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SOCIAL NETWORKS AND TRANSACTIVE MEMORY IN HUMAN–COMPUTER INTERACTION

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Abstract

This study investigates the phenomenon of transactive memory by examining trust networks and social presence in human-computer interaction. Traditional theories suggest that transactive memory can be developed by structural mechanisms that increase knowledge specialization and task coordination, but more recent research also suggests that it can be enhanced through social network mechanisms and close relationships such as trust. In this empirical study, 240 participants were randomly assigned to 3-member teams working on a business-simulation task. The results indicate that dense trust networks had a greater impact on transactive memory than sparse trust networks. When social presence was low, team members in dense trust networks developed greater transactive memory. When social presence was high, team members in sparse trust networks developed greater transactive memory. More reciprocal exchanges were found in teams with dense trust networks, but more negotiated exchanges were found in teams with sparse trust networks.

Keywords: Transactive memory, trust networks, social presence, social exchanges

Introduction

Transactive memory refers to the division of cognitive labor through a shared system of encoding, storage, retrieval, and communication of information from different knowledge domains. Research on cognitive knowledge networks and shared mental models has theorized transactive memory as a mechanism to coordinate activities in dispersed teams and a critical factor of team effectiveness (Argote 1999; Brandon and Hollingshead 2004). A significant portion of one's knowledge is derived from trust relationships and social exchanges. However, prior research in this area has considered the development of such models exclusively within traditional face-to-face teams and has not fully addressed the impact of human-computer interaction on the development of transactive memory. The lack of rich social cues in technology-mediated teams suggests the need for a high degree of communication governed by trust and social norms.

This raises the question about how social relationships in dense and sparse networks affect social and information exchanges. The phenomenal increase in studies investigating trust indicates the belief that problems regarding motivation to share knowledge can be overcome by entrusting information sharing activities to social mechanisms. Trust refers to the "willingness of a member to be vulnerable to actions of another party based on the expectation that the other will perform a particular action important to the trustor, regardless of the ability to monitor or control the other party" (Jarvenpaa and Leidner 1999, p. 798). The social network perspective has been increasingly adopted in recent studies, but little research has examined the role of trust networks. It is not clear fropm the previous research how trusting ties in such social networks underlie the development of transactive knowledge. This study seeks to explore the influence of trust network density on transactive memory.

By exploring trust networks and transactive memory in computer-supported collaborative work, the research also focuses on technological characteristics such as social presence that may be significant in improving knowledge sharing in a technology-mediated workplace. Social presence refers to "the degree to which the medium facilitates awareness of the other person and interpersonal relationships during the interaction" (Fulk et al. 1990, p. 118). Drawing upon conceptualization from information systems, organizational learning, and social psychology, this paper aims to address three main research questions: (1) What is the influence of trust network density on transactive memory in human-computer interaction? (2) Does the degree of social presence moderate the relationship between trust network density and transactive memory? (3) What types of social exchange exist in different trust networks?

Theory and Hypotheses

Distributed Cognition and Transactive Memory

The concept of distributed cognition highlights the shared division of cognitive labor that enables groups to reach cognitive goals that would be more difficult to attain individually (Faraj and Sproull 2000). Related studies have been conducted on transactive memory (Moreland 1999; Wegner 1987). Team members act autonomously with an understanding of their interdependence (Boland et al. 1994), but the collective knowledge links individual knowledge repositories to the larger knowledge network. Knowledge networks help to explain the diffusion of knowledge across a network of individuals and represent "who knows what" in an organization. Cognitive knowledge networks are similar to the concept of transactive memory, which describes a specialized division of cognitive roles with respect to the encoding, storage, and retrieval of information from different knowledge domains that develop during the course of relationships (Hollingshead 1998). Transactive memory systems are developed through four interrelated processes: expertise recognition, retrieval coordination, directory updating, and information allocation (Moreland 1999).

Effects of Trust Networks on Transactive Memory

Trust is a complex construct with multiple levels and determinants. Rousseau et al. (1998) have noted several commonalities among different definitions, namely (1) risk, (2) expectations or beliefs, and (3) willingness to place oneself at risk with the assumption and expectation that no harm will come to oneself. Trusting ties involve perception of the trustor on the attributes of trustee, mainly (1) competence, a group of skills that enable a trustee to be perceived as competent within some specific domain, (2) integrity, adherence to a set of principles (work habits) thought to make the trustee dependable and reliable, and (3) benevolence, extent to which a trustee is believed to feel interpersonal care and concern, and willingness to do good to the trustor beyond egocentric profit motive (Jarvenpaa et al. 1998). A trusting tie is established when one member believes in the competence, integrity, and benevolence of another member in exchanging information. A set of such trusting ties thus builds up a network of trust relationships. Examining trust relationships around a focal actor helps to determine network density of trusting ties. A dense network of trusting relationships among individuals may facilitate information exchange better than a standalone trusting tie between two people. One critical aspect of social relationships is the network of trusting ties that may be developed over the course of work. Hence, the density of trust networks is likely to influence the development of transactive memory.

In a seminal study, Granovetter (1973) seeded an interest for the role of weak ties in enhancing information exchange. On the other hand, information flows and trust are increased in networks that are dense and consist of strong ties (Coleman 1990). One can trust that another knows the information that one needs (competence), but may not trust that he will be forthcoming at the time when the information is needed (benevolence). Previous results reveal that knowledge exchange is more effective when the knowledge recipient views the knowledge source as being both benevolent and competent. Given the evidence of previous studies, it is likely that teams with dense networks are more willing to share information among trusted others than those networks that are less dense. Transactive memory is hypothesized as a function of the density of trust networks.

> *Hypothesis 1: Individuals in dense trust networks will develop greater transactive memory than those in sparse trust networks.*

Technological Characteristics

What is the role of information technology on trust and transactive memory? An extensive literature on human-computer interaction examined the role of interface in supporting remote communication (e.g., Alavi and Yoo 1997; Jarvenpaa and Leidner 1999; Robey et al. 2000; Townsend et al. 1998). Dispersed teams with similar backgrounds were found to lack *mutual knowledge* of each other's local context and constraints (Cramton 2001). It is generally more difficult for communication to take place in dispersed settings. The removal of visual cues, for example, might have reduced social presence sufficiently to cause group members to pursue self rather than group interests (Sia et al. 2002). A reduction in social presence might cause difficulties in arriving at mutually agreeable communication, and decreasing social construction in the learning process (Carlson and Zmud 1999). This calls for the development of a sense of social presence relating to the technologies in use. Evidently, trust networks are expected to enhance the development of transactive memory when teams are supported by a high degree of social presence among members.

> *Hypothesis 2:* *The influence of trust network density on transactive memory will be positively moderated by social presence supported by the technology.*

The Role of Social Exchange

Some theorists have used social exchange theory as a starting point for examining related areas such as trust and affective ties (Molm et al. 1999). One possible explanation of why trust networks may develop such transactive memory is the underlying social exchanges between members**.** Social exchange theory explains how people obtain valued resources through their interactions with others (Homans 1958). There are several forms of social exchange, including reciprocal exchange (Emerson 1976) and negotiated exchange (Molm et al. 1999). Reciprocal exchange is characterized by direct reciprocation that does not involve explicit bargaining about the nature and timing of reciprocation. Negotiated exchange is characterized by an open discussion of the benefits of receiving or giving. Trust and social exchanges can be strongly associated. For instance, an individual embedded in a dense network of trust relationships is likely to exchange information reciprocally as strong implicit trusting ties have been established. On the other hand, an individual in a sparse network of trust relationships may require explicit and openly negotiated exchanges due to the nature of the weak trusting ties. The existing type of social exchange may explain why trust networks facilitate the development of transactive memory in dense and sparse relations.

Social exchange can be circumscribed by the voluntary actions of individuals who are motivated by the returns these actions are expected to bring. Dense networks of trusting relationships may inculcate a norm of reciprocal exchange that facilitates development of transactive memory. Reciprocal exchanges involve intrinsic obligations and indirect exchanges. In a reciprocal exchange, members' contributions to the exchange of informational resources are performed separately and are not negotiated (Molm et al. 1999). A reciprocal exchange takes places over time when an individual performs sequential and contingent acts that vary in timing and reciprocity. Conventional studies usually investigate such reciprocal exchange relations in social settings (e.g., Blau 1964; Homans 1958). Hence, we predict that networks consisting of denser trusting ties will facilitate reciprocal exchanges that lead to greater transactive memory.

> *Hypothesis 3:* *The influence of trust network density on transactive memory will be positively mediated by reciprocal exchanges between team members.*

Negotiated exchanges involve extrinsic obligations and direct exchanges. In a negotiated exchange, members are usually involved in a joint decision process to determine the terms of exchange (Cook 1987; Molm et al. 1999). Although socially close relationships may encourage greater information exchange, dense trusting ties may inhibit the development of transactive memory because of the taken-for-granted nature of the interaction. Socially isolated members have been found to participate more in discussion and emphasize more of their unique knowledge than socially connected members (Thomas-Hunt et al. 2003). We predict sparse networks to improve transactive memory by creating more negotiated exchanges among team members.

> *Hypothesis 4:* *The influence of trust network density on transactive memory will be negatively mediated by negotiated exchanges between team members.*

Research Method

Overview

A 2 × 2 experimental design was used with two independent variables, *density of trust networks* and *social presence*. There were two types of trust networks: *dense networks*, in which a large number or all of the possible relationships in a team were trusting ties, and *sparse networks*, in which only a few or no trusting ties existed between members. Social presence was operationalized as high or low. Participants in high social presence teams communicated face-to-face while working on their own computer systems, and those in low social presence teams communicated via technological networks without physical contact. This resulted in four treatment conditions: (1) teams with dense networks of trusting ties supported with a high degree of social presence, (2) teams with dense networks of trusting ties supported with a low degree of social presence, (3) teams with sparse networks of trusting ties supported with a high degree of social presence, and (4) teams with sparse networks of trusting ties supported with a low degree of social presence. A trust-building exercise (Jarvenpaa et al. 1998) was first conducted to develop trusting ties within the teams. A social network analysis (Burt 1992) was then applied to determine the density of trusting ties. Each team member played a functional role and was given a hidden profile task (i.e., each member possessed different elements of information essential to the team), and was required to make managerial decisions during the experiment.

Participants

A total of 240 people participated in this experiment. The volunteer participants were undergraduate students at a large university who participated for extra credit in a cross-disciplinary course. There was about the same number of males and females. The average age was 22. These participants had some experience working in teams and with the computers. They were divided into 80 three-member teams, and each experimental treatment involved 20 teams.

Trust Building Exercise

All participants started with a team building exercise that helped to develop trust within the team (Jarvenpaa et al. 1998). Members exchanged information about themselves, including information assessing project-related skills (ability), work habits believed to be compatible with successful effort (integrity), and motivation for contributing to team effort (benevolence). Playing a unique functional role in their hypothetical company, each member was given a description of personal information, professional information (e.g., past job experience, current focus), challenges of working in the given environment, and concerns with regard to completion of project. They were required to provide and share this information with other members in the team. Trusting ties were predetermined using a social network questionnaire that participants completed one day before the start of the experiment. This questionnaire assessed the trust network by requiring each participant to (1) list the names of members whom he/she trusted and (2) indicate how well he/she trusted each member for the three dimensions (ability, integrity, and benevolence) on a seven-point scale. Relationships of those who reciprocally listed each other in the names of the people they trusted and indicated they trusted each other very much in the three dimensions of trust (ability, integrity, benevolence) were assigned as trusting ties. Adopting the social network perspective for computing trust networks, density of trust networks was measured by the presence of third party trust connections around a relationship (Burt 1992).

Task and Procedure

Past research in information sharing has extensively employed tasks in which all team members have equal access to every piece of information. This research is premised on the belief that developing transactive memory is necessary because no single individual possesses all the requisite information to make an informed decision or to successfully carry out a task. Hence, the task involved a business simulation game where information was distributed in the team such that there was a hidden profile. A web-based computer system built on strategic business models was developed to facilitate communication and knowledge sharing. The business game and the system were tested in a pilot study with 36 students randomly assigned to 12 teams that were randomly assigned to each of the 4 experimental conditions. In all treatments, the teams began with the same position in three major functional areas of business: marketing, production and operations, and human resources (Yoo and Kanawattanachai 2001). Each member was randomly assigned to play a role in each of the business areas. The team managed a $200 million company producing networking software, with the goal of maximizing the stock price of the company. Team members discussed how they should run the company to achieve its goal, and were required to make decisions in thethree functional areas. The discussion took place over 4 weeks in the controlled setting, and all teams met once in each week.

Dependent Measures

The survey was administered to the participants every week. As transactive memory, a group-level cognitive concept, appeared to have behavioral attributes that could be assessed by perceptions of individual members (Lewis 2003), a seven-point Likert scale questionnaire adopted from Lewis (2003) was administered to the participants at the end of each week as a surrogate measure of the transactive memory index. To ensure an appropriate level of reliability and validity, constructs were measured using tested items from previous studies. The instrument was also validated based on a two-round sorting procedure of cards with items, with three judges in every round. There were a total of 41 items for the 5 constructs. All items pertaining to the constructs were measured on seven-point interval scales. This questionnaire was randomly administered to 22 participants to pretest the instrument. No changes were made after verification with Cronbach alpha tests and correlation matrices.

To ensure adequate control and internal validity of the experiment, pertinent variables that were not included for analysis were kept consistent. Control variables such as demographic factors were included to suppress the effects of biases in rating. Group size was held constant at three per team. To control for facilitator effects, teams in all treatment conditions had the assistance of a facilitator who helped them only in technical problems, not in the discussion content. The facilitator followed a set of pre-determined agenda items prepared in the form of a script. An *ex post* analysis of participant responses was conducted to ensure no significant differences in facilitator impacts for all treatment conditions. Pertinent factors (e.g., communication frequency) were recorded to investigate potential confounds.

Manipulation Checks

To ensure that the participants were assigned the correct treatment, and that they were paying attention to the experiment, the questionnaires included a section that required the participants to provide information about their team. They were first asked whether they trusted the other team members. Almost all of the teams (98 percent) that had members correctly indicating they had trusting or no trusting ties according to the treatment assignment were included in the data analysis. The participants were also asked to indicate the extent to which the business information they were given was similar to the information given to their team members. There were no significant differences in the perceptions of the team members in terms of the information distribution, which indicated that each team member was holding some unique information that had to be shared in order to come to decisions.

Results

Descriptive statistics and ANOVA test of trust on transactive memory were computed. Main effects of trust networks were found on transactive memory, supporting Hypothesis 1. Dense networks of trusting ties were associated with greater transactive memory than sparse networks of trusting ties. The results also showed significant interaction effects involving trust networks and social presence on transactive memory. Hypothesis 2 was partially supported. As hypothesized for sparse networks, transactive memory was found to be greater when social presence was high ($t = 2.18$, $p < 0.01$). However, contrary to the hypothesis for dense networks, transactive memory was found to be greater when social presence was low ($t = 3.12$, $p < 0.01$). Figure 1 depicts the main and interaction effects of trust networks and social presence on transactive memory.

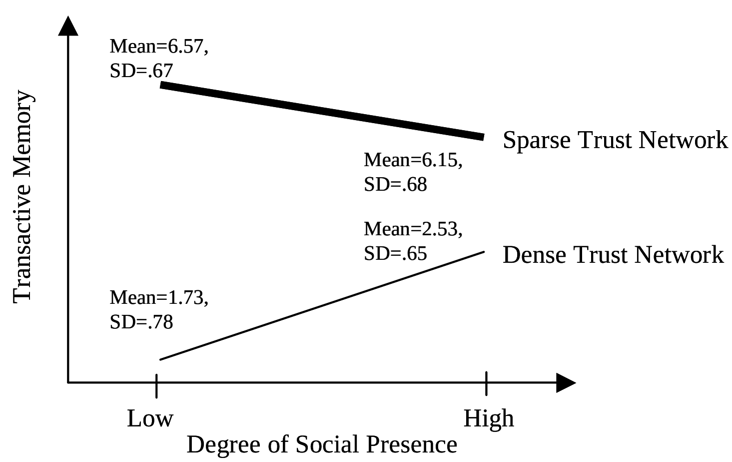


Figure 1. Effects of Trust Networks and Social Presence on Transactive Memory

Mediating effects of reciprocal exchange and negotiated exchange in Hypotheses 3 and 4 were tested using partial least squares (PLS), a structural equation modeling technique that examines path relations of the variables. PLS allowed simultaneous analysis of the relations between the items and each construct, and enabled testing of the hypothesized relations at the theoretical level. The analysis for this study was performed using PLS-Graph. We conducted a rigorous analysis of the proposed research model by validating the measurement model (primarily through factor analysis) and fitting the structural model (primarily through path analysis with latent variables).

Results in Measurement Model

The measurement model assesses each construct in the model and links the items to the construct they measure. In evaluating the measurement model, reflective items measuring the constructs were tested for convergent and discriminant validity. Convergent validity refers to the extent of agreement between two different measures of a theoretical construct. This was assessed by the test of reliability of items, which was determined by a factor analysis of the items for each construct. All factor loadings must be large and statistically significant to ensure convergent validity (Bagozzi 1980). The value of 0.5 was used to indicate adequate reliability (Hair et al. 1998). In assessing internal consistency (a measure of how consistently each item measures the same underlying construct), performance of each of the items was correlated with total performance on the test. This was represented by a correlation coefficient, and measured by applying the Cronbach alpha test to the individual scales and the overall measure (Cronbach 1951). Composite reliability of constructs was also computed, and adequate composite reliability was indicated by the value of 0.8. As a more conservative measure than composite reliability, the average variance extracted by constructs was used to determine the extent to which all the items measuring a construct tap onto the same construct. The value of 0.5 suggests adequate variance extracted (Fornell and Larcker 1981). The results suggest that the hypothesized model met the criteria for convergent validity and internal consistency (see Table 1).

Discriminant validity tests the null hypothesis that two constructs measure the same theoretical concept. In assessing discriminant validity, cross-loadings of an exploratory factor analysis of pooled constructs were examined to ensure that none of the items were loaded higher on constructs other than the intended one. Predictive validity measures how well a test predicts a criterion, and is a type of criterion validity that measures the extent to which the test is related to some criterion. Predictive validity was supported by the high correlations between constructs and their corresponding items. The tests that were evaluated suggest that the hypotheses met the criteria for discriminant validity (see Table 2).

Results in Structural Model

Parameter estimates were computed. The bootstrap resampling procedure was used to conduct tests of significance for all paths. The test of each hypothesis is mapped to each specific path (see Figure 2), and the support of each hypothesis is determined by the direction and statistical significance of the corresponding path. The structural model explained over 20.8 percent of the variance in the endogeneous construct, which has exceeded the recommended value of 10 percent as the indication of explanatory power (Falk and Miller 1992). As each hypothesis corresponded to a path in the structural model, the sign and statistical significance for the corresponding path determined the result of each hypothesis. Figure 2 depicts the results of the path analyses over three weeks.

Discussion

In contrast to the widespread adoption of computer software supporting distributed work, more research needs to be done to assess the psychological and affective aspects of people using these systems. Why should we build online trust? How can we improve transactive memory of these dispersed teams? Building on an emerging body of social networks and social exchange literature, this study found interesting results investigating the importance of trust networks, social presence, and social exchanges in such human-computer interaction. Interaction patterns in distributed work teams may result in situations where task-related knowledge is less distributed than is transactive knowledge about who knows what (Ahuja and Carley 1999). DeSanctis and Poole’s (1994) adaptive structuration theory of team interaction criticizes the techno-centric view of technology use and emphasizes the social aspects. Individuals create perceptions about the role and utility of the communication technology and how it can be applied to their activities and the people with whom they are communicating. Several important points may be drawn from this research and the results of trust network effects on transactive knowledge.

First, transactive memory helps to leverage knowledge networks and provides a shared resource for gaining access to more knowledge that any individual could possibly possess alone (Hollingshead 1998). The findings support the first hypothesis that dense trust networks foster greater transactive memory than sparse trust networks. Distant participants may understand less about who has expertise in what area as a result of restricted information flow across sites and the lack of rapport (Kiesler and Cummings 2002). However, this study suggests that developing trust relationships may help to alleviate problems arising from restricted information flow. Individuals might seek out those who know what they want to know, but they are also likely to seek information from those they trust. Developing a dense trust network implies that trust between both information seeker and information source helps to maximize knowledge flows and reduce transactive costs of information sharing. Asymmetrical relationships might not be useful for interpersonal and intra-group interactions, especially when the communication is mediated by technologies that do not support the transmission and interpretation of rich social cues.

Table 1. Item Validity and Reliability

Constructs[i]	Items	Reliability of Items	Composite Reliability	Cronbach Alpha	Variance Extracted
TR			0.90	0.889	0.86
	TR1	0.78			
	TR2	0.85			
	TR3	0.91			
	TR4	0.88			
	TR5	0.86			
	TR6	0.82			
RE			0.82	0.813	0.79
	RE1	0.80			
	RE2	0.80			
	RE3	0.88			
	RE4	0.82			
NE			0.85	0.824	0.80
	NE1	0.85			
	NE2	0.87			
	NE3	0.87			
	NE4	0.86			
TM			0.91	0.890	0.89
	TS1	0.83			
	TS2	0.79			
	TS3	0.80			
	TS4	0.81			
	TS5	0.83			
	TC1	0.75			
	TC2	0.87			
	TC3	0.87			
	TC4	0.82			
	TC5	0.76			
	TN1	0.84			
	TN2	0.82			
	TN3	0.80			
	TN4	0.88			
	TN5	0.78			

[i]TR = Trust; RE = Reciprocal Exchange; NE = Negotiated Exchange; TM = Transactive Memory

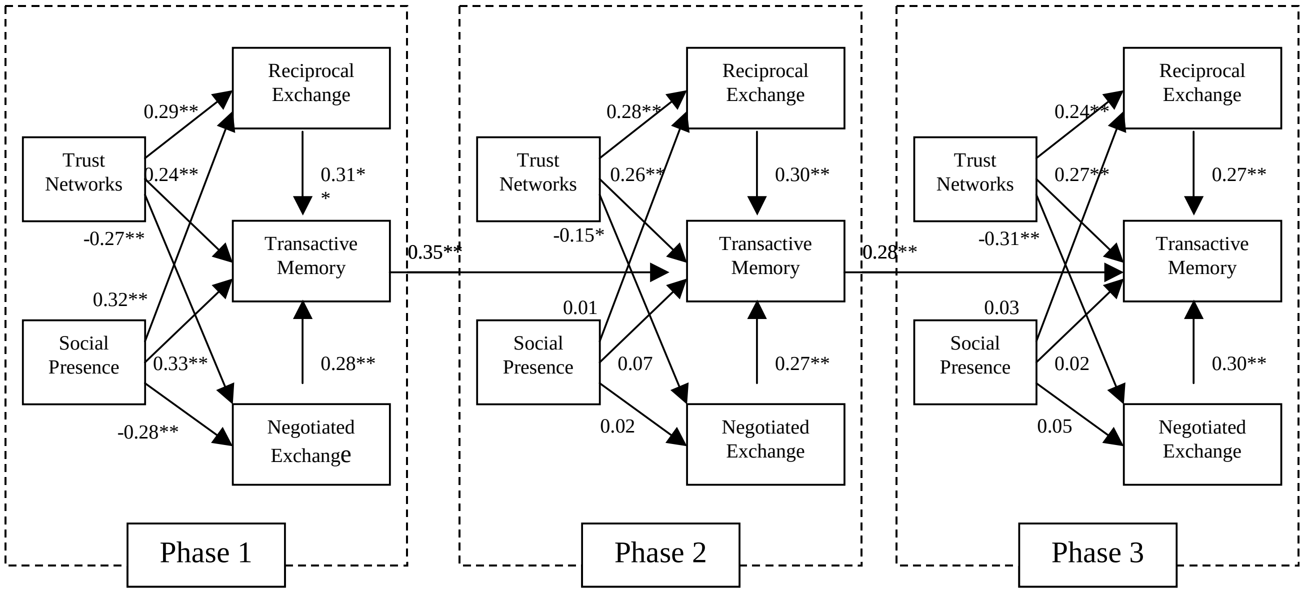
Table 2. Results of Factor Analysis for Main Variables

Constructs[i]	Item No.	Factor 1	Factor 2	Factor 3	Factor 4
TR					
	TR1	0.77	0.03	-0.01	-0.04
	TR2	0.75	0.11	0.04	-0.02
	TR3	0.80	0.01	0.02	0.13
	TR4	0.84	-0.04	0.13	0.01
	TR5	0.78	0.05	0.01	0.01
	TR6	0.85	-0.02	0.05	0.05
RE					
	RE1	-0.04	-0.15	0.85	0.01
	RE2	0.05	0.12	0.82	0.05
	RE3	0.11	0.04	0.81	0.02
	RE4	-0.01	0.10	0.87	-0.03
NE					
	NE1	0.08	0.03	0.11	0.75
	NE2	0.03	0.04	-0.01	0.83
	NE3	0.03	0.01	0.08	0.80
	NE4	0.04	0.08	0.02	0.77
TM					
	TS1	0.02	0.75	-0.12	-0.12
	TS2	0.03	0.83	0.08	0.04
	TS3	0.01	0.89	0.03	0.02
	TS4	0.08	0.85	-0.04	0.13
	TS5	0.01	0.84	0.05	0.01
	TC1	-0.05	0.80	0.11	0.01
	TC2	0.03	0.83	-0.01	0.02
	TC3	0.04	0.88	-0.15	0.02
	TC4	0.01	0.79	0.12	-0.03
	TC5	0.02	0.89	0.04	0.09
	TN1	0.02	0.85	0.03	0.03
	TN2	-0.03	0.81	-0.02	0.05
	TN3	0.05	0.80	0.09	0.01
	TN4	0.02	0.82	0.03	0.08
	TN5	0.03	0.88	0.05	0.01

[i]TR = Trust; RE = Reciprocal Exchange; NE = Negotiated Exchange; TM = Transactive Memory

Second, the results from the study provide support for the second hypothesis that sparse networks of trusting ties have greater transactive memory when social presence is high. In this case, a high degree of social presence may overcome the lack of trust relationships within the team. While sparse trust networks inhibit transactive memory development and this can be improved by increasing social presence, the results also indicate that social presence may plague the effectiveness of teams whose members have dense trusting ties. Close physical proximity and spontaneous communication may privilege interaction with people, but they may not be the right colleagues to communicate with to support productive collaboration. Hence, the results provide some evidence that trust and social presence are conceptually and empirically distinct. Research has shown that electronic teams can develop trust over time (Iacono and Weisband 1997). Whether face-to-face interaction is required for transactive memory thus becomes an empirical question. Although quantity of information is important when faced with high uncertainty and ambiguity in information gathering, the degree of richness of the information in order to lessen message equivocality is also very crucial.

Third, the results show mediating effects of social exchange on trust and transactive memory. The findings suggest that dense trust networks encourage reciprocal exchanges, while sparse trust networks encourage negotiated exchanges in the absence of social presence. A social exchange transaction involves enticing people to share knowledge by creating an incentive structure that persuades them to enter into the transaction for other information resources. There is an expectation of getting valuable knowledge in return for giving it. This generates a need to contribute one's knowledge to become a part of the knowledge network in which one is embedded. In previous research, informal information accessed in such a way is regarded as superior in quality.



$^*p < 0.05$; $^{**}p < 0.01$

Arrows indicate path relationships. Positive values indicate positive relationships, and negative values indicate inverse relationships. For e.g., in phase 1, dense trust networks is associated with greater reciprocal exchange and lesser negotiated exchange than sparse trust networks. High social presence is associated with greater reciprocal exchange and less negotiated exchange than low social presence.

Figure 2. Path Diagram over Three Weeks

Forms of rewards for social exchange include enhanced reputation and personal satisfaction such as pleasure gained from pro-social behavior (Wasko and Faraj 2005). Hence, social exchanges may engender feelings of obligation and trust. Work relationships may begin with minor transactions requiring little trust when risk involved is small. It is through reciprocation of social exchanges that an individual's trustworthiness is demonstrated, and this induces continued favors and future information supply. With a lack of social cues, these social exchanges become more explicit and negotiated, but they would enhance transactive memory, which is impossible to attain if the trust network is strictly sparse and loosely connected.

Similar to most cue-filtered-in and cue-filtered-out experiments, communication patterns in face-to-face and computer-mediated communication experimental settings are plausible in real work environments but the effects might not be generalizable. However, this study aims to provide an equifinality perspective that highlights the various paths that dense and sparse trust networks can improve transactive memory via social presence and social exchange mechanisms. The unifying theme is the premise that understanding social cognition is a critical component to interactions between humans and computers. These findings set the stage for future directions in research efforts.

Future Research

This study adds to the cumulative literature on trust and transactive memory in technology-mediated environments. The results complement the present literature by placing more emphasis on social exchanges characterized with reciprocal and negotiated interaction. A culture of reciprocal exchange is critical in a dense network of trusting ties, in which social presence plays an important role in increasing transactive memory. An interesting question for future research is to extend the study to teams with more members and larger social networks, and determine whether occupying strategic positions in the teams could affect human-computer interaction. As transactive memory is a group-level construct (Moreland 1999), investigating a collective measure of transactive memory as well as objective measures such as performance of the team could also bring insights into the dynamics of trust networks and social presence. This study provides some evidence that social behaviors play a major role in motivating technology-mediated communication. Past studies typically focus on barriers to such interaction rather than enabling factors (Homburg and Meijer 2001). In conclusion, this study suggests that transactive memory can be increased by developing networks of trust relationships supported by an appropriate degree of social presence. Underscoring the differences between dense and sparse networks of trusting ties, the research contributes empirically to the efforts in understanding cognitive and relational aspects highlighting the dynamics of technology-enhanced teams. With better understanding of trust and social exchanges in such interactions, we can provide some insights on how to cope with various types of knowledge exchanges and employ communication technologies for transactive memory with more confidence in the future.

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Appendix: Research Instrument for Survey

Trust (Source: Jehn and Mannix, 2001; Lipnack and Stamps, 1997; Jarvenpaa et al., 1998)
1-7 Likert scale with anchors "strongly disagree" and "strongly agree"

Competence:
I feel very confident about (member X)'s skills.
Member X has much knowledge about the work that needs to be done.
Member X is very capable of performing his/her task.
Member X seems to be successful in the activities he/she undertakes.

Integrity:
Member X has a strong sense of commitment.
I never am doubtful about whether member X will do what he/she promised.
I like the work values of member X on this team.
Member X displays a solid work ethic.

Benevolence:
Member X would not knowingly do anything to disrupt or slow down the project.
Member X is concerned about what is important to the team.
Member X will do anything within their capacity to help the team perform.
The outcomes of this project are very important to member X.

Social Presence (Source: Short et al., 1976; Walther, 1992; Weiner and Mehrabian, 1968)
1-7 Likert scale with anchors "strongly disagree" and "strongly agree"

There was a sense of closeness between my teammates and me.
I felt close to my teammates.
There was a sense of distance to my teammates.
I felt that my teammates were aloof in their interactions with me.
I found my teammates to be very detached from me.
My teammates were very impersonal in their dealings with me.

Reciprocal Exchange (Source: Molm et al., 1999; developed for this study)
1-7 Likert scale with anchors "strongly disagree" and "strongly agree"

I often contribute information that I deem beneficial to the team because I believe that my members will contribute in the same manner in future.
Often I share my expertise without formal requests from my team members as I believe they will also share their expertise.
Most of the time, I cooperate fully in sharing information because I believe that my team members will contribute theirs in future.
During discussion, my team members seldom state explicitly what they need for every piece of information.

Negotiated Exchange (Source: Molm et al., 1999; developed for this study)
1-7 Likert scale with anchors "strongly disagree" and "strongly agree"

I often contribute the information I have because the team has explicitly agreed upon sharing the information that I need in return.
Often when there is a formal request for my expertise, I will specify my request for other information in return.
I understand the need to cooperate fully with my other team members because we have jointly laid out the terms of exchange.
During discussion, my team members often negotiate what information they will share in exchange for information that others provide.

Transactive Memory System (Source: Lewis, 2003)
1-7 Likert scale with anchors "strongly disagree" and "strongly agree"

Specialization:
1. Each team member has specialized knowledge of some aspect of our project.
2. I have knowledge about an aspect of the project that no other team member has.
3. Different team members are responsible for expertise in different areas.
4. The specialized knowledge of several different team members was needed to complete the project deliverables.
5. I know which team members have expertise in specific areas.

Credibility:
1. I was comfortable accepting procedural suggestions from other team members.
2. I believed that other members' knowledge about the project was credible.
3. I was confident relying on the information that other team members brought to the discussion.
4. When other members gave information, I wanted to double-check it for myself. (reversed)
5. I did not have much faith in other members' "expertise." (reversed)

Coordination:
1. Our team worked together in a well-coordinated fashion.
2. Our team had very few misunderstandings about what to do.
3. Our team needed to backtrack and start over a lot. (reversed)
4. We accomplished the task smoothly and efficiently.
5. There was much confusion about how we would accomplish the task. (reversed)