2011

The Effect of Virtuality on Individual Network Centrality and Performance in On-going, Distributed Teams

Priscilla Arling
Butler University, parling@butler.edu

Mani Subramani

The Effect of Virtuality on Individual Network Centrality and Performance in On-Going, Distributed Teams

Priscilla A. Arling
College of Business, Butler University
4600 Sunset Avenue
Indianapolis, IN 46208
parling@butler.edu

Mani Subramani
Carlson School of Management, University of Minnesota
321 19th Avenue South
Minneapolis, MN 55455
msubramani@umn.edu

The Effect of Virtuality on Individual Network Centrality and Performance in On-Going, Distributed Teams

Abstract

For distributed teams to succeed, individuals must interact successfully within team social networks. To understand individual performance in distributed teams, we consider a multi-dimensional view of individual virtuality and its relationship with centrality in the team's face-to-face network and ICT network. We leverage social network theory and hierarchically analyze data from 254 individuals in 18 teams. We find that members with higher dispersion are less central in the face-to-face network while those with higher ICT use are more central in the ICT network. Centrality in the ICT network, but not centrality in the face-to-face network, is positively related to performance. The results provide insights for academics and practitioners on how to improve individual performance in distributed teams.

Keywords: communication, distributed, ICT, networks, teams, virtual

Introduction

Distributed teams in organizations comprise members who are dispersed across physical locations and who use information and communication technology (ICT) to accomplish their tasks (Griffith et al., 2003). For these teams to succeed, individuals need to succeed (Ahuja et al., 2003; Saunders and Ahuja, 2006) and individual success depends on effective interaction with team members (Cramton, 2001). Even so the physical dispersion and ICT use, or the *virtuality* of team members, can make interaction problematic and have a detrimental impact on performance (Cramton, 2001; Gibson and Gibbs, 2006). Virtuality's influence in teams is due to

a large extent to its effect on communication processes and structures (Saunders and Ahuja, 2006).

Social network theory is a valuable framework for conceptualizing and measuring communication structures. Social networks have been shown to affect a wide variety of performance measures (Ahuja et al., 2003; Cross and Cummings, 2004). In network theory outcomes are dependent on the structure of individual contacts and an individual's position in that structure (Borgatti et al., 2009; Burt, 1992).

Virtuality is likely to influence social networks since network structure is affected by physical proximity (Borgatti and Cross, 2003) as well as technology use (Burkhardt and Brass, 1990; Haythornthwaite, 2001). In distributed teams task related interactions occur through both face-to-face and ICT contact (Griffith and Neale, 2001). Face to face and ICT communications can have different implications for timing and access to information in distributed teams (Cramton, 2001). Therefore it is important to consider the effects of virtuality on two distinct distributed team social networks: those developed through face-to-face interactions and those based on ICT interactions.

Most prior work on virtuality has been concerned with *team* level dimensions of virtuality and their effects on *team* outcomes (e.g. (Maznevski and Chudoba, 2000; Griffith et al., 2003; Hinds and Bailey, 2003; Kirkman et al., 2004; Chudoba et al., 2005; Gibson and Gibbs, 2006; Cohen and Gibson, 2003). Yet in network theory, outcomes are dependent on the structure of *individual* contacts and an *individual's* position in a network structure. Few researchers have conceptualized an individual level of virtuality and considered its relationship to network structures and individual outcomes in distributed teams.

The purpose of this study is to examine, in on-going distributed teams, how the multiple dimensions of virtuality influence an individual's position in a network and the subsequent effect on individual performance. We draw on prior research and contribute to theory by proposing four dimensions of virtuality at the individual level: spatial dispersion, configurational dispersion, temporal dispersion and ICT use. In the next section we review the theoretical background on virtuality and social networks. We then present the research model, hypotheses and analysis. Finally we discuss the implications, and describe the contributions and areas for future research.

Theoretical Background

Virtuality

A number of researchers have conceptualized a *team* level of virtuality, but few studies are in agreement as to which attributes should be included in the concept. In any discussion of distributed teams, two factors are almost always included. Physical, geographic dispersion between team members is frequently a key component of team virtuality (Cohen and Gibson, 2003; Griffith et al., 2003; Bell and Kozlowski, 2002), as is the level of ICT contact compared to face-to-face contact (Cohen and Gibson, 2003; Bell and Kozlowski, 2002). While these constructs can be measured at the team level (e.g. (Gibson and Gibbs, 2006)), increasingly research has begun to suggest that an individual level conceptualization of virtuality can provide useful insights (e.g. (Chudoba et al., 2005). We build on work on team level virtuality (Bell and Kozlowski, 2002; Cohen and Gibson, 2003; Griffith et al., 2003) as well as work on team level physical dispersion (O'Leary and Cummings, 2007b) to conceptualize an *individual level of*

virtuality on four dimensions: *spatial dispersion, configurational dispersion, temporal dispersion* and *ICT use.*

Spatial dispersion reflects the *physical distance* between an individual and his team members. Physical distance must be traversed either directly by walking or using transportation technology, or bridged using communication technology. Even when users have a variety of communication technologies at their disposal, physical distance often determines who gets contacted in a work group (Olson and Olson, 2000; Slaughter and Kirsch, 2006).

Configurational dispersion reflects the *contextual distance*, the relevant differences between work sites when individuals are collocated with some team members and not with others. Differences in contexts that can influence outcomes include differences in: the accessibility and features of equipment, local work site processes and behavioral norms, and pressures from local supervisors and coworkers (Hinds and Bailey, 2003; Cramton, 2001). A shared context is critical to learning 'who knows who knows what' (Monge and Contractor, 2003), which can increase contact with others through referrals (Coleman, 1990). Team members who experience different contexts have difficulty developing mutual understandings (Clark and Brennan, 1990), which can increase conflict and decrease communication (Hinds and Mortensen, 2005; Olson and Olson, 2000). Configurational dispersion has no necessary relationship to spatial dispersion (O'Leary and Cummings, 2007b). Substantive differences in contexts can occur in relatively proximate sites, even if the sites are in the same organization. Armstrong and Cole (Armstrong and Cole, 2002) describe how a manager in one company was surprised by differences in processes and norms in a group located just nine miles away.

Temporal dispersion reflects *the distance and difficulties in coordination between team members* arising from differences in the routine work schedules. Temporal dispersion is

correlated at times to physical dispersion, but not always. For instance team members in New York and Santiago, Chile are spatially dispersed, but not temporally dispersed since these two cities are in the same time zone. Temporal dispersion makes synchronous communication more difficult and thus less frequent (O'Leary and Cummings, 2007b). However, temporal dispersion can also allow individuals to work sequentially on tasks and thereby reduce overall project execution times (Espinosa and Carmel, 2004).

We also view *ICT use* as a dimension of individual virtuality. Even if an individual is collocated with some team members, she may be viewed as being distant if she primarily relies on email to communicate (Oh et al., 2008). Studies have shown that a team's level of ICT-based interaction, as compared to face-to-face interaction, influences outcomes (Kirkman et al., 2004; Maznevski and Chudoba, 2000; Kraut et al., 2002). ICT use can help bridge physical and temporal distances, but is of limited value in bridging contextual differences (Burgoon et al., 2002). Based on work at the team level (Bell and Kozlowski, 2002; Cohen and Gibson, 2003), in this study ICT use reflects how much of an individual's total communication is conducted electronically.

The dimensions of virtuality can be important choices for managers who have the power to design their teams. The availability as well as location of individuals with specific skills is a significant consideration in selecting team members. The degree of configurational dispersion is influenced by the choice of managers to place team members in a single facility or multiple facilities. Managers may locate team members in different physical spaces in order to reduce crowding, or locate them together to increase 'social density', in efforts to increase satisfaction and performance (Monge et al., 1985). Managers can influence temporal dispersion by allowing individuals to set their own work schedule, or by dispersing team members globally, which

would aid in ensuring that work can proceed around the clock. Finally, ICT use can be influenced by the communication policies and processes and expectations established regarding communication.

The dimensions of virtuality are expected to have separate effects on outcomes for individuals in distributed teams. In the next section, we discuss one outcome expected to be influence by virtuality, an individual's position in the team's social network.

Social Networks in Distributed Teams

Social network theory posits that individual outcomes, such performance, are influenced by the structure of interactions between individuals and the position of the individual in that structure (Burt, 1992). Communication networks are frequently studied in organizations (e.g. (Cummings and Cross, 2003; Hinds and McGrath, 2006) and increasingly research has begun to study ICT networks (e.g. (Ahuja et al., 2003; Wasko and Faraj, 2005; Cucchi and Fuhrer, 2007)). Interest in ICT networks stems from work that suggests that electronic and face-to-face communication differ in characteristics and outcomes (e.g. (Burgoon et al., 2002; Finholt and Sproull, 1990; Hiltz et al., 1986). Yet despite the documented differences, few researchers have separately but simultaneously studied both types of networks (see (Haythornthwaite, 2001; Hinds and McGrath, 2006; Zack and McKenney, 1995)).

Two ways in which benefits can be derived from networks are through improved access and timing to resources (Burt, 1992). The benefits derived from face-to-face and ICT networks are expected to differ, as noted in Table 1. In terms of access benefits, face-to-face interaction is limited to proximal others, while ICT interaction is possible regardless of spatial or temporal distance from team members. Still, individuals who are physically proximate are more likely to interact (Allen, 1977), which would increase access benefits. In face-to-face networks the ability

to physically gather others together as well as a higher spontaneity of contact (Olson and Olson, 2000) enhances the timing benefits. Face-to-face more so than electronic communication requires others to give their immediate attention (Nardi, 2005; Nardi and Whittaker, 2002), providing timing benefits. On the other hand, asynchronous electronic communication can improve the timeliness of information exchange (Ramirez et al., 2002). Team members do not have to wait for individuals to be physically present to send them an email or to leave a voice message. For these reasons the level of benefits derived from and the individual outcomes associated with face-to-face and ICT networks are expected to vary.

Centrality in Distributed Team Networks

A variety of variables have been used to capture the benefits derived from an individual's position in networks (for a review see (Brass et al., 2004)). One of the most widely used network constructs in organizational and team research is *centrality*. Centrality indicates the extent to which an individual is linked to others in a group and is related to performance (Ahuja et al., 2003; Cross and Cummings, 2004; Sparrowe et al., 2001). Centrality reflects how visible and connected an individual is in a network (Knoke and Burt, 1983), which is important in distributed teams. Members of distributed teams often fail to contact physically distant members (Cramton, 2001). In addition ICT use can result in some individuals feeling 'invisible' and left out of important interactions (Finholt and Sproull, 1990; Hinds and Bailey, 2003). In this study we conceptualize *face-to-face centrality* and *ICT centrality*, to capture an individual's position in the team face-to-face and ICT networks respectively.

Social Networks and Performance

Social network ties and structures have been found to influence a variety of performance measures (Ahuja et al., 2003; Cross and Cummings, 2004). An individual's ties to others within the group have been linked to supervisor-evaluated performance (Sparrowe et al., 2003) and project performance (Cross and Cummings, 2004). Due to the differences in benefits derived from face-to-face and ICT networks, we suggest it is useful to consider how each network is related to individual performance in distributed teams. In the next section we develop a model, shown in Figure 1, which examines the influence of virtuality on centrality in the team's networks and subsequent individual performance.

---- *Insert Table 1 and Figure 1 about here* ---

Research Model and Hypotheses

Virtuality and Face-to-Face Centrality

Face-to-face centrality is linked to face-to-face interaction that can take place only when individuals are physically proximate. Therefore we posit that spatial dispersion is negatively related to face-to-face centrality. Configurational and temporal dispersion are also expected to be negatively related to face-to-face centrality. People who share the same physical location are more likely to interact (Wellman et al., 1996) and experience an increased sense of social bonding (Nardi and Whittaker, 2002), which also increases the frequency of communication (Olson and Olson, 2000). In addition, when an individual does not work at the same time as team members, the opportunities to be contacted face-to-face are reduced.

Higher ICT use is expected to have a negative relationship with face-to-face centrality. An individual whose total communication is highly electronically-based may have less face-to-face contact with team members. Members of on-going teams are often concerned with each other's

satisfaction and have time to establish norms of communication (Saunders and Ahuja, 2006). An individual with high ICT use may convey an expectation and preference for electronic contact, regardless of physical distance, which would reduce his face-to-face centrality. We therefore suggest:

Hypothesis 1a: Spatial dispersion is negatively related to face-to-face centrality.

Hypothesis 1b: Configurational dispersion is negatively related to face-to-face centrality.

Hypothesis 1c: Temporal dispersion is negatively related to face-to-face centrality.

Hypothesis 1d: ICT use is negatively related to face-to-face centrality.

Virtuality and ICT Centrality

Physical distance decreases the frequency of communication between individuals, even electronic communication (Wellman et al., 1996). Therefore spatial dispersion is expected to have a negative relationship with ICT centrality. Configurational dispersion is also likely to have a negative effect on ICT centrality since individuals who share contexts are more likely to interact (Wellman et al., 1996). In contrast we expect temporal dispersion to be positively related to ICT centrality. Team members who work with temporally distant individuals often make an extra effort to coordinate their work with those individuals (Espinosa and Carmel, 2004). This additional effort would be conducted electronically and would increase the ICT centrality of individuals with higher temporal dispersion levels.

We suggest that ICT use has a positive relationship with ICT centrality. In on-going teams, high levels of ICT use by an individual will be reciprocated by others due to norms of communication and concerns of member satisfaction (Saunders and Ahuja, 2006), so that individuals whose outgoing communication is highly electronically based will have high levels of in-coming electronic contacts as well. Therefore we hypothesize:

Hypothesis 2a: Spatial dispersion is negatively related to ICT centrality.

Hypothesis 2b: Configurational dispersion is negatively related to ICT centrality.

Hypothesis 2c: Temporal dispersion is positively related to ICT centrality.

Hypothesis 2d: ICT use is positively related to ICT centrality.

Centrality and Individual Performance

For individuals to perform effectively in distributed teams they must have access to team members that can provide needed information (Cross and Cummings, 2004; Majchrzak et al., 2005). Individuals must also utilize technology effectively in the completion of their assigned tasks (Goodhue and Thompson, 1995). Network centrality has been associated with improved performance in a variety of settings, primarily due the greater level of resources available to central individuals (Knoke and Burt, 1983). We therefore posit:

Hypothesis 3a: Face-to-face centrality is positively related to individual performance.

Hypothesis 3b: ICT centrality is positively related to individual performance.

Research Methods and Analysis

We conducted a field study of 254 individuals in 18 on-going distributed teams. All teams were long-term, on-going work units often referred to as functional teams, as opposed to project or ad-hoc teams (Saunders and Ahuja, 2006). The average individual tenure with a team was 27 months. The teams were from nine organizations. Four of the organizations were involved in technology development, three were human service organizations, one was a pharmaceutical firm and another was a university. All teams were engaged in non-routine and highly idiosyncratic tasks characteristic of knowledge work. Fourteen of the teams developed and supported information technology systems. Four teams developed and delivered educational and

social service programs. The managers all cited intra-team communication as an important factor contributing to individual performance. Teams ranged in size from 4 to 25 members with a median size of 15. Eight of the teams were international and ten teams had members in multiple time zones. Forty-three percent of the team respondents were female and eighty-five percent had at least a bachelor's degree.

Fieldwork began with semi-structured interviews, in order to become familiar with issues surrounding distributed teams. From the interviews a team member questionnaire was developed. To the extent possible items were adapted from prior research. Part one of the questionnaire included a sociometric question regarding face-to-face and ICT communication. Part two included questions on trust (a control variable), physical location, communication mode use and demographic characteristics. A pilot test was conducted to refine the questionnaire. Presentations were provided at each site to facilitate completion of the questionnaire. Instructions regarding the difference between face-to-face and electronic contacts were emphasized. Questionnaires were administered either in-person via paper or by e-mailed form. The e-mailed forms were mailed directly back to the researchers. The overall response rate for the survey was 84%. All 18 teams included in our analysis had team-level response rates over 81%. Assessments of each team member's performance were provided by the team manager in a separate survey.

Measures

Table 2 lists the measures used in this study. The questions for Performance employed a seven point Likert scale anchored on strongly disagree (1) to strongly agree (7).

Spatial Dispersion. *Spatial dispersion* was operationalized as the *sum of the physical distance in miles between an individual and his team members*. Individual *i'*s spatial dispersion with team members was calculated as (O'Leary and Cummings, 2007b):

$$Z_i = \sum_j^k \left(Miles_{s-j} * n_j \right) \Big/ \left(N^2 - N \right) / 2 \ , \quad j \neq i$$

where *s* is the individual's site location, $Miles_{s-j}$ is the miles between sites *s* and *j*, *k* is the total numbers of sites in the team, n_j is the number of team members at the j^{th} site and N is the total number of team members across all sites. The denominator accounts for the number of unique member pairs in the team.

Configurational Dispersion. *Configurational dispersion* was operationalized as *the number of team members not collocated in the same building with the individual, expressed as a proportion of the total number of team members*. Measures of configurational dispersion need to be sensitive to the context studied (O'Leary and Cummings, 2007a). Assessment of two locations sharing contextual characteristics is often a subjective judgment. Our interviews revealed that team members located in the same building felt they experienced the same context. Such feelings declined significantly among individuals in different buildings. We therefore used building location in determining configurational dispersion, which is in line with prior work (e.g. (Cummings, 2004; Mortensen and Hinds, 2001; Boh et al., 2007). Individual *i'*s configurational dispersion with team members was calculated as (O'Leary and Cummings, 2007b):

$$Z_i = 1 - \left(n_s / N \right)$$

where *s* is the individual's site location, n_s is the number of team members at *i'*s site and N is the total number of team members across all sites.

Temporal Dispersion. *Temporal dispersion* was operationalized as *the sum of differences in time zones between an individual and her team members*. Individual *i'*s temporal dispersion with team members was calculated as (O'Leary and Cummings, 2007b):

$$Z_i = \sum_j^k \left(TimeZones_{s-j} * n_j \right) \Big/ \left(N^2 - N \right)/2 \ , \quad j \neq i$$

where *s* is the individual's site location, $TimeZones_{s-j}$ is the number of time zone between sites *s* and *j*, *k* is the total numbers of sites in the team, n_j is the number of team members at the j^{th} site and N is the total number of team members across all sites.

ICT Use. Consistent with prior research (Cohen and Gibson, 2003; Griffith et al., 2003), *ICT use* was operationalized as *the number of hours spent communicating electronically each week, expressed as a proportion of the total number of hours spent communicating*, which includes both face-to-face and electronic communication.

Centrality. Following Brass (Brass, 1984) the social network question asked individuals to report the frequency of interactions with team members on whom they relied for inputs to do their job and team members who similarly relied on the outputs of the focal member. Informants indicated the frequency of communications through face-to-face and ICT on a six point scale that ranged from '0' – Don't contact, to '5' – Contact every day. Two sociomatrices were constructed for each team, one face-to-face and one ICT. Two measures were calculated for each individual, *face-to-face centrality* and *ICT centrality*. Centrality was calculated as (Burt, 1991):

$$Z_i = \sum_j \left| Z_{ji} / \max\left(Z_j\right)/(N-1) \right| \quad j \neq i$$

where z_{ji} represents the frequency of contact between respondent *j* and respondent *i*, $max(z_j)$ is the maximum frequency respondent *j* has with anyone in the team and N is the number of individuals in the team.

Performance. Following Sparrowe and colleagues' work on social networks and job performance (Sparrowe et al., 2003), we measured performance on job duties and responsibilities (Williams and Anderson, 1991).

Control Variables. Team size as well as task variety and interdependence can influence an individual's position in a network (Brass et al., 2004). The average of task interdependence and task variety in each team was calculated as *task complexity* and measured via four questions on a seven-point Likert scale (α=0.73). Interactions and performance could be influenced by an individual's *job tenure*, *team tenure*, and *organizational tenure*. All tenure measures were operationalized in terms of months. *Education*, which may impact performance, was operationalized on a four point scale. Trust is often cited as a factor influencing interactions in distributed teams (Jarvenpaa et al., 1998; Morris et al., 2002). *Trust* was measured via three questions on a seven point Likert-scale (α=0.76). Finally, an individual's *total communication* was operationalized as the total number of hours spent communicating each week, both face-to-face and electronically.

---- *Insert Table 2 about here* ----

Analysis

Convergent and Discriminant Validity. The convergent and discriminant validity of the multi-question measures for trust and performance were assessed through confirmatory factor analysis. Convergent validity was assessed in three ways. First, the standardized loading factors, which indicate the level of agreement between measurement items and a proposed

construct, were all significant ($p \leq 0.001$). Second, the internal consistency for each set of measurement items was calculated using the composite reliability score, which should exceed 0.70 (Fornell and Larcker, 1981). Finally, the average variance extracted (AVE) should be greater than 0.50 (Fornell and Larcker, 1981). Both constructs demonstrated good convergent validity.

Discriminant validity was assessed by checking if the AVE of each construct was higher than the squared correlation between the constructs (Fornell and Larcker, 1981). Discriminant validity was demonstrated for all constructs. Table 3 shows the correlations and descriptive statistics. The correlation between face-to-face centrality and ICT centrality ($r=0.58$, $p \leq 0.01$) is in line with correlations between network measures found in other studies (e.g. (Gibbons, 2004; Reagans and McEvily, 2003). To check for multicollinearity we ran an ordinary least squares regression model with performance as the dependent variable, in order to check the variance inflation factor (VIF). The VIF was less than 4.0 for all variables and within acceptable levels (Neter et al., 1996). In addition, in our fieldwork respondents indicated that they could easily differentiate between the frequency of their face-to-face and electronic interactions with others, and they considered those types of contacts as distinct.

Hypothesis Testing. We used hierarchical linear modeling (HLM) to test our hypotheses. HLM has been used for analyzing network data (Cross and Cummings, 2004) as well as multilevel relationships (Seibert et al., 2004) when the primary level of analysis (the individual) is nested within a higher level (teams). Multilevel models in HLM have increased power and unbiased estimates compared to single level models used with the same data (Raudenbush and Bryk, 2002). We ran a two-level HLM analysis (individual and team) to test the models.

To determine if there was sufficient *between-team* variance to justify multilevel modeling, we ran a null model with performance as the dependent variable and no predictors (Luke, 2004). The intra-class coefficient was 9.5%, with the chi-squared test indicating that the between group variance was significantly different from zero (p-value < 0.01). We then fit three models with three different dependent variables: face-to-face centrality (Model 1), ICT centrality (Model 2) and performance (Model 3). In multilevel modeling model fit is assessed through the change in residual variance at each level and change in deviance (-2 log likelihood). The former is termed the pseudo-R^2 and is interpreted in a similar manner as the traditional R^2 statistic (Snijders and Bosker, 1994).

--- Insert Tables 3 and 4 about here ---

Results

The results are shown in Table 4. The fit of the models is good and statistically significant, as assessed by the change in the deviance statistic. The individual level R^2 in models 1 through 3 (row 22) is 37%, 34% and 18% respectively. The group level R^2 (row 24) is 68%, 68% and 41%.

Virtuality and face-to-face centrality. The results of model 1 are used to test hypotheses 1a through 1d regarding the influence of virtuality on face-to-face centrality. The negative and significant coefficients of spatial dispersion (row 13, b=-0.02, p<0.01) and configurational dispersion (row 14, b=-23.17, p<0.001) support H1a and H1b. There is no support for hypotheses H1c and H1d regarding the negative influence of temporal dispersion and ICT use on face-to-face centrality. The control variables of team tenure (row 8, b=0.12, p<0.05) and total communication (row 12, b=0.14, p<0.05) are positively related to face-to-face centrality. The control variables of job title tenure (row 7, b=-0.11, p<0.01) and team size (row 19, b=-1.04, p<0.01) are negatively related to face-to-face centrality.

Virtuality and ICT centrality. The results of model 2 are used to test hypotheses 2a through 2d regarding the influence of virtuality on ICT centrality. The coefficients of spatial dispersion, configurational dispersion and temporal dispersion are not significant. This suggests a lack of support for H2a, H2b and H2c. The positive, significant coefficient of ICT use (row 16, $b=15.92$, $p<0.01$) supports H2d. The control variable of trust (row 11, $b=0.27$, $p<05$) is positively related to ICT centrality. The control variables of job title tenure (row 7, $b=-0.08$, $p<0.05$) and team size (row 19, $b= -1.53$, $p<0.01$), are negatively related to ICT centrality.

Centrality and performance. The results of model 3 are used to test hypotheses 3a and 3b, regarding the positive influence of face-to-face centrality on performance and ICT centrality on performance. Hypothesis 3a is not supported; the coefficient of face-to-face centrality (row 17) is not significant. Hypotheses 3b is supported. ICT centrality (row 18, $b=16137.20$, $p<0.01$) is positively related to performance. Another result in model 3 is that configurational dispersion (row 14, $b=9242.30$, $p<0.05$) is positively related to performance. The control variables of organizational tenure (row 9, $b=63.32$, $p<0.01$), education (row 10, $b=4811.41$, $p<0.01$) and trust (row 11, $b=303.74$, $p<0.01$) are positively related to performance.

Discussion

We find that the varying effects of virtuality on individual performance are due, at least in part, to differences in the individual's position in face-to-face and ICT networks. Team members who have the least spatial and configurational dispersion are most central in the face-to-face network. Team members with the highest ICT use are most central in the ICT networks. Spatial, temporal, and configurational dispersion are not related to centrality in the ICT network. Furthermore, centrality in the ICT network is positively related to performance, whereas

centrality in the face-to-face network is unrelated to performance. Unexpectedly, configurational dispersion is also positively related to performance. Next we discuss these results in detail.

In interpreting our findings, we suggest how virtuality both negatively and positively influences outcomes in distributed teams. Virtuality's negative effect on face-to-face interaction, often cited by research (Kraut et al., 2002), is supported in our study. Virtuality likely hampers face-to-face centrality through two mechanisms: physical distance and contextual distance. Centrality in a face-to-face network requires more than just reduced physical distance between team members. It also requires a shared context that facilitates development of mutual understanding and 'knowing who knows what', which can increase the frequency of direct access and increase referrals that create new contacts. Even in on-going distributed teams, where team membership and physical locations are relatively stable, lack of shared context creates a barrier to face-to-face centrality. This was evidenced in our interviews with team members. One respondent, whose team's sites were dispersed within the same city, remarked: "*I can't believe how different they do things over at (the other location). Whenever I talk to them it's like they don't get it. I just try to avoid (meeting with) them*." For managers the finding suggests that just getting team members physically together occasionally is not enough. Rather team members need to understand differences in contexts across sites and work toward establishing common processes that facilitate on-going face-to-face interaction.

Centrality in an ICT network is unaffected by an individual's level of dispersion from other team members. The level of ICT use is the only dimension of virtuality significantly related to ICT centrality. In on-going teams, extensive users of ICT are likely to communicate with team members who reciprocate by contacting them electronically as well. Other studies have found that over time, individuals learn how to effectively use ICT to communicate (Walther, 1995).

Interviews with team members indicate that they had learned to leverage ICT in a dispersed environment. One member remarked "*If I need to talk to someone, I can't wait for face-to-face meetings. I use e-mail all the time. It's a lot more efficient and (my team members) know they need to get in touch with me that way too.*" For managers the finding highlights the importance of encouraging and facilitating the use of ICT's.

We also find that ICT centrality is positively related to individual performance. However there is no evidence that face-to-face centrality influences performance. Why might this be so? The answer may reside in the timing and access benefits of the two types of communication. The access benefits derived from face-to-face centrality are limited to the information provided by proximal others, who share the same context. In contrast individuals who are central in the ICT network likely have access to contacts in a variety of locations. Contacts in diverse locations often bring new information to individuals that benefit performance (Reagans and McEvily, 2003). In addition, the egalitarian nature of many ICT's facilitates access to resources that might be constrained due to the more hierarchical nature of face-to-face communication (Sproull and Kiesler, 1986). Thus the contacts and high centrality in an ICT network could be more beneficial than centrality in the face-to-face network. The timing benefits associated with ICT centrality may also be advantageous. If the expertise required to complete a task is dispersed in distributed teams, timely access to non-proximal resources as well as the ability to send and receive information at any time, could be more critical to performance than the increased spontaneity and attention associated with interacting face-to-face with others. High performing individuals may have found that the ICT network is the fastest way to get the information they need to do their jobs. As the team member above remarked, "*If I need to talk to someone, I can't wait for face-to-face meetings".*

One unexpected finding is configurational dispersion's positive relationship with individual performance. There are two possible explanations for this finding. First, research in the area of telework has found that that working away from coworkers can be beneficial to individual productivity due to a reduction in distractions and by allowing greater focus on tasks (Bélanger, 1999; Kurland and Bailey, 1999). In our model, the bivariate correlation between configurational dispersion and performance was non-significant. The significant positive relationship emerged only after controlling for both face-to-face and ICT network centrality. A second explanation may be that individuals who are chosen to or who are allowed to work away from other team members are the higher performing individuals. Often managers of distributed teams, including several in this study, have the option of who to include on a team, as well as a choice of where they are located. Individuals allowed to work away from team members could be those who are most effective as distributed workers.

The combination of results provides insight into why the use of distributed teams continues to grow despite the challenges of physical and configurational dispersion. Through increased ICT use and the leveraging of ICT networks, distributed teams can derive the benefits of ICT networks and enhance individual performance.

Limitations

These results need to be interpreted in light of the limitations of the study. The results could have been influenced by omitted variables, such as the nature of work as well as team and organizational differences that were not included. Organizational culture, managerial style, and team norms are factors that potentially influence communication and performance. Several controls including country, industry, emotional closeness and group total communication were

tested, but had no substantive effect on the results. Those controls were removed to keep the models parsimonious. In addition, the generalizability of our results is limited by studying one ICT network, rather than separate networks for each type of ICT used. During the pilot test respondents found it difficult to differentiate between whom they contacted via types of ICT's such as telephone, email, chat, or video conferencing. Therefore in the final survey respondents were only asked to differentiate between face-to-face and ICT contacts. Future research based on multiple ICT network types could be fruitful.

Contributions and Future Research

This study makes several contributions to theory related to distributed teams, the role of ICT's and social networks. The study underscores the utility of recognizing the influence of *individual virtuality*. We highlight the multiple dimensions of virtuality that differ in their relationship with an individual's position in team networks. We are also among the first to empirically test the measures of dispersion suggested by O'Leary and Cummings (2007) and the first to offer an operationalization of those measures at the individual level.

Our findings provide a finer grain understanding of the effects of ICT use, which in prior research has often been viewed as negatively affecting performance due to its leanness and low bandwidth (Barry and Fulmer, 2004). Our results suggest that such conclusions may be mistaken because ICT use often occurs along with physical and configurational dispersion, that each have independent influences on outcomes. The findings on the relationship between centrality and performance also contribute to better understanding employee development in a virtual work setting, an area that has been understudied (Bélanger et al., 2002). Finally, our work contributes to social network theory by highlighting an individual's centrality in the ICT network as a factor

influencing performance, emphasizing the importance of differentiating networks based on communication mode. The ICT network offers benefits in the timing and access to information which can be critical to performance.

Table 1
Comparison of Access and Timing Benefits by Network Type

Network Type	General Characteristics Compared to other mode	Access Benefit	Timing Benefit
Face-to-Face	Interaction more likely when proximate More spontaneous than ICT Facilitates knowing who knows what	Increased number and frequency of contact to collocated others Access limited to proximal, primarily collocated others	Improved timing of access to proximal others through spontaneity and increased attention of the recipient Ex: easier to call spontaneous meeting, chat in hall
ICT	Spans spatial and temporal boundaries, which can increase contact Enables asynchronous communication, which can increase contact and improve timing	Access to team member regardless of proximity	More timely access to non-proximal resources; ability to send information as soon as received Ex: don't have to wait for others to be proximal; don't have to get others' attention to communicate

Table 2
Constructs, Measures and Loadings in the Measurement Model

Constructs	Measures	Std. Loading	Composite Reliability	AVE
Spatial dispersion	Sum of the difference in miles between an individual and his team members	1.00		
Configurational dispersion	Ratio of team members collocated with individual divided to team size			
Temporal dispersion	Sum of time zones differences between an individual and her team members			
ICT Use	Ratio of hours spent communicating electronically divided to total hours spent communicating (per week)	1.00		
Face-to-Face Centrality	Individual level of centrality in the face-to-face sociomatrix	1.00		
ICT Centrality	Individual level of centrality in the ICT sociomatrix	1.00		
Job Tenure	Number of months of individual tenure in the job	1.00		
Team Tenure	Number of months of individual tenure on the team	1.00		
Organization Tenure	Number of months of individual tenure in the organization	1.00		
Education	Categorical variable representing level of education	1.00		
Trust	I trust my coworkers to consider my view when making decisions that may affect me	0.79	0.76	0.52
	I trust my coworkers to take care of my interests, even when I am not present.	0.80***		
	I trust my supervisor to take care of my interests, even when I am not present.	0.55***		
Total Communication	Number of hours spent communicating each week	1.00		
Team Size	Number of individuals in the team	1.00		
Task Complexity	Average of task interdependence and task variety	1.00		
Performance	Adequately completes assigned duties	0.79	0.90	0.65
	Fulfills responsibilities specified in job description	0.93***		
	Performs tasks that are expected of him/her	0.81***		
	Meets formal performance requirements of job	0.87***		
	Neglects aspects of the job he/she is obligated to perform[a]	0.58***		

*** significant at $p \leq .001$; [a]Scored in reverse

Table 3
Correlations, Means, Standard Deviations, Minimum, Maximum Values

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1	Spatial Dispersion															
2	Configurat. Dispersion	0.13*														
3	Temporal Dispersion	0.46**	0.19**													
4	ICT Use	0.11	0.20**	0.17**												
5	Face-to-Face Centrality	-0.14*	-0.49**	-0.19**	-0.06											
6	ICT Centrality	0.25**	-0.24**	0.05	0.14*	0.58**										
7	Performance	-0.03	0.03	-0.02	0.00	0.09	0.21**									
8	Job Title Tenure	-0.13*	-0.18**	-0.08	-0.06	0.06	0.08	0.16**								
9	Team Tenure	-0.16**	-0.28**	-0.15*	-0.14*	0.29**	0.20**	0.17**	0.55*							
10	Org. Tenure	-0.15*	-0.25**	-0.17**	-0.15*	0.29**	0.27**	0.24**	0.56**	0.64**						
11	Education	-0.22**	0.04	-0.30**	-0.04	0.09	-0.02	0.08	-0.10	0.03	0.07					
12	Trust	0.01	-0.05	-0.01	-0.01	-0.01	0.11	0.22**	0.05	0.07	0.03	-0.05				
13	Total Comm.	0.26**	0.16*	0.19**	0.20**	0.03	0.14*	0.00	-0.08	-0.07	-0.06	-0.03	0.00			
14	Team Size	-0.38**	0.28**	0.21**	0.07	-0.32**	-0.44**	0.03	-0.19**	-0.21**	-0.40**	-0.10	0.06	-0.02		
15	Task Complexity	-0.27**	-0.02	-0.50**	-0.28**	-0.14	-0.20**	-0.11	0.15*	0.28**	0.10	0.31**	-0.05	-0.04	-0.28**	
	Mean	166.59	0.45	21.59	0.52	0.28	0.31	5.65	31.00	27.11	53.54	2.03	5.28	25.42	18.47	5.74
	S.D.	346.68	0.31	40.80	0.20	0.17	0.19	0.89	40.51	33.85	67.57	1.17	1.04	19.78	7.10	2.52
	Min.	0.00	0.00	0.00	0.00	0.00	0.01	2.33	1.00	1.00	1.00	1.00	2.00	1.00	4.00	4.25
	Max.	2153.00	0.96	221.00	1.00	0.80	0.96	7.00	312.00	192.00	338.00	4.00	7.00	57.00	25.00	6.25

**p≤.01; *p≤.05; two tailed tests

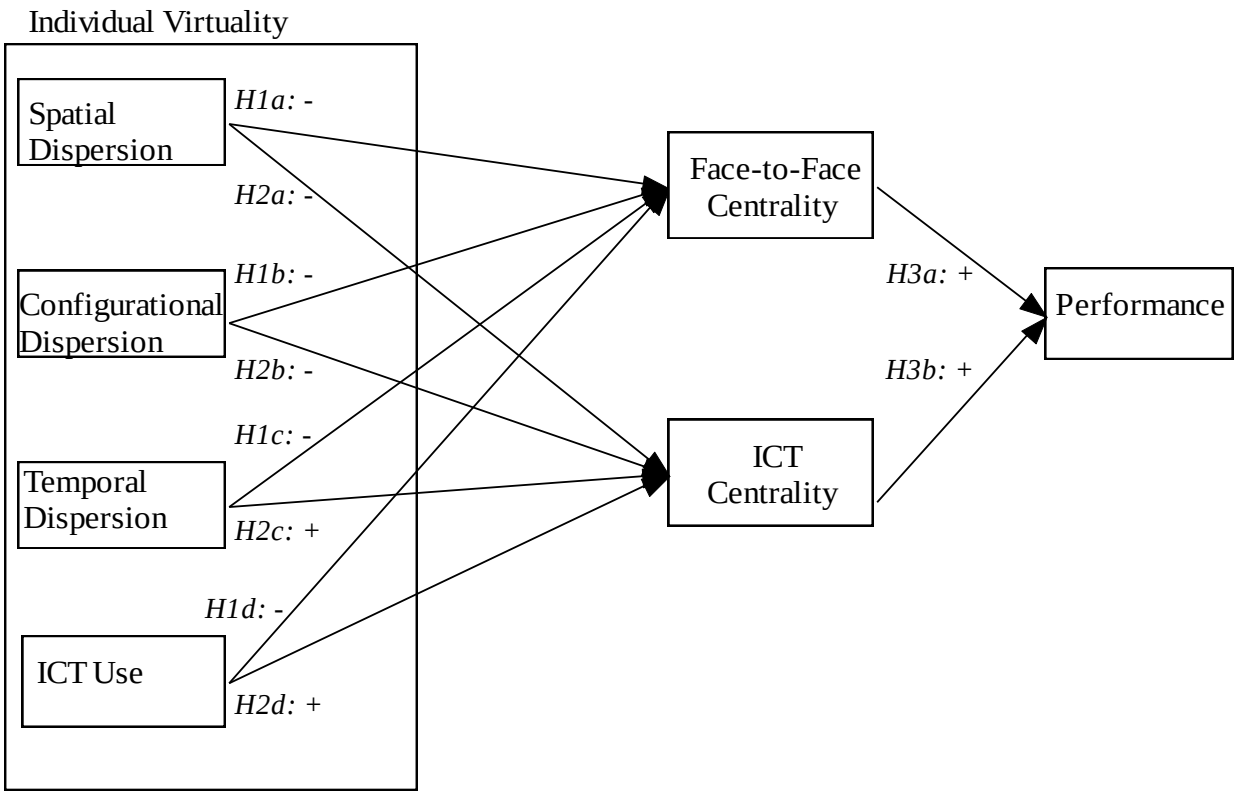
Table 4 Virtuality, Centrality and Performance

Row #		Model 1 DV =F-to-F Centrality	Model 2 DV = ICT Centrality	Model 3 DV = Performance
	Baseline Model			
1	Individual Level Residual Variance	3.36	3.89	249146108.21
2	Team Level Residual Variance	1.08	2.02	26207692.41
3	Intraclass Correlation (ICC)	0.24	0.34	0.10
4	Group level variance p-value	0.000	0.000	0.001
5	Deviance (-2LL)	-109.52	-65.43	5627.67
	Individual Level Intercept & Control Variables			
	Unstandardized Coeff (std error)			
6	Intercept	**36.47*** **	**41.71*** **	**40474.86*** **
		(1.39)	**(2.04)**	**(1263.26)**
7	Job Title Tenure	**-0.11****	**-0.08***	9.03
		(0.03)	**(0.04)**	(30.63)
8	Team Tenure	**0.12***	0.07	-8.59
		(0.04)	(0.05)	(40.89)
9	Organizational Tenure	0.02	0.05	**63.32****
		(0.03)	(0.03)	**(22.50)**
10	Education	1.28	1.12	**4811.41****
		(1.80)	(2.15)	**(1613.29)**
11	Trust	-0.05	**0.27***	**303.74****
		(0.11)	**(0.12)**	**(97.32)**
12	Total Communication	**0.14***	0.10	12.16
		(0.06)	(0.07)	(50.29)
	Individual Level Variables			
13	Spatial Dispersion	**-0.02****	0.00	-0.56
		(0.01)	(0.01)	(4.52)
14	Configurational Dispersion	**-23.17*** **	-11.18	**9242.30***
		(4.37)	(5.77)	**(4129.51)**
15	Temporal Dispersion	0.01	0.10	8.68
		(0.05)	(0.06)	(45.08)
16	ICT Use	1.74	**15.92***	-1724.93
		(5.82)	**(6.90)**	(5331.17)
17	Face-to-Face Centrality			179.31
				(6915.31)
18	ICT Centrality			**16137.2****
				(5942.83)
	Team Level Variables			
19	Team Size	**-1.04****	**-1.53****	387.64
		(0.25)	**(0.37)**	(237.75)
20	Task Complexity	0.07	0.26	594.75
		(0.74)	(1.04)	(662.76)
	Final Model			
21	Individual Level Residual Variance	2.81	3.63	226859704.12
22	Individual Level Pseudo-R^2	0.37	0.34	0.18
23	Team Level Residual Variance	0.01	0.27	168596.83
24	Team Level Pseudo-R^2	0.68	0.68	0.41
25	Deviance	-58.72	11.09	5398.60
	Change in Residual Variance			
26	ΔIndividual Level Residual Variance	0.55	2.65	22286404.09
27	ΔTeam Level Residual Variance	1.07	1.75	26039095.57
28	Δ2LL (significant at .05)[a]	**-50.80**	**-76.52**	**229.07**

* p<.05, **p<.01, ***p<.001. Standard errors in parentheses.

[a] Based on a chi-square distribution with 11, 11, 13 degrees of freedom for Models 1, 2, 3 respectively

Figure 1
Research Model



References

Ahuja, M., Galletta, D. & Carley, K. (2003) Individual Centrality and Performance in Virtual R&D Groups: An Empirical Study. ***Management Science,*** **Vol. 49, No. 1, pp. 21-39.**

Allen, T. J. (1977) ***Managing the Flow of Technology,*** **MIT Press, Cambridge, MA.**

Armstrong, D. & Cole, P. (2002) Managing Distances and Differences in Geographically Distributed Work Groups. IN Hinds, P. & Kiesler, S. (Eds.) ***Distributed Work.*** **MIT Press, Cambridge, MA, pp. 167-189.**

Barry, B. & Fulmer, I. S. (2004) The Medium and the Message: The Adaptive Use of Communication Media in Dyadic Influence. ***Academy of Management Journal,*** **Vol. 29, No. 2, pp. 272-292.**

Bélanger, F. (1999) Workers' propensity to telecommute: An empirical study. ***Information & Management,*** **Vol. 35, No. 3, pp. 139-153.**

Bélanger, F., Watson-Manheim, M. & Jordan, D. (2002) Aligning IS Research and Practice: A Research Agenda for Virtual Work. ***Information Resources Management Journal,*** **Vol. 15, No. 3, pp. 48-70.**

Bell, B. S. & Kozlowski, S. (2002) A Typology of Virtual Teams: Implications for Effective Leadership. ***Group & Organization Management,*** **Vol. 27, No. 1, pp. 14-49.**

Boh, W. F., Ren, Y., Kiesler, S. & Bussjaeger, R. (2007) Expertise and Collaboration in the Geographically Dispersed Organization. ***Organization Science,*** **Vol. 18, No. 4, pp. 595-612.**

Borgatti, S. & Cross, R. (2003) A Relational View of Information Seeking and Learning in Social Networks. ***Management Science,*** **Vol. 49, No. 4, pp. 432-445.**

Borgatti, S. P., Mehra, A., Brass, D. J. & Labianca, G. (2009) Network Analysis in the Social Sciences. ***Science,*** **Vol. 323, No. 892-895.**

Brass, D., Galaskiewicz, J., Greve, H. & Tsai, W. (2004) Taking Stock of Networks and Organizations: A Multilevel Perspective. ***Academy of Management Journal,*** **Vol. 47, No. 6, pp. 795-817.**

Brass, D. J. (1984) Being in the Right Place: A Structural Analysis of Individual Influence in an Organization. ***Administrative Science Quarterly,*** **Vol. 29, No. 4, pp. 518-539.**

Burgoon, J. K., Bonito, J. A., Ramirez, A., Dunbar, N. E., Kam, K. & Fischer, J. (2002) Testing the Interactivity Principle: Effects of Mediation, Propinquity, and Verbal and Nonverbal Modalities in Interpersonal Interaction. ***Journal of Communication,*** **Vol. 52, No. 3, pp. 657-677.**

Burkhardt, M. & Brass, D. (1990) Changing Patterns or Patterns of Change: The Effects of a Change in Technology on Social Network Structure and Power. ***Administrative Science Quarterly,*** **Vol. 35, No. 1, pp. 104-127.**

Burt, R. (1991) ***STRUCTURE Reference Manual,*** **Columbia University, New York, NY.**

Burt, R. (1992) ***Structural Holes: The Social Structure of Competition,*** **Harvard University Press, Cambridge, MA.**

Chudoba, K., Wynn, E., Lu, M. & Watson-Manheim, M. B. (2005) How virtual are we? Measuring virtuality and understanding its impact in a global organization. ***Information Systems Journal,*** **Vol. 15, No. 279-306.**

Clark, H. & Brennan, S. (1990) Grounding in Communication. IN Resnick, L., Levine, J. & Teasley, S. (Eds.) ***Perspectives on Socially Shared Cognition.*** **APA Press, Washington, D.C., pp. 127-149.**

Cohen, S. G. & Gibson, C. B. (2003) In the Beginning. IN Gibson, C. & Cohen, D. (Eds.) ***Virtual Teams that Work.*** **Jossey-Bass, San Francisco, pp. 1-17.**

Coleman, J. S. (1990) ***Foundations of Social Theory,*** **Belknap Press, Cambridge, MA.**

Cramton, C. (2001) The Mutual Knowledge Problem and Its Consequences for Dispersed Collaborations. ***Organization Science,*** **Vol. 12, No. 3, pp. 346-371.**

Cross, R. & Cummings, J. (2004) Tie and Network Correlates of Individual Performance in Knowledge-Intensive Work. ***Academy of Management Journal,*** **Vol. 47, No. 6, pp. 928-937.**

Cucchi, A. & Fuhrer, C. (2007) Lifting the Veil on Organizational Structure: A Social Network Analysis of Professional E-mail Use. ***Communications of the Association for Information Systems,*** **Vol. 20, No. 282-299.**

Cummings, J. (2004) Work Groups, Structural Diversity, and Knowledge Sharing in a Global Organization. ***Management Science,*** **Vol. 50, No. 3, pp. 352-364.**

Cummings, J. & Cross, R. (2003) Structural properties of work groups and their consequences for performance. ***Social Networks,*** **Vol. 25, No. 197-210.**

Espinosa, J. A. & Carmel, E. (2004) The Impact of Time Separation on Coordination in Global Software Teams: a Conceptual Foundation. ***Software Process Improvement and Practice,*** **Vol. 8, No. 4, pp. 249-266.**

Finholt, T. & Sproull, L. (1990) Electronic Groups at Work. ***Organization Science,*** **Vol. 1, No. 1, pp. 41-64.**

Fornell, C. & Larcker, D. (1981) Evaluating Structural Equation Models with Unobservable Variables and Measurement Error. ***Journal of Marketing Research,*** **Vol. 18, No. 39-50.**

Gibbons, D. (2004) Friendship and Advice Networks in the Context of Changing Professional Values. ***Administrative Science Quarterly,*** **Vol. 49, No. 238-262.**

Gibson, C. & Gibbs, J. (2006) Unpacking the Concept of Virtuality: The Effects of Geographic Dispersion, Electronic Dependence, Dynamic Structure, and National Diversity on Team Innovation. ***Administrative Science Quarterly,*** **Vol. 51, No. 451-495.**

Goodhue, D. L. & Thompson, R. L. (1995) Task-technology Fit and Individual Performance. ***MIS Quarterly,*** **Vol. 19, No. 2, pp. 213=236.**

Griffith, T. L. & Neale, M. A. (2001) Information Processing in Traditional, Hybrid and Distributed Teams: From Nascent Knowledge to Transactive Memory. IN Sutton, R. I. & Staw, B. M. (Eds.) ***Research in Organizational Behavior.*** **JAI Press, Stamford, CT, pp. 379-421.**

Griffith, T. L., Sawyer, J. E. & Neale, M. A. (2003) Virtualness and Knowledge in Teams: Managing the Love Triangle of Organizations, Individuals, and Information Technology. ***MIS Quarterly,*** **Vol. 27, No. 2, pp. 265-287.**

Haythornthwaite, C. (2001) Exploring Multiplexity: Social Network Structures in a Computer-Supported Distance Learning Class. ***The Information Society,*** **Vol. 17, No. 21, pp. 211-226.**

Hiltz, S., Johnson, K. & Turoff, M. (1986) Experiments in Group Decision Making: Communication Processes & Outcomes in Face-to-Face vs. Computerized Conferences. ***Human Communication Research,*** **Vol. 13, No. 225-252.**

Hinds, P. & Bailey, D. (2003) Out of Sight, Out of Sync: Understanding Conflict in Distributed Teams. ***Organization Science,*** **Vol. 14, No. 6, pp. 615-632.**

Hinds, P. & Mcgrath, C. (2006) Structures that Work: Social Structure, Work Structure and Coordination Ease in Geograpically Distributed Teams. ***Proceedings of the 2006 20th Anniversary Conference on Computer Supported Cooperative Work.*** **Banff, Alberta, Canada, Association for Computing Machinery.**

Hinds, P. & Mortensen, M. (2005) Understanding Conflict in Geographically Distributed Teams: The Moderating Effects of Shared Identity, Shared Context and Spontaneous Communication. ***Organization Science,*** **Vol. 16, No. 3, pp. 290-307.**

Jarvenpaa, S., Knoll, D. & Leidner, D. (1998) The Implications of Trust in Global Virtual Teams. ***Journal of Management Information Systems,*** **Vol. 14, No. 4, pp. 29-64.**

Kirkman, B. L., Rosen, B., Tesluk, P. E. & Gibson, C. B. (2004) The Impact of Team Empowerment on Virtual Team Performance: The Moderating Role of Face-to-Face Interaction. ***Academy of Management Journal,*** **Vol. 47, No. 2, pp. 175-192.**

Knoke, D. & Burt, R. (1983) Prominence. IN Burt, R. S. & Minor, M. J. (Eds.) ***Applied Network Analysis: A Methodological Introduction.*** **Sage, Beverly Hills, CA, pp. 195-222.**

Kraut, R. E., Fussell, S. R., Brennan, S. E. & Siegel, J. (2002) Understanding Effects of Proximity on Collaboration: Implications for Technologies to Support Remote Collaborative Work. IN Hinds, P. & Kiesler, S. (Eds.) ***Distributed Work.*** **MIT Press, Cambridge, MA, pp. 139-162.**

Kurland, N. B. & Bailey, D. E. (1999) When workers are here, there, and everywhere: a discussion of the advantages and challenges of telework. ***Organizational Dynamics,*** **Vol. Autumn, No. 53-68.**

Luke, D. (2004) ***Multilevel Modeling,*** **Sage, Thousand Oaks, CA.**

Majchrzak, A., Malhotra, A. & John, R. (2005) Perceived Individual Collaboration Know-How Development through Information Technology-Enable Contextualization: Evidence from Distributed Teams. ***Information Systems Research,*** **Vol. 16, No. 1, pp. 9-27.**

Maznevski, M. & Chudoba, K. (2000) Bridging Space over Time: Global Virtual Team Dynamics and Effectiveness. ***Organization Science,*** **Vol. 11, No. 5, pp. 473-492.**

Monge, P. & Contractor, N. (2003) ***Theories of Communication Networks,*** **Oxford Univ., New York, NY.**

Monge, P. R., Rothman, L. W., Eisenberg, E. M., Miller, K. I. & Kirste, K. K. (1985) The Dynamics of Organizational Proximity. ***Management Science,*** **Vol. 31, No. 9, pp. 1129-1141.**

Morris, S. A., Marshall, T. E. & Rainer, R. K. (2002) Impact of User Satisfaction and Trust on Virtual Team Members. ***Information Resources Management Journal,*** **Vol. 15, No. 2, pp. 22-30.**

Mortensen, M. & Hinds, P. (2001) Conflict and Shared Identity in Geographically Distributed Teams. ***International Journal of Conflict Management,*** **Vol. 12, No. 3, pp. 212-238.**

Nardi, B. (2005) Beyond Bandwidth: Dimensions of Connection in Interpersonal Communication. ***Computer Supported Cooperative Work,*** **Vol. 14, No. 91-130.**

Nardi, B. A. & Whittaker, S. (2002) The Place of Face-to-Face Communication in Distributed Work. IN Hinds, P. & Kiesler, S. (Eds.) ***Distributed Work.*** **MIT Press, Cambridge, MA, pp. 83-110.**

Neter, J., Kutner, M., Nachtsheim, C. & Wasserman, W. (1996) ***Applied Linear Statistical Models,*** **Irwin, Homewood, IL.**

O'leary, M. & Cummings, J. (2007a) The Spatial, Temporal and Configurational Characteristics of Geographic Dispersion in Teams. ***MIS Quarterly*** **Vol. 31, No. 3, pp.**

O'leary, M. & Cummings, J. (2007b) The Spatial, Temporal and Configurational Characteristics of Geographic Dispersion in Teams. ***MIS Quarterly,*** **Vol. 31, No. 3, pp. 433-452.**

Oh, H., Curley, S. & Subramani, M. (2008) The Death of Distance?: The influence of computer mediated communication on perceptions of distance. ***Twenty Ninth International Conference on Information Systems.*** **Paris.**

Olson, G. & Olson, J. (2000) Distance Matters. ***Human-Computer Interaction,*** **Vol. 15, No. 139-178.**

Ramirez, A., Walther, J. B., Burgoon, J. K. & Sunnafrank, M. (2002) Information-Seeking Strategies, Uncertainty, and Computer-Mediated Communication: Toward a Conceptual Model. ***Human Communication Research,*** **Vol. 28, No. 2, pp. 213-228.**

Raudenbush, S. & Bryk, A. (2002) ***Hierarchical Linear Models: Applications and Data Analysis Methods,*** **Sage, Thousand Oaks, CA.**

Reagans, R. & Mcevily, B. (2003) Network Structure and Knowledge Transfer: The Effects of Cohesion and Range. ***Administrative Science Quarterly,*** **Vol. 48, No. 240-267.**

Saunders, C. S. & Ahuja, M. K. (2006) Are All Distributed Teams the Same? Differentiating Between Temporary and Ongoing Distributed Teams. ***Small Group Research,*** **Vol. 37, No. 662-700.**

Seibert, S. E., Silver, S. & Randolph, W. A. (2004) Taking Empowerment to the Next Level: A Multiple-Level Model of Empowerment, Performance, and Satisfaction. ***Academy of Management Journal,*** **Vol. 47, No. 3, pp. 332-349.**

Slaughter, S. A. & Kirsch, L. J. (2006) The Effectiveness of Knowledge Transfer Portfolios in Software Process Improvement: A Field Study. ***Information Systems Research,*** **Vol. 17, No. 3, pp. 301-320.**

Snijders, T. & Bosker, R. (1994) Modeled Variance in Two-Level Models. ***Sociological Methods & Research,*** **Vol. 22, No. 3, pp. 343-363.**

Sparrowe, R., Liden, R., Wayne, S. & Kraimer, M. (2001) Social Networks and the Performance of Individuals and Groups. ***Academy of Management Journal,*** **Vol. 44, No. 2, pp. 316-325.**

Sparrowe, R., Liden, R., Wayne, S. & Kraimer, M. (2003) Social Networks and the Performance of Individuals and Groups. ***Academy of Management Journal,*** **Vol. 44, No. 2, pp. 316-325.**

Sproull, L. & Kiesler, S. (1986) Reducing Social Context Cues: Electronic Mail in Organizational Communication. ***Management Science,*** **Vol. 32, No. 11, pp. 1492-1512.**

Walther, J. B. (1995) Relational Aspects of Computer-Mediated Communication: Experimental Observations over Time. ***Organization Science,*** **Vol. 6, No. 2, pp. 186-203.**

Wasko, M. & Faraj, S. (2005) Why Should I Share? Examining Social Capital and Knowledge Contribution in Electronic Networks of Practice. ***MIS Quarterly,*** **Vol. 29, No. 1, pp. 35-57.**

Wellman, B., Salaff, J., Dimitrova, D., Garton, L., Gulia, R. & Haythornthwaite, C. (1996) Computer Networks as Social Networks: Collaborative Work, Telework and Virtual Community. ***Annual Review of Sociology,*** **Vol. 22, No. 213-238.**

Williams, L. J. & Anderson, S. E. (1991) Job Satisfaction and Organizational Commitment as Predictors of Organizational Citizenship and In-Role Behaviors. ***Journal of Management,*** **Vol. 17, No. 3, pp. 601-617.**

Zack, M. & Mckenney, J. (1995) Social Context and Interaction in Ongoing Computer-support Management Groups. ***Organization Science,*** **Vol. 6, No. 4, pp. 394-421.**