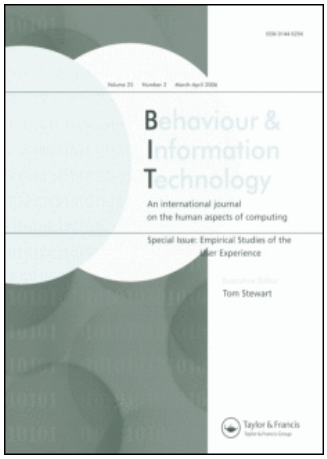

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Structural reproduction of social networks in computer-mediated communication forums

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This study explores the relationship between the structure of an existing social network and the structure of an emergent discussion-board network in an undergraduate university class. Thirty-one students were issued with laptop computers that remained in their possession for the duration of the semester. While using these machines, participants' email log files were collected directly from the University's email servers. The analysis compared structural attributes of actors evident in their social network with the emergent structural properties measured from interactions in a shared discussion board environment. A significant relationship was found between the existing social network structure and the emergent communication patterns, suggesting that existing relationships have a strong influence on subsequent computer-mediated communication. Additional matrices were used to control for gender, major and perceived computer efficacy, none of which had a significant effect.

Keywords: Social network analysis; Emergent networks; Computer-supported collaborative learning; Computer-mediated communication

1. Introduction

A wealth of research in recent years has been dedicated to studying the effects of computer-mediated communication (CMC) on individual and group dynamics. At the group level, the study of communities of practice (Brown and Duguid 1991), knowledge-building communities (Scardamalia and Bereiter 1994) and computer-supported collaborative learning (CSCL) communities (Woodruff 2002) emphasize the importance of collective participation for knowledge creation and learning. The advantage of incorporating technology into traditional learning spaces should be to promote dense, active communication networks among participants; technology should facilitate increased exchange and interaction among learning community members. However, the extent to which existing social relationships influence learning community development remains unclear. That is, the extent to which CMC actually promotes social interaction with diverse others when technology use is situated in an existing social context has received little research attention.

Social network analysis affords an effective interpretive framework to examine data reflecting the relational associations between actors in a network or system. In the current paper, a social network approach is applied to investigate relationships of communication structure across two different forums. The network patterns of participant's email messages and the emergent structure of their class online discussion board communication exchanges are analysed. Participant's postings are logged in discussion thread format, which facilitates network measurement. Discussion board posts, in the form of discussion threads, are linked responses associated with specific topics. Paths, in this context, are the possible message sequences over time. Using these attributes, network graph theory techniques can be applied to examine the structure of these online discussions.

The following review of literature associated with CMC provides a brief synopsis of insights on the dynamics of communication processes in mediated environments. After discussing the properties of new media, we highlight the dimensions of social network analysis, styles of data collection and levels of data attributes. We are applying

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social network and social computing theories to help situate this study of the relationship between email-based social network structures and the resulting communication structure within a shared discussion board forum.

2. Social computing

CMC media include a range of electronic communication environments, such as email and email listservs or discussion lists; real-time synchronous discussion environments such as internet chat rooms; and asynchronous discussion forums, such as electronic bulletin boards. The nature of data gathered in CMC environments facilitates studying patterns of interaction because exchanges are easily recorded, compared with the lengthy process of recording and transcribing face-to-face communication. Also, because mediated conversations are not restricted by time (synchronicity) and space, it is often easier to accumulate longitudinal data.

Much literature attends to the impact of social cues on group communication patterns and social behavior (Kramer 1993, McGrath 1984). Often these social cues result in status differences between participants (Bales 1950, Sherif *et al.* 1955), which affected participation. Studies in computer-mediated contexts found that the restricted bandwidth of CMC media resulted in increasingly equal participation (Rice 1984, Sproull and Kiesler 1991). These studies suggest group members participated and influenced outcomes with greater equality in computer-based discussions, as opposed to face-to-face interactions. Sproull and Kiesler (1991) attribute this effect to the lack of social information regarding other participants. Reduction of the availability of social cues masks status valuation. On this basis, communication systems that reduce or remove social context cues should promote pluralism, egalitarianism and equal participation. Predictions such as these were most often developed and supported in the context of groups using CMC, or particular groupware applications. Fewer specifically examined email (Finholt and Sproull, 1990, Rice 1994), and this medium distinction may be of great importance.

Computer support in this context is simply labeled groupware, defined as 'computer-based systems that support groups of people engaged in a common task (or goal) and that provide an interface to a shared environment' (Ellis *et al.* 1991, p.40). This general definition covers the communication spectrum from email to bulletin boards, conferencing tools, as well as other tools that allow text, audio and digital whiteboard sharing (i.e. Netmeeting). Email, on the other hand, is often a one-to-one medium, as well as a one-to-many and many-to-many medium. Thus, it can and does support dyadic or small group relationships that develop online over time (see Walther and Burgoon 1992), or on the basis of pre-existing offline relationships (Stafford *et al.* 1999).

These studies are not without criticism. For example, Weisband *et al.* (1995) argue that the status-equalizing effect within CMC environments has been an artefact of experimental procedures. In these cases, people in traditional work/task groups are keenly aware of their status differences by way of prior association, whereas participants in CMC experiments are devoid of such information. Thus, in order to obtain useful information, it is beneficial to situate technology use in the context of existing and ongoing social relationships.

More recently, Haythornthwaite (2002) studied the relationship between tie strength within social networks and the introduction of new communication media. With regard to collaborative learning and work groups, she also studied communication tool use in a learning environment (2001). Using a case study, the author (Haythornthwaite) found that students adopted different tools for specific communication goals. There has been a surge in research focusing on communication media choice and collaborative groups recently, as well as technologically mediated relationships (Haythornthwaite and Wellman 1998, Haythornthwaite 2000, Haythornthwaite 2002, Haythornthwaite 2003). However, the current study differs in that it attempts to examine the relationship between an existing social network and an emergent social network.

2.1 *The social nature of email*

Email was the original 'killer app' of the internet, and remains so. According to the Pew Internet and American Life Report (2004), roughly 30 billion emails are sent daily, and 93% (117 million) of American adult internet users use email. Katz and Aspden (1997) found in a nationwide survey that the most frequent reason given for desiring internet access was for the use of electronic mail. A total of 79% of internet users said they use email to communicate with their immediate and extended family (Pew 2004), emphasizing the interpersonal nature of the medium. Other studies have shown that email provides both informational and social support among teachers (Ruopp *et al.* 1993) and scientists (Sproull and Faraj 1995). Stafford and colleagues (1999) found that email was used overwhelmingly for interpersonal relationship purposes, regardless of demographics. Taken together, this evidence demonstrates the social and interpersonal nature of email, our rationale for operationalizing participant email structure, measured at the start of the project, as representative of the social network structure among participants.

The current study provides an opportunity to examine the extent to which prior association, or an *existing* social network, influences subsequent, emergent task-related interaction on a shared, computer-mediated discussion forum. Participant email communication patterns were used to measure the existing social network structure among the group. In this study, participant email logs were collected during the first three weeks of an academic semester, and

are used to quantify the structure of the existing social network structure among participants. The following discussion outlines social network analysis, the method used to analyse the data collected in this study.

3. Social networks

Social and behavioral sciences are interested in and study social networks because the 'relation' is utilized as the unit of analysis. The focus is on the relationship between social entities. Networks facilitate the full spectrum of human relational exchange. At their most fundamental level, social networks function as a brokerage tool for information transaction.

The idea of examining the structure of social networks has been adopted by a wide variety of researchers. Sociologists, for example, used network analysis techniques to examine the relationship between migration to urban environments and the composition and resources available through social networks (Wellman 1990). Other research explores the relationship between network structure and diffusion of innovations, including pharmaceutical drugs (Coleman *et al.* 1957). Such studies show that centrally located, or 'visible' actors in social networks tend to be perceived as opinion leaders, and are earlier to adopt new innovations.

Network analysis provides a vocabulary to identify and measure network communication flow (Monge and Contractor 1988). The greatest benefit of network research is that it considers how the communication network structure of a group shapes participant behaviour and cognition. For example, Anderson and Jay (1985) examined the adoption pattern of a computerized information system by physicians. The results suggest that network variables are better predictors of information system adoption than individual attribute variables.

3.1 *Types of data*

The nature of network data varies on two primary dimensions. Ego-centric network data are composed of the set of relations, or communication ties, surrounding an individual actor. Complete network data, on the other hand, involve the communication structure among a clearly defined population of actors. Often the overall size of the network is measured, both at the complete and ego-level analysis. Ego networks can also be reduced to proportions of strong and weak ties. Kadushin (1982) identified the importance of strong tie contacts in social networks as a source of social support. Strong ties are conceptualized as reciprocal, high-frequency contacts. These strong tie affiliations are valuable in many contexts. On the other hand, Granovetter (1973, 1982) has written extensively on the importance of weak ties in communication networks. Weak tie affiliations increase the likelihood of exposure to novel information, because they function to bridge disparate social groups. Tie strength in this study is limited to frequency of interaction, opposed to, for example, reported emotional closeness.

3.2 *Homophily*

Homophily is the tendency of people to interact with similar others based on variables such as gender and age (McPherson and Smith-Lovin 1987). Considering an organizational perspective, homogeneity in workplace environs make for generally easier communication while facilitating relationships of trust and reciprocity (Lincoln and Miller 1976). Brass (1985) studied an organizational context and found that employees communicate in same-gender networks as well.

Homophily has been differentiated on the basis of induced and choice homophily (McPherson and Smith-Lovin 1987). When homophily is a result of structural constraints, or availability, it is induced. The reverse scenario is choice homophily, based on individual actor choice of contact. Much of the research on homophily stems from theory based on interpersonal attraction, and differences are divisible along ego-centric and structural dimensions. Ego explanations focus on a preference for relationships with similar others to account for gender similarity in network composition (Brass 1985, Lincoln and Miller 1976, Marsden 1988). Structural justifications attribute the availability of contact to limiting individual contact choices (Blau 1977). Other authors cite structural limits on interaction opportunity, as well (Baron and Pfeffer 1994, Kanter 1977, Oleary and Ickovics 1992).

In summary, technology use in CSCL communities should benefit users by increasing the range of their social circles. That is, with the aid of CMC tools, learning communities have the potential to support increasingly diverse social networks, which should foster heightened collective participation. However, this rather simplistic view does not account for the influence an existing social network may exert on the community's subsequent communication patterns. Although CMC is effective at virtually eliminating geographical barriers to communication, some research suggests that the primary effect of CMC is to augment *existing* social relationships (Bikson *et al.* 1989). In addition, Child and Loveridge (1990) found that CMC systems are typically designed precisely to support ongoing hierarchical relations. Situating technology use within the ongoing social/relational context of users affords a fuller understanding of the dynamics in CSCL communities.

4. Hypotheses

The current study addresses the impact of existing social relationships by including the initial social network

structure in the analysis of emergent communication within a CSCL community. In this study, a physical community of students meeting in a traditional classroom was supplemented by mobile computers and CMC tools in an attempt to foster a parallel virtual learning community. The email communication patterns among participants at the start of the semester are used as a representation of the existing social network structure among participants. Conceptually, this is justifiable given the ubiquity of email as a communication medium.

The evidence presented above suggests that participants' social relationships will impact emergent communication patterns in a shared CMC environment. That is, participants who are engaged in a continuing relationship will be more likely to communicate in the shared discussion board environment. Thus:

> H1: Tie strength between dyads in the class email network is significantly related to tie strength in the discussion board network.

Hypothesis 1 addresses individual actor relationships in terms of tie strength. Defining subgroups within the community may reveal communication pattern similarity, as well. Subgroups, or cliques, identified in the email network may be more likely to communicate with each other in the emergent discussion board environment. Thus:

> H2: Tie strength in the discussion board network is significantly related to clique co-membership in the email network.

The positional model of influence maintains that individuals will be most influenced by others who share similar status in a network. Actors who maintain similar levels of status have been shown to also share similar patterns of communication, thus being considered 'structurally equivalent,' even though they may not communicate directly (Burt 1980). Other research supports this contention. For example, Walker (1985) has shown that structurally equivalent actors share ideas about project goals and strategy in an organizational context. Although participants may not communicate directly through the email network, it is likely that structurally equivalent actors in the email network will communicate with each other through the discussion board. Thus:

> H3: Tie strength in the discussion board is significantly related to structural equivalence in the email network.

Finally, the discussion above relating to homophily suggests that emergent communication structure among participants is likely related to gender similarity, academic department similarity, and similarity in perceived computer efficacy. Thus:

> H4: Tie strength in the discussion board network is a function of homophily in the form of gender, participant academic department, and perceived computer efficacy.

5. Methods

As part of a larger, multiphase research effort, laptop computers functioning in conjunction with a newly installed campus wireless modem network (802.11b) were loaned to each participant in this study. Participants were enrolled in a graduate and undergraduate course at a large research university. All participants were required to sign a consent form that informed them of their responsibilities and the scope of data collection. The class, consisted of 31 students, 25% of whom were graduate students, incorporated several group projects and discussion topics related to CMC. Considering the entire class, 68% were male and 32% female. About 45% of the students majored in Communication; 16% majored in Computer Science. The remainder of the class had a variety of different majors.

5.1 *Apparatus*

Students, all of which volunteered to participate in this study, were each issued a laptop computer equipped with a wireless modem card, which remained in their possession through the duration of the semester. Web browsing was set to pass through a proxy server, and network protocol breakdowns and statistics were gathered daily. A series of wireless transceivers (access points) connected together over the campus composed the network infrastructure, exchanging low power microwave signals of limited range. Each access point keeps track of the wireless devices within its range while communicating with other access points. This enables automatic assignment of devices based on best reception allowing users movement from place to place throughout the network, much like a cell phone moves between cell phone towers. As long as the laptop remains in range of any of the access points, users are able to seamlessly move from place to place.

5.2 *Class description*

When the class physically met each week, the format alternated between discussion and lecture. No policy was implemented regarding use of laptops during class, and students were encouraged to engage in open discussion. The class was organized as an example of a CSCL community. The class website functioned as a portal through which students could post contributions which would be

made publicly available to teaching staff, as well as the rest of the students. Asynchronous tools included a semi-moderated class listserv and a web-based class discussion board. Two students were randomly selected each week and asked to post questions associated with class readings to these online forums. This activity was required throughout the duration of the semester, and discussion threads allowed users to retrace topics in dialog form.

6. Measures

This study employed two modes of data collection. Email log files were collected during the beginning of the semester, and included time and date stamp, sender and receiver. Email communication data were limited to all exchanges between participants of this study during the first three weeks of class, and a matrix was created indicating the frequency of communication between participants. The email data represent raw frequency of communication, thus do not account for messages replied to, etc. Data from the discussion board were also coded into matrix format, where each cell indicates the frequency of postings between student pairs. These data were coded into two separate matrices.

Hypothesis one predicts that the frequency of dyadic interaction via the online discussion board is a function of the strength of network ties in the email network. To test this hypothesis, the network matrices described above were used. The discussion board network consists of communication links within the online discussion board. The frequency of dyadic interactions was measured by counting the number of interactions between students in the form of discussion threads. For instance, if person A responded three times to messages posted by person B, then the tie strength between A and B was '3.' The frequency data were arranged into a 31×31 matrix. For example, an 'X' in a cell formed by the intersection of row i and column j in the matrix meant that actor i had interacted with actor j X times. This matrix reflected all of the possible pairings between each student.

In a similar vein an email network matrix was created using email log file data. The strength of a tie was defined as the frequency of interactions so that the number in cell $X(i, j)$ represents person i and j exchanged X number of emails during the course of the semester.

6.1 *Group affiliation/cohesion*

Hypothesis two predicts that the frequency of dyadic interaction via the online discussion board is a function of actors' joint membership in cohesive subgroups. To operationalize the structural basis of the group affiliation mechanism, a clique was used, one of the most stringent definitions of a cohesive group (Doreian 1979). A clique was defined as any group of at least three actors for which any pair are tied to one another, or, in other words, for which three or more actors were maximally linked to one another. All cases meeting these conditions were identified using the clique algorithm in UCINET V (Borgatti *et al.* 1999), which implements the Bron and Kerbosch (1973) algorithm to find all Luce and Perry (1949) cliques.

The algorithm identified 42 cliques in the email network, in which 29 out of 31 participants (94%) were in at least one clique of at least three actors. The clique membership data were arranged into a matrix of size a 31×31 matrix in which a cell vector of Xij represents the number of times each pair of actors were in the same clique. Since this clique matrix counted all cases including all sub-cliques of larger cliques, the matrix was transformed into a binary matrix which had cell values of $X(i, j) = X(j, i)$ equal to 1 if the actors i and j were in a clique together at least once. Otherwise, the cell was given a value of zero.

6.2 *Structural equivalence*

Hypothesis three predicts that the interaction likelihood of discussion board postings can be better predicted by participants' positional similarity in the email network. Several excellent discussions of the method of finding structurally equivalent positions in a network exist (see for reviews Michaelson and Contractor 1992 and Wasserman and Faust 1992). In the present study, structural equivalence was defined as the degree to which two separate individuals interact with a similar group of others (Burt 1982). Using the PROFILE algorithm in UCINET V (Borgatti *et al.* 1999), the email network was successively split into positions, and the degree of similarity between *i*'s and *j*'s relations in the network was measured. The final output was a 31×31 matrix with cell values representing actor-by-actor positional similarity.

6.3 *Homophily-attribute matrices*

Hypothesis four predicts that people who have the same gender, major, or who have a similar level of computer efficacy, may interact more frequently than those with different social and attitudinal categories. In order to test the effects of these attribute similarities, three demographic characteristics were measured and entered in the test model: gender, department similarity and computer efficacy. To measure computer efficacy, eight items measuring user confidence regarding computer and internet use and problem solving, adapted from questions proposed by Compeau and Higgins (1995) and Nahl (1996), were administered via likert-type survey questions (alpha = 0.77). These attribute data were converted to network form using two different methods provided in UCINET V (Borgatti et al. 1999). Attribute matrices for gender and major

similarity were created by using the 'exact matches' method in which

$$Y\ exact = Y\ exact(i,\ j) = 1 \quad if\ V(i) = V(j)\ and\ 0\ otherwise$$

where *Y exact* is the matrix of similarities between actors for a given attribute measure and *V*y(*i*) and *V*y(*j*) are vectors of individual scores on that variable.

The attribute matrix for computer efficacy/similarity was formed by using absolute difference method in which

$$Y\ diff = Y\ diff(i,\ j) = |V(i) - V(j)|.$$

7. Analysis

The primary purpose of this study is to examine and compare the communication structures in email and groupware systems among a set of ubiquitous network users, via network analytic procedures. However, in the present study the network data were symmetrized before performing the analyses. Symmetrizing a matrix forces cell X(*i*, *j*) to equal X(*j*, *i*) for all actors *i* and *j*. When working with directed, asymmetric network data, where the strength of relationship between actors *i* and *j* may not be equal, the need to symmetrize matrices often occurs. For example, in the context of the discussion board data collected in this study, participants' initial message posts are not directed at anyone specific because they are the start of a discussion thread. However, a reply to that message logically reflects a connection, or relationship. In the present study, the discussion board matrix was symmetrized by maximum, where X(*i*, *j*) equals the maximum value reported by either actor *i* or *j*, because often participants responded more than one time to a single post. The present authors feel this is the most appropriate way to handle the data, as the analyses focuses on the more general relationship between participants.

To be consistent, the email matrix was symmetrized, as well. However, this matrix was symmetrized by average, where X(*i*, *j*) equals the average of the values reported by both actors *i* and *j*. Average cell values were computed because of the nature of email: it is a much more accessible and frequently used communication channel in comparison to an online discussion board, and emails can be sent to multiple recipients simultaneously. Unfortunately, the data collected do not indicate whether or not emails were sent to multiple recipients, and the current authors decided to use a conservative estimate for the frequencies in this matrix. For example, in some cases cell frequencies for X(*i*, *j*) exceeded 120, while X(*j*, *i*) were less than 50. This suggests that although there certainly is a relationship evident between *i* and *j*, a cell frequency of 120 is not an accurate reflection of the strength of that relationship.

Significance tests of regression models were evaluated by successive application of Krackhardt's nonparametric multiple regression technique, based on the quadratic assignment procedure (QAP) (Krackhardt 1987, 1988). This procedure takes into account the auto-correlated error terms inherent in social network data. The 930 dyads observed from 31 participants in this study may not be independent because, for example, the Euclidean distance between actor A and actor B is not independent of the Euclidean distance between actor B and actor C (both observations include the same data from actor B). The QAP has been developed to deal with data of this type: systematically interdependent dyadic observations (see Hubert and Schultz 1976, Krackhardt 1988).

The QAP algorithm proceeded in two steps. In the first step, it performs a standard multiple regression across corresponding cells of the dependent and independent matrices. In the second step, it randomly permutes rows and columns (together) of the dependent matrix and recomputes the regression, storing resultant values of *r*-square and all coefficients. This step was repeated 2000 times in order to estimate standard errors for the statistics of interest. For each coefficient, the program counted the proportion of random permutations that yielded a coefficient as extreme as the one computed in step 1. A low proportion (<0.05) suggests a strong relationship between the matrices that is unlikely to have occurred by chance. All estimations reported in this analysis were made using UCINET V (Borgatti *et al*. 1999).

8. Results

The analysis tested varying predictors of network structure. The communication structure of the email (social) network was compared with the emergent network structure on the class discussion board. The strength of association via email messaging was a significant predictor of discussion board network structure. That is, students with strong email relationships tended to communicate with each other on the class discussion board. The examination of structural equivalence was also a significant predictor of discussion board network structure. Clique membership was not a significant predictor of the discussion board communication network structure.

Table 1 summarizes the interaction patterns in the two networks. Overall, members in both networks contain similar numbers of network partners and interaction frequencies, although subjects used the email network more often than the discussion board.

Table 2 reports the results of all hypotheses testing based on the QAP regression analyses. The first model (model I) tested multiple linear relationships between the three proximity measures from the email network—strength of interaction (cohesion), structural equivalence and co-clique

Table 1. Summary statistics of interaction patterns in the two networks.

	M	*SD*	Min.	Max.
*Email network (n = 31)**				
Number of network partners per individual	5	3.45	1	20.5
Frequency of interactions per individual	12.97	12.94	2	77
Discussion board network (n = 31)†				
Number of network partners per individual	4.90	4.57	0	19
Frequency of interactions per individual	7.42	8.64	0	42

*Network matrix was symmetrized by average.
†Network matrix was symmetrized by maximum.

Table 2. QAP multiple regression models showing standardized Beta coefficients.

	Model	
Variables	I	II
Dependent variable		
Interaction strength in discussion board network		
Independent variables		
Intercepts	0.00	0.00
Interaction strength in email network	0.072*	0.075*
Structural equivalence in email network	0.151*	0.165*
Co-clique membership in email network	0.028	0.030
Dissimilarity in computer efficacy		−0.043
Similarity in department_major		−0.046
Similarity in gender		−0.031

Note: All significance tests based on 2000 random permutations using quadratic assignment procedure (QAP).
*$p < 0.05$ (2-tailed).

membership—and interaction strengths on the discussion board network. The second model (model II) added attribute variables to the first model to control for the effects of dyadic similarities in gender, major (department), and computer efficacy. The regression model incorporating those attributes variables was

$$\begin{aligned} Yfreq = {} & \beta 0 + \beta 1(\text{STRENGTH}) \\ & + \beta 2(\text{STRUCTURAL EQUIVALENCE}) \\ & + \beta 3(\text{CLIQUE}) + \beta 4(\text{GENDER}) + \beta 5(\text{MAJOR}) \\ & + \beta 6(\text{COMPUTER EFFICACY}) + \in \end{aligned}$$

where $\beta 0$ is the intercept term, STRENGTH, STRUCTURAL EQUIVALENCE and CLIQUE are the adjacency matrices capturing network proximities between network ties, GENDER, MAJOR and COMPUTER EFFICACY are the matrices identifying whether or not the ties share similarities in those attributes and $\in$ is the error term.

In the first model, consistent with Hypothesis one, the strength of dyadic interaction in email network (interaction strength) is a significant predictor of interaction strength in discussion board network (beta = 0.072, $p = .049$). That is, in the entire network, students with more frequent interactions via email are more likely to respond to each other in the discussion board environment, opposed to those with less frequent interactions.

Hypothesis three was also supported. The regression analysis showed that structural equivalence in the email network was a significant predictor of interaction strength in the discussion board network (beta = 0.151, $p = .029$). That is, students holding similar structural positions in the email network are more likely to interact with each other on the discussion board, than are those with less similar positions.

The effect of group/clique membership, which was predicted in Hypothesis two, was not supported. This indicates that the two proximity measures-interaction strength and structural equivalence, have more significant relationships with the dependent variable when group membership effects are controlled for.

Model II reports the results of adding the attribute similarity variables, i.e., gender, major and computer efficacy, to the baseline models. Two patterns are evident. First, none of the attribute similarity variables have significant relationship with the dependent variable, negating Hypotheses four. Contrary to our prediction, members in both networks were less bounded by demographic and attitudinal similarities, and more likely to interact with people with diverse backgrounds. Second, the effects of significant variables in model I remain the same, although the coefficients and significance levels lose a little strength after the attributes similarities are controlled for.

9. Conclusion and discussion

The conclusions presented herein support the contention that social–relational structure, residing in existing, evolving social networks, has a significant impact on emergent interpersonal communication patterns in CMC forums. Overall, in this study CMC tools function to support existing social ties, opposed to facilitating new ties. However, the participants in this study were co-located, and thus had opportunities for face to face communication. The novel contribution of the analyses presented is that the *existing* social structure of participants was evaluated, and its relationship to subsequent behaviour explored. The approach used to assess the state of the existing social structure of participants at the start of the project was collection of email communication in the form of log files. As mentioned earlier, the email network was conceptualized as representative of the social network owing to the ubiquity of email as a communication application.

Therefore, with great reliability, data were collected on the actual communication patterns between participants. This unobtrusive method promises to be an effective means of data collection as people become increasingly reliant upon CMC channels. Although this increases the ethical considerations and responsibilities of researchers, it is encouraging the application of increasingly sophisticated conceptualizations and methodologies that account for existing social network influence on group dynamics.

The results suggest validation of recent findings regarding the influence existing social structures have on CMC use (Bikson *et al.* 1989, Child and Loveridge 1990). Specifically, although the clique co-membership hypothesis was not supported, a significant relationship between tie strength and the two communication networks was hypothesized and supported. This evidence again suggests the importance of existing relationships in CMC environments, as participant interaction patterns are influenced by their 'social boundaries.' The structural equivalence hypothesis proposed that structurally equivalent actors in the email communication network would have higher tie strength in the shared discussion board environment, which was found to be significant. Participants utilizing the discussion board typically responded to and interacted with those actors whom they shared structural similarity with in the email network. This evidence supports research done by Bikson *et al.* (1989), Child and Loveridge (1990), and Fulk *et al.* (1987). The findings presented herein support the conclusion that the ultimate function of CMC channels is to support existing interpersonal relationships and social structure when it is used in tandem with face-to-face communication.

This evidence challenges the findings of early theories pertinent to CMC, while improving on methodology. The early body of literature on mediated communication holds that CMC group interactions are less affected by group social or contextual cues. As a result, these studies concluded that interaction is less affected by normative or affective influence (see for review Culnan and Markus 1987; Hiemstra 1982, Sproull and Kiesler 1991). Some of these preliminary examinations of CMC were flawed because they did not situate technology use in a social context. In fact, studies often utilized *ad hoc* groups assembled only for the purpose of the research project, which lack both prior interaction experience and anticipation for future interaction. Further, the interaction time allotted for participant CMC exchange was limited to a short span. As Weisband *et al.* (1995) appropriately point out, equalizing effects inherent in these research findings tend to be an artefact of these experimental procedures.

Existing literature demonstrates extensive differences in communication styles between males and females. Maccoby (1990) suggests significant differences in communication styles that result in differences in the types of social contacts maintained. Further, gender differences have been found in how people view and use technology (Sherman *et al.* 2000). For these reasons, the homophily matrices measuring the variables of gender, department/major and computer efficacy were included in the analysis. Model II shows that none of these variables had an impact on the resultant communication structure in the on-line discussion board. Further, none of the homophily variables had an effect on the original three hypotheses of tie strength, clique co-membership and structural equivalence.

These results can be attributed to the homogenous nature of participants. All of the students involved in this study were upper-level undergraduate or graduate students who have been embedded in the same university environment for years. Also, all participants have a high level of experience with computers and communication technology. Although there exists a negative trend between the homophily variables and the dependent variable, discussion board tie strength, it is likely that the results were attenuated by the homogeneity of the participants. This negative trend is surprising, and worthy of future investigation.

The results presented contribute to the growing theoretical base of social network analysis, as well. Although Burt (1983) suggests structural equivalence is a more accurate method of parsing subgroups from within a network or system, network analysts continue to apply a broad range of methodologies for this purpose. In the current study, the independent variable of structural equivalence of actors in the email network was shown to be a better predictor of interaction strength regarding the emergent communication patterns within the shared online discussion board than the measure of clique co-membership. Often clique co-membership is critiqued as being too restrictive a definition of subgroups (Burt 1980). Clique co-membership was calculated by assessing the cohesiveness of communication bonds within groups of actors. There was no significant relationship found between clique affiliation in the email network and tie strength within the discussion board. The results support Burt's contention that indeed structural equivalence offers greater accuracy and predictability concerning other actor characteristics, such as communication patterns across different computer-mediated forums. Focusing on a positional approach to subgroup identification, such as structural equivalence, affords researchers greater predictive ability regarding the behaviour of actors.

This study is not without limitations, such as the cross sectional study design. It is reasonable to expect that communication patterns of the participants could change over time. Also, only two types of communication were measured, and other types of communication were not controlled for. Longitudinal data collection and analysis would yield more precise findings about the influence of existing friendship networks on subsequent computer-mediated communication use. Also, participants in this

study had ample opportunity for face to face interaction, which limits the overall generalizability to groups whose communication is entirely computer-mediated.

As group CMC applications continue to grow in popularity, the methodology presented here offers a powerful and flexible framework from which to evaluate participation in commensurable systems. In the future, research should examine network characteristics in larger groups consisting of increasingly diverse participants.

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