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Access to Information in Connective and Communal Transactive Memory Systems

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This research tested a transactive theory model of how individuals allocate and retrieve task-related information in work teams. It extended prior research by exploring the role of communal information repositories in the context of human information resources. Structural equation modeling of six integrated hypotheses revealed several significant results. First, usage of information repositories was significantly related to individual access to information. However, the relationship between individual direct information exchange with team members (the human repositories) and individual access to information was significant only among average-level users of organizational information repositories. Second, development of individual expertise directories significantly influenced individual direct information exchange with team members. Third, perceived usage of organizational information repositories by team members significantly influenced actual usage. Finally, technology-specific competence in using intranets significantly influenced the actual usage of intranets as organizational information repositories.

Keywords: *communication technologies; social influence; transactive memory*

Work in contemporary organizations typically is rarely a solo act. The speed and complexity of information and communication flows often exceed the processing capacities of individuals. There are two common responses to the challenges created by increased information-processing demands (Galbraith, 1977). The first is to reduce the demands on any one individual. This reduction can be accomplished

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by increasing the amount of resources allocated for completing tasks, primarily by asking people to work collaboratively in the form of groups, teams, committees, and task forces. Teams have access to more expertise, information, and experiences when each member possesses different knowledge resources (Moreland, 1999). The second response is to increase information-processing capacity by providing supplemental information systems to improve the speed and reach of information search and retrieval. This strategy is less useful for tacit knowledge, which is difficult to codify for transmission in information systems (Polanyi, 1967). Both of these responses have become important trends in how information is shared and processed in contemporary organizations.

Theory and research in the area of team collaboration and information sharing has generated considerable interest (e.g., Argote, 1999; Hansen, Mors, & Lovas, 2005). In particular, theory and research on transactive memory (TM) systems have contributed important insights on the structures and processes of team information-processing (Moreland, 1999). At the same time, a separate strand of theory and research on information systems support for collaboration via information repositories has produced valuable findings (DeSanctis, 1993). Yet TM research has been slow to incorporate information repositories into foundational premises regarding how differential expertise of collaborating team members can be translated into effective teamwork. We contend that a promising advance is to incorporate information systems into TM research, bringing it more into line with practice in contemporary organizations, where databases, Web pages, archives, intranets, and other types of information repositories are well integrated into information search and retrieval procedures.

The article begins with an overview of TM theory and highlights its contributions toward understanding the processes and effects of collaborative information sharing in teams to which members bring diverse expertise sets. Premises are developed regarding how information systems are fundamentally involved in team transactive information processing. A model comprised of six interrelated hypotheses is tested on a sample of 179 individuals functioning in 15 teams in a variety of industries. The article concludes with suggestions for future theoretical integration.

TM Theory of Team Information Processing

A TM system is built when individuals coordinate their information retrieval and distribution to create a team-level information-processing system that transcends the sum of the individual parts (Wegner, 1987; Wegner, Erber, & Raymond, 1991; Wegner, Giuliano, & Hertel, 1985). Individuals create a division of labor for encoding, storing, and retrieving task-relevant information; each individual specializes in one or more knowledge domains. Individuals rely on other team members to serve as human repositories for information outside of their own domains (Wegner, 1995). Thus, when individuals need information in others' areas of expertise, they can query those experts rather than having to invest personally in learning that information. TM theory is consistent with core organizational theories that specify that organizations achieve coordination and control through specialization and division of labor (Galbraith, 1977; Weber, 1947).

Coordination requires that individuals fulfill their commitments to maintaining up-to-date expertise in their assigned knowledge domains. Success also depends on effective *expertise recognition*: Team members must have accurate maps of how expertise is distributed throughout the team (Wegner, 1987). These maps of the locations of other knowledge domains are needed to know (a) whom to query for information or answers in areas of expertise outside their own areas and (b) to whom to send new incoming information relevant to those other domains. Communication and information exchange among team members during the process of task completion are critical for maintaining expertise recognition.

Recent work offers new theoretical developments for TM theory. One advance explicates the previously unexplored role of task assignments in TM, highlighting how tasks are linked to people and expertise in team memory systems (Brandon & Hollingshead, 2004). A second promising development explores the motivational element, focusing on incentives and disincentives to developing and maintaining TM systems (Xu, Fulk, Hollingshead, & Levitt, 2004). This theoretical stream draws on motivational premises from public goods theory and the theory of collective action (Marwell & Oliver, 1993). A third conceptual development is expansion of the theory to a multilevel perspective that contains mechanisms by which the system at the team level emerges from actions by individuals (Yuan, 2004; Yuan, Monge, & Fulk, 2005). This expansion is consistent with Simon's (1991) observation that a team has to rely on its members to engage in collective cognitive activities. Building on the emergence model proposed by Kozlowski and Klein (2000), Yuan, Monge, and Fulk (2005) proposed that individuals' respective perceptions of expertise distribution at the micro level form the "elemental content" (Kozlowski & Klein, 2000) for the emergent TM at the macro level. Frequent information exchange and social interaction among team members are the action process through which idiosyncratic expertise perceptions are shared and transformed into team knowledge.

The individual-level component of TM systems and its later developments (Yuan, Monge, & Fulk, 2005) have focused on the development of the human expertise directories about "who knows what." However, as Wegner observed (1987), members of a team can use multiple means to store organizational information, including human beings and information repositories. Therefore, the focus of the current research is to extend the individual-level component of the multilevel TM model to explore how human interaction and information repositories can influence information-sharing activities. As noted earlier, studying both types of information sources together is important because organizational members typically rely on their colleagues and information stores to gain information.

Accessing Information

A key purpose of TM systems is to increase access to information for each member of the team. Timely access to quality information is essential for making good decisions (Levinthal & March, 1993), especially in an information society in which information is one of the primary resources that can give an organization a competitive edge (Drucker, 1999). Team members acquire information mainly from two avenues. First, team members engage in *direct information exchange* among themselves; individuals retrieve information from their team members and in return they allocate information that they hold to those in need. Such direct information exchanges are an important avenue for people to gain access to information stored in other people, particularly when the information has tacit elements that cannot be easily codified for sharing through written archives (Polanyi, 1967). Direct information exchanges provide opportunities for the learners to acquire tacit knowledge through close observations and joint personal interaction, a process that Nonaka and Takeuchi (1995) labelled "socialization of knowledge." Following Fulk, Flanagin, Kalman, Monge, and Ryan (1996), we label this type of access "connective."

Second, team members can obtain needed information from information repositories (Wegner, 1987). For instance, corporate intranets have been adopted widely by organizations to facilitate internal communication. Although top-down communication remains one central function that intranets fulfill, an important use of corporate intranets is to facilitate peer-to-peer communication (Fulk, Heino, Flanagin, Monge, & Bar, 2004). For example, according to D. Yaun (personal communication, October 6, 2005), vice president of internal communication at IBM, the corporate level controls less than 3% of the total information on the intranet, with a vast majority of the contents contributed by IBM employees, and with the topics ranging from best practices to blogs of major events. As a result, the intranet has become a rich organizational information repository.

Information repositories offer at least four specific benefits beyond those offered by direct contact with other team members (Kalman, Monge, Fulk, & Heino, 2002). The first is the ability of information holders and information retrievers to carry out their tasks at their own paces, asynchronously. As long as information holders have contributed their information to the repository at any time prior to the request for that information, it will be available on demand to information seekers. Second, repositories can reduce information-processing load in a team because information holders may satisfy multiple requests by a single contribution to the repository. Third, Fulk et al. (2004) argued that such repositories reduce the need for individuals to know "who knows what" or "who needs what":

> One advantage of intranets, expert databases, bulletin boards, and other communal repositories is that each user need *not* know who knows what to receive benefit—as long as those people have contributed their information to the repository. Communal

> repositories offer generalized exchange (Ekeh, 1974) as a replacement for direct exchange with known knowledge holders. (pp. 571-572)

Thus, the third advantage of repositories is that they can compensate to some degree for faulty or incomplete individual expertise directories. A fourth benefit of organizational repositories is that they offer team members direct access to "external" information from outside the team when multiple teams of the same organization are all active users of a common repository. As a consequence, team members need not depend on other members to know about external information or to secure access to it on behalf of the team. Following Fulk et al. (1996), we label such information stores as "communal."

Communal sources, then, may not simply substitute for connective sources but may offer access to information that might otherwise be difficult to obtain because knowledge holders were unavailable at the time of the request, or because seekers did not know to whom to address the request, or because no one in the team had access to important external information. Thus, communal sources can be important complements as well as substitutes for connective sources. Communal repositories can serve these functions to the degree the repositories are "produced," that is, potential participants actually use them by retrieving information contained in them and allocating to them from their personal knowledge bases any information that other users of the repositories would find valuable (Fulk, Monge, & Hollingshead, 2005). These arguments provide the basis for the first two hypotheses:

Hypothesis 1: Individual direct information exchange with team members predicts better individual access to information.
Hypothesis 2: Individual actual usage of organizational information repositories predicts better individual access to information.

Antecedents

This section describes several important factors influencing the extent that people use team members and communal repositories as means of access to information. TM theory offers important insights about factors linked to use of direct communication with team members to secure access to information. Insights from public goods theory and social influence premises extend these ideas to usage of communal repositories.

Individual direct information exchange with team members. Effective and efficient information exchange among team members relies on well-developed TM systems (Liang, Moreland, & Argote, 1995; Wegner, 1987). According to TM theory, individuals store expert knowledge when they learn new information or gain experience in particular knowledge domains. Team members are not only information storage places for one another but also individual expertise directories of "who knows what" in the system. At the individual level these expertise directories also form the elemental content for the emergent TM systems at the team level (Yuan, Monge, & Fulk, 2005). Although such expertise directories may not be completely accurate or up-to-date all the time, they nevertheless play a vital role in the functioning of TM systems. Expertise directories provide connections among otherwise isolated pockets of expert knowledge (Wegner, 1987). People need to know what expert knowledge is available before they can use it. Without such knowledge, retrieving or allocating information through direct exchange will become difficult and inefficient. Mere storage of expert knowledge does not make it automatically usable. Team members have to know the location of expert knowledge before they can make full use of these resources. Therefore, developing individual expertise directories is crucial for the functioning of the whole system.

Yuan, Monge, and Fulk (2005) proposed to measure the level of development of individual expertise directories by two dimensions. Similar to Palazzolo, Serb, She, Su, and Contractor (2006), *accuracy* reflects the deviation of individual perceptions from the team-level perception about expertise distribution. *Extensiveness* refers to the scope of individual expertise directories. Expertise directories are accurate but not extensive when people can correctly report the expertise of several team members, while remaining ignorant about the rest of the team. Expertise directories are extensive but not accurate if people have a rough idea of everyone's expertise area even though the information is not completely correct. Individual expertise directories are considered well developed only when they are accurate and extensive. Well-developed individual expertise directories can facilitate direct information exchange among team members. When team members know where the information is located in the team, they are more likely to retrieve information from these experts instead of looking for help from outside the team. An individual's ability to allocate information to the right person is also improved because a person who already has expert knowledge in a particular area can better process new incoming information and thereafter function as a more competent storage place for organizational knowledge (Palazzolo, 2005). Based on these arguments, it is hypothesized that

> *Hypothesis 3:* The level of development of an individual's expertise directory predicts more individual direct information exchanges with team members.

Individual actual usage of communal repositories. Although effective usage of team members' expertise rests on the knowledge of "who knows what," effective usage of information repositories is linked to "who uses what" and "what contains what." In our earlier research, we (Yuan, Fulk, et al., 2005) found that individuals' usage of organizational information repositories was positively related to those individuals' perceptions of how frequently team members used the repository. The theoretical rationale centered on findings in the field of technology studies that making technology available does not guarantee its use and that social factors can influence technology adoption and use (Fulk, 1993; Fulk, Steinfield, & Schmitz, 1990; Poole & DeSanctis, 1990; Walther, 1996). For instance, recent research showed that team norms exerted stronger influence on how technologies were used than technological features per se (Fulk et al., 2004). Also, the same technology can engender social changes in very different directions among different users (Barley, 1990).

Earlier, arguments were presented that information repositories could offer four transactive memory benefits: (a) pace control in responding to individual queries from team members, (b) efficiencies in responding to repeated information requests from team members on the same topics, (c) diminished need for accurate individual expertise directories, and (d) access to organizational information external to the team. For these benefits to accrue, however, information holders must actually make contributions to repositories, and information seekers must query them for answers; that is, team members must use their repositories for team-related information exchange. Also, external team contacts in the same organization must contribute valuable information to repositories that can be retrieved by team members; that is, repositories must be transactive. Also, team members must be aware of the contributions and retrievals of others to know "who uses what" in the team and "what contains what." In other words, people must know that needed information can be accessed through the repositories; they must be seen as an integral part of the team's transactive memory system.

However, creating incentives for individuals to use the repositories is complex because repositories face critical mass challenges. The creation and maintenance of organizational information repositories rely heavily on user contributions. Yet contributions can be difficult to obtain because noncontributors can enjoy the same retrieval benefits as contributors without the associated time costs of contributing. The public goods nature of repositories suggests that individuals typically contribute and retrieve to the extent that others contribute and retrieve (Marwell & Oliver, 1993). We can examine others' contribution behaviors at two levels: the team and the organization as a whole. For instance, Google employees are more likely to use the Google intranet to gain information on search engine–related issues if they know that other members of their team are frequent contributors to the intranet on this topic. In addition, Google employees are more likely to use the Google intranet to gain information when other Google employees from different teams are frequent contributors to the intranet on a wide range of topics; that is, the more other people contribute and retrieve information, the higher the provision level of the organizational information repository. Moreover, the likelihood of usage will increase further on seeing the high "provision level" of the information repository in the organization.

Consistent with the major predictions from Bandura's (1986) social cognitive theory, perceived usage of information repositories by others can motivate actual usage of those repositories through observational learning: People are encouraged to follow the suit of others and become contributors as well. Perceived level of provision of information repositories can also motivate actual usage by serving as *environmental enhancement*: People are more likely to use information repositories when they observe widespread use of the system by many others. Becoming aware of provision level through either of these two processes is more difficult for the organizational level than the team level because participation by others must be inferred by examining the contents of repositories rather than direct observation of local team member behaviors. Based on these arguments, we hypothesize that

Hypothesis 4: Individual perceived usage of organizational information repositories by team members predicts more individual actual usage of those repositories.
Hypothesis 5: Individual perceived provision level of organizational information repositories predicts more individual actual usage of those repositories.

Individual technology-specific competence. Developing technology-specific expertise can facilitate effective use of communication technologies (Fulk, 1993; Schmidtz & Fulk, 1991). Earlier research (Yuan, Fulk, et al., 2005) showed that proficiency in using intranets was related to retrieving and allocating information from these information repositories. The finding is consistent with Bandura's (1986) argument about the importance of self-efficacy in individual actions. In the context of the current research, individuals need to gain competence in using intranets before they can join their peers in participating in organizational information repositories. Based on these arguments, we incorporate Yuan, Fulk, et al.'s (2005) hypothesis:

Hypothesis 6: Individual technology-specific competence in using organizational information repositories predicts more individual actual usage of those repositories.

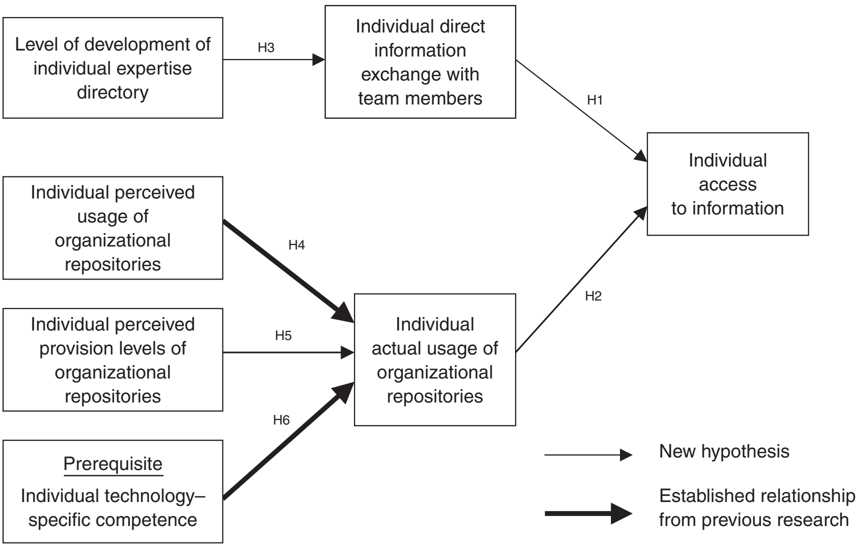
Figure 1 provides a graphic representation of the set of hypotheses.

Method

Design and Procedure

The proposed model was tested on data collected from 179 people in 15 project teams in organizations from a variety of industries. In an earlier article published out of a partially overlapping data set, we (Yuan, Fulk, et al., 2005) used a sample of 150 people from 13 teams. Subsequently, we collected data from three more teams. For this article, we used the data from 12 of the original 13 teams, in addition to these three new teams. One team, included in the earlier article, was excluded in this research because it was a functional team. Unlike project teams, functional teams are usually made up of people who have expertise in the same knowledge domain, and they do not necessarily

Figure 1
Baseline Conceptual Model



share task interdependence, a precondition for TM (Brandon & Hollingshead, 2004). Therefore, we decided to exclude this particular functional team in the current research. The data set of 179 persons in the current study includes 133 of the 150 persons from the prior study. Hypotheses 4 and 6 were established for the prior research and are retested here; Hypotheses 1, 2, 3, and 5 are completely new to the current research.

Interviews were conducted with team managers prior to collecting individual data. Managers served as informants with regard to the names of team members, the knowledge areas required to finish each task, and some other nonconfidential contextual information about the teams and their work. Information obtained from these interviews was used to tailor the online data collection instrument for each team. The response rate was 100%, although there were missing values for certain questions. Overall, the median team size was 13 with the largest team consisting of 20 members and the smallest with 5 members. On average, they had worked together for 2.51 years (*SD* = 3.90). Sixty-eight percent of the respondents were male, and the average age was 37.84 (*SD* = 9.82).

Measurement

Level of development of individual expertise directory was measured along two dimensions: accuracy and extensiveness. Accuracy of individual expertise directory evaluated whether team members' knowledge about expertise distribution in the team was congruent with that of the team. Participants were asked to rate the level of expertise of each team member in each of the knowledge areas required to finish the team project. The response categories were (a) don't know, (b) none, (c) beginner, (d) intermediate, and (e) expert. The specific question used to measure this variable is provided in the appendix, along with measurement for other variables. Team maps about expertise distribution were derived by averaging across each individual team member's report. Accuracy of expertise recognition for respondents was then calculated by totaling the absolute differences between the respondents' individual cognitive maps of expertise distribution across team members and the team map. Large individual deviation scores from the team maps indicated a lack of accurate knowledge about team expertise distribution. To facilitate cross-team analysis, composite scores were normalized. These deviation scores were then multiplied by –1 so that high scores implied high levels of accuracy. Extensiveness of expertise directory was derived from the same matrix. The *don't know* response was coded as 0, and all the other values were coded as 1. The proportion of nonzero values in the matrices was then calculated to represent extensiveness of individual cognitive mental maps. Measures of accuracy and extensiveness were transformed so that they were similarly scaled to permit summation. Correlation between the two dimensions was .77 ($p < .05$, $N = 179$). They were then summed together to represent the level of development of individual expertise directory.

Individual direct information exchange with team members was computed from data arrayed in two sets of matrices, one for information allocation and one for information retrieval. Participants were asked to record whether they had allocated information to or retrieved information from each team member for each knowledge area needed for the team tasks. The responses were binary where 0 represented "no allocation (retrieval)" and 1 stood for "some allocation (retrieval)." Because teams differed in the number of areas of expertise needed for their tasks, the information allocation and retrieval matrices were averaged across tasks to facilitate aggregation. The average information allocation and retrieval matrices were summed to build the information exchange network for each team. To facilitate across-team comparisons, the entries in each row were averaged to measure individual direct information exchange with team members, excluding the focal person's self-report on individual information allocation and retrieval.

Individual perceived usage of organizational repositories was collected as network data in java applets. Respondents were asked to report their perceptions about how often each of their team members had provided information to and acquired information from the organizational information repositories compiled in the company-wide intranet. The responses were on a 5-point scale where 0 represented *never* and 4 *very often*. Individuals' mean perceptions of all other team members' contributions to and retrieval from the intranet were examined. This measure was consistent with measures of social influence used by Schmitz and Fulk (1991) and Fulk (1993).

Individual perceived provision level of organizational repositories[1] was measured by six items (Yuan, Fulk, et al., 2005). Example questions are “To what extent do people in (a particular company) provide all their work-related information on the intranet?” and “To what extent is that information used by everyone else?” The responses were on an 11-point scale that ranged from *none* to *totally*. A composite scale measuring access to information was created by averaging the six items. Cronbach’s alpha for the resulting scale was .92.

Individual technology-specific competence was measured by one item assessing proficiency in using the intranet. The responses were on a 5-point scale ranging from *not at all proficient* to *extremely proficient*. This measure was adapted to intranets from the measure used by Fulk (1993) and Schmitz and Fulk (1991).

Individual actual usage of organizational repositories[2] was evaluated by two dimensions (Yuan, Fulk, et al., 2005). Individual information retrieval from the repositories was measured by a 7-item scale focusing on how frequently respondents obtained information from the intranet for different goals during a week. An example is, “During your last full week of work, how often did you use the intranet to access a database to obtain information needed for your job that was not available elsewhere?” Individual information allocation to repositories was measured by a 3-item scale focusing on the frequency of uploading information to organizational information repositories during a typical week. An example is, “During your last full week of work, how often did you use the intranet to contribute information to an intranet site for use by people that otherwise would not readily be available elsewhere?” Both scales used 5-point Likert-type response categories that varied from *never* to *very often*. A composite scale measuring actual usage of organizational information repositories was created by averaging the 10 items. Cronbach’s alpha for the final scale was .91.

Individual access to information was measured using a 4-item scale asking about the quality and quantity of information obtained to perform tasks. Response options were arrayed on a 5-point scale that ranged from *strongly disagree* to *strongly agree*. A composite scale measuring access to information was created by averaging the four items. Cronbach’s alpha for the resulting scale was .85.

Analysis

The hypotheses were combined into a single model displayed in Figure 1 and analyzed using the LISREL 8.72 structural equation modeling (SEM) program. LISREL provides global tests of the adequacy of the entire model, simultaneous estimation of all structural coefficients, and tests of statistical significance for all coefficients (Jöreskog & Sörbom, 1996). The χ^2 goodness-of-fit statistic is reported as an index of model adequacy, where a nonsignificant value indicates good fit of the model to the data. Because χ^2 has been shown to be sensitive to sample size (Bollen, 1989), the χ^2 to degrees of freedom ratio is also reported, where a value less than 5 indicates a good fit. Other common fit indices are reported that show how well the specified model accounts for the data, including the root mean square error of approximation (RMSEA), the Goodness-of-Fit Index (GFI), the Adjusted Goodness-of-Fit Index (AGFI), and Comparative Fit Index (CFI). RMSEA values less than .05 typically indicate good fit. For GFI, AGFI, and CFI indices, values range from 0 to 1.00, with higher values indicating better fit; .90 and above is generally considered to represent good fit. Regression coefficients for the hypothesized structural relations are also reported along with their statistical significance. The alpha level for all tests was set at .05.

The LISREL 8.72 program provides a modification index for each possible parameter that was not specified in the original theoretical model. A large modification index indicates that model fit would likely be improved by addition of that path to the model (Jöreskog & Sörbom, 1996). Modification indices usually are employed in conjunction with theory to determine whether addition of any paths to the model is defensible. A typical procedure is to delete nonsignificant paths if such deletion is theoretically defensible, and then to add theoretically defensible paths that have large modification indices one at a time, reviewing the results after the addition of each parameter (Byrne, 1998).

Prior to running SEM tests, we calculated intraclass correlations (Raudenbush & Bryk, 2002) to examine whether the data were clustered by teams. As displayed in Table 1, intraclass correlation coefficients ranged from .16 to .48, indicating that observations in the current sample were not independent of each other. To deal with this nested nature of our data, we group centered the data prior to running SEM analysis because our focus was on examining relationships at the individual level of analysis, but not on studying cross-level interactions, or across-group differences in means (Kreft, Leeuw, & Aiken, 1995). In addition to SEM using group-centered data, we also conducted a path analysis using hierarchical linear modeling (HLM) techniques on the original raw data to examine the robustness of results. The two methods may yield different results because they handle the clustered nature of the data differently. When the data is group-mean centered, the grouping effect of the data has essentially been removed. In contrast, when using the raw data, the clustered nature of data has been dealt with using statistical measures (Kreft et al., 1995).

Results

Descriptive statistics are displayed in Table 1. Although the overall response rate was 100%, there were missing values across different survey questions. The effective sample size for data analysis with list-wise deletion was 136. Using the imputation function provided in PRELIS, 24 more cases were included by replacing the missing values of the model variables with the most likely choices selected by similar participants in the sample. Therefore, the final data used for model testing contained 160 cases. The correlation coefficients are displayed in the upper triangle of

Table 1
Descriptive Statistics

Variables	1	2	3	4	5	6	7
1. Level of development of individual expertise directory	2.72	.17*	–.12	.21*	.07	.09	.06
2. Individual direct information exchange with team members	.04	.03	.15	.16	.10	–.06	.08
3. Individual perceived usage of organizational repositories by team members	–.36	.02	1.91	.33*	.18*	.35*	.21*
4. Individual perceived provision levels of organizational repositories	.31	.02	.61	2.99	.27*	.17*	.35*
5. Individual technology-specific competence	–.13	.02	.02	.21	.79	.42*	.28*
6. Individual actual usage of organizational repositories	.01	.02	.17	.20	.21	.57	.34*
7. Individual access to information	–.02	.01	.004	.23	.09	.09	.29
M	5.98	.50	2.06	5.35	3.48	2.76	3.64
SD	1.85	.24	1.76	2.22	1.08	.94	.65
Intraclass correlation	.16	.48	.33	.30	.24	.23	.35

Note: Pearson correlation coefficients are provided in the upper triangle of the matrix, variances are located on the diagonal, and covariances are reported in the lower triangle.
$*p < .05$ (two-tailed test).

the matrix in Table 1, and the covariance coefficients are displayed in the lower triangle of the matrix in Table 1, with variances reported along the diagonal. The zero-order correlation matrix was generated in SPSS 14.0 prior to data imputation using the original raw data; and the covariance matrix was generated in the PRELIS package of LISREL 8.72 after data imputation using group-centered data. The covariance matrix was used for SEM tests following the recommendations from the research community (e.g., Byrne, 1998; Jöreskog & Sörbom, 1996).

Tests of the Hypothesized Conceptual Model

The results for the global tests of the hypothesized conceptual model are presented in Table 2 as the "baseline model." The χ^2 value was 20.55 ($df = 9$, $p < .05$). The significant p value indicated a less-than-adequate fit between the overall model and the observed data, Whereas the χ^2/df ratio of less than 5 showed a good model fit for the sample size. AGFI and CFI were below the .90 conventional criteria, while GFI was above .90. The RMSEA fit index was .09, somewhat higher than the conventional criterion of .05. Overall, these results show only a moderate fit of the model to the data.

Table 2
Summary of Fit Indicators

Models	χ^2	*df*	*p*	χ^2/df	RMSEA	GFI	AGFI	CFI
1. Baseline conceptual model	20.55	9	.01	2.28	.09	.96	.89	.80
2. Revised model[a]	13.97	9	.12	1.55	.06	.98	.92	.91

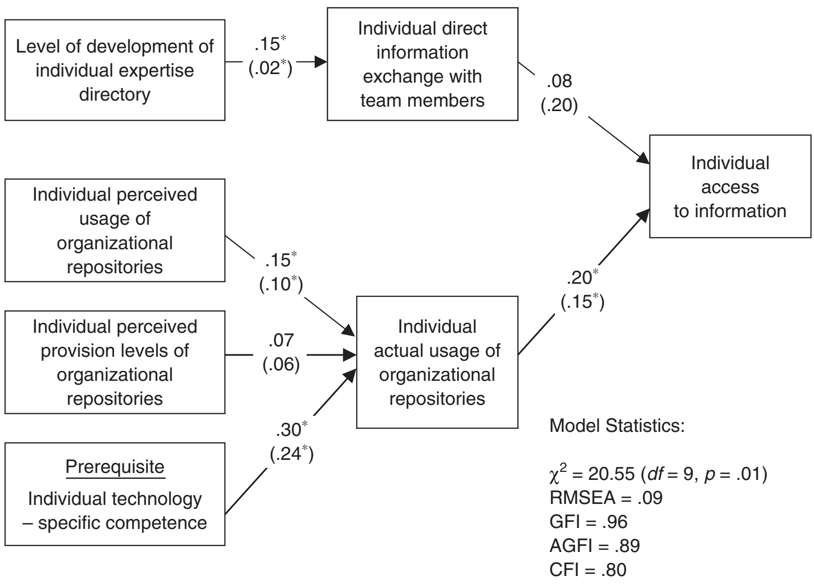
Note: RMSEA = root mean squared error of approximation; GFI = Goodness-of-Fit Index; AGFI = Adjusted Goodness-of-Fit Index; CFI = Comparative Fit Index.
a. Revisions from Model 1 to Model 2 in order of application: (a) deleted the nonsignificant path from individual perceived provision level of organizational repositories to individual actual usage of organizational repositories and (b) added a path from individual perceived provision level of organizational repositories to individual access to information.

The results of the statistical tests for the individual paths, including the magnitude and significance of the coefficients, are displayed in Figure 2. Hypothesis 1 proposed that individual direct information exchange with team members would predict better individual access to information. The standardized regression coefficient was $\beta = .08$ ($t = 1.05$, $p > .05$). Therefore Hypothesis 1 was not supported. Hypothesis 2 proposed that individual actual usage of organizational information repositories would predict better individual access to information. The standardized regression coefficient was $\beta = .20$ ($t = 2.52$, $p < .05$). Hence, Hypothesis 2 was supported. Hypothesis 3 proposed that development of individual expertise directory would predict more individual direct information exchange with team members. The standardized regression coefficient was $\beta = .15$ ($t = 1.88$, $p < .05$), supporting Hypothesis 3. Consistent with earlier research on a subset of the current sample, the current study found that perceived usage of organizational information repositories and technology-specific competence predicted individuals' actual usage of these repositories ($\beta = .15$, $t = 1.98$, $p < .05$ for perceived usage; $\beta = .18$, $t = 4.00$, $p < .05$ for technology-specific competence), supporting Hypotheses 4 and 6. Hypothesis 5 proposed that individual perceived provision levels of organizational information repositories would predict individual actual usage of those repositories. The standardized regression coefficient was $\beta = .07$ ($t = .89$, $p > .05$). Therefore, Hypothesis 5 was not supported.

Model Revisions

Analysis of the overall model fit indices along with the tests of individual hypotheses indicated that opportunities existed for improving the model. Hence, the baseline model was modified. The nonsignificant path from individuals' perceived provision levels of organizational repositories to individuals' actual usage of those repositories was first removed. Based on the size of its modification index, a direct link was added between individuals' perceived level of provision of organizational

Figure 2
Results for the Test of the Baseline Model



Note: RMSEA = root mean square error of approximation; GFI = Goodness-of-Fit Index; AGFI = Adjusted Goodness-of-Fit Index; CFI = Comparative Fit Index. The standardized solution from structural equation modeling (SEM) analysis and the unstandardized solution from hierarchical linear modeling (HLM) path analysis are reported, with the latter in parentheses.

information repositories and individuals' access to information. The rationale for this modification was that people might perceive themselves as having adequate access to information when they perceived themselves working in a resource-rich environment, regardless of whether they had actually used these repositories. For instance, students at universities with well-stocked libraries are very likely to perceive themselves as having good access to information even if they have not fully explored all their resources. In the baseline model, the link from individual direct information exchange with team members to individual access to information was not significant either. We decided to keep this link because this link was of primary importance in studying the interplay between the usages of connective and communal information repositories. Further post hoc analyses were conducted and are reported later to address this question.

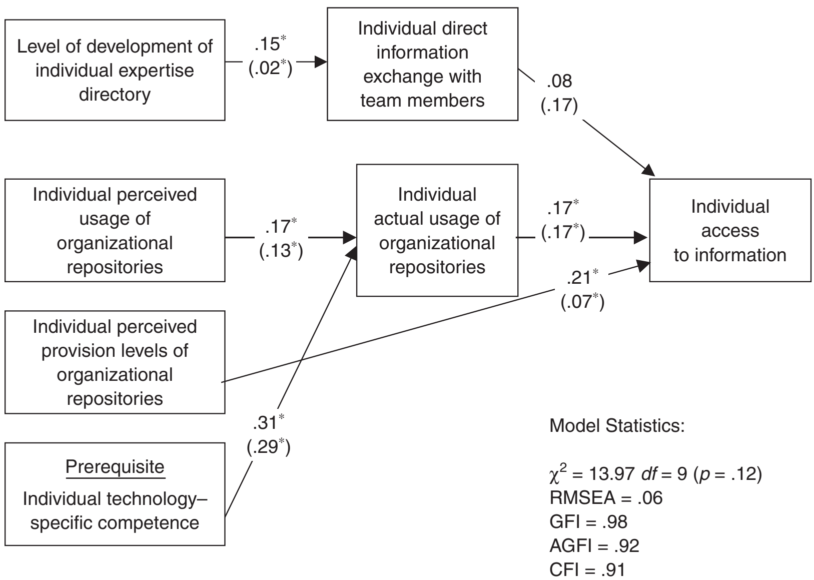
After adding the above mentioned link, the overall fit of the model improved substantially. As reported in Table 2, the χ^2 value for Model 2 was 13.97 ($df = 9$, $p = .12$), with a χ^2/df ratio of 1.55. GFI, AGFI, and CFI all exceeded the conventional value of .90, indicating improved fit. The new path was significant ($\beta = .21$, $t = 2.79$, $p < .05$), supporting the addition of the link. Also, the RMSEA dropped to .06, just slightly higher than the conventional cutoff value of .05.

To examine the robustness of the results obtained from SEM modeling of group-centered data, we also conducted path analyses using HLM techniques on the raw data. HLM path analyses were conducted on the original baseline model and the final revised model. The results were consistent with SEM analyses in all aspects. In Figures 2 and 3, the unstandardized regression coefficients obtained from HLM path analyses are displayed in parentheses below the standardized structural coefficients generated in SEM analyses.

Post Hoc Analysis

Although the path between individual direct information exchange with team members and individual access to information was nonsignificant in all modeling tests, the link was retained for two reasons: The first is the theoretical advantage to maintaining parallelism in use of human repositories to that of communal repositories in predicting access to information. The second is the possibility that the ability of direct information exchange to affect access to information may depend on how effective communal resources are in securing access to the same information. One possible explanation for the nonsignificant link would be an interaction with communal sources such that connective sources may be less valuable to some users of information repositories than others. To examine interaction possibility, a post hoc analysis was conducted. The sample was divided into three subgroups based on people's actual usage of organizational information repositories. Because the variable was normally distributed, dividing the sample at .50 standard deviations around the mean produced three subgroups of nearly equal size, which was substantively interpretable as low, average, and high users. Regression analyses were then conducted for the three subgroups. Among heavy users of communal repositories the relationship between individual direct information exchanges with team members and individual access to information was nonsignificant ($\beta = .11$, $t = .78$, $p > .05$). This finding suggests that for relatively heavy users, organizational information repositories may have generated sufficient information that there were few incremental information access benefits from individual direct information exchange with team members. Among the average-level intranet users, the relationship between the two variables was positive and significant ($\beta = .26$, $t = 2.03$, $p < .05$). This means that medium intranet users needed to rely on human and communal information repositories to gain satisfactory access to information. Among the light users, the relationship was nonsignificant ($\beta = -.21$, $t = 1.56$, $p > .05$), indicating that persons who did not use the intranet much also did not achieve increased access to information by directly exchanging information with team members. Interpretation of these post hoc findings will be further elaborated in the discussion section.

Figure 3
Results of the Final Model



Note: RMSEA = root mean square error of approximation; GFI = Goodness-of-Fit Index; AGFI = Adjusted Goodness-of-Fit Index; CFI = Comparative Fit Index. The standardized solution from structural equation modeling (SEM) analysis and the unstandardized solution from hierarchical linear modeling (HLM) path analysis are reported, with the latter in parentheses.

Discussion

This research employed TM theory to study how individuals gain access to information in organizations. Building on Yuan (2004) and Yuan, Monge, and Fulk (2005) the current research expanded the individual-level components of multilevel TM systems by studying how usage of human and communal repositories influenced individual-level access to information. Existing TM research mainly has focused on developing human information repositories of "who knows what." Very little research has been conducted on communal repositories in TM systems. Yet in contemporary organizations most employees rely on multiple avenues to gain access to information. They exchange resources with their peers in direct social interaction. They also employ intranets or other organizational information repositories to locate needed information and, in the case of online expertise directories, to find out which human sources are likely to have certain types of information. Therefore, TM systems, which can be viewed as meta-memories of organizational knowledge, should be conceptualized to include knowledge stored in human and communal sources, as well as the processes through which it is accessed and employed by members of the TM system. TM systems should contain information on not only "who knows what," but also on "who accesses what" and "where to find what."

Based on the major arguments from TM theory and social cognitive theory, several hypotheses were tested regarding how individual access to information is linked to use of human repositories. Consistent with extant theory, level of development of individual expertise directories predicted individual direct information exchanges with team members (Hypothesis 3). However, counter to predictions, individual direct information exchange did not influence individual reports of access to information (Hypothesis 1).

Issues related to gaining access to information via communal repositories are complicated for at least two reasons. First, organizational information repositories are information public goods that depend on the voluntary information contributions of individuals (Fulk et al., 2004). Sustaining such systems is difficult when noncontributors cannot be excluded from beneficially retrieving stored information that has been contributed by other individuals. In the current study, Bandura's (1986) social cognitive theory was used to test whether observational learning would motivate actual usage when perceived usage of these systems by team members was high. The hypothesis linking individual perceived team member use of repositories to an individual's actual use (Hypothesis 4) was supported and is consistent with the findings from earlier analyses. In addition, the research tested whether individual perceived provision level of organizational information repositories could motivate individual actual usage by functioning as environmental enhancement. However, the proposed relationship was not supported (Hypothesis 5). Instead, a direct relationship was found from individual-perceived provision level of organizational information repositories to individual access to information. It seems that perception of provision level can produce positive judgments about access to information without the mediation of actual usage.

The second complicating factor for motivating actual usage of intranet-supported organizational information repositories is that users need to be competent in using communication technologies. Competence in using these technologies can boost behavioral self-efficacy (Bandura, 1986). Lack of the needed skills can stifle actual usage despite a motivation not to free ride. The result supported Hypothesis 6 and is consistent with the findings from earlier research. Furthermore, an individual's actual usage of organizational repositories, as would be facilitated by such technology competence, was found to influence reports of access to information, supporting Hypothesis 2.

The Interplay Between Usage of Connective and Communal Information Repositories

The analysis yielded interesting findings about the interplay between usage of connective and communal information repositories in gaining access to information.

As shown in the final model, using communal information repositories predicted access to information, whereas direct information exchange with team members did not. Although extant TM theory does not account for communal repositories, the data from the current study strongly suggest that not only are such repositories important sources of access to information in TM systems but also that their benefits eclipse those of interpersonal direct exchange. Post hoc analysis showed that for heavy users of organizational information repositories, direct information exchange had no impact on access to information. This analysis implies that communal organizational information repositories could actually replace team members as sources of information for heavy users. Among average-level users, the connective and communal information repositories complemented each other in accessing information. However, among light users, direct information exchange was not related to access to information. It is possible that light users had less need for external information in general, regardless of source. On the other hand, the coefficient for the light users was negative and approached significance ($p < .07$). If confirmed as significant in future studies, this result would suggest that use of team members could detract from individuals acquiring useful communal information from repositories (or vice versa), ultimately having a dysfunctional effect. Overall, the SEM tests showed strong support for the central role that communal information repositories play in gaining access to information. They also suggested an interesting and complex "dance" between connective and communal sources of information in securing access to information.

Limitations of the Current Research

There are several limitations of the current research. First, the current research mainly focused on expanding the individual-level component of Yuan, Monge, and Fulk's (2005) multilevel model of TM systems. Due to the limitation of sample size, we cannot conduct a comprehensive test of the full multilevel model that includes not only individual- and collective-level relationships but also cross-level interaction effects. Moreover, the sample size of the current research, particularly at the group level, does not provide adequate statistical power to test interaction effects via examining the significance level of random slopes. A related issue is that the small sample size suggested the use of methods to recover missing data. Imputation is more precise and more conservative than simply replacing missing values with means; it also enhances representativeness by preserving more cases than is possible by simply deleting listwise any case with missing values. In this research, a supplemental analysis using listwise deletion without imputation reproduced the results presented here, except with an even smaller sample size.

Second, technology-specific competence was measured by only one item. This item has shown predictive validity in other research (Fulk, 1993; Schmitz & Fulk, 1991). Nevertheless, single items are of unknown reliability (Nunnally, 1978).

Third, the data were collected at a single point in time; however, the hypotheses were predictive in nature. SEM procedures only imply causality from cross-sectional correlation coefficients; they evaluate whether the covariance structure of the data is consistent with the proposed hypothetical relationships. Thus, SEM procedures on cross-sectional data cannot lead to conclusive acceptance of a model but only to failure to reject. As such, SEM procedures serve only as a basis for provisionally accepting a theoretical causal model.

Directions for Future Research

The original model contained a hypothesis proposing that using connective information sources could contribute to better access to information. However, counter to the prediction, the relationship between individual direct information exchange with team members' and individual access to information was not significant. Post hoc analysis showed that the relationship was significantly positive only among the medium users of organizational information repositories. The relationship was nonsignificant among heavy and light users. The results might have been different if the research focus had been on learning new knowledge rather than gaining access to information. Managing organizational knowledge involves learning tacit knowledge and storing codified information in organizational information repositories (Argote & Ophir, 2002). Sharing tacit knowledge usually requires joint experiences and direct information exchange (Polanyi, 1967). Future research should investigate whether different knowledge management tasks function as different contingency factors influencing the relative importance of connective versus communal information repositories in accessing information.

Practical Implications

These findings suggest that information exchange among team members can be boosted by informing team members about their peers' areas of expertise (Hypothesis 4). Second, because perceived usage of organizational information repositories by team members can motivate individuals' actual usage (Hypothesis 4), management should inform their employees about who is using the systems and how frequently they have been used. Third, access to information can be boosted simply by making the provision level of information repositories known to employees for well-stocked repositories (the link added in the revised model). Finally, training to increase proficiency in using communication technologies is a prerequisite for increasing participation in technology-supported organizational information repositories (Hypothesis 6).

Conclusion

In contemporary organizations people meet information-processing needs through two primary ways. The first is by engaging in direct information exchange among

TM system members, thereby acquiring information that is "stored" in those other persons. This method requires the information seeker to have a well-developed expertise directory to know whom to approach in seeking information. The second is by participating in "generalized exchange" via communal information repositories (Fulk et al., 1996). With generalized exchange, people can access stored information without having to know who holds such information. All that is needed is that the information stored by others be made available through a communal repository. Transactive memory systems depend on effective use of both sources of information. The current study's findings highlight the complex dance of people and knowledge caches in contemporary knowledge enterprises.

Appendix
Measurement Items

Level of Development of Individual Expertise Directory

At the bottom of the adjacent screen are icons that represent levels of knowledge in various knowledge areas that were identified by people in your team. We would like to know how much knowledge you think the members of your team (including yourself) have in each of these areas.

Individual Direct Information Exchange With Team Members

Please indicate whether you have provided unsolicited information to Member XX about Knowledge Area YY in a typical week.

Please indicate whether you have retrieved information from Member XX about Knowledge Area YY in a typical week.

Individual Perceived Usage of Organizational Repositories

Note: [intranet] was replaced with the specific name of the intranet in each company.

1. How often do you think you and other members of your team retrieved information from the intranet during the past week about (certain knowledge area)?
2. How often do you think you and other members of your team provided information to the intranet during the past week about (certain knowledge area)?

Individual Perceived Provision Level of Organizational Repositories

Select one number from 0 to 10 that describes how you see the [intranet] being used today.

1. To what extent do people in X company provide all their work-related information on the intranet?
2. To what extent is that information used by everyone else?
3. To what extent are you able to access everyone's work-related information?
4. To what extent are employees willing to share work-related information with everyone else?
5. To what extent is everyone able to access everyone's work-related information?
6. To what extent are employees willing to use work-related information that others have made available via the intranet?

Individual Technology-Specific Competence

How proficient do you consider yourself at using intranet?

Individual Actual Usage of Organizational Repositories

During your last full week of work, how often did you use the intranet to. . .

1. access a database to obtain information needed for your job that was not available elsewhere?
2. access a database to obtain information needed for your job from persons you did not know?
3. access a database to obtain information needed for your job that was from persons you did know?
4. locate someone who could get you needed information for your work?
5. find information posted by others?
6. access information to find out who was knowledgeable about a particular problem, issue, or topic?
7. identify experts in a particular area?

During your last full week of work, how often did you use the intranet to

1. contribute information to a database that otherwise would not readily be available to others who need it?
2. contribute information to an intranet site without knowing who, specifically, might find it useful?
3. contribute information to an intranet site for use by people with whom you were already acquainted?

Individual Access to Information

In responding to the following items, keep in mind activities that you have worked on in the last week

1. The amount of information available to me is sufficient for me to make good decisions.
2. Most information I receive is very valuable.
3. I have found that information is generally complete enough for me to make good decisions.
4. I have full confidence that I make decisions based on accurate information.

Notes

1. In Yuan, Fulk, et al. (2005), this variable was named "level of provision." The two measures are identical. However, we choose to use a slightly different name in this article to stress that the variable measures level of provision of organizational level information repositories.

2. In Yuan, Fulk, et al. (2005), this variable was named "actual usage." The two measures are identical. For a similar reason mentioned in Footnote 1, we have slightly changed the variable name in this paper to stress that the variable focuses on organizational level resources, not team-level resources.

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