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Sirkka Jarvenpaa
University of Texas at Austin

Ann Majchrzak
University of Southern California

DEVELOPING INDIVIDUALS' TRANSACTIVE MEMORIES OF THEIR EGO-CENTRIC NETWORKS TO MITIGATE RISKS OF KNOWLEDGE SHARING: THE CASE OF PROFESSIONALS PROTECTING CYBERSECURITY

Sirkka L. Jarvenpaa
Center for Business, Technology, and Law
McCombs School of Business
University of Texas at Austin
Austin, TX U.S.A.
Sirkka.jarvenpaa@mccombs.utexas.edu

Ann Majchrzak
Information and Operations Management
Marshall School of Business
University of Southern California
Los Angeles, CA U.S.A.
Majchrza@usc.edu

Abstract

A memory of who knows what, so called transactive memory, can be an important cognitive structure in facilitating knowledge sharing in situations where successful collaboration depends on simultaneously maximizing sharing while mitigating its risks. We examine the development of transactive memory in cross-organizational networks—or ego-centric networks—that individuals build and maintain in their work. How do individuals develop transactive memory about who knows what in personally driven social networks that operate at the boundaries of cross-organizational work? In this paper, we advance a model of factors affecting the development of an individual's transactive memory of his/her ego-centric work network and test the model with a group of professionals engaged in responding to unforeseen events related to national security. Overall, we find that frequent use of dialogic practices explain much of the degree to which an individual has developed a transactive memory of his/her ego-centric network. Dialogic practices are, in turn, affected by the degree to which the task is perceived as interdependent on the knowledge and actions of others and organizational support for learning. We note theoretical extensions to the literatures of transactive memory and information systems design for ego-centric networks.

Introduction

An important resource in today's distributed work environments is professionals' own social networks that reach beyond organizational boundaries (Nardi, Whittaker, and Bradner 2000; Nardi, Whittaker, and Schwarz 2002). Ego-centric networks are informal, organizational boundary-crossing structures that individuals build, maintain, and rely on for *ad hoc* collaborations. Ego-centric networks become particularly relevant when individuals operating at organizational boundaries face unforeseen problems for which no single individual or group within the organization has the necessary knowledge to solve. Such networks bring different (and often the best) skills to bear on a problem under conditions of extreme time urgency. Networks are comprised of people with whom an individual has collaborated in the past, but can also include those with whom the individual might anticipate collaborating in the future. Ego-centric networks share characteristics with virtual teams and electronic communities, but also have differences. Ego-centric networks are not structured or controlled by an organization, as virtual teams are; they are intentionally assembled by self-directed professionals for getting their work done. And ego-centric networks are different from networks of communities in the sense that they rally around a person, not a set of practices (Nardi, Whittaker, and Schwarz 2002).

The ego-centric network exposes professionals and their employers to larger pools of expertise, but at the same exposes them to greater risks of confidential information leaks. Such risks are varied and may include difficulties in appropriating strategic resources (Norman 2002), threats to organizational reputation (Scott and Walsham 2005), and material harm to employees and assets. When the need for *ad hoc* cross-organizational collaboration occurs, knowledgeable team members need to be brought together rapidly and the work coordinated and performed efficiently. Since these structures are beyond the formal control of the organization, it is the responsibility of the individuals involved to know what knowledge can or cannot be shared in the network. Although the ego-centric network is likely to include members who are perceived as generally trustworthy, there are still situations where sharing might pose a vulnerability to a member's organization, and that vulnerability might increase if the professional does not have a good grasp of who knows what—or transactive memory (TMS).

With a well-developed TMS, *ad hoc* team members may be better able to predict the collective behaviors of others, and thus better able to assess the risks of sharing (Majchrzak and Jarvenpaa 2005). In an ego-centric network, what knowledge is sensitive might change very rapidly and unpredictably. At a moment's notice, a member in the network may move from being a collaborator to being a competitor. Often the sensitivity results not from any particular piece of information, but rather from a combination of information pieced together from different individuals who might not even know each other. The increased use of collaborative tools such as electronic mail and virtual workspaces in such networks speeds the information flow and distributed nature of the knowledge and makes it particularly difficult to reliably predict the potential of knowledge violation. Unless a professional has a good transactive memory, he or she will be unable to assess potential dangers.

An example of risk-prone collaboration involves homeland security. Professionals working on cybersecurity events are members of what we call high-risk networks. Cyber attacks are highly distributed in information infrastructures that span organizations, countries, and specialists from both the private and public sectors. Response requires coordinating this knowledge across organizations and physical distances in order for joint action to be taken. But such knowledge integration can also expose a member or a member's organization to vulnerabilities including knowledge leaks and anticompetitive accusations. Knowledge integration can stop cyber attacks, but if inappropriate information is shared, it can also increase the potential for a sharer, or even the whole collective, to be attacked.

In this paper, we identify factors that help people develop a cognitive structure of who knows what, or transactive memory, in ego-centric networks. Although organizations are not in charge of structuring ego-centric networks, it is important for organizations to understand how these networks develop. As Nardi, Whittaker, and Schwarz (2002, p. 209) note, "people do not magically come together 'virtually.'" A better understanding can facilitate the development of design principles for technologies supporting such forms. In this paper, we present and then empirically test a model of predictors of TMS development specifically suited for environments where sharing entails both risks and benefits.

Theoretical Model

The existing literature on group cognition suggests that well-developed TMS, or knowledge of who knows what, can improve knowledge sharing, knowledge integration, and the overall performance of teams (Faraj and Sproull 2000; Lewis 2003). When members know what others know, they can more accurately assess the relevance of other's knowledge. Past empirical literature on TMS has been limited to tightly knit organizational work groups that are structured in formal relationships (Faraj and Sproull 2000) or in extemporized encounters with well-developed professional scripts (Faraj and Xiao 2005). Our goal is to extend TMS theory to apply to improving knowledge sharing among loose informal networks, even when parties face knowledge-sharing risks.

TMS appears to be particularly critical in ego-centric networks that need to respond to unforeseen events. In such situations, professionals need to efficiently access information from others outside the team (Argote et al. 2000), as well as assess the relevance of that information and judge what knowledge can be shared and what must be protected. A professional armed with a well-developed TMS of his or her ego-centric network will be able to avoid some of the knowledge gaps and uncertainties theorized to exist in formal organizations (Anand et al. 1998).

But one's TMS of ego-centric networks can also be difficult to maintain and exploit. Not only are these work forms characterized by a variety of people unpredictably involved in collaborative knowledge work, but these people represent different and changing roles and organizations over time. Ego-centric networks can exist and form in a landscape of great heterogeneity with a plethora of educational and employment histories, work practices, languages, and media choices (Nardi, Whittaker, and Bradner 2000; Nardi, Whittaker, and Schwarz 2002). To make matters worse, the people who make up *ad hoc* teams may also be geographically distributed and not in direct communication with one another. Remembering who is in the network and what they all know is a major impediment to efficient operations, particularly as the network size grows (Nardi, Whittaker, and Schwarz 2002).

Definition of TMS

TMS has traditionally been defined as a group's shared memory of "who knows what" so that individuals are able to specialize in different knowledge domains, yet locate and integrate the specialized expertise of others in the group more efficiently (Hollingshead 1998a; Wegner 1987). A person who needs some information in an area outside his expertise can ask others instead of learning it himself. While the concept of TMS has been suggested as facilitating organization-wide knowledge sharing (see Anand et al. 1998), TMS has not yet been applied to interorganizational collaboration. Recently, however, the need for such an application has been suggested (Moreland and Argote 2003).

TMS has two components: (1) internal memory, or what the individual members know personally, and (2) external memory, or what the individuals know about what is known by other team members or can be located and retrieved from various storage devices (Wegner 1987). A well-developed TMS makes transactions (or interactions) more efficient and can help integrate disparate or changing knowledge within a group (Faraj and Sproull 2000). Even though TMS theory was originally developed for dyads in close relationships and small, well-defined interacting groups, Anand et al. (1998) extended TMS theory to settings where knowledge is distributed in the minds of people who belong to groups both inside and outside the organizational boundaries. In such settings, TMS exists at individual, group, and organizational levels.

Development of TMS

The TMS theory suggests that TMS forms and is continually updated as individuals accumulate knowledge about others' domains of expertise via communication, shared experiences, observation, joint decision making, and so on, as they work in a variety of formal and informal roles (Wegner 1987). While the constant changes in formal organizational roles as well as in membership of various virtual teams make the organizational-level TMS of a team easily obsolete, they simultaneously build the TMS for the ego-centric network. Nardi, Whittaker, and Schwarz (2002) argue that in today's lean and turbulent organizations, formal structures can be more transient than informal ego-centric networks. In fact, as assessed by the individual, ego-centric networks may be more robust than the organizational or team structures in which they participate. Ego-centric networks evolve over the years as a person works in a profession (i.e., security professional), in different formal roles and structures. Ego-centric networks provide important stability as membership grows slowly and trusted members are added.

Our vantage point is the individual's view of the TMS for the ego-centric network associated with a particular work domain or profession. We adopt an individual's view of the network because it is the individual who participates in *ad hoc* collaborations, builds and maintains the network, decides what knowledge to share, and evaluates and combines this knowledge (Brandon and Hollingshead 2004). In high-risk informal networks, deciding to share confidential knowledge, in particular, requires that the individual assess the risks of sharing, not only to his home organization, but to himself personally.

Following the convention in TMS literature, we adopt a memory metaphor to describe the TMS of ego-centric networks. TMS refers to an individual's cognitive knowledge structure that accumulates as he or she is engaged over time. The structure encompasses others' knowledge, experience, joint work, and so forth. Our conceptualization of TMS is different from that in the literature in the sense that the memory is not defined or configured by an organizational or institutional agency. The network changes and transforms as the individual is involved in activities with network members.

Existing TMS theories suggest that the best way to build a TMS is through shared face-to-face experiences such as joint training (Moreland and Levine 2000). Virtual settings constrain TMS development (Alavi and Tiwana 2002). When team members are trained together, rather than apart, they are able to better locate, integrate, and use each others' skills and knowledge. But such shared experiences may be rare among the members of the ego-centric network, especially over time. Hollingshead et al. (2001) noted ways other than training to convey expertise. We argue that it is not the face-to-face experiences, per se, that develop the TMS, but rather what occurs during these experiences; and as such, these experiences might be fostered in computer-mediated networks.

How will individuals develop TMS for their ego-centric networks in sufficient enough detail to meet their needs when *ad hoc* teams must respond to unforeseen events? How will they gain the confidence to share knowledge with others in the network? Faraj and Xiao (2005) suggest that when the task requires novel interactions among people from different domains (in their case, different health care professionals working in an emergency room), dialogic practices are needed to share knowledge. Similarly, Boland et al. (1994) argue that crossing organizational and functional boundaries often requires dialogic practices; namely, understanding the reasons behind decisions and alternative solutions.

Boland et al. describe five types of dialogic practices: identifying ownership (in which the sources of knowledge contributing to the dialogic practices are known), observing emergence (in which knowledge evolution is transparent), comparing multiple perspectives (in which alternative ideas are surfaced and compared), keeping knowledge indeterminant (in which knowledge is repeatedly revisited and modified in response to new information), and easy travel (between summary level knowledge and detailed analysis). These dialogic practices encourage "heedful interrelating" between those with relevant differentiated knowledge (Weick and Roberts 1993); such interrelating might include the exchange of confidential knowledge. Dialogic practices can lead to constructive disagreements that can cause members to think about others' expertise more deeply and contribute to better understanding of the unique expertise of different members (Faraj and Xiao 2005). Dialogic practices can also help develop the depth and breadth of TMS that allow a person to feel confident about what information can or cannot be shared in a dynamic and volatile situation. It is often not one particular, unique piece of information that should or shouldn't be shared, but rather the combination of several individual pieces of knowledge that, when pieced together with unique information from other sources, leads to knowledge leaks or inappropriate sharing of confidential knowledge (Majchrzak and Jarvenpaa 2005). When members of the ego-centric network frequently use dialogic practices, they should develop more differentiated representation of other members' expertise, especially in high-risk networks confronted with novel events.

> ***H1. In risk prone collaboration, the more that individuals use dialogic practices in discussions with members of their network, the more developed they will perceive the TMS of their ego-centric networks.***

One might question how such dialogic practices can take place when members are physically dispersed. McGrath's (1991) TIP model, media richness theory (Daft et al. 1987), and social presence theory (e.g., Short et al. 1976) question whether it is possible to create the necessary shared interpretive context for dialogic practices via electronic media, where knowledge is fraught with ambiguity and uncertainty. While we do not refute these theories, we claim that dialogic practices can be mediated by communication technologies in the presence of certain antecedent conditions. Here we look at three antecedents: task interdependence of the professional, administrative norms, and the organizational goals for learning.

Focusing on the individual and organizational levels, Te'eni (2001) argues that dialogic practices are more likely to occur under conditions of communication complexity, since dialogic practices are needed to resolve that complexity. At the individual level, perceptions of task interdependence contribute to communication complexity. When a task is perceived as jointly determined by others in the network, it cannot be subdivided. This raises the complexity and encourages individuals to engage with other parties in dialogic practices. Communication complexity can also be fostered by the expectations that an individual brings to the practices.

> ***H2: In risk prone collaboration, the greater the perceived task interdependence, the more the individuals will engage in dialogic practices with other network members.***

Perceived network-level norms for knowledge sharing are also likely to affect whether dialogic practices are used. Norms help individuals feel comfortable knowing what to share during an *ad hoc* collaboration. Norms that clarify expectations of ownership, privacy, sensitive knowledge, frequency of updates, and so forth, provide explicit instructions on what, and how, to share within the network. For example, Faraj and Xiao (2005) found in their study of emergency room teams that such clear norms, referred to as administrative coordination policies, facilitated knowledge integration. Structures that facilitate knowledge sharing and knowledge integration should also help build more accurate TMS of the network.

> ***H3: In risk prone collaboration, the more that administrative norms are perceived as adequate, the more the individuals will engage in dialogic practices.***

Expectations from the formal work organization can influence behavior in informal structures. Although ego-centric activities are largely hidden from the organization, the organization can still convey expectations regarding the goals of such structures. When organizational expectations for dialogic practices in ego-centric networks call for learning (versus short-term performance), individuals are more likely to use dialogic practices rather than simply deconstruct a task and coordinate inputs (Boland 1978). This is likely to be the case in cross-organizational collaborations that bear risks for both the organization and the professional (Norman 2002).

> ***H4. In risk prone collaboration, the more that the organization to which the individual belongs encourages learning from the ego-centric network, the more the individuals will use dialogic practices with other members.***

Control Variables

Interaction in ego-centric networks occurs in settings in which individuals at least partly work across space, time, and firm boundaries with the help of information technologies (Maznevski and Chudoba 2000). Engaging in dialogic practices electronically can be difficult (Walther 1995). The lack of individuating information can in turn mask differences in opinions; make it difficult to discover, and therefore resolve, misunderstandings and conflicts; and prevent bridging across different disciplinary boundaries. Hollingshead (1998b) found that teams using computer-mediated communication were less likely to explain the how and why of their answers than those meeting face-to-face. The lack of know-how and know-why can seriously limit the effective use of dialogic practices. Therefore, we include in our model a control for interactions that are purely virtual, expecting that more virtual-only interaction within the network will result in less use of dialogic practices. Finally, to minimize alternative explanations, we identified two control variables—size and tenure in network—that could impact the development of TMS independent of the antecedents identified above. Larger networks may harm TMS development, while an individual's tenure in the network should help TMS development.

Method

Sample

We tested our model on a sample of security professionals. We solicited the sample from an FBI e-mail distribution list of individuals who are cleared to receive information about security-related issues. Individuals on the distribution list had been approved to receive high-security threat notices through the FBI InfraGard program, an initiative that has received attention recently as a mechanism that might encourage private–public knowledge sharing in security threat situations. InfraGard is organized into regional chapters, the members of which may gather occasionally for face-to-face meetings of a few dozen people. The FBI has an interest in promoting greater knowledge sharing among the individuals, and gave us the opportunity to solicit the opinions of individuals from two chapters through intermediaries appointed by InfraGard. Owing to the sensitive nature of the e-mail distribution list, we had no access to survey respondents' names, e-mail addresses, or other individually identifying information. We interviewed the intermediary at each chapter about InfraGard's role and interorganizational collaborations in response to security threats. We also interviewed 10 other individuals involved in the security domain. We had initially expected InfraGard to be a virtual network, but learned that most e-mail recipients did not identify InfraGard as anything other than an e-mail distribution list, a point that was confirmed in our survey. We found that the interviewees had extensive personal networks that they had built over the years, which sprawled across many organizations and individuals. Further, we found that they relied on their networks for *ad hoc* collaboration. Therefore, we reformulated our hypotheses around ego-centric networks and structured the survey to ask questions about interorganizational collaborations and each individual's own social network, whether or not it included members from InfraGard.

The InfraGard intermediary sent an e-mail to the list of people who regularly receive information from the FBI (500 in one region and 120 in another region) requesting them to complete the survey by clicking on a link indicating the survey was administered through a university, independent of the FBI. Respondents were informed that completing the survey would provide feedback to InfraGard on ways to improve knowledge sharing among public and private organizations, as well as within their own networks.

A total of 104 individuals completed the web-based survey. It is impossible to assess the representativeness of this sample. The InfraGard intermediaries determined that individuals they considered "key informants" (i.e., those security professionals who collaborated with others and who had an interest in providing feedback to InfraGard) had completed the survey. Moreover, the intermediaries conducted follow-on interviews with individuals who did not complete the survey and determined that their reasons for not participating included that they were not a security professional who acted on security information (only stayed informed), they did not collaborate with other security professionals outside their organization, or they did not feel any affiliation or identification with InfraGard and they considered the frequent e-mails to be solely informational, and thus had no interest in providing feedback to InfraGard. Therefore, we believe that our sample can be characterized as consisting of *active security professionals* engaged in security-related cross-organizational collaborations, with some interest in developing further collaborations through InfraGard. Since our objective is not to assess the prevalence of the conditions that foster TMS, but rather to examine the theoretical links between the key constructs, the representativeness of the sample should be less of an issue.

Measures

Survey questions directed the respondents to describe their personal ego-centric network of security professionals. We defined this network as *an informal personal network or circle of professionals interested in security generally, or interested in a specific* *aspect of security, with whom you have collaborated in the past to better understand new security information or confront a security risk*. Network sizes ranged from 4 to 500, with a mean of 103; on the average, people reported that 16 to 30 percent of the members in their network were new each year. As expected, the respondents identified, on average, less than 15 percent of the members of these networks as InfraGard members. Individuals reported collaborating in the past with an average of only 31 to 45 percent of their network members, where collaboration was defined as working with another member as partners in a joint problem-solving process. A total of 75 percent of the respondents reported that their network consisted of individuals from both formal associations (or organizations including federal government and the private sector) and from personal networks or circles they had developed over the years. On the average, 46 to 60 percent of the members in their network were geographically local (within driving distance). Despite the geographical closeness, the most common media for interaction among network members was one-on-one e-mail and group e-mail lists, followed by phone calling. Face-to-face meetings were the least-used mode of interaction, occurring, on average, "a few times per year."

Respondents had been members of their networks for 10 years, on average, with a substantial range (from .5 to 42 years). They came from a variety of organizations: 61 percent private (versus 39 percent public), 50 oercebt for-profit (versus 50 percent nonprofit), and 31 percent with security as the main line of business. They had held their security jobs, on the average, for 15 years (range 1 to 42 years).

We measured five perceptual constructs. The specific items are shown in Appendix A.

- **Transactive memory development (TMS)**. Since we were interested in an individual's perception of the TMS of his or her ego-centric network, we asked each respondent to rate the network's TMS based on his or her own personal interactions with the network. As these were ego-centric networks, independent confirmation of the network's TMS was not feasible. We measured transactive memory using the 10-item instrument developed by Lewis (2003).

- **Frequency of use of dialogic practices**. We adapted the scale measuring the use of dialogic, or discursive, practices during interactions among network members from Majchrzak et al. (2005) based on the five elements of dialogic practices identified by Boland et al. (1994)—ownership, easy travel, multiple perspectives, emergence, and indeterminance—measuring each element by two items. Refer to Majchrzak et al. for a discussion of the development of this scale. The original scale focused on IT support for these elements, but we changed the question to have respondents focus on the frequency with which these elements take place among network members regardless of the media used.

- **Organizational learning objectives**. We used Norman's (2002) five-item measure of organizational learning objectives from strategic alliances.

- **Task interdependence**. Task interdependence refers to the degree to which the individual believes that responses to security threats require interdependent action with others outside his or her own organization. We measured task interdependence based on the scale adapted from Goodhue and Thompson (1995).

- **Adequacy of administrative norms**. Faraj and Sproull (2000) developed a general measure for adequacy of administrative coordination mechanisms. We used their instrument and added items specifically for the security context, including security norms and procedures, knowledge ownership, knowledge sharing, and information sensitivity.

- **Controls**: We measured network size with a single-item question asking respondents to estimate the number of people who belong to their network. We also asked respondents to report on the number of years they were members of their network. Finally, to control for virtual-only-interaction in the network, we asked respondents to estimate the percentage of network members who were geographically distant and with whom they interacted exclusively through electronic means, normalizing this index by network size.

Analysis Strategy

We used partial least squares (PLS), a latent structural equation modeling technique that utilizes a correlational, principle component-based approach to estimation (Chin 1998). Each multi-item construct was modeled as reflective (versus formative) of the latent variable because we expected the items measuring each construct to co-vary. For example, the items corresponding to organization learning objectives measured the underlying construct of learning. Our model exceeded Chin's (1998) sample size recommendation of 5 to 10 times the largest number of structural paths to any one construct. To estimate the significance of the path coefficients, we used bootstrapping with a sample size of 200, as recommended by Chin.

Results

Measurement Model

Results of the PLS component-based analysis, correlations among the constructs, alpha coefficients, reliability tests, PLS-computed variability for each construct, and inter-construct correlations are presented in Tables 1 and 2. Of the 10 items in the TMS instrument, 4 were dropped for low loadings on the TM construct, following suggestions for trimming by Gray and Meister (2004).

Table 1 provides the correlations of each item to its intended construct (i.e., loadings) and to all other perceptual constructs (i.e., cross loadings). Although there is some cross-loading, all items load more highly on their own construct than on other constructs, and all constructs share more variance with their measures than with other constructs. Table 2 shows that the alpha coefficients for the items within each construct are sufficiently high, as are the more accurate composite reliabilities. Table 2 also presents average variance extracted as well as correlations between constructs, including the control variables. Comparing the square root of the average variance extracted (AVE) (i.e., the diagonals in Table 2 representing the average association of each construct to its measures) with the correlations among constructs (i.e., the off-diagonal elements in Table 2 representing the overlap association among constructs) indicates that each construct is more closely related to its own measures than to those of other constructs. Moreover, all AVEs are well above the 0.50 recommended level (Chin 1998). In sum, these results support the convergent and discriminant validity of our constructs.

Structural Model

Figure 1 presents a graphical depiction of the PLS results, and Table 3 contains the outer-model loadings of the items on each construct. The hypothesized paths of predictors of the use of dialogic practices are significant (note the control variable of virtuality was insignificant but in the expected direction), accounting for 30 percent of the variance. In addition, the hypothesized paths between dialogic practices and TMS development are also significant, accounting for 39 percent of the variance in TMS development. The control variables are not significant.

The results support the first hypothesis that individuals' TMS of their ego-centric network are encouraged through the active use of dialogic practices—even in environments where improper knowledge sharing carries high risk, and where members have little or no face-to-face contact or shared experiences with many of the other members of an informal network. As hypothesized, the use of dialogic practices is fostered when administrative norms clarify knowledge sharing, individuals perceive their tasks to be interdependent with other members of the network, and the formal organization supports learning from the network. We checked to determine if the effect of the antecedents on TMS development was mediated through dialogic practices and found that neither task interdependence nor organizational support had a direct relationship with TMS development once mediated through dialogic practices. Administrative norms had a direct relationship in addition to its mediated relationship, suggesting that administrative norms serve two different roles: one to encourage dialogic practices and the other to encourage TMS development.

Discussion

The objective of this research was to extend theory on TMS to incorporate informal networks of professionals that are used for *ad hoc* collaboration where knowledge sharing carries risks. We performed an initial empirical test of the extensions via a survey study. There are numerous limitations with a survey study, including difficulty in assessing causation, the potential for common method variance, and the inability to assess representativeness of the surveyed sample relative to the population. However, as an initial exploratory study of the development of TMS in an ego-centric network, this study raises several important considerations for TMS theory building and information systems design.

The results support the research model. As hypothesized, dialogic practices used among network members had a positive direct effect on an individual's development of TMS for the network. Moreover, we found support for our second hypothesis, identifying three antecedents of frequent dialogic practices: task interdependence, organizational support for collaboration, and administrative norms.

Table 1. Item Discriminant Analysis (Cross-Loadings)

Construct/ Items	TM	Disc	Org Obj	tskInt	Admin
TMA	**.61**	.37	.21	.25	.24
TMD	**.80**	.53	.30	.20	.32
TME	**.87**	.41	.25	.10	.38
TMF	**.88**	.41	.26	.08	.43
TMH	**.66**	.39	.14	.21	.42
TMI	**.72**	.37	.29	.16	.49
DISCA	.50	**.76**	.27	.25	.25
DISCB	.45	**.69**	.27	.28	.31
DISCC	.41	**.84**	.44	.29	.21
DISCD	.44	**.86**	.34	.26	.20
DISCE	.54	**.85**	.33	.25	.39
DISCF	.41	**.84**	.33	.20	.30
DISCG	.42	**.81**	.40	.27	.25
DISCH	.47	**.83**	.30	.27	.34
DISCI	.38	**.80**	.27	.27	.24
DISCJ	.36	**.78**	.40	.20	.21
OBJA	.24	.34	**.88**	.10	.08
OBJB	.25	.38	**.86**	.03	.10
OBJC	.28	.32	**.91**	.11	.19
OBJD	.30	.38	**.89**	.23	.29
OBJE	.34	.40	**.85**	.26	.20
TSKINTA	.17	.27	.20	**.91**	.14
TSKINTB	.20	.27	.09	**.88**	.20
TSKINTC	.22	.30	.19	**.93**	.18
TSKINTD	.13	.26	.08	**.78**	.20
ADMINA	.45	.19	0	.21	**.77**
ADMINB	.40	.32	.28	.15	**.77**
ADMINC	.35	.17	.14	.13	**.75**
ADMIND	.39	.30	.09	.16	**.90**
ADMINE	.43	.39	.21	.17	**.86**

Boldface numbers are loadings (correlations) of indicators to their own constructs; other numbers are cross-loadings. To calculate cross-loadings, a factor score for each construct was calculated based on the weighted sum, provided by PLS-Graph, of that factor's standardized and normalized indicators. Factor scores were correlated with individual items to calculate cross-loadings. Boldface item loadings should be greater than cross-loadings. See Appendix A for actual item wording in the surveys.

Table 2. Inter-Construct Correlations: Consistency and Reliability Tests

Construct	Cronbach Alpha	Composite Reliability	AVE	TMS	Disc	Org Obj	Tskint	Admin	Size of Network	Years in Network
TMS	.84	.89	.59	**.76**						
Disc	.94	.95	.66	.51	**.81**					
Org Obj	.93	.94	.78	.32	.42	**.88**				
Taskint	.90	.93	.77	.21	.32	.17	**.87**			
Admin	.87	.90	.66	.49	.36	.19	.20	**.81**		
Size of Network	na	na	na	-.17	.16	.08	.13	.001	**na**	
Years in Network	na	na	na	.10	.10	.07	.13	.03	.14	**na**
Virtuality	na	na	na	-.22	-.26	-.21	-.33	-.17	-.33	-.13

Boldface numbers on diagonal are the square root of the variance shared between the constructs and their measures. Off-diagonal elements are correlations among constructs. For discriminant validity, diagonal elements should be larger than off-diagonal elements

Table 3. Outer Model Loadings

	Entire Sample Estimate	Mean of Subsamples	Standard T-Statistic Error	t-statistic
TM Development				
TMA	.6276	.6341	.0958	6.5541
TMD	.8158	.8165	.0390	20.7587
TME	.8662	.8594	.0424	20.4078
TMH	.6668	.6514	.0680	9.8054
TMI	.7212	.7109	.0587	12.2888
Dialogic Practices				
DISCA	.7678	.7600	.0547	14.0454
DISCB	.6988	.6962	.0809	8.6352
DISCC	.8506	.8540	.0266	31.9305
DISCD	.8605	.8574	.0263	32.7288
DISCE	.8587	.8532	.0306	28.0878
DISCF	.8395	.8313	.0357	23.5211
DISCG	.8150	.8086	.0484	16.8514
DISCH	.8276	.8174	.0358	23.1432
DISCI	.8058	.7950	.0528	15.2507
DISCJ	.7892	.7783	.0506	15.5828
Org Objectives for Learning				
OBJA	.8889	.8839	.0455	19.5203
OBJB	.8609	.8593	.0378	22.7465
OBJC	.9147	.8969	.0780	11.7198
OBJD	.8992	.8818	.0838	10.7326
OBJE	.8587	.8513	.0515	16.6875
Task Independence				
TSKINTA	.9166	.9145	.0233	39.2940
TSKINTB	.8895	.8889	.0357	24.9353
TSKINTC	.9342	.9315	.0224	41.6660
TSKINTD	.7819	.7823	.0572	13.6730
Admin Norms				
ADMINA	.7706	.7455	.1124	6.8562
ADMINB	.7798	.7769	.0652	11.9669
ADMINC	.7559	.7334	.0762	9.9264
ADMIND	.9006	.8948	.0312	28.8784
ADMINE	.8637	.8866	.0248	34.8440

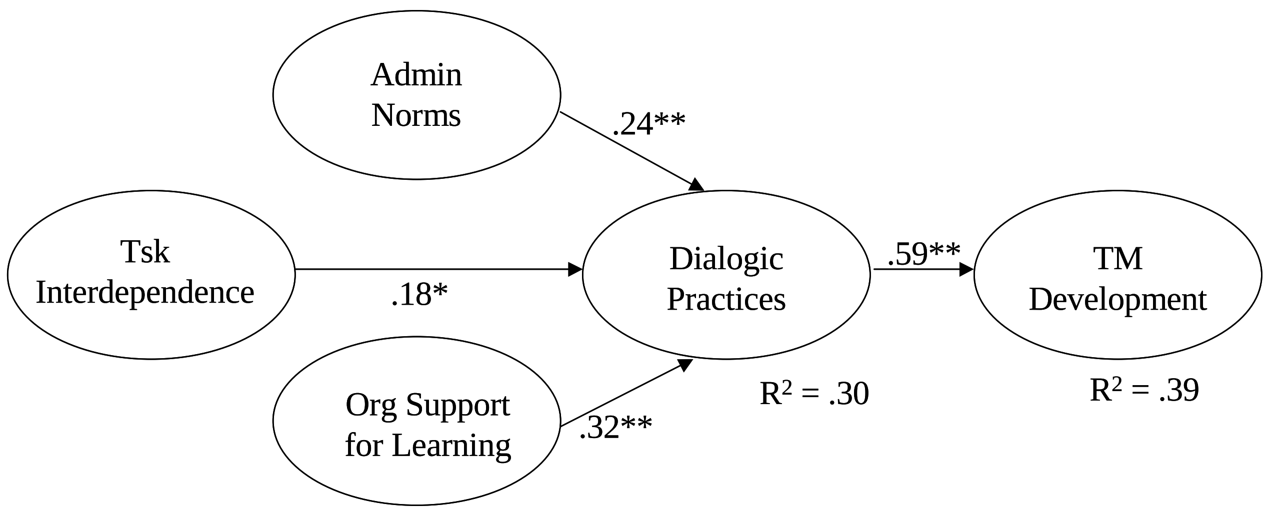

Figure 1. Results

These results help to extend TMS theory to informal networks that are centered around a professional. First, our findings indicate that individuals in an ego-centric network maintain a mental model of that network that takes on characteristics of the transactive memory. Thus, as suggested by Anand et al. (1998) and Moreland and Argote (2003), organizational level, or in this case, network level, transactive memory is a concept that is worth exploring. As modern organizations are increasingly transitory and unstable in their formal structures (DeSanctis and Monge 1999), it may be the informal structures that provide the more stable basis for TMS. Since ego-centric networks are centered around an individual (i.e., each individual has his or her own network that overlaps with the networks of others to some extent, but is not entirely redundant), this suggests that, at the ego-centric network level, the concept of transactive memory becomes an individual one. Thus, paradoxically, transactive memory for informal networks becomes simultaneously an organizational-level (rather than a team-level) and an individual-level concept. Future research should further explore the extent to which the conceptualization of TMS within an ego-centric network should be similar to, or different from, the conceptualization of TMS at the team or organizational level.

Second, our findings suggest ways in which an individual's TMS for his/her network can be developed. While future research should examine this longitudinally, our findings suggest that TMS can be developed through dialogic practices. Such dialogic practices are possible in informal networks if certain conditions prevail. No previous study has documented these effects. While Boland et al. (1994), Faraj and Xiao (2005), Te'eni (2001), and others have all suggested the importance of dialogic practices in joint problem-solving, our findings suggest that dialogic practices are important not just for joint problem-solving, but to understand each others' expertise. In addition, and most important, the TMS literature has consistently argued for the importance of building TMS within the confines of the team. Thus, recommendations for having joint training exercises are seen as a way to build a common transactive memory among team members. Individuals rarely work with all other members of the ego-centric network; the network is built over many years and over different encounters. Our findings suggest that dialogic practices carried out among members of the network can serve a function similar to that of joint training. These practices can signal and convey expertise. The practices themselves might occur through virtual network meetings, discussion threads, phone calls, or jointly attended technical seminars;,planned or unplanned. Future research should explore the dialogic practices themselves in more detail. Should they be focused on specific events within the context of an *ad hoc* team, or are general discussions not focused on specific events sufficient for building a TMS of the network? How do the practices build, versus maintain, the networks over the years?

Third, our findings suggest the contextual conditions in which dialogic practices are likely to occur among ego-centric network members. We found that at the network level, having norms that clarify knowledge sharing is important. Interestingly, as suggested by Faraj and Xiao (2005), we also found that these same norms had a direct effect on TMS development, suggesting that the norms clarify both the condition for dialogue and the condition for TMS development. We found that an individual's views of the degree of task interdependence were important for predicting his or her use of dialogic practices. This may become particularly important in a context such as security where there may be a bias against reliance on others. Finally, we found that the learning goals of the professional's formal organization had an impact on dialogic practices. Dialogic practices were more likely when the organization encouraged learning from others.

These findings suggest several conclusions. First, the TMS literature may help to explain the behavior of individuals in ego-centric networks, in general, as well as in the computer-mediated networks among individuals who may not naturally collaborate, as in security. There has been much concern in the public sector about the inadequate knowledge sharing among national security entities. Our findings suggest that participants build TMS of their security-related networks, and this TMS can be developed when the conditions for dialogic practices are in place.

For theory on TMS, our findings suggest several modifications.

1. TMS may need to be considered as an individual-level phenomenon when informal networks, specifically ego-centric networks, are the focus.

2. Dialogic practices may be the antecedent to TMS development, with face-to-face interactions and joint training as only one set of mechanisms by which dialogic practices can occur.

3. An individual's TMS for the ego-centric network is affected by several antecedents that have not been given adequate consideration in past TMS research.

4. There has been a bias in the TMS literature toward more knowledge sharing, ignoring the value accorded the individual of withholding shared knowledge.

TMS may have utility to help explain not just sharing of knowledge, but also when sharing is not appropriate or well-intentioned.

Finally, our findings have implications for information systems design, since these ego-centric networks are dependent on information technology. Much of the knowledge sharing in the security community occurs through a portal broadcasting information (such as about the latest terrorist threat) to a selectively vetted membership, technical seminars web-cast over the Internet, teleconferencing, e-mail distribution lists, or discussion boards. Knowledge integration can be supported by various virtual spaces. It is unlikely that the members will rely on any one particular virtual space, but rather that they will span different virtual communities and spaces. Our findings suggest that information systems need to be developed that foster the use of dialogic practices across a number of different virtual communities. While our survey did not examine the specific features of information systems used by the respondents to foster dialogic inquiry, others have recently provided suggestions. For example, Majchrzak et al. (2005), building on theory by Boland et al. and Te'eni, describe a strategy for designing virtual workspaces to foster dialogic practices through contextualization. In this strategy, the five dialogic practices of ownership, multiplicity, emergence, indeterminism, and easy travel were found to increase knowledge sharing effectiveness among virtual team members. Applying a similar view of information systems design to foster dialogic inquiry among informal network members may help build the TMS.

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Appendix A

Label	Item
TM DEVELOPMENT: Based on your personal interactions with the members of this network (1 = strongly disagree to 7 = strongly agree)	
TMA	Each member has highly specialized knowledge of some aspect of security
TMD	I am comfortable accepting security-related suggestions from the other members
TME	I trust that other members' knowledge about security is credible
TMF	I am confident relying on the information that other members bring to a discussion
TMH	Members in this network know each other and work together in a well-coordinated fashion
TMI	Members respond to security problems smoothly and efficiently
DIALOGIC PRACTICES: When you think of discussions you have had with others in your network, how frequently do the following happen? (1 = never to 7 = daily)	
DISCA	Develop several options for interpreting information or responding to a threat
DISCB	Describe problems at both the summary level as well as the detailed level
DISCC	Discuss alternative scenarios for a problem
DISCD	Brainstorm about ideas or possible solutions
DISCE	Describe detailed context of threat information
DISCF	Understand how information changes over time
DISCG	Discuss sources of ideas for handling threat
DISCH	Discuss how time is affecting information
DISCI	Revisit decisions or interpretations about security issues made earlier
DISCJ	Discuss source of threat information
ORG OBJS FOR LEARNING: When participating in your community of security professionals, to what degree are these objectives especially important to your employer? (1 = completely unimportant to 7 = strongly important)	
OBJA	Learn about new technology
OBJB	Learn about new management techniques
OBJC	Learn about new ways to prevent security problems
OBJD	Learn about new ways to respond to security threats
OBJE	Access to others' skills and knowledge
TASK INTERDEPENDENCE: My security responsibilities in my organization: (1 = strongly disagree to 7 = strongly agree)	
TSKINTA	Requires me to talk with staff from other organizations
TSKINTB	Often involves me sharing information with staff at other organizations
TSKINTC	Often involves using information and solutions from other organizations
TSKINTD	Creates results that are dependent on the efforts of others from other organizations
ADMIN: How adequate are the following administrative procedures used in your community for meeting your security needs? (1 = completely inadequate to 7 = completely adequate)	
ADMINA	Norms and procedures for informing others about security threat information
ADMINB	Protocol for having regularly scheduled meetings
ADMINC	Norms about who owns what rights to knowledge, inventions, or discoveries
ADMIND	Procedures for identifying what information is sensitive
ADMINE	Safeguards to protect the privacy of the source
Controls	
Network Size	Approximately how many people are in this network, defined as an informal personal network or circle of professionals interested in security generally or interested in a specific aspect of security with whom you have collaborated with in the past to better understand new security information or confront a security risk
Years in network	For how many years have you been a member of this network?
Virtuality	"Approximately what percentage of the people in this network are geographically local (within driving distance) of you," weighted by "Percentage of people with whom you interact virtually via e-mail, portals or instant messaging" normalized by network size