87	*0.83*	0.04
No. of contacts initiated	3.42	0.86	*0.73*	0.28	3.37	0.91	*0.81*	0.17
Quantity of work	3.60	1.00	*0.66*	0.32	3.57	1.33	*0.62*	−0.05
No. of higher contacts init.	3.47	0.68	0.25	*0.74*	3.57	0.73	0.47	−0.36

Table 1 (continued)

Expectations and Outcomes [e]	Expected		*Effective*	*Media*	Reported		*Effective*	*Media*
Letters sent	3.45	0.74	0.04	*0.88*	3.13	1.07	0.32	*0.81*
Phone calls made	2.83	0.65	*0.63*	−0.02	2.73	0.79	−0.03	*0.78*
Other paper produced	2.90	1.42	0.38	*0.75*	3.38	1.27	0.38	*0.77*
Ability to reach someone	3.43	0.96	0.13	0.16	3.53	1.04	0.21	*−0.67*
Eigenvalue			4.04	1.35			3.40	2.13
Percent variance			44.9	15.0			37.7	23.6
Critical mass [f]								
Connectedness	0.45	0.29			–	–		
Critical mass adoption	–	–			75.23	60.62		
Social influence [g]								
Social info. work outcomes	−3.79	32.15			8.91	37.60		
Social media outcomes	−4.13	37.96			−7.86	39.30		

$n = 30$ to 36.
[a] A third factor had an eigenvalue of 1.14, with a loading of 0.92 for the telephone item.
[b] The second factor, with an eigenvalue of 1.69, represented task routineness.
[c] Scale is total of items measured as 0 = not appropriate, 1 = appropriate. Value for individual items is percent responding 1 = appropriate.
[d] Adoption is 1 = any use of electronic mail, 0 = otherwise.
[e] Measured as 1 = significantly reduced to 5 = significant increased.
[f] Connectedness is number of directed links *i* has with other 35 respondents. Critical mass adoption for each is sum of strength of *i*'s links with those *j*s who adopted the EMS.
[g] Computed as sum of (*i*'s network relations with *j*s multipled by *j*'s factor scores) divided by number of *ij* links).

all, to 7 = very much. Four items loaded on one factor representing task analyzability and five items loaded on a second factor representing task routineness. These two factors are consistent with Perrow's (1967) argument for two task dimensions, but Hypotheses 1a-A and 1a-O make a prediction only for task analyzability, so we used only the analyzability factor. Nine outcome items ("expected" at T1 and "reported" at T2) were coded from 1 = significantly reduced to 5 = significantly increased. Increases in the rate of handling information, the quality and the quantity of work and the number of contacts initiated, loaded on an "effectiveness" factor, while increased use of letters, paper and telephone and decreased ability to reach someone, loaded on a "media" factor. The ninth item, changes in number of higher contacts, did not load on either factor at T2.

Both T1 and T2 questionnaires also included a network roster which listed every member of the office at that time period. Respondents were asked to indicate the amount of communication they had with each

other person about: "Task network: This refers specifically to communication about the work tasks you do, including work you do with others, or work that only others do, in this organization. Communication can involve the telephone, memos, face-to-face talk, meetings, etc." Next to each person's name, the respondent circled 0 = not at all, 1 = about once a month, 2 = about once a week, 3 = about two or three times a week, 4 = about once a day, or 5 = several times a day. These values were then squared to approximate the number of interactions per month, as suggested in earlier network studies (Rice and Richards 1985).

4.3. Procedures

Hypotheses 1a through 1d and 2d were tested by a combination of three methods. First, because adoption is a dichotomized measure, discriminant analysis was used to predict adoption of EMS and to determine the extent to which respondents could be correctly classified as adopters or nonadopters. Second, the two outcome factors were predicted using multiple regression. Third, covariance analysis was used to determine the influence of group membership controlling for the joint influence of the significant independent variables. Because of the small sample size and the exploratory nature of the present study, we used a significance level of $p < 0.1$. However, most results were significant at $p < 0.05$.

Several network analysis methods were used to construct variables and to test Hypotheses 2a through 2d.

(1) A "basic" 36×36 communication frequency matrix for both T1 and T2 was created from the questionnaire roster data. The critical mass at T1, or connectedness, was calculated as the number of reported links divided by the total possible ($N = 35$).

(2) A dissimilarity matrix was constructed from the vector of adoption values. Because we are interested in the similarity of adoption between any two respondents, cells in the symmetric adoption dissimilarity matrix were set to the absolute value of the difference between respondent i's adoption level and respondent j's adoption level (e.g., $|i-j|$ where i or $j = 1$ if respondent i or j adopted, 0 if not) as in Dean and Brass's study (1985).

(3) In order to compare the frequency of communication between dyads in the work communication network to the dissimilarity matrix created in the previous step, the "basic" frequency communication network was symmetrized by setting both cells (i, j) and (j, i) equal to the average value of the two cells. [We assume that measurement error is evenly spread throughout the responses and there is no basis to assume that one respondent was more correct than another (Rice and Richards 1985).] We used quadratic assignment, the nonparametric procedure for testing the similarity of pairs of matrices (Baker and Hubert 1981).

(4) NEGOPY (Richards and Rice 1981) was used to detect groups within this office communication network. NEGOPY is based upon principles of graph theory, but uses scalar values (frequency of communication) instead of only binary values (the presence or absence of a communication link). Parameters of the program were set to force reciprocation, with a combined strength cutoff at 10 (e.g., an average of at least one communication contact per day). Multidimensional scaling (MDS) was used on the dissimilarity matrix derived from the *row* relations of the "basic" frequency matrix to portray visually the network groupings. [4]

(5) The extent to which a focal individual communicates with another individual is one indicator of the strength of the other's influence (the degree of affect, positive or negative, toward an attribute or behavioral outcome). To construct the value of others' adoption of the EMS—critical mass adoption—the frequency of communication with each individual's others at T2 was multiplied by the others' (binary) level of adoption, and then summed over all the individual's communication partners. To construct the cumulative social influence of others' perceived outcomes—social media outcomes and social effectiveness outcomes—the frequency of communication with each individual's others at T2 was multiplied by the others' reported outcome scores, summed over all the individual's communication partners and then divided by the number of present P_{ij} links, separately for each category of outcomes.

[4] The adequacy of the NEGOPY solution was confirmed in a variety of ways. Results from the MOCA routine in the AL networks package found that the three-group solution significantly fit the "basic" matrix on the basis of oneway analysis of variance ($F(3, 7374) = 193$, $p < 0.0001$) and quadratic assignment (*gamma* $z = 14.9$). Results from CONCOR found almost the exact same corresponding memberships in three blocks, except that two isolates were joined with three Group 1 members into a fourth block. Results from principal components found one factor, with all the Group 1 and 2 members and associated isolates loading negatively, and all the Group 3 members loading positively.

5. Results

Table 2 shows discriminant and regression results.

5.1. Predicting adoption: Organizational information processing and critical mass

The discriminant analysis shows that greater individual connectedness (H2a-A), lower task analyzability (H1a-A) and greater use of written media (H1b-A) all measured at T1 are significant predictors of T2 adoption of EMS (canonical $R^2 = 0.55$, Wilks' *lambda* $= 0.67$, $p < 0.01$). Appropriateness of EMS (H1c-A) is not a significant predictor. These three variables are sufficient to correctly classify 94% of the 35 respondents as adopters or nonadopters.

5.2. Predicting outcomes: Organizational information processing

The first regression analysis shows that the significant influences on T2 reported increases in effectiveness are T1 expected changes in effectiveness (H1d-O), T1 perceived appropriateness of EMS (1c-O) and lower T1 task analyzability (H1a-O) ($F = 11.62$, $R^2 = 0.61$, $p < 0.01$). Use of written media at T1 (H1b-O) and critical mass adoption at T2 (H2a-O) are not significant predictors. The regression analysis for reported changes in T2 media outcomes shows that higher T1 task analyzability (H1a-O) and greater T2 critical mass adoption (H2a-O) were significant predictors ($F = 3.13$, $R^2 = 0.35$, $p < 0.05$). Appropriateness (H1c-O), use of written media (H1b-O) and expected changes in media use (H1d-O) are not significant predictors.

Note that adoption of the EMS is not an independently significant influence on either outcome, although the bivariate correlation between adoption and effectiveness outcomes is $r = 0.47$ ($p < 0.01$). This result supports the conclusion by Rice and Case (1983) that factors such as those tested here [and presumably other factors not measured here, such as accessibility and interface design (Rice 1987; Rice and Shook 1989)] mediate the relationship between using and EMS and potential outcomes.

5.3. Predicting adoption and outcomes: Network influence

Hypothesis 2d-A, that group membership is related to an individual's adoption of an EMS independent of the influence of individual-level variables, is supported.

Table 2
Results of discriminant and regression analyses to predict adoption and outcomes nine months after implementation, showing only significant predictors

Independent variables		*Dependent variables*
		Adoption (T2)
		Discriminant function structure:
Critical mass	(T1)	0.70 **
Analyzability	(T1)	−0.32 **
Use written media	(T1)	0.39 *
Canonical R^2		0.55
Wilks' *lambda*		0.67 **
		Effectiveness outcomes (T2)
		Regression beta weights:
Expected effectiveness	(T1)	0.62 **
Appropriateness	(T1)	0.39 **
Analyzability	(T1)	−0.24 *
F-ratio		11.62 **
Adj. R^2		0.61
		Media outcomes (T2)
		Regression beta weights:
Critical mass adoption	(T2)	−0.68 **
Analyzability	(T1)	0.61 *
F-ratio		3.13 *
Adj. R^2		0.35

$n = 21$ to 35.
* $p < 0.05$.
** $p < 0.01$.

Table 3 and Figure 2 show the results of the cohesion network analysis, which identified three groups and a set of five isolates. Over 80% of the members of Group 1 and Group 3 adopted the EMS, while no members of Group 2 adopted, as Figure 2, based upon MDS results, clearly shows (MDS stress = 0.15). The fact that Group 2 members are all non-users of the EMS suggests that the critical mass (e.g. network connectedness) cannot be the sole network influence on adoption in this organization, because if it were, then all members of the three groups should be users and the isolates should be nonusers. The similarity of adoption level between Groups 1 and 3 might lead one to expect that they would be similar with respect to social influences; yet they are quite different. Group 1 has an average negative social influence concerning the effectiveness factor (−14.6), and an average positive social influence concerning the media reduction factor (−32.2).

Table 3
Differences among network groups

Variables	Network groups				F-ratio
	Group 1	Group 2	Group 3	Isolate	
N	13	7	11	5	
Percent EMS use	10.9	0.00	10.70	1.20	2.35 *
Percent adoption of EMS	0.83	0.00	0.82	0.40	8.33 ***
Task analyzability	0.27	0.69	−0.20	1.86	0.60
Written factor	0.51	−1.07	0.07	0.12	5.09 ***
Appropriateness	4.09	7.50	5.11	6.25	1.43
Expected effectiveness	−0.18	0.00	0.02	0.32	0.31
Expected media	−0.09	0.00	−0.22	0.70	1.08
Reported effectiveness	−0.30	0.00	0.36	0.39	1.54
Reported media	−0.14	0.00	0.44	−0.59	1.98
Connectedness	0.59	0.28	0.49	0.25	3.35 **
Critical mass adoption	107.17	43.53	75.78	43.33	2.51 *
Social influence on expectations, T1					
Social effectiveness	−20.03	18.26	9.83	−21.98	4.42 ***
Social media	−8.89	20.21	−31.67	27.48	6.32 ***
Social influence on outcomes, T2					
Social effectiveness	−14.55	14.47	35.87	3.69	4.91 ***
Social media	−32.18	−30.84	16.93	5.19	4.71 ***

Note: The means are tested by an unbalanced designs ANOVA.
* $p < 0.1$.
** $p < 0.05$.
*** $p < 0.01$.

Group 3 has just the opposite pattern (35.9 and 17.9), while Group 2 (nonusers of the EMS) has positive social influences on both outcome factors (14.5, −30.8). The means for the three groups and the set of isolates differ significantly with respect to connectedness, adoption, daily percent usage of EMS, use of written media and all the social influence variables.

The covariance analysis showed that the set of covariates [connectedness (H2a-A), analyzability (H1a-A) and use of written media (H1b-A)] was a significant predictor of adoption of the EMS (covariate $F = 14.09$, $p < 0.001$), while the influence of group membership was only marginally independently significant (main effect $F = 2.8$, $p < 1$; overall $R^2 = 0.65$). *Hypothesis 2d-O*, that group membership is related to an individual's reported outcomes from using an EMS independent of the influence of individual-level variables, is not supported. The first

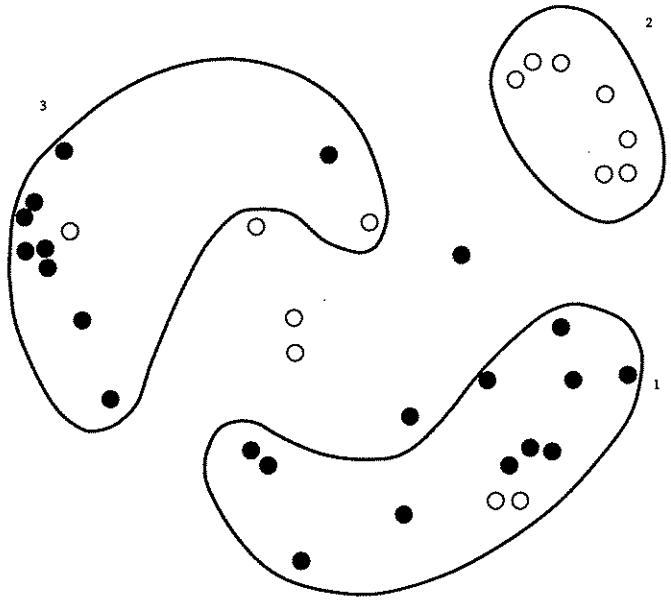

Fig. 2. Visual relationship between group membership (as determined bv NEGOPY and located by multidimensional scaling) and adoption of an electronic messaging system. *Legend*: Open circle = respondent who did not adopt EMS. Closed circle = respondent who adopted EMS. 1, 2, 3 = Groups numbered and circled (as in Table 3); isolates do not belong to the circled groups. See footnote 4.

covariance analysis found the set of covariates [expected effectiveness (H1d-O), appropriateness (H1c-O) and analyzability (H1a-O)] to be a significant predictor of effectiveness (covariate $F = 11.5$, $p < 0.001$), but did not find group membership to be an independently significant predictor (main effect $F = 0.9$, n.s.; overall $R^2 = 0.71$). The second covariance analysis found critical mass adoption (H2a-O) to be significant predictor of media outcomes (covariate $F = 5.3$, $p < 0.05$), but did not find group membership to be a significant predcitor (main effect $F = 2.0$, n.s; overall $R^2 = 0.32$).

Hypothesis 2b-O, that an individual's reported outcomes of an EMS are positively associated with the average social influence concerning those outcomes, is not supported. The social influence outcome variables were not significant predictors of the respective outcome variables in the two regression equations.

Hypothesis 2c-A, that pairs of individuals who frequently communicate with each other before the implementation of an EMS will

similarly adopt, or not adopt, the EMS after its implementation in an organization, is supported. The frequency of dyadic communication at T1 is negatively associated with T2 dyadic dissimilarity of adoption ($r = -0.24$, quadratic assignment *gamma* = 1408, $p < 0.001$). That is, dyads who communicate frequently with each other about work-related topics at T1 are significantly, but weakly, likely to either both adopt, or both not adopt, EMS at T2.

6. Conclusions

Figure 1 summarized the results of each hypothesis test.

6.1. Individual-level influences: Organizational information processing

Individual-level organizational information processing factors play a significant role in explaining the adoption of an EMS and its reported outcomes (at least those measured here) and should not be discarded in favor of a strictly network or social influence approach. For example, one's perceived appropriateness of an EMS for various communication activities predicts perceived improvements in effectiveness. One's own expectations about potential outcomes before implementation have a small influence on reported effectiveness outcomes from using an EMS. These expectations about the appropriateness of an EMS and about EMS outcomes should be considered while planning the implementation of such systems. Otherwise, pre-existing and perhaps uninformed or unrealistic expectations will shape later attitudes toward and assessments of, EMS regardless of users' actual experience with the system. Not only may such assessments represent biased measures of system success (or failure), but empirical tests of theories that do not take such pre-existing attitudes into account will be significantly mis-specified.

Current media usage, particularly the higher use of written media, influences adoption in an expected way and reinforces, to some extrent, models of rational or task-based choice of organizational media. However, lower task analyzability positively influenced adoption of EMS. This result is counter to organizational information processing theory's assumption that media are more or less substitutable depending on their social presence or information richness (Daft and Lengel 1984, 1986). Similar counterintuitive results have been found in studies which

consider how EMS can play a complementary role in the context of other organizational media (Picot, Klingensberg and Kranzle 1982; Rice and Case 1983).

An EMS can be a complementary medium because it does not require communicators to be at the same place or to use the system at the same time, yet it provides instant delivery of messages. In this respect, an EMS is less constraining than either a telephone call or a meeting. An EMS may complement face-to-face communication by allowing high-level managers and others who spend much of their time communicating face-to-face and who may have less analyzable tasks, to send follow-up replies, schedule meetings, or brainstorm (Rice 1987; Rice and Bair 1984). This interpretation would help explain the other counterintuitive result, the significant bivariate relationship of lower task analyzability with both the effectiveness outcomes and the media outcomes.

6.2. Network influence

The critical mass aspect of interactive media is a strong predictor of individuals' adoption of an EMS and, to a lesser degree, of individuals' evaluations of some EMS outcomes. The value of an EMS derived from the use of the system by one's frequent communication partners (critical mass adoption) significantly influences only the media reduction outcome and not the effectiveness outcome. This result makes sense insofar as print media are more likely to be reduced when one's communication partners also use an EMS to communicate. However, perhaps in a small closed organization such as the present site, improvements in one's own effectiveness can result independently of whether one's frequent communication contacts also use the system.

Social information processing, in the form of others' perceptions as a means of creating shared expectations and behavior, has a small effect on the adoption of an EMS and no independent effect on reported outcomes of an EMS. Furthermore, social influence in the form of network group membership has a small significant effect, over and above the influence of the other variables measured here, on the adoption of EMS. The three groups and the set of isolates in the network differ in their patterns of social influence, as well as their patterns of EMS adoption. Yet group membership is not a statistically significant independent influence on individuals' reported outcomes of

an EMS. Either other social influences on one's perceptions operate through attitudes not measured here, or the network group structure may reflect formal organizational structure, which could influence the adoption of EMS by individuals who thereby have similar task requirements, share supportive supervisors, or are similarly required to use the EMS.

Alternatively, it may be argued that the significant differences in adoption and social influence outcomes among the three groups is sufficient evidence of social information processes operating through work relations. That is, it may be preferable to assume that social influence is a theoretically more parsimonious explanation of individual attitudes and behaviors than are individual differences. However, a separate analysis [using methods that space limitations prevent discussing here (Dow, Burton and White 1982)] shows that these independent variables are not autocorrelated with each other in patterns that match the "basic" network matrix.

Thus, present results do not provide much support for an independent effect of attitude-based social information processing (whether through social information processing, social comparison, or some similar "peer effect" mechanism), on the evaluation of a new organizational medium, but they suggest that network group membership is a factor to explore further in subsequent studies of organizational media use and outcomes.

Indeed, one possible explanation for the lack of a significant effect of the social influence variables is their present operationalization. Referring to the "positional" network perspective, social influence could be operationalized in two additional theoretically persuasive ways.

The first would be to identify structurally equivalent positions of actors who have similar patterns of interaction with the same others. We feel that it is less clear what the mechanisms for social influence on attitudes and behavior are under this conceptualization, though Burt (1987) makes a strong case for such an operationalization. A more straightfoward application of the positional perspective entails using formal positions in the organization, considering occupants of hierarchical roles (i.e. direct supervisors, all co-workers in the same workunit, etc.) as the relevant sources of influence in the organizational network, regardless of levels of interaction. Depending on organizational norms, policies about the required use of EMS and the importance of authority in a governmental bureaucracy, this operationalization may provide stronger results.

Second, the several theories of social influence noted earlier each conceptualizes different influence mechanisms which, when included in a network approach, may improve the operationalization of others' influence. For example, the present social influence variables do not take into account the perceived credibility, trust, or attraction between the focal individual and each of the others in the individual's work communication network which social learning or social information processing theories specify as necessary. However, we also collected responses to a second network roster for "general communication", which included social interaction, hallway chats, etc. thus capturing more of the positive, socially desired influence. Results were *less* significant. A more explicit form of the simple "peer effects" model that incorporates this measure of salience would be: $SIP_i = Mcj_i'^*(P_{ij}B_j')$ where B_j' = the vector of each j's attitude, P_{ij} = the proximity matrix, row-normalized by the number of ij links and Mcj_i' = the vector of importance of j's class c to i.

6.3. *Qualifications and strengths*

The present study has several weaknesses in its research design and site. Like many other organizational studies, our sample of respondents came from a single organization, yet past research indicates that an organization's norms for information-sharing affect how, when and to what extent organizational members communicate (Dewhirst 1971; O'Reilly 1977). While our sample size is small, many other organizational network studies have not used appreciably larger network samples. Our results may not be generalizable to other organizations, although the model may be. Computer-monitored measures of EMS adoption and usage would be preferable to self-reports if only because they would reduce common-method bias between self-reported usage and interaction patterns (see Rice and Borgman 1983; Rice and Shook 1988). It would have been very useful to have been able to collect data on messaging patterns among EMS users to test the direct effect of critical mass of adopters.

However, the present study also has some strengths. The small office provided a naturally bounded system in which to test the critical mass hypothesis and to collect network data that might otherwise be impos-

sible in a larger organization. The longitudinal nature of the study added some confidence to the results. The marked influence of pre-adoption expectations and the absence of an independent influence of the adoption of an on the effectiveness outcomes nine months later, indicate that the typical cross-sectional analyses of the outcomes of using new organizational media may involve questionable assumptions. Have past evaluations of office systems simply measured enduring attitudes and expectations rather than real outcomes? The present results, as well as those of Hiltz (1983) and Rice and Case (1983), suggest that, in part, the answer may be yes.

This study proposed specific hypotheses, based on theories of organizational information processing, critical mass and social information processing, about individual-level and network-level influences on the adoption and perceived outcomes of organizational electronic mail. We use a longitudinal research design. While several theoretical and operational qualifications have been identified, the results are quite strong. Based upon baseline measures, the adoption status nine months later of all but two of the sample was correctly predicted. Furthermore, from a one-third to two-thirds of the variance in two outcome factors was predicted. Such results provide a promising foundation for elaborating an explicit model of social information processing and providing further tests of the critical mass hypothesis.

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