6-21-2011 12:00 AM

A Social Relations Analysis of Transactive Memory in Groups

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A thesis submitted in partial fulfillment of the requirements for the degree in Doctor of Philosophy

A SOCIAL RELATIONS ANALYSIS OF TRANSACTIVE MEMORY IN GROUPS

(Spine title: Social Relations Analysis of Transactive Memory)

(Thesis format: Monograph)

by

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Graduate Program in Psychology

A thesis submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy

The School of Graduate and Postdoctoral Studies
The University of Western Ontario
London, Ontario, Canada

THE UNIVERSITY OF WESTERN ONTARIO
SCHOOL OF GRADUATE AND POSTDOCTORAL STUDIES

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entitled:

A Social Relations Analysis of Transactive Memory in Groups

is accepted in partial fulfillment of the
requirements for the degree of

Doctor of Philosophy

Date____________________________ ____________________________
Chair of the Thesis Examination Board

ABSTRACT

Transactive memory is the knowledge of what others in a group know and the exchange of that knowledge. In groups with effective transactive memory systems, members know "who knows what", send knowledge to the appropriate individuals, and develop strategies for retrieving that information (Mohammed & Dumville, 2001; Wegner, 1995). Transactive memory studies tend to focus on the group as a whole, but useful information might be gathered by investigating transactive memory in *dyads within groups*. The purpose of this research was to use the social relations model (Kenny & LaVoie, 1984) as the basis for operationalizing transactive memory and to examine this new operationalization of transactive memory as it related to group performance. In social relations model terms, an effective transactive memory system was operationalized as consensus about expertise and knowledge seeking. Data were collected from two samples of student engineering project groups (n = 55 groups and n = 77 groups) and a sample of organizational engineering project groups (n = 7 groups). Groups whose members had spent significant time working together were hypothesized to have effective transactive memory systems and to exhibit significant consensus. Groups whose members had spent relatively less time with one another were hypothesized to have poorer transactive memory systems and to make use of unique relations in the group and assimilation as the basis for identifying expertise. The hypotheses were partially supported. In groups whose members spent relatively more time together, there was some agreement about who was expert and from whom to seek knowledge; however, knowledge exchange tended to be mostly based on seeking knowledge from no one or everyone in the group. In addition, group members made use of their unique dyadic relationships with particular others when identifying expertise and seeking knowledge. In fact, members of groups that performed better were likely to exchange knowledge based on their unique dyadic relationships with others. This study advances earlier research on transactive memory by suggesting that dyadic relations within groups are important to fully understanding transactive memory and its relationship with performance.

KEYWORDS: transactive memory, social relations model, groups, teams

ACKNOWLEDGEMENTS

Although only one name graces the cover of a dissertation, so many people make that dissertation possible. I would especially like to thank my advisor, Natalie Allen. Natalie has played various roles in our supervisor-student dyad—she has mentored, advised, reassured, and supported me throughout my years as a graduate student. I am forever grateful for her understanding as I tackled parenthood and a full time job at the same time as my dissertation. The compassion and understanding that Natalie provided made the balance of work, family, and school possible.

This dissertation certainly would not exist without my student and organizational samples. I am grateful to the Faculty of Engineering organizers and instructors for working with us over the past few years to provide a source for data collection for my project and for others. To all of the organizations whose employees were willing to complete my lengthy questionnaires—thank you for taking a chance with this study. In particular, a huge thank you to the engineering organization that participated in my final study. The time and effort that you put into this project was incredible, and the passion that you put into your own work inspired me.

I am so grateful for all of the wonderful members of The TeamWork Lab— Kevin Doyle, Helen Lee , Tom O'Neill, and Hayden Woodley—who helped so much with data collection that this dissertation truly would not be possible without them. Kevin was particularly helpful in orchestrating data collection for one of my studies and answering questions from me at all hours of the day.

To the members of my various committees—Joan Finegan, Lorne Campbell, John Meyer, Fernando Olivera, and Chet Robie. Thank you for the time you took to review my work. Your wonderful comments helped to make my dissertation better.

To Justin Veenstra for his prompt, clear, and helpful stats advice. I know few people quicker to respond to e-mails about stats. I am very grateful to Justin for helping me to work through alternative methods for analyzing my data.

To everyone at work— Dr. Elizabeth Finger, Dr. Stephen Pasternak, Dr. Sarah Morrow, Sarah Jesso, Kathy Ayers, Darlene ten Haaf, Jack Morlog, and Darlyne Morlog—for aiding with ideas for new samples and allowing me the time and flexibility to pursue this dissertation. This thesis was made much easier with your support.

To my parents, grandparents, aunts, and uncles—for taking Kyla for sleepovers when I had to enter data, for showing interest in what I do, for being excited to brag about my dissertation to everyone they know, and for listening to my complaints over the years. Thanks for being there to listen and provide advice.

To my incredible daughter, Kyla—your smiles, laughter, tears, witty comments, hugs, kisses, and even the temper tantrums were a welcomed distraction from conducting analyses and writing lit reviews. You mean the world to me. Finally, to my wonderful husband, Fred. I can't thank you enough for everything you have been through with me over the past few years as I completed my dissertation and we started a family. You provided advice when I was unsure and encouraged me when I wanted to give up. I can't wait to start this next part of our life together.

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INTRODUCTION

Despite widespread interest in and use of teams in organizations (Devine, Clayton, Philips, Dunford, & Melner, 1999; Ilgen, Hollenbeck, Johnson, & Jundt, 2005; Osterman, 1994), teams do not always work (Hackman, 1998; Locke, Tirnauer, Roberson, Goldman, Latham, & Weldon, 2001). Teams may be ineffective for numerous reasons, such as lack of cohesion (Beal, Cohen, Burke, & McLendon, 2003), abundance of conflict (De Dreu & Weingart, 2003), or inadequate systems of knowledge exchange (HR Zone, 2009; Kozlowski & Ilgen, 2006). The latter problem is particularly worrisome due to the fairly recent increase in knowledge-based work (see Kunzler & Payne, 2004).

One interesting line of knowledge exchange research concerns *transactive memory*. Transactive memory is "a combination of individual minds and the communication among them" (Wegner, Giuliano, & Hertel, 1985, p. 256). More specifically, transactive memory consists of (a) *organized knowledge* held by group members and (b) *transactive processes* that occur amongst those group members (Wegner et al., 1985).

The *organized knowledge* held by group members includes the knowledge that each group member possesses plus the information that each member has about what his or her teammates know. In other words, organized knowledge is comprised of "knowing" and "knowing who knows what" in a group (Liang, Moreland, & Argote, 1995; Mohammed & Dumville, 2001; Moreland, Argote, & Krishnan, 1996; Rau, 2005; Rulke & Rau, 2000; Wegner et al., 1985). The notion of knowing "who knows what" is, perhaps, what sets transactive memory apart from related constructs. Individuals only need to know *who* has the information they are looking for—rather than actually possessing that knowledge themselves.

Knowing who possesses information is only useful if that information can be communicated in some way. Through communication or *transactive processes* amongst group members, encoding, storage, and retrieval of knowledge take place—much as individual memories encode, store, and retrieve information (Hollingshead & Brandon, 2003; Wegner et al., 1985). Thus, in groups with effective transactive memory systems, members know who knows what, send new or incoming knowledge to the appropriate group members, and develop strategies for retrieving that information within the group (Mohammed & Dumville, 2001; Wegner, 1995).

According to Brandon and Hollingshead (2004), an important component of an effective transactive memory system is *sharedness*. That is, who to send knowledge to and who to seek knowledge from should be shared amongst group members. Shared ideas about who knows what and who to seek knowledge from are important because they allow for a smooth flow of information to and from the group members who are most likely to remember that information.

Above is an overly simplistic explanation of transactive memory. For example, although first introduced as a dyadic construct in intimate couples (Hollingshead, 1998a, 1998d; Johansson, Andersson, & Ronnberg, 2000; Wegner, 1986, 1995; Wegner, Erber, & Raymond, 1991; Wegner et al., 1985; Wegner & Wegner, 1995), transactive memory research has expanded to include studies of groups (e.g., Austin, 2003; Lewis, 2003; Liang et al., 1995; Moreland & Myaskovsky, 2000) and even organizations (e.g., Anand, Manz, & Glick, 1998; Brauner & Becker, 2006; Jackson & Klobas, 2008; Moreland &

Argote, 2003; Nevo & Wand, 2005; Peltokorpi, 2004). In addition, transactive memory has been operationalized in many ways. For example, Lewis (2003) defined transactive memory as group member self-reports of whether their teammates had specialized knowledge, trust in others' knowledge, and coordination in their groups, and then aggregated results within the group. Moreland and Myaskovsky (2000) coded videotapes for behaviors that would reflect transactive memory in groups. Wegner et al. (1991) examined the number and types of words recalled by dyads composed of strangers versus intimate couples. Peltokorpi (2004) asked individuals to respond to three items about who had what expertise in their organizations.

Evidently, differences exist in the content of transactive memory measures and levels of analysis at which transactive memory is studied, and sense must be made of these differences. The goal of this research was to review the numerous conceptualizations of transactive memory, outline their differences, and propose a novel way of conceptualizing and studying transactive memory that takes into account the dyadic relationships that are present within groups. Kenny's social relations model (Kenny & La Voie, 1984) was the basis of this new definition of transactive memory. Then, analyses were conducted with group acquaintance and performance to show the benefits of using this new conceptualization of transactive memory. The purpose of this research was to determine whether transactive memory, defined on the basis of the social relations model, differed in lower- and higher-acquaintance groups and was associated with performance. Transactive memory theory, empirical research, and measurement will be examined next.

Transactive Memory Theory

Wegner and his colleagues (Wegner, 1986, 1995; Wegner et al., 1985, 1991; Wegner & Wegner, 1995) established the concept of transactive memory in their work on relationships in close couples. In an intimate couple, Wegner proposed, partners develop a sense of what the other person knows through disclosure of interests, skills, education, and other personal characteristics. Similarly, identity negotiation researchers (e.g., London, Polzer, & Omoregie, 2005) suggested that, in the early stages of group formation, group members disclose information about themselves. As the relationship progresses, members realize that they converge in some knowledge domains and diverge in others. That is, in some domains members share information and interpretation of this information; in other domains, members specialize or diverge in the information they hold.

While sharedness of knowledge is indeed important, the focus in much of the recent transactive memory literature is on divergence or distribution of knowledge (e.g., Hollingshead, 1998a, 1998d; Lewis, 2003; Moreland & Argote, 2003; Wegner, 1995)[1]. When knowledge is distributed and members are aware of this distribution, they simply need to ask for this information rather than possess it themselves. For example, a person only needs to know that his partner is a computer expert rather than learn about computers. Distributed or specialized knowledge is essential to the development of an efficient group memory system; however, importantly, group members must *take responsibility* for information in their areas of expertise (cognitive interdependence; Brandon & Hollingshead, 2004; Hollingshead, 2001).

[1] Convergence or integration is discussed to the extent that group members share knowledge of who knows what (Hollingshead, 1998b; Wegner, 1995).

In order to develop a distributed or specialized memory system, group members need *reasons* for assigning responsibility for certain domains of knowledge to particular individuals (Hollingshead & Fraidin, 2003; London et al., 2005; Wegner, 1986, 1995; Wegner et al., 1991). Most sensibly, responsibility would be assigned to the person perceived to be an “expert” in a particular domain; however, identification of expertise is not a straightforward process. Assigning responsibility for domains of knowledge might be made based on anything from surface characteristics to actual knowledge (Nickerson, 1999; Wegner, 1995; Wegner et al., 1991; Wittenbaum, Stasser, & Merry, 1996). For example, early in a group’s life, members might be presumed experts on a topic based on their *surface characteristics*—such as gender, age, and ethnicity. Without knowing anything else, group members may need to rely on the surface characteristics of their teammates in order to assign responsibility for knowledge domains. Craig (2004) and Hollingshead and Fraidin (2003) found that participants used gender information to infer the expertise of their partners. Note that such surface characteristics are not necessarily accurate indicators of expertise (see Myaskovsky, Unikel, & Dew, 2005; Wegner, 1986). In addition, responsibility might be established by someone *volunteering* or *being volunteered* to be accountable for certain knowledge. As well, responsibility for information may be assigned through *circumstance*; that is, the group member who presented a piece of information first (primacy), most recently (recency), or most often (duration) could be assigned responsibility for that domain. Finally, once group members have had the chance to communicate and interact with one another, the opportunity exists for members to learn about each other’s skills, education, interests, abilities, and other *personal characteristics* that more appropriately signify “true” expertise. For example, Craig (2004) found that participants made use of information about their partner's school major when deciding which words to recall.

Partly due to their ability to accurately recognize "true" expertise, teams with transactive memory systems are hypothesized and found to perform well (Austin, 2003). Indeed, awareness of others' expertise is vital to a transactive memory system. However, not only must members learn who knows what, they must also send relevant information to the appropriate group member and retrieve that information when needed (Mohammed & Dumville, 2001; Wegner, 1995). The strength of the transactive memory construct is evident when members are assigned responsibility for knowledge based on their expertise, have shared ideas of who knows what, and fulfill their expected responsibilities within the group (Brandon & Hollingshead, 2004).

Empirical Research

The volume of empirical work on transactive memory is explained here in terms of five different phases of research. The five phases discussed here include the pioneering, expertise recognition, experience-in-groups, development, and field studies. Each is described below, generally in order from the earliest to the most recent work.

The Pioneering Studies

The pioneering studies include Wegner's (Giuliano & Wegner, as cited in Wegner, 1986; Wegner et al. 1991) and Hollingshead's (Hollingshead, 1998a, 1998d, 2000, 2001) laboratory research with dating couples and pairs of strangers. Studies by both researchers required participants to remember lists of words in various domains. Research within this phase highlighted (a) the importance of accepting responsibility for particular knowledge domains (Giuliano & Wegner, 1985; as cited in Wegner, 1986;

Hollingshead, 2000, 2001; Wegner et al., 1991) and (b) the role of communication in transactive memory systems (Hollingshead, 1998a, 1998d).

Accepting responsibility for information. Using dating couples, Giuliano and Wegner (as cited in Wegner, 1986) illustrated the importance of dyad members accepting responsibility for particular domains of knowledge. Generally, participants in this study recalled words within their self-reported areas of expertise—an unsurprising finding explained by individual memory research. However, in addition to remembering words in their own areas of expertise, partners took responsibility for remembering words based on circumstance. Specifically, the member of each dating couple who was provided with more time took responsibility for remembering words in those domains in which his or her partner was not an expert. Wegner considered this finding as evidence of transactive memory. Participants were aware of what their partners did and did not know and, when given more time to view the words, participants took responsibility for those domains with which their partners were not familiar.

In the above study, researchers examined the *natural* assignment of responsibility within close couples. In later work, Wegner and colleagues (1991) allowed for such natural assignment of responsibility in some dating couples and stranger dyads; but, in other pairs, the researchers themselves *assigned responsibility* for recalling certain categories of words. Results of these latter studies suggested, first, that members of dating couples agreed more than strangers about who was expert in each domain. More substantive results revealed that, when the researchers *did not* assign responsibility for learning certain domains of knowledge, dating couples recalled more words than strangers. However, when the researchers *did* assign responsibility for learning certain domains of knowledge, dating couples recalled fewer words than strangers. In addition, dating couples that were not assigned responsibility for particular domains outperformed dating couples that were assigned responsibility for particular domains. This "impairment" for dating couples suggests that dating couples have their own transactive memory systems in place; these memory systems become unusable when participants are assigned to use a memory system that is not familiar to them.

Work by others supported Wegner's research on the assignment of responsibility within pairs. Hollingshead (2000) was interested in which categories of words participants would choose to learn when assigned to work with either a partner with similar knowledge or a partner with different knowledge. Participants were clerical workers at a university who were assigned to work with a partner (who did not really exist) to recall words from various categories related to clerical work. Results of this study indicated that, when participants thought that their partners had different expertise (relative to their own), they recalled significantly more words inside their expert categories than they did when they thought their partners had similar expertise. In a later study (Hollingshead, 2001) participants were again told that, compared to their own expertise, their partners had either the same or different expertise. In addition, participants were given incentives to learn information that was the same as or different from the information that their partners were assigned to learn. The most differentiation in transactive memory occurred when partners had distinct expertise from one another and were given incentives to remember different information; transactive memory was most integrated when partners had comparable expertise and were given incentives to remember similar information.

Wittenbaum et al. (1996) found similar results in their study of tacit coordination. That is, when working on a task in which differentiation was assumed to be important to success (i.e., a collective recall task), participants remembered different information from what they expected their teammates to remember. When working on a task in which integration was assumed to be important to success (i.e., a group decision-making task), participants remembered similar information to what they expected their teammates to remember.

The above studies illustrated the importance of accepting responsibility for information based on circumstance or expertise. Dyad partners use factors such as circumstance or expertise to ensure that all information is accounted for by one member or another. Important in uncovering and making use of this expertise is the communication process, another key line of research in the pioneering studies.

The role of communication. Communication was an important variable in Hollingshead's (1998a, 1998d) work. Hollingshead (1998d) examined communication at *retrieval* in dating couples and dyads composed of strangers. Dating couples working face-to-face were more effective at retrieving knowledge than were strangers in the face-to-face condition and dating couples working via a computer system. Further analyses indicated that dating couples performed well when they had access to nonverbal or paralinguistic cues to aid in retrieval of knowledge. However, dating couples made fewer explicit references to their individual expertise, presumably because their partners were already aware of the knowledge differentiations within the dyad. Later work by Andersson and Ronnberg (1996) was consistent with Hollingshead's (1998d) findings. Andersson and Ronnberg found that, on a memory task, stranger dyads did not perform as well as nominal groups (i.e., individuals working alone whose outputs are pooled); however, friendship couples did perform as well as nominal groups. The authors suggested that the improved results for friends were due to friends being able to cue each other during recall—an explanation that fits with Wegner's transactive memory theory.

Interestingly, communication during *learning* can be problematic for dating couples (Hollingshead, 1998a). In fact, communication during learning led dating couples to disregard their expertise and use alternative means of assigning responsibility for knowledge categories. This resulted in dating couples recalling fewer words than stranger couples when communication was allowed during learning.

Summary. The pioneering studies provided the first empirical support for the existence of transactive memory. In particular, research demonstrated that dyads develop means of ensuring that each member is responsible for some of the knowledge within the dyad. When possible, responsibility is based on actual expertise in the dyad (Hollingshead, 1998a, 1998d; Wegner et al., 1991); in other situations, circumstance is used as a basis for determining who is responsible for what information (Giuliano & Wegner, 1985; as cited in Wegner, 1986). Furthermore, this phase of research examined the advantages and disadvantages of communication in transactive memory systems. Specifically, communication at learning can be detrimental to familiar couples (Hollingshead, 1998a), whereas nonverbal communication at retrieval is particularly useful to such pairs (Andersson & Ronnberg, 1996; Hollingshead, 1998d). Overall, these studies stressed that dyad members take responsibility for particular domains of knowledge, and they use their knowledge of "who knows what" for encoding, storing, and retrieving information within the dyad. *Recognizing* "who knows what" or who is expert at which domains became an important topic in the next phase of empirical research.

The Expertise Recognition Studies

The literature on expertise recognition is vital to understanding transactive memory (Austin, 2003; Hollingshead & Fraidin, 2003; London et al., 2005; Wegner, 1986, 1995; Wegner et al., 1991). Studies on expertise recognition have focused on (a) the ability of groups to uncover “hidden” expertise (Stasser, Stewart, & Wittenbaum, 1995; Stasser, Vaughan, & Stewart, 2000; Stewart & Stasser, 1995) and (b) the accurate recognition of expertise (e.g., Henry, Strickland, Yorges, & Ladd, 1996; Libby, Trotman, Zimmer, 1987; Littlepage & Mueller, 1997; Littlepage, Schmidt, Whisler, & Frost, 1995; Littlepage & Silbiger, 1992). Each line of research is discussed below.

Uncovering hidden expertise. Stasser and his colleagues used the hidden profile paradigm (Stasser & Titus, 1985) to investigate recognition of expertise in groups. The essence of the hidden profile paradigm is that group members working together to solve a problem often arrive at a particular solution based on *the information held in common* amongst the members; however, a different (and better) solution would be favoured if the information that is *unique* to each group member were revealed during discussion. Hence, the better solution tends to be *hidden* from group members due to common information being shared over and above unique information. The hidden profile will only be revealed if group members reveal information that each holds uniquely prior to group discussion.

Stasser and his colleagues sought ways to reduce the preference for discussing shared over unshared information. In particular, Stasser et al. (1995) suggested that unshared information may be revealed more often during group discussion if members were aware of others' expertise in the group. Students performed a murder mystery task in which the goal was to discover which of three suspects committed a crime. Clues were distributed amongst three group members. In order to simulate expertise, each group member was provided with all the clues for a particular suspect. In one condition, the researcher made known to groups which member held information on which suspect; hence, in this condition, expertise was evident to the group. Results of Stasser et al.'s study indicated that groups in which expertise was evident (i.e., groups in which members were told they were experts on a particular suspect) mentioned unshared information and selected the correct suspect more often than groups in which expertise was not evident.

Further support for these findings was provided by Stewart and Stasser (1995) and Stasser et al. (2000). In both a decision-making task and a collective recall task, the researchers discovered that groups that were assigned expertise in particular categories mentioned unshared information more often than groups that were not assigned expertise. Stasser et al. (1995) speculated that, in groups in which expertise is assigned, members divide their responsibilities during retrieval according to that expertise; this division of labour during retrieval was presumed to explain the better performance of groups in the expertise condition. However, Stasser et al. (2000) found no evidence for this division of labour explanation in their study.

Accurate recognition of expertise. With respect to the second line of expertise recognition research, Libby and his colleagues (1987) discovered that participants are moderately accurate at recognizing expertise in groups; Henry and her colleagues (Henry, 1993, 1995; Henry et al., 1996) reported positive results as well. In their work, Henry and her colleagues asked participants to identify the members in their group who were most accurate at responding to a variety of questions and to state their confidence in their responses. Generally, participants agreed on who the most accurate member was and were reasonably accurate in their decisions (Henry, 1993, 1995). Further, and most relevant to the transactive memory literature, participants in Henry's research were asked to explain how they determined who the most accurate member was for a particular question (Henry et al., 1996). The most popular response was that participants relied on "relevant background information", followed by "backing up an estimate with sound reasoning" and "how confident the person seemed".

Unfortunately, participants are not always accurate at determining expertise in their groups. Littlepage and colleagues (Littlepage & Mueller, 1997; Littlepage et al., 1995) were interested in the characteristics that group members used to identify experts. Results from their research suggested that group members were perceived as experts if they talked relatively more than other group members. Thus, participants seemed to use talkativeness to identify expertise in the group. But, while talkativeness predicted perceived expertise, it was not associated with actual expertise (Littlepage et al., 1995). Participants appear to infer incorrectly that participation by group members is indicative of actual expertise. Thus, this research suggested that participants are not accurate at recognizing expertise in groups.

Summary. The expertise recognition phase of empirical research suggested some controversy as to whether participants are able to accurately recognize the expertise of others in their group. While some research demonstrated reasonable accuracy in recognizing "who knows what" (Henry, 1993, 1995; Henry et al., 1996; Libby et al., 1987), other research suggested that participants are not so accurate (Littlepage et al., 1995). Perhaps such controversy is based on the length of time or the number of experiences that participants share together. In groups whose members have ample experience working together, expertise recognition should be fairly accurate; in groups whose members have little chance to learn what others know, expertise may be more difficult to recognize (Littlepage, Robison, & Reddington, 1997). Experience working with others was the next line of empirical research on transactive memory.

The Experience-in-Groups Studies

Expertise may become apparent when participants (a) are familiar with one another or (b) are trained together.

Familiarity. Research by Goodman and colleagues (Goodman & Garber, 1988; Goodman & Leyden, 1991; Goodman & Shah, 1992) examined the construct of familiarity in crews working in underground coal mines. Familiarity was defined as the amount of knowledge a person had about his or her crew members, work environment, and job. Goodman hypothesized that absenteeism would change the familiarity within a crew. Goodman and Garber (1988) found that periods of absence led to more accidents, perhaps because absenteeism provided less opportunity for crew members to become familiar with one another and to gain knowledge about each other. Later work by Goodman examined the relationship between familiarity and productivity. Results suggested that crew members with greater familiarity experienced higher productivity (Goodman & Leyden, 1991; Goodman & Shah, 1992). Similarly, Gruenfeld, Mannix, Williams, and Neale (1996) found that, compared to unfamiliar groups, familiar groups were more effective at a decision making task in which members held distinct information from their teammates.

Training together. Expertise may become particularly apparent when groups of individuals are trained together on a task (Rulke & Rau, 2000). Research by Moreland and his colleagues (e.g., Liang et al., 1995; Moreland, 1999; Moreland & Argote, 2003; Moreland et al., 1996; Moreland, Argote, & Krishnan, 1998; Moreland & Myaskovsky, 2000) focused on whether individuals trained together would develop transactive memory systems and perform better than individuals trained alone on a task. In perhaps the first group-based empirical transactive memory study, Liang and her colleagues (1995) developed a paradigm for understanding the transactive memory of individuals trained in groups and trained alone. The premise behind this paradigm was that those groups whose members were trained together (and, thus, shared experiences) should have transactive memory systems not present in those groups whose members were trained apart. While working in groups, team members have the opportunity to experience the task together, observe expertise in the group, and divide tasks according to expertise. Because members know who knows what, they can seek information from the experts, trust that the expertise they receive is correct, and coordinate their actions efficiently. In addition, Wong (2003) suggested that collectively learning information, as group members trained together are able to accomplish, can create an accurate mental map about who knows what.

In Moreland’s paradigm (e.g., Liang et al., 1995; Moreland et al., 1996; Moreland & Myaskovsky, 2000), participants were either asked to work alone or placed in three-person groups in which they were trained to build radios. Following this training phase, participants were released and asked to return the following week for a testing phase. During the testing phase, those who were trained in groups were asked to work in these same groups. Those who were trained individually were paired up with others who worked individually, thus creating groups from those who previously worked alone. So, during the testing phase, all participants were part of a group.

During the testing phase, participants were asked, as a group, to recall the procedure for building a radio. Then, participants were asked to build a radio without assistance from the experimenter; groups' accuracy and speed were measured during this building process. Thus, each of recall, accuracy, and speed were performance measures. Transactive memory was measured as judges' ratings on three dimensions: knowledge specialization within the group (memory differentiation), participants' trust that the other group members knew their areas of expertise (task credibility), and coordination in group interactions (task coordination).

Across multiple studies (i.e., Liang et al., 1995; Moreland et al., 1996; Moreland & Myaskovsky, 2000), Moreland's findings were clear. The performance of groups whose members were trained together was significantly greater than the performance of groups whose members were trained alone; transactive memory mediated this training-performance relationship. Thus, training members together in groups improved groups' transactive memory systems, which strengthened their task performance.

In addition, Moreland and his colleagues were able to rule out other possible explanations for the training-performance relationship, including cohesion (Liang et al., 1995), team-building (Moreland et al., 1996), building radios in groups (Moreland et al., 1996), and communication (Moreland & Myaskovsky, 2000). First, Moreland's studies revealed that, during testing, groups of individuals trained together were no more cohesive than groups of individuals trained alone—suggesting that cohesion was not responsible for the training-performance relationship. Second, team-building exercises did not increase the performance of groups of individuals trained alone; that is, the training-performance relationship could not be explained by more "teaminess" or group development in groups whose members were trained together versus groups whose members were trained alone. Third, the training-performance relationship seemed to be a result of training in a particular group, not training in "any old group", since reassignment to new groups resulted in poor performance[2]. Finally, what seemed to be important was not the actual communication processes that occurred in a group but, rather, *what was communicated* during this process: expertise information. Moreland and Myaskovsky (2000) found that groups whose members were trained alone but received paper-based expertise information prior to testing performed as well as groups whose members were trained together; in addition, the two groups evidenced similar amounts of behaviours indicative of transactive memory.

Others who used Moreland's paradigm found similar results. In particular, Hollingshead's (1998c) participants worked individually or in groups on two trials of a rule-induction task, then all participants worked in groups for the third trial. Results showed that participants trained in groups performed better than participants trained alone, supporting Moreland's work. As well, Lewis and her colleagues (Lewis, Belliveau, Herndon, & Keller, 2007; Lewis, Lange, & Gillis, 2005) used Moreland's paradigm and discovered that performance on a telephone assembly task was better in

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[2] Note, however, that Baumann (2001) found no evidence of a link between reassignment and decreased performance when the reassigned members had the same expertise as the members they replaced.

groups with intact transactive memory systems than in groups where transactive memory had been disabled by reassigning participants.

However, not all studies using this paradigm produced significant results. Joerding (2004) made use of Moreland's paradigm, but discovered that performance on a bridge building task was no better for participants trained in groups than participants trained alone. Joerding rationalized these findings by suggesting that her task had no clearly correct answer and that her participants were not together for as many sessions as were Moreland's participants. Myaskovsky (2002) found no differences in the performance of participants trained together versus participants trained alone and no relationship between transactive memory and performance. Myaskovsky suggested that transactive memory was generally weak within her study, thus providing a potential explanation for her results.

Summary. In summary, experience with others can be valuable to the development of transactive memory systems. Familiarity working with others (Goodman & Garber, 1988; Goodman & Leyden, 1991; Goodman & Shah, 1992) and training in groups (e.g., Liang et al., 1995; Moreland et al., 1996; Moreland & Myaskovsky, 2000) both allow participants the opportunity to gain fairly accurate knowledge about "who knows what" in the group. While at this point researchers recognized that experience with others was important to transactive memory development, little else was understood about transactive memory development. The next phase of research more clearly outlined the development of transactive memory.

The Development Studies

Rulke and Rau (2000) used Moreland's paradigm to further explore transactive memory development. By coding group members' communication during the training phase of the radio building task, they were able to discover the process by which transactive memory is developed. Rulke and Rau found that members of groups trained together began the process of transactive memory development by asking questions or indicating a lack of knowledge about the task. This was followed by group members declaring expertise in a particular domain and by the group evaluating members' expertise. Finally, the encoding process ended with coordination of who does what in the group. Evident from Rulke and Rau's (2000) work is that (a) self-disclosure and (b) communication are vital to transactive memory development.

Self-disclosure. Xu (2006) and Lewis (2004) also recognized the importance of self-disclosure to transactive memory development. Xu (2006) found that, when group members disclosed their strengths and weaknesses to their teammates, the group could develop a better idea of who knows what. Lewis (2004) discovered that division of expertise and familiarity of group members early on in a group's tenure were important for the later development of transactive memory; self-disclosure can aid the development of familiarity and the division of labour.

Communication. Rulke and Rau (2000) were not the only researchers to recognize the importance of communication in the development of transactive memory. Yoo and Kanawattanachai (2001) noted that communication early in virtual teams' tenure is important for understanding who knows what. Similarly, Xu (2006) found that, in a study of MBA teams working on a semester-long project, frequent communication was important to the development of transactive memory. Lewis (2004) discovered that face-to-face communication was important in the emergence of transactive memory systems. However, Yoo and Kanawattanachai (2001) suggested that *quantity* of communication becomes less important once groups have developed their transactive memory systems.

Work by Prichard and Ashleigh (2007) on team-skills training also provides clues to the development of transactive memory. Prichard and Ashleigh argued that knowing who knows what in a group may be insufficient if group members cannot effectively communicate this information within the group. Hence, they developed a program to train groups on team skills such as interpersonal relations, allocation of roles, and equality of participation. Half of the groups received the training, while the other half did not. Results indicated that transactive memory and performance were greater for groups provided with team-skills training. Thus, having team skills such as interpersonal relations, allocation of roles, and equality of participation appeared to aid in the development of transactive memory.

Summary. Research on the development of transactive memory was important in tying together the "loose ends" in the empirical literature to this point. Development research showed that communication is vital early on in the development of a transactive memory system. When group members are given the opportunity to work together (e.g., Liang et al., 1995; Moreland et al., 1996; Moreland & Myaskovsky, 2000), they can ask questions (Rulke & Rau, 2000) or use background information supplied by group members (Henry et al., 1996) to engage in a process of self-disclosure and determine who knows what in the group. Knowing who knows what allows group members to accept and declare responsibility for domains they are particularly knowledgeable about

(Giuliano & Wegner, 1985; as cited in Wegner, 1986; Hollingshead, 2000; Rulke & Rau, 2000; Wegner et al., 1991). Once such expertise assignments are in place, quantity of communication becomes less important to smooth functioning of the group (Yoo & Kanawattanachai, 2001). With transactive memory empirically established using laboratory studies, researchers then turned to field settings in the most recent phase of transactive memory research.

The Field Studies

Research in the field focused on the positive relationship between transactive memory and performance. This relationship was demonstrated in numerous industries, including sporting goods (Austin, 2003), technology (Faraj & Sproull, 2000; Lewis, 2003; Wong, 2003; Zhang, Hempel, Han, & Tjosvold, 2007), consulting (Lewis, 2003, 2004), electricity production (Ashworth, 2008), financial services (Rau, 2005; Wong, 2003), health care (Wong, 2003), day care (Peltokorpi & Manka, 2008), product development (Akgun, Byrne, Keskin, Lynn, & Imamoglu, 2005), and sales (Peltokorpi, 2004). Performance in these studies was defined in terms of goal attainment (Austin, 2003), external evaluation (Austin, 2003), internal evaluation (Austin, 2003), knowledge sharing effectiveness (Majchrzak & Malhotra, 2004), team effectiveness (Faraj & Sproull, 2000), efficiency (Faraj & Sproull, 2000; Wong, 2003), viability (Lewis, 2004), return on average assets (Rau, 2005), technical innovation (Wong, 2003), work excellence (Wong, 2003), new product success (Akgun et al., 2005), speed-to-market (Akgun et al., 2005), team learning (Akgun et al., 2005), and accurate response to customer requests (Peltokorpi, 2004).

Importantly, the field studies built a solid case for the transactive memory-performance relationship. Even more intriguing, the transactive memory-performance relationship existed despite the highly diverse measures used to operationalize transactive memory across studies. These measures are the focus of the following section.

Transactive Memory Measurement

Transactive memory has been measured in a variety of ways (e.g., Austin, 2003; Faraj & Sproull, 2000; Hollingshead, 1998a; Lewis, 2003; Liang et al., 1995; Palazzolo, 2003, 2005; Rau, 2001; Wegner et al., 1991). Due to the abundance of measures available in the literature, the need exists for their categorization. Based on the empirical literature on transactive memory, transactive memory measures are categorized and described here according to their *level*, *format*, and *content*. Table 1 provides short summaries of many of the available measures.

Level

Transactive memory measures vary in their level of measurement and their level of analysis. *Level of measurement* is the level at which data are gathered (Kozlowski & Klein, 2000) or the source of the data (Klein, Dansereau, & Hall, 1994). For example, Liang and colleagues (1995) had judges observe groups of participants interacting together and rate the extent of transactive memory based on group interactions; here, the level of measurement was the group. Lewis (2003) asked participants to provide individual ratings of specialization within the group; thus, Lewis' level of measurement was the individual. Interesting research in the social network literature has begun to

Table 1

Transactive Memory Measures

Authors	Description of Measure	Others Who Used the Measure	Level of Measurement, Analysis	Format of Measure	Content of Measure
Ashworth (2008)	Group members individually reported *frequency of communication* and *expertise* for each teammate. Transactive memory was defined as the density of the networks derived from the above two items, where density was the proportion of actual communication (or expertise) to maximum possible communication (or expertise).		Individual, Group	Self-report	Expertise
Austin (2003)	Group members were asked individually about each member's expertise on 11 skills/knowledge areas (e.g., written communication, product testing) identified through semi-structured interviews with organizational members. The resulting information was used by the researcher to operationalize transactive memory in terms of 4 dimensions: *group knowledge stock* (total resources available within the group), *transactive memory consensus* (agreement about who is an expert for a particular skill), *knowledge specialization* (identification of different individuals as experts on different skills), and *transactive memory accuracy* (matching of an individual's self-rated expertise on each skill with others' expertise ratings of that individual).		Individual, Group	Self-report	Expertise
Ellis (2003)	Coded frequency of communication about *directory updating* (verbal communication in which team members shared expertise or requested expertise), *information allocation* (verbal communication in which information was sent to team members thought to be expert on a topic), and *retrieval coordination* (request of information by someone known to be the expert on that topic), then aggregated to the group level.	Ellis (2006)	Individual, Group	Observed behaviors	Expertise Knowledge exchange

Authors	Description of Measure	Others Who Used the Measure	Level of Measurement, Analysis	Format of Measure	Content of Measure
Faraj & Sproull (2000)	Group members individually responded to 11 items on a 5-point Likert scale measuring three dimensions: *knowing expertise location*, *recognizing where expertise is needed*, and *bringing expertise to bear*. Individual responses were aggregated to the group level.	Majchrzak & Malhotra (2004) Wong (2003)	Individual, Group	Self-report	Expertise Knowledge exchange
Fraidin (2004)	Dyad members were *assigned areas of specialization* (i.e., different information) on a murder mystery task and on a hiring task. In the control condition, all participants received all information.		Group, Group	Unclear	Expertise
Hollingshead (1998a)	Dyad members worked with their significant other or with a stranger to learn and recall words in various domains (e.g., math, fashion). Transactive memory was assessed based on the *number of words recalled* (total, unique, and overlapping recall) *by the strangers versus the couples*.		Individual, Dyad	Recall	Expertise
Hollingshead (1998d)	Dyad members worked with their *significant other or with a stranger* to answer questions on a *knowledge-based* test. Transactive memory was assessed based on the number of questions answered correctly by strangers versus couples as well as behaviors indicative of *expertise* and *transactive memory searches* (captured by computers or on videotape).		Individual, Dyad	Recall Observed behaviors	Expertise Knowledge exchange
Hollingshead (2000)	Participants worked with a partner (who did not really exist) to recall words in various categories. Transactive memory was operationalized as the *types of words recalled* (i.e., words within or not within one's areas of expertise).	Hollingshead (2001) Hollingshead & Fraidin (2003)	Individual, Individual	Recall	Expertise

Authors	Description of Measure	Others Who Used the Measure	Level of Measurement, Analysis	Format of Measure	Content of Measure
Joerding (2004)	Developed a 24-item measure of transactive memory that assessed five content areas on a 5-point Likert scale: *learning from group members*, *sharing information in groups*, *recognizing expertise*, *feeling responsible for the information you possess*, and *using others as a memory aid*.		Individual, Group	Self-report	Expertise Knowledge exchange
Johansson et al. (2000)	Married couples were asked about whether they were both *aware of a transactive memory system* and were asked to provide examples of *transactive memory use*.		Individual, Dyad	Self-report	Expertise Knowledge exchange
Kotlarsky & Oshri (2005)	Interviews, documentation, and archival records were used to identify *transactive memory and its frequency* in groups.		Individual, Unclear	Self-report	Unclear
Lewis (2003)	Group members individually responded to 15 items on a 5-point Likert scale measuring three transactive memory dimensions: *specialization*, *credibility*, and *coordination*. Individual responses were aggregated to the group level.	Akgun et al. (2005) Lewis (2004) Lewis et al. (2005) Pearsall & Ellis (2006) Pearsall et al. (2010) Peltokorpi & Manka (2008) Zhang et al. (2007)	Individual, Group	Self-report	Expertise Outcomes

Authors	Description of Measure	Others Who Used the Measure	Level of Measurement, Analysis	Format of Measure	Content of Measure
Liang et al. (1995)	Coders analyzed videotapes of groups performing a radio-building task. Transactive memory was measured as judges' ratings on three dimensions: knowledge specialization within the groups (*memory differentiation*), participants' trust that the other group members knew their areas of expertise (*task credibility*), and coordination in group interactions (*task coordination*).	Grace (2004) Joerding (2004) Moreland et al. (1996) Moreland & Myaskovsky (2000) Myaskovsky (2002) Myaskovsky et al. (2005) Prichard & Ashleigh (2007) Rulke & Rau (2000) Smith (2000), Study 1	Group, Group	Observed behaviors	Expertise Outcomes
Littlepage et al. (2008)	Dyad members were asked about their own and their partners' knowledge in six domains. Members were individually quizzed in these knowledge domains. Transactive memory was defined by *agreement* about who knows what, *knowledge specialization*, *accuracy*, and *performance improvement*.		Individual, Dyad	Self-report	Expertise
Moreland et al. (1998)	Participants responded to questions used to determine the *complexity* of members' beliefs about each other's radio-building knowledge, the *accuracy* of those beliefs, and the level of *agreement* about knowledge distribution in the group.	Smith (2000), Study 2-3	Individual, Group	Self-report	Expertise
Ohtsubo (2005)	Participants were either (a) given all clues to a puzzle or (b) given a subset of clues, such that the group as a whole had all clues. The latter case, in which a *division of labour* exists, may be more likely to develop a transactive memory system.		Unclear	Recall	Expertise

Authors	Description of Measure	Others Who Used the Measure	Level of Measurement, Analysis	Format of Measure	Content of Measure
Palazzolo (2003)	Participants were asked for their self-reports of their *own expertise*, group members from whom they are likely to *retrieve information*, and their *perceptions of others' knowledge*. This information was used in social network analysis.	Palazzolo (2005)	Individual, Group	Self-report	Expertise Knowledge exchange
Peltokorpi (2004)	Subsidiary members responded to 3 items on a 5-point Likert scale referring to member *expertise*. For example, "I know who has what kind of specialized expertise in my company".		Individual, Individual	Self-report	Expertise
Rau (2001)	From a list of ten possible *areas of expertise*, participants selected, for each group member, the two most important areas of expertise contributed by that member. Cohen's kappa was used to calculate a *coefficient of agreement* for each pair of group members in a group. Agreement scores were then averaged within a group.		Individual, Group	Self-report	Expertise
Rau (2005)	Group members responded to items on two transactive memory dimensions: *expertise composition* (diversity and depth of cognitive resources available to the group) and *expertise location* (group agreement about areas of expertise contributed by each team member). Expertise composition was operationalized as dispersion in functional background, industry experience and organizational tenure as well as average industry and organizational experience. Expertise location was operationalized as per Rau (2001).	Rau (2006)	Individual, Group	Self-report	Expertise
Ren et al. (2006)	Links between group members were defined by whether or not group members had *knowledge of others' resources*. Transactive memory was calculated using a density measure of the actual knowledge of who knows what divided by the maximum possible knowledge of who knows what in the group.		Individual, Group	Self-report	Expertise

Authors	Description of Measure	Others Who Used the Measure	Level of Measurement, Analysis	Format of Measure	Content of Measure
Wegner et al. (1991)	Participants worked with their *dating partner or a stranger* and were either *assigned or not assigned responsibility for recalling items* from particular domains (e.g., food, science). Transactive memory was inferred from the recall scores in the different conditions.		Individual, Dyad	Recall	Expertise
Xu (2006), Study 1	Participants responded to 9 items on a 5-point Likert scale assessing *directory updating* (e.g., "I frequently learn about the expertise of other members of my group"), *information allocation* (e.g., "When I come across information that is not closely related to my expertise, I'll pass it to a relevant expert and let the expert be responsible for processing and storing that information"), and *retrieval coordination* ("My group coordinates knowledge well").		Individual, Group	Self-report	Expertise Outcomes Knowledge exchange
Yoo & Kanawattanachai (2001)	Group members responded to 3 *expertise-based* items on a 5-point Likert scale (e.g., "Team members know what task-related skills and knowledge they each possess"); responses were aggregated within the group. Items were derived from Faraj & Sproull (2000).		Individual, Group	Self-report	Expertise
Yuan et al. (2007)	Group members were asked to indicate the amount of *knowledge* possessed by themselves and their teammates. Responses were used to create indices of *accuracy* (shared ideas of knowledge distribution within the team) and *extensiveness* (awareness of expertise in the team). Group members also indicated whether they *provided* and *retrieved information* from each other member. Data were aggregated within the group.		Individual, Group	Self-report	Expertise Knowledge exchange

measure transactive memory at the individual level, but with items focusing on relations between particular group members. For example, Palazzolo (2003, 2005) asked participants to report from whom in the group they retrieved information; participants thus responded to items about each particular group member separately.

Level of analysis "describes the treatment of the data during statistical procedures" (Klein et al., 1994, p. 198). If a construct is measured at the individual level but data are aggregated to the group level for conducting analyses, the level of analysis is the group. Early research analyzed transactive memory data at the dyad level. In particular, Wegner (Giuliano & Wegner, as cited in Wegner, 1986; Wegner et al. 1991) and Hollingshead (Hollingshead, 1998a, 1998d) examined the types of words recalled or the information known by participants working together as intimate couples or dyads comprised of strangers. Generally, though, transactive memory data are analyzed at the group level. For example, Lewis' (2003) participants responded to self-report items, and then data were aggregated to the group level for analyses. Austin (2003) asked participants to rate how proficient group members were on a set of skills. Data were aggregated to the group level to form measures of accuracy, consensus, specialization, and knowledge stores within the group. Although data are typically analyzed at the dyad or group levels, Su's (2008) research is an exception. Su considered the knowledge area as a level of analysis, such that data were analyzed separately within each area of knowledge important to a team. For example, one knowledge area was the "organizational contract and rules" of Team A. Thus, researchers have analyzed data in transactive memory studies at the knowledge area, dyad, and group levels, with the latter two levels being the most common in the literature.

Format

Lewis (2003) outlined three formats that researchers have used to assess transactive memory: recall, observation, and self-report. Early research on transactive memory in dyads tended to use a *recall* format (Hollingshead, 1998a; Hollingshead, 2001; Wegner, 1986; Wegner et al., 1991), in which transactive memory systems were inferred based on the "quantity, content, and structure of what participants remembered individually and with their partners" (Lewis, 2003, p. 588). As explained earlier, much of Wegner's (Giuliano & Wegner, as cited in Wegner, 1986; Wegner et al. 1991) and Hollingshead's (Hollingshead, 1998a, 2001) work required participants to recall (as pairs of strangers or dating couples) lists of words in various domains. The *observation* format was developed by Moreland and his colleagues (Liang et al., 1995; Moreland & Myaskovsky, 2000). Moreland asked judges to observe videotapes of groups and note evidence of three dimensions of transactive memory systems: knowledge specialization within the groups (i.e., memory differentiation), participants' trust that the other group members knew their areas of expertise (i.e., task credibility), and coordination in group interactions (i.e., task coordination). Finally, researchers have used *self-reports* of transactive memory. For example, Moreland and colleagues (1998) operationalized transactive memory as self-reports of knowledge complexity, accuracy, and agreement. Knowledge complexity was defined as the intricacy of beliefs about knowledge distribution in the group; accuracy was operationalized as correctness about expertise distribution in the group; and agreement was the sharedness of beliefs about expertise distribution in the group. Participants individually responded to items about the above mentioned dimensions of transactive memory. Currently, most researchers use self-report measures to operationalize transactive memory (e.g., Austin, 2003; Faraj & Sproull, 2000; Johansson et al., 2000; Lewis, 2003; Palazzolo, 2003, 2005; Peltokorpi, 2004). Austin (2003) noted that self-report measures may be most appropriate in ongoing groups in which individuals have the opportunity to continuously assess their skills.

Content

Finally, transactive memory measures tend to vary in their content. Generally, measures fall into one of three categories of content: outcomes, expertise, and knowledge exchange. Measures of *outcomes* operationalize transactive memory as the *result* of participants' interactions with one another. For example, Lewis' (2003) "coordination" dimension of transactive memory asked participants about whether the group accomplished its task smoothly and efficiently. Liang et al. (1995) coded videotapes based on whether participants seemed to trust the knowledge of others in the group and whether participants coordinated smoothly. However, such measures seem to assess the products of transactive memory, rather than the transactive memory construct itself. For example, Yuan, Fulk, and Monge (2005) noted that credibility and coordination are perhaps antecedents and products of transactive memory rather than about transactive memory itself. Zhu (2009) suggested that trust and coordination might be considered *transactive memory manifestation*, while *transactive memory structure* is comprised of specialization, sharedness, and accuracy. Outcome measures may be an indirect way of examining transactive memory.

Transactive memory measures that are based on *expertise* investigate (a) whether knowledge is specialized in the group or (b) whether individuals know "who knows what" in the group. For example, Lewis' (2003) specialization dimension asked participants to report whether their teammates had particular specializations in the group. Faraj and Sproull's (2000) expertise location dimension asked team members about whether they knew what knowledge was possessed by each group member. Peltokorpi (2004) had participants respond to three items about knowledge specialization, such as "I know who has what kind of specialized expertise in my company". Operationalizing transactive memory in terms of awareness of expertise or knowing "who knows what" may capture the construct more directly than an outcomes measure. However, just because participants know who knows what in the group does not mean that those experts are actually consulted for their knowledge or that respondents are accurate about "who knows what".

Some studies have operationalized transactive memory in terms of *knowledge exchange* (Faraj & Sproull, 2000; Joerding, 2004; Johansson et al., 2000; Palazzolo, 2003, 2005; Rau, 2001; Smalls, 2007; Yuan et al., 2007). For example, Faraj and Sproull's (2000) measure included a dimension called "bringing expertise to bear". The four items in this dimension tapped whether team members shared their expertise with others in the group, such as "People in our team share their special knowledge and expertise with one another". Johansson and colleagues (2000) asked participants (intimate couples) for examples of how they used transactive memory in their personal lives. Yuan and colleagues (2007) asked participants to indicate whether they provided information to and retrieved information from each teammate in numerous knowledge areas. Other knowledge exchange measures asked participants to indicate the frequency with which information was exchanged (Rau, 2001; Smalls, 2007) or the group members with whom information was exchanged (Palazzolo, 2003, 2005; Rau, 2001).

Summary

Transactive memory measures vary in their level, format, and content. Regarding level, data tend to be collected at the individual level but analyzed at the group level. With respect to format, early measures were recall-based, whereas the format of more recent measures was self-report. Finally, while recent research focused more on knowledge exchange, the content of measures still tends to be about whether group members know “who knows what”.

Evident from this review of transactive memory measurement are gaps in the literature. In particular, although data from transactive memory studies tend to be analyzed at the group level, useful information might be gathered by investigating transactive memory *within* groups—particularly from *dyads* within groups. Wegner and his colleagues (1985) noted that individuals hold the knowledge of who knows what in the group. Although interactions are required amongst members, knowledge ultimately resides in the minds of each group member individually. That is, “transactive memory must be understood as a name for the interplay of knowledge… this interplay, no matter how complex, is always capable of being analyzed in terms of communicative events that have individual sources and individual recipients” (Wegner et al., 1985, p. 256). Morgeson and Hofmann (1999) emphasized this point about collective constructs in general. Specifically, collective constructs are about the interactions of individuals, and the need exists to study individuals’ interactions. Because transactive memory researchers aggregate to and analyze their data at the group level, no opportunity exists to understand transactive memory at a lower level.

The main purpose of the present research was to conceptualize and assess transactive memory as an interaction of dyads within a group. Transactive memory was defined as the agreement amongst group members about what each group member knows and about who to seek knowledge from in the group. This conceptualization of transactive memory was then examined in lower- and higher-acquaintance groups and was correlated with group performance to determine whether there is any value in understanding transactive memory as the exchange of information between dyads in a group. The approach offered by the social relations model (Kenny & La Voie, 1984) may be useful in accomplishing this goal. Below, the social relations model is explained.

The Social Relations Model

Kenny and La Voie (1984) developed the social relations model (SRM) to describe relationships between individuals who are part of multiple dyads (e.g., four individuals who chat with one another at work). Essentially, the social relations model "quantifies the degree to which a variable is fundamentally dyadic" (Kenny, Kashy, & Cook, 2006, p. 187). More specifically, the model is designed to understand the amount of variance in dyadic behaviour that is due to dyadic effects or to relationship effects.

Although many of the earlier studies that applied the social relations model were of a social psychological nature, more recently researchers have recognized the value of the social relations model in organizational research (e.g., Greguras, Robie, & Born, 2001; Greguras, Robie, Born, & Koenigs, 2007; Livi, Kenny, Albright, & Pierro, 2008; Marcus, 1998; Woehr & Rentsch, 2003). For example, Marcus (1998) proposed the use of the social relations model in leadership, and Livi et al. (2008) conducted an empirical study on leadership using the SRM. Greguras and colleagues (2001, 2007) used the social relations model to assess performance ratings in teams. Finally, Woehr and Rentsch (2003) investigated team member ratings of each other's performance with a social relations analysis.

The Round-Robin Design

In the social relations model, two common designs are the round-robin design and the block design (Kenny, 1994). In the round-robin design, used in the current research, each member of the group interacts with and rates every other member of the group. Consider, for example, a group consisting of Ann, Bob, Carl, and Diane. Ann would rate each of Bob, Carl, and Diane; Bob would rate each of Ann, Carl, and Diane; and so on. Essentially, each group member rates each other group member, creating a matrix of ratings. Self-ratings are not included in the analyses conducted using the round-robin design, though they can be used for other purposes that are discussed later. Appendix A provides an illustration of the social relations model data structure.

Actor, Partner, and Relationship Effects

The matrix of ratings gathered from group members can be examined to see whether there are any patterns in the data. Consider again the group of Ann, Bob, Carl, and Diane. Each individual may be asked to rate the extent to which he or she seeks knowledge from each other individual. Suppose that *Ann reports seeking knowledge from Bob*. Why does Ann seek knowledge from Bob? Ann's level of knowledge seeking could be explained by four components: group mean, actor effect, partner effect, and relationship effect (Kenny et al., 2006).

At the group level, Ann and Bob's group might experience more knowledge seeking than others. That is, some groups may engage in more knowledge seeking than others. Thus, one component in Ann's level of knowledge seeking from Bob is the level of knowledge seeking in their group as a whole, or the *group mean*.

Second, Ann's level of knowledge seeking from Bob might be based on Ann's tendency to seek knowledge from all others. That is, Ann might have a general tendency to seek knowledge from people with whom she interacts. Such a general tendency to respond in a particular way with many interaction partners is coined an *actor effect*.

Third, Ann's level of knowledge seeking from Bob may depend on the degree to which all group members seek knowledge from Bob. That is, Bob might elicit knowledge seeking behaviour from all others with whom he interacts—called a *partner effect*. According to Kenny (1994), the partner effect represents consensus or agreement.

Finally, Ann might seek knowledge from Bob, over and above Ann's tendency to seek knowledge from others and Bob's tendency to elicit knowledge seeking behaviour from others. This component of the social relations model is called the *relationship effect*. The relationship effect represents an individual's behaviour toward another individual, beyond the contributions of the actor and partner effects.

Note that the actor and partner effects exist at the individual level, while relationship effects exist at the dyadic level. Consider that, if the only information that we had was that Ann sought knowledge from Bob, we would be unable to understand the extent to which each of the seeker, the one being sought, or the unique relationship between the two individuals was driving this behavior (Marcus, 1998). The social relations model allows one to understand the reason or patterns behind ratings.

Actor, Partner, and Relationship Variance

Above was an explanation of *effects*. However, the goal of the social relations model is to examine *variance in effects* (Kenny et al., 2006). An effect describes a particular score, while a variance describes results across people. Often, results of a social relations study are explained in terms of the proportion of variance due to each of the model components (i.e., actor, partner, and relationship variance)[3]. To continue with the example above, *actor variance* captures the degree to which some people seek knowledge from all partners while other people seek knowledge from none of their partners[4]. *Partner variance* assesses the degree to which some people elicit knowledge-seeking by all group members, whereas others are not sought for their knowledge. Finally, *relationship variance* measures the degree to which knowledge seeking is unique or idiosyncratic between members in the group. Table 2 outlines each of these components for an example of interpersonal behavior (knowledge seeking) and an example of interpersonal perception (perceptions of expertise).

Assumptions and Considerations

Researchers using the social relations model may also be interested in individual-difference variables—variables such as demographic characteristics (e.g., age, gender) or personality measures (e.g., extraversion, neuroticism). Such individual difference measures can be correlated with actor and partner effects. As well, self ratings can be correlated with others' ratings to determine self-other agreement.

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[3] Note that, in the social relations literature, the terms *actor* and *partner* are used in studies of interpersonal behaviour, and the terms *perceiver* and *target* are used in studies of interpersonal perception. Both interpersonal behaviour and perception are studied here; however, to avoid confusing the reader, the terms *actor* and *partner* are maintained throughout.

[4] For illustrative purposes only, variances are explained here as a dichotomy or an "all or none" phenomenon (e.g., seeking knowledge from *no one* or *everyone*). Keep in mind that, in most cases, the variances are not as clear cut.

Table 2

Explanations of the Social Relations Model Components for Interpersonal Behaviour and Interpersonal Perception

Source of Variance	Explanation	Example	Key Term
Interpersonal Behaviour			
Actor	Each group member behaves similarly with all other group members.	Ann seeks knowledge a great deal from all others, whereas Bob seeks knowledge from no one in the group.	Behavioural Consistency
Partner	Group members consistently elicit knowledge seeking from all teammates.	Everyone seeks knowledge from Bob, and no one seeks knowledge from Ann.	Behaviour Elicitation
Relationship	Knowledge seeking amongst group members is idiosyncratic.	Knowledge seeking is a function of the relationship between Ann and Bob.	Uniqueness
Interpersonal Perception			
Actor	Each group member sees all other group members as similar.	Ann perceives everyone as an expert, and Bob perceives no one as an expert.	Assimilation
Partner	Group members agree about who is an expert and who is not an expert.	Everyone agrees that Bob is an expert, and everyone agrees that Ann is not an expert.	Consensus, Agreement
Relationship	Perceptions are idiosyncratic about the extent to which someone is expert.	Ann thinks that Bob is an expert, apart from Ann's general ratings of others' expertise and Bob's tendency to be viewed as an expert by others.	Uniqueness

Note: Many of the key terms were taken from Back & Kenny (2010).

A couple of assumptions are important to note prior to utilizing this model. First, social interactions are assumed to be exclusively dyadic (Kenny et al., 2006). This assumption does not hold when individuals are part of a group. For example, Ann and Bob may talk about Carl; hence, the relationship effects of Ann and Bob with Carl would be correlated. Such "extradyadic effects" can affect the variance components. Researchers note that the effects of violating this assumption are not well understood (Kenny et al., 2006; Marcus, 1998), but that researchers should make their readers aware when this assumption is not met.

Second, individuals are assumed to be randomly sampled from a population (Kenny et al., 2006), and use of intact groups violates this assumption. However, researchers have encouraged the use of the social relations model in groups (Marcus, 1998). In addition random sampling is presumed to be an assumption in many areas of research when, in fact, random sampling is not used. Again, the effects of violating this assumption are not known.

An important consideration to keep in mind with the social relations model is that, in order to tease apart the relationship effect from error, multiple indicators are required (Kenny, 1994; Kenny et al., 2006). This is akin to needing multiple indicators in structural equation modeling in order to estimate an error-free latent construct. Essentially, the relationship effect is what remains after removing the effects of the actor and the partner. According to Kenny, the relationship effect represents "the leftovers" (1994, p. 82). Because measurement error is also included in these leftovers, relationship variance would be overestimated if it were simply considered all that remained after the actor and partner effects were removed. Multiple measures or measurements at multiple times can be used to differentiate relationship and error sources of variance (Kenny, 1994). For example, Ann and Bob might interact twice, and knowledge seeking would be measured at both occasions. Inconsistencies over time or across indicators are considered error.

Suitability of the Social Relations Model

The social relations model is well suited to the current study for three reasons in particular. First, the social relations model allows for the analysis of non-independent data (Malloy & Kenny, 1986), as is the case when individuals interact with multiple others. It is difficult to analyze interactions within groups with methods that do not allow for interdependence of people and data points. Second, the social relations model overcomes a problem, common in past research, of viewing transactive memory solely as a group-level construct without consideration of the interactions between pairs of group members. In her critiques of the transactive memory literature, Yuan declared that transactive memory "falls short of spelling out the multilevel nature of group cognition" (Yuan et al., 2005, p. 4). Because the social relations model captures variance due to both individual- and dyad-level effects, Yuan's criticism is dealt with by the social relations model. Third, because the social relations model allows for the separation of all of actor, partner, and relationship variance, transactive memory can be understood in more depth than it has been in the past. For example, relationship variance is the unique or idiosyncratic ratings or behaviours made between pairs of group members within a group. Because most transactive memory studies involve self-report questionnaires that assess group functioning as a whole, such information on relationships between group members is lost. For example, if the only information that we had was that Ann sought knowledge from Bob, we would be unable to understand the extent to which each of the seeker, the one being sought, or the unique relationship between the two individuals was driving this behavior (Marcus, 1998). Thus, keeping the above assumptions and considerations in mind, the social relations model appears to be well-suited for the purposes of these studies. In the following section, the transactive memory and social relations literatures are brought together to create a definition of transactive memory according to the social relations model.

Transactive Memory and The Social Relations Model

Although transactive memory requires interactions amongst group members, it begins in the minds of individuals. The social relations model, discussed above, appears well-suited to understanding transactive memory in terms of individuals and their dyadic interactions in groups. Here, the literature on transactive memory and the social relations model are brought together to create a definition of transactive memory according to the social relations model.

Because of the confusion in how transactive memory is defined and operationalized, it is vital that the construct be clearly outlined here. As illustrated in an earlier section on transactive memory measurement, the content of transactive memory measures varies across studies. Specifically, the content of transactive memory measures has included expertise, outcomes, and knowledge exchange. An argument was put forth earlier in this research that outcomes should not be part of transactive memory measures. Hence, transactive memory will be defined here in terms of *expertise* (ratings of "who knows what") and *knowledge seeking* (ratings of communication with others in the group in pursuit of information). For an effective transactive memory system to exist, members should know who has what expertise in the group and seek knowledge from those group members.

Brandon and Hollingshead note that transactive memory is a “shared division of cognitive labor with respect to the encoding, storage, retrieval, and communication of information from different knowledge domains” (2004, p. 633). In effective transactive memory systems group members have a shared idea about who knows what in the group, which allows them to assign responsibility for knowledge to the most expert person in the group. That information can be retrieved from the agreed-upon expert, when needed. The notion of *sharing* knowledge about the division of labour in the group implies *consensus* or *agreement* about who knows what and who to seek knowledge from.

In the social relations model, consensus or agreement is represented by *partner variance* (Kenny, 1994). Partner variance is high when there is (a) agreement between actors about how to rate a particular partner and (b) differences in ratings across partners. The second example in Appendix A illustrates partner variance in ratings. Partner variance is *low* if actors provide different ratings of a particular partner. Partner variance is also low if *all* partners receive *exactly the same* rating. In the general sense of the word, agreement should be high if everyone received the same rating from one another; thus, one may wonder how partner variance is synonymous with agreement. However, consider in this study that the interest is in agreement about a division of labour in the group. That is, the purpose of this study is to understand whether group members agree about their teammates having different expertise. If all members provide the same rating of each other, there would be agreement in the general sense of the word, but not agreement about a division of labour. Hence, partner variance was found to be a good operationalization of transactive memory. Transactive memory would be represented by partner variance in ratings of expertise and knowledge seeking.

Some empirical research exists to support this notion that agreement, or partner variance, is indicative of transactive memory. Moreland and his colleagues (e.g., Liang et al., 1995; Moreland, 1999; Moreland & Argote, 2003; Moreland et al., 1996, 1998; Moreland & Myaskovsky, 2000) demonstrated, across multiple studies, that a significant relationship existed between training in groups and transactive memory. Moreland et al. (1998) showed that transactive memory—defined by complexity, accuracy, and agreement about knowledge beliefs—was stronger in groups whose members were trained together. Palazzolo studied teams whose members had a work history together. Results suggested that multiple members of a group were likely to retrieve information from the same individual.

How do actor and relationship variance contribute to the definition of transactive memory? Actor variance is defined as consistency in people's ratings of all others. In an effective transactive memory system, one may expect little actor variance in expertise. Viewing everyone as an expert or viewing no one as an expert suggests poor knowledge of who knows what in the group—unless everyone is an expert, which is likely a rare circumstance. Going back to Brandon and Hollingshead's (2004) definition of transactive memory as "a shared division of labour", *division* of labour implies different individuals being responsible for different information—presumably on the basis of their expertise. Significant actor variance would presume that a rater is not aware of the division of labour in the group.

In addition, in an effective transactive memory system, one may expect little actor variance in knowledge seeking. Again, Brandon and Hollingshead's (2004) definition implies that knowledge is sought on the basis of the shared division of labour in the group. So, group members should seek knowledge from the person known to hold that information. One might assume that knowledge seeking from everyone in the group would be a good idea—however, such a strategy would be very time-consuming and, as a result, ineffective.

Similar arguments can be put forth about relationship variance as well. Relationship variance is the unique or idiosyncratic ratings of others in the group. High levels of relationship variance suggest very idiosyncratic ideas of "who knows what" and who to seek knowledge from. Relationship variance does not fit well with Brandon and Hollingshead's (2004) notion of transactive memory as a shared division of cognitive labour; in fact, relationship variance implies little sharedness in the group.

To summarize, transactive memory is defined here as a combination of expertise awareness and knowledge seeking. An effective transactive memory system would be represented by significant partner variance and relatively little actor or relationship variance in expertise and knowledge seeking. Keeping this new definition of transactive memory in mind, the following section outlines the current research.

CURRENT RESEARCH

The purposes of this research were (a) to develop a new way of understanding transactive memory according to the SRM notion of partner variance; (b) to examine this new definition of transactive memory in groups with lower and higher levels of acquaintance; and (c) to relate this definition of transactive memory to group performance. In Study 1, open-ended responses by group members from three different organizations were used to explore ways of knowing who is an expert in the group and reasons for seeking knowledge in the group. In Study 2 and Study 3, student engineering project groups were used to examine the new operationalization of transactive memory and to relate transactive memory to performance. The purpose of Study 2 was to determine whether transactive memory, defined as significant partner variance in expertise and knowledge seeking, was greater in higher-acquaintance groups and was associated with performance. The purpose of Study 3 was to extend the previous study by considering the correlation between relationship variance and performance. In Study 4, a small sample of organizational engineering project groups was used to illustrate the application of the new transactive memory measure to an organizational sample. Each of these studies is presented below.

STUDY 1

The goal of this first study was simply to gain a better understanding of knowledge exchange in work groups. Although group members were assumed to make use of expertise information as the basis for seeking knowledge, it was unclear what other reasons might exist for seeking knowledge and to what extent these other reasons played out in groups. Employees working in groups were asked, through open-ended questions, how they decided who had expertise in a particular domain and how they decided from whom to seek knowledge in a group.

Numerous factors could affect the choice to seek knowledge within a group. Research suggests that individuals seek information from and provide information to others based on knowing their expertise (Austin, 1998; Borgatti & Cross, 2003;

Palazzolo, 2003), having the time to provide information (Borgatti & Cross, 2003; Smalls, 2007), sparing the effort to provide information (Borgatti & Cross, 2003), being in close proximity (Borgatti & Cross, 2003; Smalls, 2007), sharing social relationships (Austin, 1998), trusting one another (Austin, 1998; Cross et al., 2001b), getting along with one another or being friends (Austin, 1998; Cross, Rice, & Parker, 2001b; Shah, 1998), having task interdependence (Cross et al., 2001b), perceiving low risks (Borgatti & Cross, 2003; Smalls, 2007), being willing to exchange information (Smalls, 2007), and being committed to exchange information (Smalls, 2007).

In the words of Moreland (1999), "Once [people who possess the task knowledge that a worker needs] have been identified, will that worker ask them for help? Maybe he or she is too shy, would feel embarrassed to admit ignorance about the task, or is worried about becoming indebted to others for their help. And if such help is requested, are the people who can provide it willing to do so?" (p. 25). Borgatti and Cross proposed that the search for information is a "dynamic choice process… informed by characteristics of the relationship between the seeker and a set of other people he or she might turn to" (p. 434). The above review suggests that there are numerous reasons for seeking knowledge from others in the group and that members may not always exhibit consensus about who to seek knowledge from. The purpose of Study 1 was to determine the reasons for knowledge seeking in groups of employees in IT support, engineering, and product development organizations.

Method

Participants

Participants were 60 employees (54 males, 6 females) in 16 groups across three organizations (software, engineering, and product development). The average age of the employees was 37.42 years (*SD* = 9.90). Employees had been with their organization for a minimum of 9 months to a maximum of 35 years (*M* = 7.39 years, *SD* = 7.84 years).

Task

As part of a longer questionnaire, participants were asked the following questions: “How do you know that a particular group member is an expert in or knowledgeable about a particular domain?” and “What factors influence your decision to seek information from a particular group member rather than other group members?” Participants were allowed to indicate as many reasons as they wished; hence, the same participant may contribute multiple responses to each question. Responses were read and organized by the author into categories of similar responses.

Results

Based on employees’ open-ended responses, Table 3 illustrates that, not surprisingly, the most commonly reported factor used in determining expertise in organizational groups is knowledge of, or experience with, another person. Interestingly, however, many group members from the product development organization endorsed formal documentation (e.g., job descriptions or roles) as a means of determining ‘who knows what’ in the group. Other responses included knowing expertise through the confidence level of a group member, referrals or recommendations of a group member by others, and volunteering of knowledge by a group member. Interestingly, although

Table 3

Factors that Influence Group Member Awareness of Expertise

	IT Support (*n* = 16 responses)	Engineering (*n* = 50 responses)	Product Development (*n* = 24 responses)
Confidence level of expert	0%	2.00%	0%
Formal documentation	18.75%	8.00%	41.67%
Knowledge or experience	75.00%	76.00%	41.67%
Referrals or recommendations	6.25%	6.00%	12.50%
Volunteering of information	0%	8.00%	4.17%

Note: Participants were allowed to provide multiple responses; hence, the sample size represents the number of responses rather than the number of participants.

confidence level of a group member was mentioned, it was mentioned infrequently. This finding is in contrast to Henry et al. (1996) who reported that, following background information and sound reasoning, confidence level was the third most common means of determining someone's accuracy about a topic.

Next, participants were asked what factors influenced their choice to seek knowledge from a particular group member. As shown in Table 4, employees often relied on expertise as a means of choosing someone from whom to seek knowledge. Interestingly, employees were also sought for their knowledge for less obviously reasons, such as their compatibility with the knowledge seeker, personality, availability, approachability, timeliness, physical proximity, and personal relationship with the knowledge seeker. These open-ended results suggest that, although employees tend to seek knowledge from the perceived expert in the group, personal characteristics of, and relationships with, the person from whom knowledge is sought are also important determinants of knowledge seeking.

Discussion

Results of this study suggested that, as expected, employees report seeking knowledge from the perceived expert in the group. However, employees also endorsed seeking knowledge from others based on availability, timeliness, physical proximity, personal relationships, personality, and compatibility. Thus, although particular individuals tend to stand out as experts and to be sought for their knowledge in groups, there is reason to believe that unique dyadic experiences in the group are also important to understanding knowledge exchange. For example, if Ann and Diane seek knowledge from one another because they are both mothers and Bob seeks knowledge from Carl

Table 4

Factors that Influence Group Member Knowledge Seeking

	IT Support (*n* = 17 responses)	Engineering (*n* = 61 responses)	Product Development (*n* = 25 responses)
Approachable	5.88%	8.20%	0%
Available	5.88%	11.48%	0%
Compatible	0%	8.20%	8.00%
Expert	29.41%	42.62%	36.00%
Particular personality characteristics	5.88%	16.39%	8.00%
Particular roles	0%	4.92%	24.00%
Personal relationship	0%	3.28%	0%
Physically proximate	0%	3.28%	0%
Recommended by others	11.76%	1.64%	8.00%
Timely	17.65%	0%	0%
Worked with in the past	23.53%	0%	12.00%
Volunteer information	0%	0%	4.00%

Note: Participants were allowed to provide multiple responses; hence, the sample size represents the number of responses rather than the number of participants.

because their personalities are compatible, significant relationship variance will result. So, all of these possible reasons for knowledge seeking reinforce the contribution of the social relations model and, in particular, highlight the value of relationship variance in understanding transactive memory. One interesting question is whether these unique dyadic experiences, and the resulting relationship variance, are typically found in lower-acquaintance groups in which members are not yet familiar or comfortable enough with one another to identify and seek knowledge from the expert. Study 2 explored this question.

STUDY 2

The previous study demonstrated qualitatively that unique dyadic relationships may contribute to transactive memory in groups. Study 2 took a quantitative approach to understanding dyadic relationships and transactive memory. Transactive memory was assessed in groups of lower- and higher-acquaintance, and transactive memory was also correlated with performance. The purpose of Study 2 was to determine whether transactive memory, defined as significant partner variance in expertise and knowledge seeking, was greater in higher-acquaintance groups and was associated with performance.

Hypotheses about expertise and knowledge seeking. As past research has demonstrated, transactive memory develops over time as partners in a relationship (Wegner et al., 1985), or group members (e.g., London et al., 2005), disclose information about themselves. Early on in a group's life, members may be unaware of each other's expertise and, instead, rely on gender, age, or other surface characteristics when making judgments of expertise and seeking knowledge. Once group members have had a chance to communicate and interact with one another, they learn about each other's skills, education, and abilities that may provide clues about true expertise (Nickerson, 1999; Wegner, 1995; Wegner et al., 1991; Wittenbaum et al., 1996). According to Brandon and Hollingshead (2004), a successful transactive memory system is one in which members are assigned responsibility for knowledge based on their expertise, have shared ideas of who knows what, and fulfill their expected responsibilities within the group.

Some research exists to suggest that, in groups whose members have had the opportunity to work together, more effective transactive memory systems exist. Moreland and his colleagues (e.g., Liang et al., 1995; Moreland, 1999; Moreland & Argote, 2003; Moreland et al., 1996, 1998; Moreland & Myaskovsky, 2000) demonstrated, across multiple studies, that a significant relationship existed between training in groups and transactive memory. For example, Moreland et al. (1998) showed that transactive memory—defined by complexity, accuracy, and agreement about knowledge beliefs—was stronger in groups whose members were trained together. Thus, some evidence exists to suggest that members of well-acquainted groups possess effective transactive memory systems. It was hypothesized here that higher-acquaintance groups would have effective transactive memory systems, with transactive memory defined as significant partner variance in expertise and knowledge seeking.

Hypothesis 1. In higher-acquaintance groups, expertise ratings will show significant partner variance, such that all group members will tend to rate a particular partner similarly.

Hypothesis 2. In higher-acquaintance groups, knowledge-seeking ratings will show significant partner variance, such that all group members tend to seek knowledge from the same teammate.

Groups whose members are not familiar with one another may exhibit poorer transactive memory systems and, as such, less agreement in their ratings of expertise. That is, partner variance is unlikely to be a significant source of variance in ratings of expertise by groups whose members have not had significant opportunities to work together. Instead, members of lower-acquaintance groups may exhibit one of two patterns of ratings: substantial actor variance or substantial relationship variance.

In lower-acquaintance groups, ratings of expertise are potentially explainable by the person making the ratings. Kenny (1994) suggests that this tendency to see all partners as similar declines with familiarity. This line of thinking is consistent with the in-group/out-group literature, which suggests that out-group members tend to be seen as more homogeneous than the in-group members (Judd & Park, 1988). In groups whose members are not yet familiar with one another, individuals may be viewed as the out-group and to be rated similarly. Therefore, substantial actor variance may exist in ratings of expertise for lower-acquaintance groups.

Hypothesis 3a: In lower-acquaintance groups, expertise ratings will show significant actor variance, such that the tendency will exist to rate all partners similarly.

Also possible is that members of lower-acquaintance groups may rate expertise idiosyncratically, such that expertise ratings are dyad-specific. For example, group members who are not familiar with one another may use different stereotypes when rating expertise (Craig, 2004; Hollingshead & Fraidin, 2003; Nickerson, 1999; Wegner, 1995; Wegner et al., 1991; Wittenbaum et al., 1996). Some members might use gender stereotypes; others might consider ethnicity or age when making their ratings. As such, ratings of expertise may be dyad-specific, evidencing significant levels of relationship variance.

Hypothesis 3b: In lower-acquaintance groups, expertise ratings will show significant relationship variance, such that ratings of expertise are dyad-specific.

Hypotheses about the expertise-knowledge seeking relationship. Assuming that Hypothesis 1 and Hypothesis 2 are supported, the correlation can be examined between partner effects in expertise and partner effects in knowledge seeking for the higher-acquaintance groups. Group members perceived as experts in a particular domain are likely to elicit knowledge seeking from their teammates. Borgatti and Cross (2003) proposed that individuals are expected to seek information from others whose expertise is known and valued. Past research supports these ideas. For example, Palazzolo (2005) showed that work group members were especially likely to retrieve information from perceived experts. Faraj and Sproull (2000) found that expertise location was related to bringing expertise to bear, such that knowing who knows what in software development teams was positively related to knowledge sharing within those teams. Xu (2006) noted a positive relationship between directory updating (i.e., learning about and being aware of expertise in the group) and retrieval coordination (i.e., coordinating knowledge well) for groups of Masters students working on semester-long projects. Team members in Su's (2008) research retrieved information from human or digital sources with perceived expertise. Finally, aerospace engineers in Morrison and Vancouver's (2000) study sought information from sources perceived to be experts. Hence, past research supports the following hypothesis:

Hypothesis 4. In higher-acquaintance groups, members who are perceived as experts in the group are likely to elicit knowledge seeking behaviour from other group members. That is, there will be a positive partner-partner correlation.

Hypotheses about self-other agreement. If there is consensus in ratings of expertise across members of a group (i.e., partner variance), one may then consider the relationship between self-ratings and others' ratings of a person's expertise. Studies that focus on expertise recognition suggest some discrepancy as to whether participants are able to accurately recognize the expertise of others in their group. While some research demonstrated reasonable accuracy in recognizing "who knows what" (Henry, 1993, 1995; Henry et al., 1996; Libby et al., 1987), other research suggested that participants are not so accurate (Littlepage et al., 1995). Littlepage et al. (1997) suggest that this discrepancy may be a function of the length of time or number of experiences that participants share with one another. In groups whose members have ample experience working together, expertise recognition should be fairly accurate; in groups whose members have little chance to learn what others know, expertise may be more difficult to recognize. In higher-acquaintance groups, then, members are hypothesized to be accurate in rating the expertise of others.

Hypothesis 5. In higher-acquaintance groups, members who are perceived by others as experts in the group are likely to rate themselves as experts in the group. That is, there will be a positive self-partner correlation.

Hypotheses about transactive memory and performance. Multiple studies have demonstrated that the performance of groups whose members were trained together was significantly greater than the performance of groups whose members were trained alone—and transactive memory mediates this relationship (i.e., Liang et al., 1995; Moreland et al., 1996; Moreland & Myaskovsky, 2000). Lewis and her colleagues (Lewis, et al, 2005, 2007) discovered that performance on a telephone assembly task was higher in groups with intact transactive memory systems than in groups in which transactive memory had been disabled by reassigning participants. Numerous organizational studies support this relationship between transactive memory and performance (e.g., Austin, 2003; Faraj & Sproull, 2000; Lewis, 2003; Wong, 2003; Zhang et al., 2007). Based on this research, one would predict a positive relationship between transactive memory and performance. In social relations model terms, transactive memory would be represented by significant partner variance in both expertise and knowledge seeking. That is, in high-performing groups, members should agree about who knows what and from whom to seek information.

Hypothesis 6. Groups with significant partner variance in expertise are likely to perform better. That is, there will be a positive partner-performance correlation.

Hypothesis 7. Groups with significant partner variance in knowledge seeking are likely to perform better. That is, there will be a positive partner-performance correlation.

In addition to the hypotheses listed above, a couple of exploratory analyses were conducted. Data on extroversion and conscientiousness were collected for purposes other than this study and were used to examine their relationships with actor and partner variance in expertise and knowledge seeking.

Method

The purpose of Study 2 was to determine whether transactive memory, defined as significant partner variance in expertise and knowledge seeking, was greater in higher-acquaintance groups and was associated with performance. For exploratory purposes only, ratings of conscientiousness and extroversion were collected to determine whether relationships existed between scores on these personality variables and ratings of transactive memory.

Participants

Engineering science students participated in this study. A requirement of the engineering class was that students complete a design project, in groups of 4-5 students, over the duration of the full-year course. Students were assigned to their groups by a member of the research team, such that teams were diverse in the skill set of each group member. Each student was asked to rank order four skills (analytical skills, communication skills, computer skills, and "hands-on" skills) from the skill he/she was most proficient in to the skill he/she was least proficient in. Then, the research team created groups that mixed each of these skills. This study was comprised of 231 students (161 males, 42 females, 28 no response) in 55 groups, with a mean age of 18.33 years (*SD* = 1.55).

Although there are certainly disadvantages to using student groups, there are definite advantages as well. For example, students were assigned to groups of similar sizes (i.e., 4-5 person groups) and were provided with the same project requirements. Therefore, comparison of results across groups was easier in this student sample than would be possible in a somewhat "messier" organizational sample. Although engineers perform diverse tasks, they tend to conduct knowledge-based work and to rely on interpersonal interactions for at least some of their expertise and information (e.g., Fidel & Green, 2004; Hertzum & Pejtersen, 2000; Pinelli, 1991; Yitzhaki & Hammershlag, 2004). In fact, Tom Allen (as cited in Cross, Parker, Prusak, & Borgatti, 2001a) discovered that engineers were five times more likely to seek information from people than from databases. Hence, this sample of student engineering groups seemed appropriate for Study 2.

Task

As required by their course, participants had to complete a design project in groups of 4 to 5 students. The design project required participants to work together over the duration of the 8-month course to design a process or product that could improve student life. In the month prior to completion of the project, participants were asked to fill out measures of expertise, knowledge seeking, and acquaintance. Personality data were collected six months prior to collection of the expertise and knowledge seeking data. In addition, data on organizational citizenship behaviour, values, goal orientation, conflict, self-monitoring, team viability and demographics were collected for purposes other than this dissertation.

Before conducting this study, information was needed about the areas of expertise that were critical to the group projects. Ten engineering students (1 female, 9 males) took part in a group discussion with the purpose of generating a list of skills and knowledge areas required for successful completion of their group projects. The author asked questions and initiated discussion amongst the participants. Responses were hand-written and audiotaped during the discussion. The focus group lasted for approximately 1 hour and 10 minutes, at which point no new information was provided by the participants. Participants were asked questions such as “What are the requirements of the project?” and “What skills do you think would be important to completing the design project?”

Participants generated a list of nine knowledge areas and skills important to completing their design projects: building and assembly; computer-aided design (CAD) programs; competitors’ processes and products; computer programming; creativity; engineering design process; presentation/verbal communication; sketching; and written communication. Creativity, presentation, and written communication were removed from this list in order to make the questionnaire a manageable length. The choice was made to remove these particular areas of expertise for a couple of reasons. First, these areas of expertise tended to be mentioned later on in the focus group. Second, they were more abstract in nature, and possibly difficult for group members to define and rate. Next, these skill and knowledge areas were compiled in a questionnaire designed to assess expertise and knowledge seeking in the student engineering groups (see Appendix B for ethics approval and Appendix C for measures).

Measures

Participants completed all measures through an online survey.

Acquaintance. Participants were asked to indicate interaction frequency, or the average number of hours that group members reported interacting with one another about the project. Because students had to keep track of meetings, time sheets, and hours devoted per week to the project, this information would be likely to be readily available to students. A median split was used to separate higher-acquaintance and lower-acquaintance groups based on their interaction frequency.

Expertise. Each group member was asked to respond to the following statements about each other group member and about themselves, for each skill or knowledge domain: "[Group member] has expertise in [skill/knowledge domain]" and "[Group member] knows a lot about [skill/knowledge domain]"; Group members responded using a 7-point Likert type scale from 1 (strongly disagree) to 7 (strongly agree).

Knowledge seeking. Each group member was asked to respond to the following two statements about each other group member and about themselves, for each skill or knowledge domain: "I frequently seek information from [group member] about [skill/knowledge domain]" and "I often ask [group member] to answer my questions about [skill/knowledge domain]". Group members responded using a 7-point Likert type scale from 1 (strongly disagree) to 7 (strongly agree).

Extroversion. Extroversion was assessed using 24 items from the International Personality Item Pool (Goldberg, 1999). Group members responded to items on a 5-point scale from 1 (very inaccurate) to 5 (very accurate).

Conscientiousness. Conscientiousness was assessed using 24 items from the International Personality Item Pool (Goldberg, 1999). Group members responded to items on a 5-point scale from 1 (very inaccurate) to 5 (very accurate).

Performance. Students were required to complete, in small groups, a project that involved designing a process or product that could improve student life. Each group was required to submit a written final report that described a solution for their design problem. In addition, groups were graded on the oral presentation of their design projects. Course administrators graded the written final report and presentation of the design projects.

Results

Analyses

Although programs are available to analyze data using the social relations model (SOREMO; Kenny, 1998b), the choice was made to use multilevel modeling in SPSS to compute results. SPSS was preferred for a couple of reasons. First, SOREMO does not allow for missing data, whereas multilevel modeling in SPSS does allow missing data. Second, SOREMO requires the input of data into a text file, with each group member taking up five or more lines in the text file. Thus, the size of such a file was deemed quite cumbersome for data entry and analysis with SOREMO. Kenny (2007) noted that multilevel modeling can be used with SPSS to obtain similar estimates to those obtained with SOREMO. Unfortunately, it is not clear how relationship variance can be separated from error variance using the analyses available in SPSS. In this study at least, relationship variance could not be modeled for other reasons (see below), and so multilevel modeling in SPSS provided a reasonable solution for determining variances. One-sample t-tests were used to determine whether variances were significantly different from zero. Paired t-tests were used to determine whether actor and partner variances were significantly different from one another.

In order to estimate the parameters of the model, groups must contain *at least four members* for a round-robin design (Marcus, 1998). Thus, groups with non-respondents were removed from the analyses to which that data applied. Imputation may not make sense for this type of data. For example, consider one non-respondent in a group of four individuals. In the round-robin matrix, that single non-respondent affects an entire row of data and would result in imputation of a full quarter of the data for that matrix. Thus, the choice was made to simply remove groups with missing data from the particular analyses to which that data applied. Importantly, the amount of missing data was so small in comparison to the non-missing data that the effects of the missing data on the analyses were negligible.

As mentioned earlier, in order to separate relationship variance from error, multiple measures must be used. To obtain multiple measures, multiple different measures of a variable may be included in the same questionnaire or the same measure could be provided at multiple points in time (Kenny, 1994). In this study, multiple measures of the same variable were included in one questionnaire. Unfortunately, observations made by the author during data collection and examination of the data suggested that participants recognized the similarity in the multiple measures and strived to provided identical responses to the two different measures. As a result, relationship variance was perhaps inflated beyond what it was in actuality, and a decision was made not to calculate relationship variance for this sample. Results presented below are in terms of actor and partner variance only.

Findings

One-sample t-tests were used to determine whether the amounts of variance due to each of actor, partner, and residual were significantly different from zero. As Table 5 illustrates, ratings of *expertise* within the student groups were explained by all of the actor, partner, and residual sources of variance. Note that the proportions of actor and partner variance differed across areas of expertise. For example, only 9.55% of variance

Table 5

Amount (and Percentage) of Variance in Expertise Due to Actor, Partner, and Residual

Area of Expertise	Actor Variance	Partner Variance	Residual Variance
Building and assembly	0.485 (25.77)**	0.643 (34.17)**	0.754 (40.06)**
CAD programs	0.635 (29.25)**	0.682 (31.41)**	0.854 (39.34)**
Competitors' processes and products	0.820 (51.54)**	0.152 (9.55)**	0.619 (38.91)**
Computer programming	0.778 (38.71)**	0.356 (17.71)**	0.876 (43.58)**
Engineering design process	0.716 (43.03)**	0.262 (15.75)**	0.686 (41.23)**
Sketching	0.669 (35.04)**	0.495 (25.93)**	0.745 (39.03)**
Mean	0.684 (36.54)**	0.432 (23.08)**	0.756 (40.38)**

Note: ** $p < .01$. The sample size was $n = 55$ groups. Values outside of brackets are variances; values inside brackets are proportions of variance.

in ratings of expertise in competitors' processes and products was due to the partner, while 34.17% of variance in ratings of expertise in building and assembly was due to the partner. In addition, although the percentage of partner variance may seem low, it is quite similar to the partner variance that Kenny (1994) reported across personality dimensions in numerous studies.

Next, as seen in Table 6, variance in expertise due to each of actor, partner, and residual was examined separately for lower-acquaintance and higher-acquaintance groups. One sample t-tests demonstrated that, across most areas of expertise, actor and partner variance were both significant for each of lower-acquaintance and higher-acquaintance groups. Hypothesis 1 and Hypothesis 3a are both supported.

Paired t-tests were used to test differences between actor and partner variances in expertise (see Greguras et al., 2007). Results showed that, in lower-acquaintance groups, the mean actor variance in expertise (44.46%) was greater than the mean partner variance in expertise (17.09%), $t(26) = 3.12$, $p < .01$. Thus, although both actor and partner variance were significant, there was greater actor than partner variance in lower-acquaintance groups. In contrast, in higher-acquaintance groups, there were no significant differences between the amount of variance in expertise due to the actor (28.90%) and the amount due to the partner (28.85%), $t(27) = 0.00$, *ns*. Thus, there was just as much partner variance as actor variance for higher-acquaintance groups. Kenny (1994) suggests that partner variance is more difficult to find than actor variance, so the finding of substantial partner variance in higher-acquaintance groups is quite interesting.

Next, variance in *knowledge seeking* due to each of actor, partner, and residual was examined. Table 7 illustrates that all of the actor, partner, and residual were

Table 6

Amount (and Percentage) of Variance in Expertise for Lower- and Higher-Acquaintance Groups

Area of Expertise	Source of Variance		
	Actor	Partner	Residual
Building and assembly			
Lower Acquaintance	0.566**	0.541**	0.706**
Higher Acquaintance	0.408**	0.741**	0.800**
CAD programs			
Lower Acquaintance	0.809**	0.429**	0.865**
Higher Acquaintance	0.467**	0.926**	0.843**
Competitors’ processes and products			
Lower Acquaintance	0.938**	0.148	0.608**
Higher Acquaintance	0.706**	0.156**	0.631**
Computer programming			
Lower Acquaintance	0.954**	0.342*	0.819**
Higher Acquaintance	0.608**	0.369**	0.931**
Engineering design process			
Lower Acquaintance	0.935**	0.123*	0.588**
Higher Acquaintance	0.505**	0.395**	0.780**
Sketching			
Lower Acquaintance	0.804**	0.340**	0.748**
Higher Acquaintance	0.538**	0.644**	0.742**
Mean			
Lower Acquaintance	0.835 (44.46)**	0.321 (17.09)**	0.722 (38.45)**
Higerh Acquaintance	0.539 (28.90)**	0.538 (28.85)**	0.788 (42.25)**

Note: $^{**}p < .01$, $^{*}p < .05$. The sample size for lower-acquaintance groups was $n = 27$, and the sample size for higher-acquaintance groups was $n = 28$. Values outside of brackets are variances; values inside brackets are proportions of variance.

Table 7

Amount (and Percentage) of Variance in Knowledge Seeking Due to Actor, Partner, and Residual

Area of Expertise	Actor Variance	Partner Variance	Residual Variance
Building and assembly	0.999 (37.63)**	0.509 (19.17)**	1.147 (43.20)**
CAD programs	1.134 (40.85)**	0.684 (24.64)**	0.958 (34.51)**
Competitors' processes and products	1.241 (54.43)**	0.245 (10.75)**	0.794 (34.82)**
Computer programming	1.348 (48.85)**	0.328 (11.79)**	1.106 (39.76)**
Engineering design process	1.011 (45.89)**	0.219 (9.94)**	0.973 (44.17)**
Sketching	1.269 (50.68)**	0.287 (11.46)**	0.948 (37.86)**
Mean	1.167 (46.05)**	0.379 (14.96)**	0.988 (38.99)**

Note: ** $p < .01$. The sample size was $n = 55$ groups. Values outside of brackets are variances; values inside brackets are proportions of variance.

significant sources of variance in ratings of knowledge seeking. Table 8 provides the amount of variance in knowledge seeking due to actor, partner, and residual in both lower-acquaintance and higher-acquaintance groups. Across all areas of expertise, both actor variance and partner variance were important contributors to ratings of knowledge seeking for both lower-acquaintance and higher-acquaintance groups. Hypothesis 2 is supported.

Interestingly, compared to ratings of expertise, there was quite a bit of actor variance in ratings of knowledge seeking for both lower-acquaintance (50.62%) and higher-acquaintance (41.54%) groups. Although partner variance was also significant in both lower-acquaintance (12.41%) and higher-acquaintance (17.45%) groups, much of the variance was captured by the actor. That is, group members tend to seek knowledge either from none, or all, of their group members. In fact, paired t-tests indicated that, for both lower-acquaintance groups, $t(26) = 4.33$, $p < .01$, and higher-acquaintance groups, $t(27) = 2.92$, $p < .01$, there was more variance in knowledge seeking due to actor than partner.

Next, analyses were conducted to determine whether a correlation existed between partner effects in expertise and partner effects in knowledge seeking. That is, the goal of this analysis was to understand whether group members who are perceived as experts in the group are likely to elicit knowledge seeking behavior from other group members. As seen in Table 9, for both lower-acquaintance and higher-acquaintance groups, there are partner-partner correlations. Thus, Hypothesis 4 is supported.

Table 8

Amount (and Percentage) of Variance in Knowledge Seeking for Lower- and Higher-Acquaintance Groups

Area of Expertise	Source of Variance		
	Actor	Partner	Residual
Building and assembly			
Lower Acquaintance	1.050**	0.376*	1.154**
Higher Acquaintance	0.950**	0.638**	1.140**
CAD programs			
Lower Acquaintance	1.279**	0.563**	0.945**
Higher Acquaintance	0.994**	0.801**	0.971**
Competitors' processes and products			
Lower Acquaintance	1.337**	0.197**	0.845**
Higher Acquaintance	1.149**	0.290**	0.744**
Computer programming			
Lower Acquaintance	1.381**	0.351**	1.107**
Higher Acquaintance	1.317**	0.306**	1.105**
Engineering design process			
Lower Acquaintance	1.262**	0.167**	0.744**
Higher Acquaintance	0.769**	0.269*	1.194**
Sketching			
Lower Acquaintance	1.500**	0.259**	0.903**
Higher Acquaintance	1.046**	0.314**	0.992**
Average			
Lower Acquaintance	1.301 (50.62)**	0.319 (12.41)**	0.950 (36.96)**
Higher Acquaintance	1.038 (41.54)**	0.436 (17.45)**	1.025 (41.02)**

Note: $^{**}p < .01$, $^{*}p < .05$. The sample size for lower-acquaintance groups was $n = 27$, and the sample size for higher-acquaintance groups was $n = 28$. Values outside of brackets are variances; values inside brackets are proportions of variance.

Table 9

Correlations between Partner Effects for Expertise and Partner Effects for Knowledge Seeking

Area of Expertise	Lower-Acquaintance	Higher-Acquaintance
Building and assembly	.744**	.704**
CAD programs	.720**	.721**
Competitors' processes and products	.393**	.611**
Computer programming	.602**	.560**
Engineering design process	.588**	.545**
Sketching	.671**	.629**

Note: $^{**}p < .01$. The sample size for lower-acquaintance groups was $n = 110$, and the sample size for higher-acquaintance groups was $n = 119$.

Although results suggest that group members agree about 'who knows what', agreement does not guarantee *accuracy* of these perceptions. A self-other comparison may determine whether agreement about expertise is accurate. In addition to rating everyone else in the group, group members provided ratings of their own expertise. Self ratings were correlated with partner effects to determine whether members who are perceived as experts in the group are likely to rate themselves as experts in the group. Table 10 provides results of this analysis. For most areas of expertise, there were significant correlations between partner effects and self-ratings, suggesting self-other agreement about expertise. Hypothesis 5 is supported.

Next, actor and partner variances in expertise and knowledge seeking were correlated with performance. It was hypothesized that groups with significant partner variance in expertise and knowledge seeking were likely to perform better. That is, groups whose members agree about who knows what and from whom to seek knowledge are likely to be better performers. As Table 11 and Table 12 illustrate, partner variance in expertise is positively related to performance as defined by grades on the group report, $r(53) = .33$, $p < .05$, but is not significantly related to performance on the group presentation, $r(53) = .19$, *ns*. However, performance was not related to partner variance in knowledge seeking for either the group report, $r(53) = .19$, *ns*, or group presentation, $r(53) = .22$, *ns*, measures of performance. Hypothesis 6 is partially supported, and Hypothesis 7 is not supported.

Table 10

Correlations between Self-Ratings and Partner Ratings of Expertise

Area of Expertise	Lower-Acquaintance	Higher-Acquaintance
Building and assembly	.285**	.335**
CAD programs	.329**	.410**
Competitors' processes and products	.149	-.122
Computer programming	.421**	.265**
Engineering design process	.109	.080
Sketching	.216*	.331**

Note: $^{**}p < .01$, $^{*}p < .05$. The sample size for lower-acquaintance groups was $n = 112$, and the sample size for higher-acquaintance groups was $n = 119$.

Table 11

Correlations between Group Performance and Actor and Partner Variance in Expertise

Area of Expertise	Group Report	Group Presentation
Actor Variances		
Building and assembly	.040	.064
CAD programs	-.143	-.099
Competitors' processes and products	-.001	.015
Computer programming	-.138	-.171
Engineering design process	-.377**	-.176
Sketching	-.196	-.133
Across areas of expertise	-.192	-.122
Partner Variances		
Building and assembly	.271*	.078
CAD programs	.304*	.291*
Competitors' processes and products	.059	-.107
Computer programming	.060	.176
Engineering design process	.331*	.071
Sketching	.296*	.109
Across areas of expertise	.334*	.193

Note: $^*p < .05$. The sample size was $n = 55$.

Table 12

Correlations between Group Performance and Actor and Partner Variance in Knowledge Seeking

Area of Expertise	Group Report	Group Presentation
Actor Variances		
Building and assembly	-.077	.136
CAD programs	-.070	-.019
Competitors' processes and products	-.069	.133
Computer programming	.033	-.032
Engineering design process	.162	.189
Sketching	-.075	.016
Across areas of expertise	-.021	.079
Partner Variances		
Building and assembly	.201	.046
CAD programs	.190	.206
Competitors' processes and products	.079	.244
Computer programming	.025	.139
Engineering design process	.082	.145
Sketching	.187	.233
Across areas of expertise	.189	.218

Note: $*p < .05$. The sample size was $n = 55$.

Finally, although hypotheses were not put forth for the relationship between actor and partner effects and personality, relationships between these effects were considered in exploratory analyses. As Table 13 and Table 14 demonstrate, few correlations existed between actor or partner variance and extroversion or conscientiousness[5]. Perhaps one notable finding is the relationship between partner effects in expertise and knowledge seeking with conscientiousness. In particular, conscientious individuals were more likely to be perceived as experts in computer programming, $r(195) = .17$, $p < .05$, and the engineering design process, $r(195) = .15$, $p < .05$. In addition, conscientious individuals were more likely to have knowledge sought from them about computer programming, $r(195) = .25$, $p < .01$, and the engineering design process, $r(195) = .14$, $p < .05$. That is, individuals who self-report being conscientious are likely to be seen as knowledgeable by others and to be viewed as the 'go to' person for knowledge about computer programming and the engineering design process. These findings should be interpreted with caution considering that, of the six areas of expertise, only two showed significant findings.

[5] Note that, because the correlation between group and each of these variables was essentially zero, a simple Pearson correlation was used rather than a correlation that partialled out effects of the group.

Table 13

Correlations between Actor Effects and Partner Effects in Expertise and Each of Extroversion and Conscientiousness.

Area of Expertise	Extroversion	Conscientiousness
Actor Effects		
Building and assembly	.022	-.002
CAD programs	-.080	.014
Competitors' processes and products	-.083	-.085
Computer programming	-.013	-.054
Engineering design process	-.029	-.152*
Sketching	-.061	-.094
Partner Effects		
Building and assembly	.064	-.054
CAD programs	-.157*	.058
Competitors' processes and products	-.066	.115
Computer programming	-.117	.171*
Engineering design process	-.017	.151*
Sketching	-.003	.112

Note: $**p < .01$, $*p < .05$. The sample size was $n = 197$.

Table 14

Correlations between Actor Effects and Partner Effects in Knowledge Seeking and Each of Extroversion and Conscientiousness.

Area of Expertise	Extroversion	Conscientiousness
Actor Effects		
Building and assembly	.060	.039
CAD programs	.148*	.008
Competitors' processes and products	.081	.025
Computer programming	.131	-.025
Engineering design process	.012	-.033
Sketching	.070	-.016
Partner Effects		
Building and assembly	.072	.060
CAD programs	.028	.094
Competitors' processes and products	.060	.138
Computer programming	-.027	.246**
Engineering design process	.073	.141*
Sketching	.051	.126

Note: $^{**}p < .01$, $^{*}p < .05$. The sample size was $n = 197$.

Discussion

Two key hypotheses were that higher-acquaintance groups would exhibit effective transactive memory systems and that transactive memory would be associated with performance. Transactive memory was operationalized, in social relations terms, as significant partner variance in expertise and knowledge seeking. Results of this study were partially supportive of the hypotheses.

Results of this study suggested that both actor and partner variance are important contributors to transactive memory ratings in both lower-acquaintance and higher-acquaintance groups. Looking at the percentage of variance in expertise due to the actor versus partner suggests that actor variance plays more of a role than partner variance in lower-acquaintance groups. The large amount of actor variance suggests that, in groups whose members have not worked together for a long time, members tend to rate all others similarly. As Kenny (1994) noted, there are various reasons for why a person tends to provide similar ratings across all partners. One of these reasons is response set. That is, some raters may tend to use high numbers while other raters tend to use small numbers; in essence, this reason reflects measurement bias. However, another possibility is that individuals in lower-acquaintance groups have a view of other people in general—be it negative or positive. This line of thinking is consistent with the in-group/out-group literature, which suggests that out-group members tend to be seen as more homogeneous than the in-group members (Judd & Park, 1988). To the extent that in lower-acquaintance groups individuals are seen as the out-group, one would expect a significant amount of actor variance.

In higher-acquaintance groups there was evidence for transactive memory, as defined by significant partner variance. In fact, in higher-acquaintance groups, partner variance was just as influential as actor variance. This finding is in line with research by Wegner and colleagues (1991), which suggested that members of dating couples agree more than strangers about expertise. Further, Moreland et al. (1998) showed that transactive memory—defined by complexity, accuracy, and agreement about knowledge beliefs—was greater in groups whose members were trained together. One may ask whether the agreement about 'who knows what' is accurate, and results of the associations between self-ratings and partner ratings support this thought. For all of building and assembly, CAD programs, computer programming, and sketching, positive associations were found between self ratings of expertise and others' ratings of expertise.

Although amounts of actor and partner variance in expertise differed depending on acquaintance, much of the variance in *knowledge seeking* was actor variance. That is, group members tend to seek knowledge from no one or everyone in the group, suggesting a characteristic of the person seeking the knowledge rather than the person from whom knowledge is being sought. Taken together with the results presented above, group members who are familiar with one another may be in agreement about 'who knows what', but some tend to be choosier knowledge seekers than others.

Interestingly, the amounts of actor and partner variance in expertise differed across areas of expertise. For example, more than a third of the variance in ratings of who knows about *building and assembly* was partner variance, whereas less than a tenth of the variance in ratings of who knows about *competitors' processes and products* was partner variance. These findings reflect, perhaps, the knowledge/skill distinction; that is, some areas of expertise were knowledge, whereas others were skills. Less partner variance was found for the knowledge areas (i.e., *competitors' processes and products* and *engineering design process*) than the skills (i.e., *building and assembly*, *CAD programs*, *computer programming*, and *sketching*).

Two reasons may explain the greater partner variance in skills than knowledge. First, an expert in the skill areas may be more *readily observable* than an expert in the knowledge areas. For example, expertise at sketching is easier to observe than expertise with competitors' processes and products. Second, skills can be more *difficult to learn* than knowledge. Thus, one person may have stood out as the clear expert in sketching from the beginning, perhaps because he or she had a sketching background coming out of high school. Conversely, potentially *anyone* could have taken on the task of learning about competitors or understanding and implementing the correct steps in the engineering design process. Therefore, experts in the skill areas may have stood out and resulted in more agreement about expertise than experts in the knowledge areas.

Another interesting finding suggests that perhaps group members rely on personal characteristics of the person from whom knowledge is sought. For example, findings from the exploratory analyses with personality suggest that individuals who self report being conscientious were likely to be viewed as experts in computer programming and the engineering design process and to be sought for their knowledge in these domains. Note, however, that significant relationships were found between conscientiousness and only a couple of the six areas of expertise that were examined, so results should be interpreted with caution. In addition, because the personality data was collected primarily for purposes other than this research, the particular personality dimensions of conscientiousness and extroversion may not have been the most relevant to this study. Future research could consider the relationships between actor and partner variance in expertise or knowledge seeking and different personality traits.

Perhaps the most interesting results in this study came from the analyses with group performance. Group performance was measured by a group report and a group presentation. Greater partner variance in expertise was associated with better performance, as rated by course administrators. That is, groups whose members agree about who knows what in the group are more likely to receive better grades on a group report. This finding fits with research by Lewis (2003) and others suggesting that knowing ‘who knows what’ is associated with group performance. Interestingly, however, agreement about who to seek knowledge from in the group was not associated with group performance. Certainly, a missing piece from this analysis is the contribution of relationship variance to performance. The primary purpose of Study 3 was to assess the contributions of relationship variance to performance in student engineering project groups.

STUDY 3

The previous study demonstrated that actor and partner variance are both important contributors to ratings of transactive memory. However, relationship variance could not be separated from error in Study 2. In addition, Study 2 did not include published measures of transactive memory, which could provide a useful comparison to the operationalization of transactive memory studied here. Thus, the purposes of Study 3 were (a) to assess the relationships between published measures of transactive memory, the current operationalization of transactive memory, and performance, and (b) to assess all of actor, partner, and relationship variance in another sample of student engineering project groups, at two points in time. Key hypotheses were that transactive memory, defined as partner variance in expertise and knowledge seeking, would be greater after group members had worked together for a significant period of time and would be associated with performance.

Time in groups can be operationalized in multiple ways. For example, time may be defined as the amount of contact or acquaintance that group members have had with one another; this operationalization of time was used in Study 2. An alternate operationalization (and one that does not rely on a median split) is the passage of time; this definition of time was used in Study 3. A benefit of measuring passage of time is that it is factual and does not rely on group member reports.

Hypotheses about expertise and knowledge seeking. Research suggests that, in groups whose members spent time working together and were trained together, agreement existed about who is expert in a particular domain (Liang et al., 1995; Moreland et al., 1998; Moreland & Myaskovsky, 2000) and from whom to seek knowledge (Palazzolo, 2003, 2005). Thus, some evidence exists to suggest that, once group members have spent significant time together, effective transactive memory systems will exist—as defined by agreement in ratings of expertise and knowledge seeking.

Hypothesis 8. At time 2, expertise ratings will show significant partner variance, such that all group members will tend to rate a particular partner similarly.

Hypothesis 9. At time 2, knowledge-seeking ratings will show significant partner variance, such that all group members tend to seek knowledge from the same teammate.

In contrast, partner variance is unlikely to be a significant source of variance in ratings of expertise before group members have had significant opportunities to work together. Instead, early on in a group's life, ratings of expertise are potentially explainable by the person making the ratings. Kenny (1994) suggests that this tendency to see all partners as similar declines with familiarity. Also possible is that, early on in a group's life, members may rate expertise in a dyad-specific manner. That is, group members who have not spent much time working together and are not familiar with one another may use different stereotypes when rating expertise (Craig, 2004; Hollingshead & Fraidin, 2003; Nickerson, 1999; Wegner, 1995; Wegner et al., 1991; Wittenbaum et al., 1996). Some members might use gender stereotypes; others might consider ethnicity or age when making their ratings. As such, ratings of expertise may be dyad-specific, evidencing significant levels of relationship variance.

Hypothesis 10a: At time 1, expertise ratings will show significant actor variance, such that the tendency will exist to rate all partners similarly.

Hypothesis 10b: At time 1, expertise ratings will show significant relationship variance, such that ratings of expertise will be dyad-specific.

Hypotheses about performance. Based on published research (e.g., Austin, 2003; Faraj & Sproull, 2000; Lewis, 2003; Liang et al., 1995; Moreland & Myaskovsky, 2000; Wong, 2003; Zhang et al., 2007), one would predict a positive relationship between transactive memory and performance. In social relations model terms, transactive memory would be represented by significant partner variance in both expertise and knowledge seeking. That is, in a high performing group, members should agree about who knows what and from whom to seek information.

Hypothesis 11. Groups with significant partner variance in expertise are likely to perform better. That is, there will be a positive partner-performance correlation.

Hypothesis 12. Groups with significant partner variance in knowledge seeking are likely to perform better. That is, there will be a positive partner-performance correlation.

Method

Participants

A new sample of engineering students participated in this study. A requirement of the engineering class was that students complete a design project, in groups of 4-5 students, over the duration of the first semester. As in Study 2, each student was asked to rank order four skills (analytical skills, communication skills, computer skills, and "hands-on" skills) from the skill he/she is most proficient in to the skill he/she is least proficient in. Then, the research team created groups that mixed each of these skills. This sample was comprised of 328 students (268 males, 60 females) in 77 groups, with a mean age of 18.49 years (*SD* = 1.90).

Task

As required by their engineering design course, participants had to complete a design project in groups of 4 to 5 students. Participants worked together on a design project during the first semester. Students were required to build a car, using a limited supply of materials (e.g., cardboard, elastics, and wooden dowels), that would move through the use of elastic bands. Then, students submitted a report on the design and engineering of their cars. At the beginning of the year, following an hour of team-building exercises (time 1), participants completed measures of expertise and knowledge seeking in addition to two published measures of transactive memory (Faraj & Sproull, 2000; Lewis, 2003). Participants completed this same set of measures two months later (time 2).

Measures

Participants completed all measures (except performance) through a paper-based questionnaire.

Expertise. Each group member was asked to respond to the following statements about each other group member and about themselves, for each skill or knowledge domain: “This group member has expertise in [skill/knowledge domain]” and “This group member knows a lot about [skill/knowledge domain]”. Group members responded using a 5-point Likert type scale from 1 (strongly disagree) to 5 (strongly agree).

Knowledge seeking. Each group member was asked to respond to the following two statements about each other group member, for each skill or knowledge domain: “I frequently seek information from this group member about [skill/knowledge domain]” and “I often ask this group member to answer my questions about [skill/knowledge domain]”. Group members responded using a 5-point Likert type scale from 1 (strongly disagree) to 5 (strongly agree).

Expertise coordination. Faraj & Sproull’s (2000) measure of expertise coordination consists of 11 items across three dimensions: expertise location (4 items), expertise needed (3 items), and bring expertise to bear (4 items). Participants responded on a scale from 1 (strongly disagree) to 5 (strongly agree). Sample items included "Team members know what task-related skills and knowledge they each possess" (expertise location), "Some people on our team do not have enough knowledge and skill to do their part of the team task" (expertise needed), and "People in our team share their special knowledge and expertise with one another" (bring expertise to bear). Alpha reliabilities for expertise location ($\alpha = .72$), expertise needed ($\alpha = .86$), and bring expertise to bear ($\alpha = .68$) were reasonable.

Transactive Memory System Scale. Lewis' (2003) transactive memory measure is comprised of 15 items split evenly across three dimensions: specialization (e.g., "I know which team members have expertise in specific areas"), credibility (e.g., "I was comfortable accepting procedural suggestions from other team members"), and coordination (e.g., "Our team worked together in a well-coordinated fashion"). Items were on a 5-point scale from 1 (strongly disagree) to 5 (strongly agree). Alpha reliabilities for specialization ($\alpha = .71$), credibility ($\alpha = .78$), and coordination ($\alpha = .77$) were reasonable.

Performance. Groups were required to build a car using a limited supply of materials (e.g., cardboard, elastics, and wooden dowels) that would move through the use of elastic bands. As a group, the students submitted a report on the design and engineering of their cars. Group performance was assessed by the grade on the final report submitted to course administrators in each lab of the engineering course.

Results

Analyses

Although multilevel modeling in SPSS was used to calculate variance estimates in the previous study, that option was not possible in this study due to the need to tease apart relationship variance from error. Because of the concerns of missing data and size of the data set, the choice was again made not to use SOREMO. So, instead of using SPSS multilevel modeling or SOREMO for this study, the analyses made use of a *two-way random effects model* in SAS[6].

The social relations model is described by SRM researchers as a two-way random effects model in which actor and partner are factors, and relationship is the interaction between those factors (Greguras et al., 2001; Kashy & Kenny, 2000; Kenny, 1996, 1998a). As seen in Appendix A, a social relations data set can be described using a matrix, in which the actor variance is represented by the row main effect and the partner variance is represented by the column main effect. The relationship variance, which describes uniqueness of ratings across actor-partner pairs, is represented by the variance in individual cells after removing the main effects (actor and partner). Thus, the two-way random effects model conceptually makes sense as a way to analyze social relations data.

Two indicators of each area of expertise were used, which allowed for separation of relationship from error variance. Although three or more indicators may be ideal, there were a couple of reasons why two indicators were deemed sufficient. First, the length of the questionnaire was already quite long; adding another indicator meant that participants would have to provide responses about that indicator for each group member and for each area of expertise. The goal was to generate the best quality of data with as

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[6] As a test to ensure that the two-way random effects model was essentially "doing the same thing" as the SPSS analyses, in Study 2, data were analyzed with both SPSS multilevel modeling and the two-way random effects model. Similar variances were obtained using both methods, and all variances significant using one method were significant using the other method as well.

few indicators as possible. Second, variances can be estimated with the random effects model as long as at least two indicators are used. The decision was made to balance questionnaire length with ability to estimate the model, so two indicators were used.

Consistent with Study 2, groups with non-respondents were removed from the analyses to which that data applied. Again, imputation may not make sense for this type of data. Thus, the choice was made to simply remove groups with missing data from the particular analyses to which that data applied. However, importantly, the amount of missing data was so small in comparison to the non-missing data that the effects of the missing data on the analyses were negligible.

Findings

As Table 15 illustrates, at time 1, for domains of *building and assembly*, *CAD programs*, *computer programming*, and *sketching*, all of actor, partner, and relationship variance are needed to explain ratings of expertise. For *competitors' processes and products*, ratings of expertise are best explained by only actor and partner variance. Finally, for the *engineering design process*, ratings of expertise are best explained by a model that includes only actor variance. Thus, for most areas of expertise, when group members made ratings of expertise after working together for only a couple of hours, those ratings were best explained by all of actor, partner, and relationship variance. Hypothesis 10, that expertise ratings will show significant actor and relationship variance at time 1, was supported. However, interestingly, the percentage of actor, partner, and relationship variance differed considerably across areas of expertise. For example, there was considerable partner variance in *sketching* (34.61%) and relatively little partner variance in *engineering design process* (2.41%).

Table 15

Time 1 Amount (and Percentage) of Variance in Expertise Due to Actor, Partner, Relationship, and Residual

Area of Expertise	Actor Variance	Partner Variance	Relationship Variance	Residual Variance
Building and assembly	0.071 (22.33)**	0.047 (14.78)**	0.048 (15.09)**	0.152 (47.80)
CAD programs	0.090 (18.75)**	0.150 (31.25)**	0.062 (12.92)**	0.178 (37.08)
Competitors' processes and products	0.092 (35.66)**	0.018 (6.98)**	0 (0)	0.148 (57.36)
Computer programming	0.074 (17.13)**	0.141 (32.64)**	0.045 (10.42)**	0.172 (39.81)
Engineering design process	0.101 (34.83)**	0.007 (2.41)	0.007 (2.41)	0.175 (60.34)
Sketching	0.065 (15.51)**	0.145 (34.61)**	0.058 (13.84)**	0.151 (36.04)
Mean	0.082 (22.40)	0.085 (23.22)	0.037 (10.11)	0.162 (44.26)

**indicates that a particular variance source was required in the model, $p < .01$. The sample size was $n = 77$ groups. The mean variances were not tested for significance but, rather, are presented here as a summary.

At time 2, once group members had worked together for two months, actor, partner, and relationship variance were again assessed and examined. Results in Table 16 suggest that, at time 2, a considerable amount of variance in ratings of expertise was relationship variance (22.18%). That is, after working together for a significant period of time, group members' ratings of expertise tended to include a considerable amount of idiosyncratic rating of others' expertise, in addition to considerable amounts of actor and partner variance. Hypothesis 8 was supported. One might expect increased agreement about expertise over time; however, interestingly, partner variance in expertise did not increase from time 1 to time 2. This finding is, however, supported by Kenny's (1994) review across multiple studies that consensus does not always increase across time.

Results for knowledge seeking at time 1 (see Table 17) show that much of the variance in ratings of knowledge seeking was explained by actor variance (41.53%). Having said that, for *building and assembly*, *CAD programs*, *computer programming*, and *sketching*, all of actor, partner, and relationship variance were needed to explain ratings of knowledge seeking. For *competitors' processes and products*, ratings of knowledge seeking were best explained by actor and partner variance. Finally, for the *engineering design process*, ratings of knowledge seeking were best explained by a model that includes only actor variance. Thus, when group members made ratings of knowledge seeking after working together for only a couple of hours, those ratings were best explained by all of actor, partner, and relationship variance. Finally, Table 18 illustrates that, at time 2, ratings of knowledge seeking are best explained by a model that

Table 16

Time 2 Amount (and Percentage) of Variance in Expertise Due to Actor, Partner, Relationship, and Residual

Area of Expertise	Actor Variance	Partner Variance	Relationship Variance	Residual Variance
Building and assembly	0.142 (18.00)**	0.233 (29.53)**	0.237 (30.04)**	0.177 (22.43)
CAD programs	0.246 (27.18)**	0.289 (31.93)**	0.172 (19.01)**	0.198 (21.88)
Competitors' processes and products	0.309 (47.10)**	0.007 (1.07)	0.136 (20.73)**	0.204 (31.10)
Computer programming	0.307 (35.21)**	0.181 (20.76)**	0.156 (17.89)**	0.228 (26.15)
Engineering design process	0.228 (33.93)**	0.080 (11.90)**	0.163 (24.26)**	0.201 (29.91)
Sketching	0.179 (21.41)**	0.215 (25.72)**	0.185 (22.13)**	0.257 (30.74)
Mean	0.235 (29.78)	0.168 (21.29)	0.175 (22.18)	0.211 (26.74)

**indicates that a particular variance source was required in the model, $p < .01$. The sample size was $n = 77$ groups. The mean variances were not tested for significance but, rather, are presented here as a summary.

Table 17

Time 1 Amount (and Percentage) of Variance in Knowledge Seeking Due to Actor, Partner, Relationship, and Residual

Area of Expertise	Actor Variance	Partner Variance	Relationship Variance	Residual Variance
Building and assembly	0.157 (42.78)**	0.017 (4.63)**	0.045 (12.26)**	0.148 (40.33)
CAD programs	0.162 (33.40)**	0.090 (18.56)**	0.056 (11.55)**	0.177 (36.49)
Competitors' processes and products	0.158 (46.33)**	0.017 (4.99)**	0 (0)	0.166 (48.68)
Computer programming	0.207 (43.58)**	0.062 (13.05)**	0.046 (9.68)**	0.160 (33.68)
Engineering design process	0.172 (48.59)**	0 (0)	0.011 (3.11)	0.171 (48.31)
Sketching	0.188 (38.21)**	0.095 (19.31)**	0.039 (7.93)**	0.170 (34.55)
Mean	0.174 (41.53)	0.047 (11.21)	0.033 (7.87)	0.165 (39.38)

**indicates that a particular variance source was required in the model, $p < .01$. The sample size was $n = 77$ groups. The mean variances were not tested for significance but, rather, are presented here as a summary.

Table 18

Time 2 Amount (and Percentage) of Variance in Knowledge Seeking Due to Actor, Partner, Relationship, and Residual

Area of Expertise	Actor Variance	Partner Variance	Relationship Variance	Residual Variance
Building and assembly	0.373 (34.99)**	0.215 (20.17)**	0.194 (18.20)**	0.284 (26.64)
CAD programs	0.456 (41.80)**	0.181 (16.59)**	0.184 (16.87)**	0.270 (24.75)
Competitors' processes and products	0.536 (58.84)**	0.038 (4.17)**	0.072 (7.90)**	0.265 (29.09)
Computer programming	0.591 (54.47)**	0.088 (8.11)**	0.145 (13.36)**	0.261 (24.06)
Engineering design process	0.481 (48.00)**	0.085 (8.48)**	0.167 (16.67)**	0.269 (26.85)
Sketching	0.470 (41.93)**	0.180 (16.06)**	0.189 (16.86)**	0.282 (25.16)
Mean	0.485 (46.32)	0.131 (12.51)	0.159 (15.19)	0.272 (25.98)

**indicates that a particular variance source was required in the model, $p < .01$. The sample size was $n = 77$ groups. The mean variances were not tested for significance but, rather, are presented here as a summary.

includes all of actor, partner, and relationship variance. Thus, Hypothesis 9, that knowledge-seeking ratings at time 2 show significant partner variance, was supported.

Next, the actor/ partner variances for each group and published measures of transactive memory and expertise (Faraj & Sproull, 2000; Lewis, 2003) were correlated with performance. Results from Table 19 show that there were no significant relationships between performance and any of the dimensions of Lewis' (2003) measure. However, there was a significant positive relationship between Faraj and Sproull's (2000) dimension of bringing expertise to bear and performance, $r(62) = .29$, $p < .05$. That is, groups that performed better on their final report were more likely to self-report using the knowledge of others in the group.

Most interesting for the purposes of this study, significant positive relationships existed between relationship variance in expertise and performance, $r(67) = .43$, $p < .01$ and between relationship variance in knowledge seeking and performance, $r\ (67) = .32$, $p < .05$. In other words, groups whose members reported 'who knows what' in the group in an idiosyncratic, unique fashion were more likely to perform better on their final reports. In addition, groups whose members sought knowledge based on unique, idiosyncratic relationships in the group were more likely to perform better on their final reports. Finally, there was a significant positive relationship between partner variance in expertise and performance, $r(67) = .27$, $p < .05$, suggesting that agreeing about 'who knows what' is associated with better performance scores. Hypothesis 11 was supported, but Hypothesis 12 was not supported.

Table 19

Correlations between Performance and Dimensions of Transactive Memory

Measure of Transactive Memory	Final Report
Expertise	
Actor Variance	-.168
Partner Variance	.274*
Relationship Variance	.432**
Knowledge Seeking	
Actor Variance	-.120
Partner Variance	.070
Relationship Variance	.323*
Faraj & Sproull's Measure	
Expertise Location	.188
Expertise Needed	-.080
Bringing Expertise to Bear	.289*
Lewis' Measure	
Specialization	.085
Credibility	-.067
Coordination	.025

Note: $^{**}p < .01$, $^{*}p < .05$. The sample size is $n = 69$ groups.

Discussion

Results of Study 3 suggested that, for ratings of expertise, variance tended to be distributed as all of actor, partner, and relationship variance. However, for knowledge seeking, ratings were primarily a result of actor variance or, in other words, group members tending to seek knowledge from everyone or from no one at all. Partner variance, although smaller in magnitude than actor variance, also contributed to ratings of expertise and knowledge seeking. Partner variance in ratings of expertise suggests that group members tend to agree in their ratings of who is an expert at what in the group. Partner variance in ratings of knowledge seeking suggests that group members tend to seek knowledge from the same members of the group. Interestingly, although significant, the amount of partner variance in knowledge seeking tended to be fairly low (i.e., about ten percent). This finding suggests that knowledge seeking tends to depend more on the seeker than on the person being sought.

Of most interest to this study, relationship variance provided a significant contribution to ratings of expertise and knowledge seeking after group members had been together for two months. Relationship variance in ratings of expertise and knowledge seeking suggests that ratings of transactive memory are made, to some extent, on the basis of particular dyads in the group. So, for example, Ann may rate Bob differently than Ann rates anyone else or Bob is rated by anyone else in the group. As well, Ann may seek knowledge from Bob more than Ann seeks knowledge from anyone else or more than knowledge is sought from Bob by anyone else. These findings suggest that ratings of transactive memory depend to some extent on unique relationships that exist between group members. This is critically important, as transactive memory studies tend not to consider these unique, dyadic relationships that are evidently very important to understanding transactive memory in groups.

One of the most interesting findings in this study was the relationship between the sources of variance and group performance. First, groups whose members tended to agree about ‘who knows what’ in the group were more likely to perform better on their final reports. This finding is in line with the results of Study 2. Even more interesting, however, is that, after working together for two months, groups whose members had unique ideas about who knows what in the group and who sought knowledge from others in idiosyncratic ways were more likely to receive good grades on their final report than groups with smaller amounts of relationship variance. This finding is in contrast to the hypotheses that relationship variance was more likely in lower-acquaintance groups and early on in a group’s life. Thus, it appears that knowledge seeking in idiosyncratic ways in a group provides some benefit to the group in terms of performance. One possibility is that groups work best not necessarily when there are ‘stars’ in the group who stand out as experts and go-to individuals, but rather when group members develop and make use of their own personal ideas about who to seek knowledge from in the group.

Interestingly, there were no significant relationships between Lewis’ (2003) dimensions of transactive memory and performance; and only one of Faraj and Sproull’s (2000) dimensions, bringing expertise to bear, was associated with performance. This finding is important, as it suggests that published measures of transactive memory may not be capturing the whole picture of expertise and knowledge exchange in groups. Because Lewis’ (2003) transactive memory measure was not associated with performance, one may argue that, in fact, transactive memory did not exist in these groups and that the new SRM-based transactive memory measure was capturing a different construct. However, the finding that one of Faraj and Sproull's (2000) dimension—bring expertise to bear—was associated with performance, suggests that transactive memory was being captured in this study.

One of the limitations of the studies discussed above, of course, is that data collected from student samples may not provide the same results as data collected from organizational samples. In Study 4, this limitation is addressed by considering sources of variance in work groups from an engineering organization.

STUDY 4

The purpose of Study 4 was to examine transactive memory in organizational groups. Many transactive memory studies are conducted in laboratory settings using small groups of students (e.g., Liang et al., 1995; Moreland & Myaskovsky, 2000). However, differences may exist in the dynamics of student groups and organizational groups. For example, in student groups, members tend to be physically proximate to each other, making knowledge searches quick and members easily approached. In organizational groups, expertise awareness and knowledge seeking may be trickier. In such teams, multiple experts may exist for a particular topic (Palazzolo, 2003, 2005), and the search for knowledge in large groups may be more extensive (Ren et al., 2006). For these reasons, it made sense to examine expertise and knowledge seeking in an organizational setting using real work groups.

The organizational groups examined in this study had all worked together for extended periods of time. As such, teammates were assumed to be well acquainted with one another and aware of each other group member's expertise. Furthermore, because they were well-acquainted and comfortable with one another, group members were expected to approach the same teammates about their expertise. That is, transactive memory, defined as significant partner variance in expertise and knowledge seeking, was expected in these groups.

Hypothesis 13. Expertise ratings will show significant partner variance, such that all group members tend to rate a particular partner similarly.

Hypothesis 14. Knowledge-seeking ratings will show significant partner variance, such that all group members tend to seek knowledge from the same teammate.

Hypothesis 15. Self-ratings will be correlated with partner effects, such a particular group member's ratings of expertise will have a positive relationship with other members' perceptions of that expertise.

Method

Before collecting data, knowledge and skill areas important to team functioning needed to be identified. The author examined job descriptions and other documentation to determine knowledge and skills important to team functioning. Then, the knowledge manager revised the list into the following eight knowledge and skill areas: business processes (e.g., purchasing, reporting, time entry); organizational and customer technical standards; organizational knowledge groups and experts; project management; system commissioning and testing; system design; system programming; and system troubleshooting. Group members completed a questionnaire in which they identified who in the group was expert in each of these skill/knowledge areas and from whom in the group they sought information about each of these domains.

Participants

Participants were 23 employees (3 females, 20 males) in 7 groups (ranging in size from 3 to 4 members) in an engineering organization. The organization creates solutions for its clients in various industries, including automotive and environmental. In addition, the organization has received numerous awards for its practices. The average age of the employees was 33.65 years (*SD* = 8.90). Employees had been with the organization for a minimum of 9 months to a maximum of 11 years (*M* = 3.61 years, *SD* = 3.07 years). Although the number of groups was small, Greguras et al. (2001; cited Kenny, 1994) noted that a minimum of six groups of four to eight members is required to obtain stable estimates.

Measures

Participants completed all measures through an online survey.

Expertise. Each group member responded to the following statement about each other group member and about themselves, for each skill or knowledge domain: "[Group member] has expertise in [skill/knowledge domain]". Group members responded using a 7-point Likert type scale from 1 (strongly disagree) to 7 (strongly agree).

Knowledge seeking. Each group member was asked to respond to the following statement about each other group member, for each skill or knowledge domain: "I frequently seek information from [group member] about [skill/knowledge domain]". Group members will respond using a 7-point Likert type scale from 1 (strongly disagree) to 7 (strongly agree).

Results

The purpose of Study 4 was to determine the variance due to actor, partner, and relationship in an organizational sample. A key hypothesis was that, due to the organization's focus on knowledge management and the familiarity of group members, effective transactive memory systems would exist in these groups. Effective transactive memory systems were defined as substantial partner variance in expertise and knowledge seeking.

As mentioned earlier, in order to separate relationship variance from error, multiple measures must be used. To obtain multiple measures, two different measures of a variable may be included in the same questionnaire or the same measure could be provided at two or more points in time. Conversations with the knowledge manager indicated that participants would become frustrated with responding to two different measures in the same questionnaire; hence, the same measure was provided at two different points in time, separated by a two-week period. Unfortunately, the response rate at the second time point was poor, and analyses were based on the first questionnaire only. As a result, relationship variance could not be calculated for this sample. Results presented below are in terms of actor and partner variance only.

As seen in Table 20 and Table 21, results from the organizational groups suggested that much of the variance in ratings of both expertise and knowledge seeking was due to partner variance. Hence, Hypothesis 13 and Hypothesis 14 were supported. Next, self ratings of expertise were correlated with partner effects of expertise. As seen in Table 22, self ratings tended to be correlated with partner effects, suggesting agreement between self and other ratings of expertise. Hypothesis 15 was supported.

Table 20.

Amount (and Percentage) of Variance in Expertise Ratings Due to Actor, Partner, and Residual for a Sample of Engineering Employees

Knowledge/Skill	Source of Variance		
	Actor	Partner	Residual
Business processes (e.g., purchasing, reporting, time entry)	.488 (30.37)	1.024 (63.72)	.095 (5.91)*
Organizational and customer technical standards	.238 (13.16)	1.131 (62.52)*	.440 (24.32)
Organizational knowledge groups and experts	.119 (7.09)	.929 (55.33)	.631 (37.58)
Project management	.214 (10.10)	1.643 (77.54)*	.262 (12.36)
System commissioning and testing	.179 (15.98)	.679 (60.63)*	.262 (23.39)
System design	.429 (25.92)*	1.036 (62.60)*	.190 (11.48)
System programming	.035 (3.23)	.868 (80.15)*	.180 (16.62)
System troubleshooting	.036 (4.80)	.226 (30.13)*	.488 (65.07)

Note: numbers outside of brackets are variances and numbers inside brackets are percentage of variance. $*p < .05$. The sample size is $n = 7$ groups.

Table 21.

Amount (and Percentage) of Variance in Knowledge Seeking Ratings Due to Actor, Partner, and Residual for a Sample of Engineering Employees

Knowledge/Skill	Source of Variance		
	Actor	Partner	Residual
Business processes (e.g., purchasing, reporting, time entry)	2.171 (45.51)*	1.397 (29.29)	1.202 (25.20)*
Organizational and customer technical standards	2.464 (36.48)	2.143 (31.73)	2.147 (31.79)
Organizational knowledge groups and experts	1.155 (34.28)	1.631 (48.41)	.583 (17.30)
Project management	1.030 (23.71)	1.905 (43.85)	1.409 (32.44)
System commissioning and testing	1.892 (45.55)	1.500 (36.11)*	.762 (18.34)
System design	2.440 (49.51)	1.333 (27.05)	1.155 (23.44)
System programming	1.429 (34.59)	2.071 (50.13)*	.631 (15.27)*
System troubleshooting	1.857 (40.20)	1.810 (39.19)*	.952 (20.61)*

Note: numbers outside of brackets are variances and numbers inside brackets are percentages. $*p < .05$. The sample size is $n = 7$ groups.

Table 22.

Relationship Between Self-Ratings of Expertise and Partner Effects

Area of Expertise	Correlation
Business processes (e.g., purchasing, reporting, time entry)	.331
Organizational and customer technical standards	.359
Organizational knowledge groups and experts	.303
Project management	.524*
System commissioning and testing	.564**
System design	.529*
System programming	.580**
System troubleshooting	.370

Note: $^{**}p < .01$, $^{*}p < .05$. The sample size is $n = 22$ individuals.

Discussion

The organization used in this sample was one with a focus on knowledge management and expertise awareness. Thus, the expectation was that group members would agree about who was expert in the group and agree about from whom to seek knowledge in the group. Results suggest that this was, indeed, the case. Across areas of expertise, much of the variance in ratings of expertise was partner variance—agreement about who knows what in the group. In addition, for most of the skills and knowledge areas, there were significant correlations between self ratings of expertise and others' ratings of that group member's expertise. Hence, in groups whose organization has a clear focus on knowledge awareness and knowledge management, significant partner variance and self-partner correlations were evident. In addition a significant amount of variance in ratings of knowledge seeking was due to partner variance—agreement about who to approach for knowledge in the group. Considering Kenny's (1994) suggestion that partner variance is difficult to find, such findings are certainly interesting.

One limitation of this study was the inability to examine group performance—and, hence, to relate transactive memory to performance. Due to the complexity of the teams, performance was difficult to measure in a comparable fashion—especially across different groups working on different projects. A second limitation was the poor response rate at the second time point in this study. A secondary time point would have allowed analyses involving relationship variance. A third limitation of this study was its small sample size. Although the results seem even more promising when considering that the sample size was only seven teams, a larger sample size would certainly be desired. Furthermore, for social relations analysis to be used, groups must consist of at least four members. Although three-person groups can be used, analyses should not be conducted if dyadic reciprocity is expected. Dyadic reciprocity means that a correlation exists between Ann's relationship effect with Bob and Bob's relationship effect with Ann. Marcus (1998) suggests that studies of strangers who are unfamiliar with one another may meet this assumption, but groups of familiar members may not. All of the groups in Study 4 contained more than three members. However, after removing missing data, many of the analyses had to be conducted on groups with data for only three members. Thus, the results from Study 4 should be considered in light of this assumption violation.

GENERAL DISCUSSION

The purpose of this research was to fill a gap in the transactive memory literature by attempting to understand transactive memory in terms of relationships between pairs of individuals interacting within a larger group. Transactive memory was defined, in social relations model terms, as significant partner variance in expertise and knowledge seeking. I hypothesized that effective transactive memory systems would be evident in higher-acquaintance groups and that transactive memory would be associated with performance. In four studies of student and organizational groups across time, the results generally support the idea that partner variance is useful in operationalizing transactive memory, but also that relationship variance contributes to understanding ratings of expertise and knowledge seeking. Table 23 summarizes the results of this research.

Perhaps the most interesting and novel results from this research are the following: (a) all of actor, partner, and relationship variance contribute to an

Table 23

Summary of Key Results Across the Studies

Study	Findings
1	• In open-ended questions, employees reported seeking knowledge primarily on the basis of expertise or experience, but also based on characteristics of the knowledge seeker (e.g., his/her personality or availability) or a relationship with the knowledge seeker (e.g., personal relationships or compatibility).
2	• In lower-acquaintance groups, members tend to rate the expertise of all others in the group similarly, whereas in higher-acquaintance groups there tends to be agreement about who is expert.
	• Others' ratings of expertise are associated with self-reports of expertise.
	• In both lower- and higher-acquaintance groups, members tend not to discriminate between members from whom knowledge is sought. That is, knowledge seeking tends to work on an 'all or none' strategy.
	• Members tend to view conscientious individuals as expert and seek knowledge from them.
	• Better scores on group reports are associated with agreement in the group about who knows what but not with agreement about who to seek knowledge from.
3	• All of actor, partner, and relationship variance are required to explain ratings in expertise and knowledge seeking, particularly after group members have worked together for a period of time.
	• While ratings of expertise tend to be explained equally by the actor, partner, and relationship variance, knowledge seeking depends on the knowledge seeker.
	• Groups whose members are idiosyncratic in their ratings of expertise and knowledge seeking are more likely to perform well on the final report.
	• Groups whose members agree about 'who knows what' in the group are more likely to perform well on the final report.
4	• In organizational engineering groups whose members have worked together for a significant period of time, there is substantial agreement about who knows what in the group and from whom to seek knowledge. In addition, agreement is associated with self-reported ratings of expertise.

understanding of expertise and knowledge seeking; (b) the contributions of actor, partner, and relationship variance differ depending on group member familiarity and time spent in the group; and (c) partner variance and relationship variance are associated with performance ratings. Each of these results is discussed in turn below, followed by implications, limitations, and future directions.

Sources of Variance and Their Contributions to Transactive Memory

Across studies, it was evident that all of actor, partner, and relationship variance were required to explain ratings of expertise and knowledge seeking. This finding is particularly interesting because it suggests that dyadic relationships between group members are a necessary contributor to understanding transactive memory. Yet, few transactive memory researchers focus their measures on the unique relationships within groups. Consider, for example, transactive memory measures in which individuals are asked about expertise and knowledge seeking in their groups, but scores are aggregated to the group level for analyses (e.g., Austin, 2003; Ellis, 2003). In such studies, expertise awareness and knowledge exchange at the dyad level, between two group members, are masked by expertise and knowledge seeking in the group as a whole. In my study, however, these dyadic relations were observed.

Another interesting finding was that knowledge seeking is largely a function of the seeker: some people tended to be seekers regardless of who they sought knowledge from, while others tended to seek knowledge from no one. Consistent with this, Marcus (1998) notes that although studies of interpersonal perception find substantial partner variance, the partner does not often account for much variance in interpersonal behavior.

Applied to this research, then, one might expect (and I found) significant partner variance in expertise but little partner variance in knowledge seeking.

Sources of Variance and Group Member Familiarity

Although all of actor, partner, and relationship variance contribute to understanding transactive memory, they may make different contributions depending on member familiarity or time spent in the group. I hypothesized that transactive memory would be most evident in higher-acquaintance groups, with transactive memory defined as significant partner variance in expertise and knowledge seeking. The results of Study 2 suggested that much of the variance in lower-acquaintance groups is due to the actor, while both actor and partner variance contributed equally to ratings of expertise made in higher-acquaintance groups. That is, in support of the hypotheses, group members tend to agree more about who is expert in the group once they have become familiar with the other group members. In lower-acquaintance groups whose members spent relatively less time together, knowing ‘who knows what’ was best explained by the person making the rating of expertise. However, the pattern of results in Study 3 was slightly different. Results of this study suggested that variances in expertise and knowledge seeking stayed quite stable over time. That is, there were few changes in the percentages of actor and partner variance from early in the group members’ time together (time 1) to later in groups members’ time together (time 2).

Relationship variance also contributed to both ratings of expertise and ratings of knowledge seeking; however, its contributions were greater once group members had spent time working together. In fact, relationship variance doubled its contributions between time 1 and time 2. Hence, in groups whose members have spent significant time together, a substantial contribution to ratings of expertise and knowledge seeking in the group involves idiosyncratic views of expertise and idiosyncratic knowledge seeking. These findings are particularly interesting because they are in contrast to the hypotheses put forth about substantial partner variance in groups whose members know each other well. According to Livi et al. (2008), significant relationship variance may signify disagreements between group members, but it may also reveal personal preference or friendships between group members.

Sources of Variance and Group Performance

Probably the most interesting findings in this research are the relationships between sources of variance and performance. I hypothesized that transactive memory, defined as substantial partner variance in expertise and knowledge seeking, would be associated with performance. Results from the two student samples suggested that agreement about member expertise is associated with performance. This finding is supported by numerous other transactive memory studies suggesting that knowing 'who knows what' is predictive of performance (e.g., Austin, 2003; Lewis, 2003; Moreland & Myaskovsky, 2000; Wegner et al., 1991). Thus, this finding of partner variance is not surprising. Perhaps more interesting is the fact that partner variance in knowledge seeking was *not* significantly associated with performance. That is, agreement about who to seek knowledge from is not associated with better scores on groups' final reports.

The most novel and interesting results may be that, contrary to predictions, relationship variance is significant in groups whose members have spent significant time together and, in fact, is associated with group performance. Support for this result comes from the qualitative study as well. That is, members of groups who have significant work experience and, presumably, work in high performing groups report knowledge seeking based on factors other than expertise.

Taken together, these results suggest that group members generally know ‘who knows what’ in the group and from whom knowledge should be sought, but they often make use of their own personal relationships in the group when deciding who is expert and from whom to seek knowledge. In addition, these idiosyncratic methods of knowledge seeking appear beneficial, as relationship variance was associated with group performance. An interesting comparison can be made between the group-level focus in transactive memory literature and the dyad-level focus in personal life—Facebook, LinkedIn, and other social networking tools have led to an emphasis on the dyad, but the research literature is still very much focused on the group.

Implications for Research

One implication for researchers is that dyadic relationships within groups are important contributors to ratings of expertise and knowledge seeking. Researchers should strive to create measures that account for dyadic perceptions of expertise and patterns of knowledge seeking in groups rather than aggregating results to the group level. Studies by Palazzolo (2003) and Yuan et al. (2007) certainly show promise in this regard, as both researchers focused on communication between individuals within a group.

Implications for Practice

Results of these studies showed that, ultimately, a combination of actor, partner, and relationship variance contributed to understanding transactive memory systems. The focus in this section is on the implications of each source of variance for practitioners. In particular, I consider (a) the effects that *actor variance* in expertise has on *familiarity* in groups; (b) the effects that *actor variance* in knowledge seeking has on *information exchange* in groups; (c) the effects that *partner variance* in expertise has on *knowledge management and training*; and (d) the effects of *relationship variance* on *group member relations*.

Implications for inducing familiarity in groups. Results showed significant actor variance, or assimilation, in ratings of expertise; that is, people tend to be somewhat consistent in their ratings of all others. This finding may reflect the relative unfamiliarity of group members, even in the higher-acquaintance student groups. Indeed, results of the organizational study, in which group members worked together more frequently than either of the lower- or higher-acquaintance student groups, showed little actor variance in ratings of expertise. Significant actor variance, then, may be a symptom of relative unfamiliarity in a group. In addition, actor variance in expertise was not associated with performance. Thus, there appears to be no benefit of actor variance in expertise for groups. Organizations should seek to remove this actor variance by breaking barriers between group members and promoting familiarity and knowledge of "who knows what" in their groups.

Implications for information exchange. Results showed behavioural consistency in knowledge seeking across groups—even in groups with members who were familiar with one another. Thus, managers must be cognizant of the fact that individual differences may drive information exchange groups, such that some members are seekers while others are not. There was no relationship between actor variance in knowledge seeking and performance, suggesting no benefit to this "all or none" strategy of seeking knowledge. Organizations might strive to bring employees "out of their shell" to interact with particular others and avoid consistent knowledge seeking from all others.

Implications for knowledge management and training. Results showed that agreement in groups about 'who knows what' was associated with performance. An implication for practitioners is that expertise can be enhanced by having a group leader or knowledge manager identify experts early on and make all group members aware of this information (e.g., see Moreland & Myaskovsky, 2000). For example, Schreiber and Engelmann (2010) created a digital tool that aided in expertise awareness by mapping what knowledge individuals hold. Such tools may be useful for accelerating perceptions of expertise and creating consensus about expertise in the group. Also, Greguras et al. (2001) proposed that a lack of partner variance can highlight the need for training to improve agreement. As such, areas of expertise with low partner variance may become the focus of training to improve agreement and accuracy about "who knows what" in the group.

Implications for group member relations. Another implication for practitioners is that group members should be allowed or even encouraged to develop relationships in the group that focus on comfort and compatibility between members rather than solely on knowledge exchanges with experts. Results of this research showed that relationship variance was associated with performance. This finding contrasts with the common recommendation in the literature to seek knowledge from the most expert members in the group. One prescription is that, instead of improving transactive memory by training group members together, organizations might be better to improve personal relationships and comfort levels of employees with one another.

Limitations

Measure length. One challenge in this research was the length of the expertise and knowledge seeking measures. In order to obtain a full data set for a round-robin social relations model, data must be collected from each group member about every other group member. In addition, because expertise was a focus in this study and expertise varies across skills and knowledge areas, data also had to be collected about multiple areas of expertise. Hence, the measures tended to be long and perhaps frustrating for group members to complete—factors which may have contributed to inflated actor or residual variances in particular.

Relationship variance calculations. Another limitation across studies, inherent in the social relations model, is that relationship variance was impossible to calculate in some instances. In order to calculate relationship variance and separate it from error variance, multiple measures or measurements at multiple times can be used to differentiate sources of variance (Kenny et al, 2006). One problem with using multiple measures taken at the same time is that participants may recognize the similarity between measures and explicitly seek to respond to items similarly, possibly inflating relationship variance. A solution to this problem would be to take measurements at multiple times; however, an ideal duration of time between measurements that is not too long to allow substantive changes in the group is difficult to determine.

Future Directions

Larger samples. Certainly one of the next directions in this research is to examine sources of variance in a larger sample of organizational groups. The organizational results presented here were limited by the small sample size and the very low response rate after the second round of data collection. Future research should consider the contributions of relationship variance to ratings of expertise and knowledge seeking in a larger sample of organizational groups.

Sizes and types of groups. Future research might also consider different sizes and types of groups. The groups used in this study tended to be rather small, but similar in size to the organizational project groups. Interesting research might consider how patterns of variance change in larger groups. As well, the current research focused mostly on engineering project groups. Additional samples might consist of other knowledge workers such as software development teams or surgery teams.

Actual expertise. Expertise is a variable for which some "truth" can be determined. So, although the main interest was in whether expertise was *recognized and agreed upon* by group members, accuracy of those ratings can also be considered. Thus, another avenue for future research would involve teasing apart actual expertise from expertise recognition to determine the similarities between the two variables and their relationships with performance. Actual expertise could be measured by student grades or supervisor ratings of performance in different content areas.

CONCLUSION

Transactive memory was defined according to the social relations model as significant partner variance in expertise and knowledge seeking. I hypothesized that effective transactive memory systems would exist in higher-acquaintance groups and that transactive memory would be associated with performance. This research showed that group members agree about 'who knows what' in the group, but they are not always likely to seek knowledge based on these perceptions of expertise. Instead, knowledge seeking is explained by a combination of actor variance, partner variance, and relationship variance. In particular, relationship variance played a surprisingly important role, and it was the unique knowledge-seeking relationships that exist in groups that are associated with performance. An implication of this research is that transactive memory must not be examined exclusively as a group phenomenon. Instead, the interactions and relationships within groups are *vital* to understanding transactive memory among group members.

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APPENDIX A

An Example of The Social Relations Model

Suppose that Ann, Bob, Carl, and Diane are each asked to provide ratings of the extent to which they seek knowledge from every other individual. The values in the boxes are the raw scores provided by each of the four people (actors) about each other (partners).

A. An example illustrating only actor effects

Actor		Partner: Ann	Bob	Carl	Diane	Actor Effects
	Ann	---	1	1	1	-1.5
	Bob	2	---	2	2	-0.5
	Carl	3	3	---	3	0.5
	Diane	4	4	4	---	1.5
	Partner Effects	0	0	0	0	

B. An example illustrating only partner effects

Actor		Partner: Ann	Bob	Carl	Diane	Actor Effects
	Ann	---	2	3	4	0
	Bob	1	---	3	4	0
	Carl	1	2	---	4	0
	Diane	1	2	3	---	0
	Partner Effects	-1.5	-0.5	0.5	1.5	

C. An example illustrating all of actor, partner, and relationship effects

		Partner: Ann	Bob	Carl	Diane	Actor Effects
Actor	Ann	---	1	2	5	-0.625
	Bob	5	---	4	2	-0.625
	Carl	6	2	---	7	1.25
	Diane	4	3	3	---	0
	Partner Effects	1.125	-1.875	-0.25	1.0	

APPENDIX B

Ethics Approval

Department of Psychology The University of Western Ontario
Room 7418 Social Sciences Centre,
London, ON, Canada N6A 5C1
Telephone: (519) 661-2067Fax: (519) 661-3961

Western

Use of Human Subjects - Ethics Approval Notice

Part of the study "Understanding Team Composition Effects in Project Teams"

Review Number	09 03 09	**Approval Date**	09 03 16
Principal Investigator	Natalie Allen/Sarah Ross	**End Date**	09 04 30
Protocol Title	Expertise and knowledge seeking in engineering project groups		
Sponsor	n/a		

This is to notify you that The University of Western Ontario Department of Psychology Research Ethics Board (PREB) has granted expedited ethics approval to the above named research study on the date noted above.

The PREB is a sub-REB of The University of Western Ontario's Research Ethics Board for Non-Medical Research Involving Human Subjects (NMREB) which is organized and operates according to the Tri-Council Policy Statement and the applicable laws and regulations of Ontario. (See Office of Research Ethics web site: http://www.uwo.ca/research/ethics/)

This approval shall remain valid until end date noted above assuming timely and acceptable responses to the University's periodic requests for surveillance and monitoring information.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the PREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of research assistant, telephone number etc). Subjects must receive a copy of the information/consent documentation.

Investigators must promptly also report to the PREB:
a) changes increasing the risk to the participant(s) and/or affecting significantly the conduct of the study;
b) all adverse and unexpected experiences or events that are both serious and unexpected;
c) new information that may adversely affect the safety of the subjects or the conduct of the study.

If these changes/adverse events require a change to the information/consent documentation, and/or recruitment advertisement, the newly revised information/consent documentation, and/or advertisement, must be submitted to the PREB for approval.

Members of the PREB who are named as investigators in research studies, or declare a conflict of interest, do not participate in discussion related to, nor vote on, such studies when they are presented to the PREB.

Clive Seligman Ph.D.

Chair, Psychology Expedited Research Ethics Board (PREB)

The other members of the 2008-2009 PREB are: David Dozois, Bill Fisher, Riley Hinson and Steve Lupker

CC: UWO Office of Research Ethics

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Western

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Use of Human Subjects - Ethics Approval Notice

Review Number	09 09 10	**Approval Date**	09 09 15
Principal Investigator	Natalie Allen/Sarah Ross	**End Date**	10 04 30
Protocol Title	The knowledge network project		
Sponsor	n/a		

This is to notify you that The University of Western Ontario Department of Psychology Research Ethics Board (PREB) has granted expedited ethics approval to the above named research study on the date noted above.

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Clive Seligman Ph.D.

Chair, Psychology Expedited Research Ethics Board (PREB)

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Use of Human Subjects - Ethics Approval Notice

Review Number	09 12 08	**Approval Date**	09 12 17
Principal Investigator	Natalie Allen/Sarah Ross	**End Date**	10 04 30
Protocol Title	The knowledge network project		
Sponsor	n/a		

This is to notify you that The University of Western Ontario Department of Psychology Research Ethics Board (PREB) has granted expedited ethics approval to the above named research study on the date noted above.

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Clive Seligman Ph.D.

Chair, Psychology Expedited Research Ethics Board (PREB)

The other members of the 2009-2010 PREB are: David Dozois, Bill Fisher, Riley Hinson and Steve Lupker

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Use of Human Subjects - Ethics Approval Notice

Review Number	10 09 14	**Approval Date**	10 09 17
Principal Investigator	Natalie Allen/Sarah Ross	**End Date**	11 04 30
Protocol Title	Measuring transactive memory in engineering project groups		
Sponsor	n/a		

This is to notify you that The University of Western Ontario Department of Psychology Research Ethics Board (PREB) has granted expedited ethics approval to the above named research study on the date noted above.

The PREB is a sub-REB of The University of Western Ontario's Research Ethics Board for Non-Medical Research Involving Human Subjects (NMREB) which is organized and operates according to the Tri-Council Policy Statement and the applicable laws and regulations of Ontario. (See Office of Research Ethics web site: http://www.uwo.ca/research/ethics/)

This approval shall remain valid until end date noted above assuming timely and acceptable responses to the University's periodic requests for surveillance and monitoring information.

During the course of the research, no deviations from, or changes to, the protocol or consent form may be initiated without prior written approval from the PREB except when necessary to eliminate immediate hazards to the subject or when the change(s) involve only logistical or administrative aspects of the study (e.g. change of research assistant, telephone number etc). Subjects must receive a copy of the information/consent documentation.

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b) all adverse and unexpected experiences or events that are both serious and unexpected;
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Clive Seligman Ph.D.

Chair, Psychology Expedited Research Ethics Board (PREB)

The other members of the 2009-2010 PREB are: David Dozois, Bill Fisher, Riley Hinson and Steve Lupker

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Appendix C

Expertise and Knowledge-Seeking Measures

Please respond to the following statements about yourself.

	Strongly Disagree				Strongly Agree
1. I have expertise in building and assembly.	1	2	3	4	5
2. I have expertise in CAD (computer-aided design) programs.	1	2	3	4	5
3. I have expertise in competitors' processes or products.	1	2	3	4	5
4. I have expertise in computer programming.	1	2	3	4	5
5. I have expertise in the engineering design process.	1	2	3	4	5
6. I have expertise in sketching.	1	2	3	4	5

List each group member's <u>first name and first initial of last name</u> (NOT including your own) below:

(A) ______________________________

(B) ______________________________

(C) ______________________________

(D) ______________________________

Write the name of group member (A) here: ____________________. Respond to the following statements with respect to group member A.

	Strongly Disagree				Strongly Agree
1. This group member has expertise in building and assembly.	1	2	3	4	5
2. This group member has expertise in CAD (computer-aided design) programs.	1	2	3	4	5
3. This group member has expertise in competitors' processes or products.	1	2	3	4	5
4. This group member has expertise in computer programming.	1	2	3	4	5
5. This group member has expertise in the engineering design process.	1	2	3	4	5
6. This group member has expertise in sketching.	1	2	3	4	5
7. I frequently seek information from this group member about building and assembly.	1	2	3	4	5
8. I frequently seek information from this group member about CAD (computer-aided design) programs.	1	2	3	4	5
9. I frequently seek information from this group member about competitors' processes or products.	1	2	3	4	5
10. I frequently seek information from this group member about computer programming.	1	2	3	4	5
11. I frequently seek information from this group member about the engineering design process.	1	2	3	4	5
12. I frequently seek information from this group member about sketching.	1	2	3	4	5

Please respond to the following statements about yourself.

	Strongly Disagree				Strongly Agree
1. I know a lot about building and assembly.	1	2	3	4	5
2. I know a lot about CAD (computer-aided design) programs.	1	2	3	4	5
3. I know a lot about competitors' processes or products.	1	2	3	4	5
4. I know a lot about computer programming.	1	2	3	4	5
5. I know a lot about engineering design process.	1	2	3	4	5
6. I know a lot about sketching.	1	2	3	4	5

List each group member's <u>first name and first initial of last name</u> (NOT including your own) below:

(A) ______________________________

(B) ______________________________

(C) ______________________________

(D) ______________________________

Write the name of group member (A) here: ____________________. Respond to the following statements with respect to group member A.

	Strongly Disagree				Strongly Agree
1. This group member knows a lot about building and assembly.	1	2	3	4	5
2. This group member knows a lot about CAD (computer-aided design) programs.	1	2	3	4	5
3. This group member knows a lot about competitors' processes or products.	1	2	3	4	5
4. This group member knows a lot about computer programming.	1	2	3	4	5
5. This group member knows a lot about the engineering design process.	1	2	3	4	5
6. This group member knows a lot about sketching.	1	2	3	4	5
7. I often ask this group member to answer my questions about building and assembly.	1	2	3	4	5
8. I often ask this group member to answer my questions about CAD (computer-aided design) programs.	1	2	3	4	5
9. I often ask this group member to answer my questions about competitors' processes or products.	1	2	3	4	5
10. I often ask this group member to answer my questions about computer programming.	1	2	3	4	5
11. I often ask this group member to answer my questions about the engineering design process.	1	2	3	4	5
12. I often ask this group member to answer my questions about sketching.	1	2	3	4	5

Faraj & Sproull (2000)

Reflecting on your experiences in your project team so far, please rate your team on the following items by circling the appropriate number from 1 to 5.

	Strongly Disagree		Neutral		Strongly Agree
1. Some team members do not have the necessary knowledge and skill to perform well—regardless of how hard they try.	1	2	3	4	5
2. Team members know what task-related skills and knowledge they each possess.	1	2	3	4	5
3. More knowledgeable team members freely provide other members with hard-to-find knowledge or specialized skills.	1	2	3	4	5
4. If someone in our team has some special knowledge about how to perform the team task, he or she is not likely to tell the other members about it.	1	2	3	4	5
5. Some people on our team do not have enough knowledge and skill to do their part of the team task.	1	2	3	4	5
6. Some team members lack certain specialized knowledge that is necessary to do their task.	1	2	3	4	5
7. The team has a good “map” of each others’ talents and skills.	1	2	3	4	5
8. There is virtually no exchange of information, knowledge, or sharing of skills among members.	1	2	3	4	5
9. Team members know who on the team has specialized skills and knowledge that is relevant to their work.	1	2	3	4	5
10. Team members are assigned to tasks commensurate with their task-relevant knowledge and skill.	1	2	3	4	5
11. People in our team share their special knowledge and expertise with one another.	1	2	3	4	5

Lewis (2003)

Reflecting on your experiences in your project team so far, please rate your team on the following items.

	Strongly Disagree		Neutral		Strongly Agree
1. Our team had very few misunderstandings about what to do.	1	2	3	4	5
2. I was confident relying on the information that other team members brought to the discussion.	1	2	3	4	5
3. I was comfortable accepting procedural suggestions from other team members.	1	2	3	4	5
4. Different team members are responsible for expertise in different areas.	1	2	3	4	5
5. I know which team members have expertise in specific areas.	1	2	3	4	5
6. There was much confusion about how we would accomplish the task.	1	2	3	4	5
7. I did not have much faith in other members' "expertise".	1	2	3	4	5
8. Each team member has specialized knowledge of some aspect of our project.	1	2	3	4	5
9. We accomplished the task smoothly and efficiently.	1	2	3	4	5
10. The specialized knowledge of several different team members was needed to complete the project deliverables.	1	2	3	4	5
11. When other members gave information, I wanted to double-check it for myself.	1	2	3	4	5
12. Our team needed to backtrack and start over a lot.	1	2	3	4	5
13. I trusted that other members' knowledge about the project was credible.	1	2	3	4	5
14. I have knowledge about an aspect of the project that no other team member has.	1	2	3	4	5
15. Our team worked together in a well-coordinated fashion.	1	2	3	4	5

CURRICULUM VITAE

Education

University of Western Ontario, London, ON
Ph.D. in Industrial/Organizational Psychology 2011
Thesis title: A Social Relations Analysis of Transactive Memory in Groups

University of Western Ontario, London, ON
M.A. in Psychology 2005
Thesis title: Evaluating shared mental model measures

University of Western Ontario, London, ON
B.A. Honors Psychology 2003
Thesis title: Evaluating task performance: Can individuals develop "group-like" strategies?

Awards

SSHRC Canada Graduate Scholarship—Doctoral Award	2005-2008
Ontario Graduate Scholarship	2004-2005
SSHRC Canada Graduate Scholarship—Masters Award	2003-2004
Graduate Tuition Scholarship	2003-2004
University of Western Ontario Admission Scholarship	1999-2003
Faculty of Social Science Alumni Award	2003
University of Western Ontario Scholarship in Honors Psychology	2002

Special projects

Employee Engagement 2010
Worked with a small organization to analyze and present data on employee engagement

Introduction to Industrial & Organizational Psychology 2010
Reviewed chapters for a new Canadian textbook about industrial and organizational psychology

Training Evaluation 2005
Aided in the development of training evaluation for a large international organization

Job Satisfaction 2004
Collected and analyzed data on job satisfaction for a local organization

Teaching Experience

University of Western Ontario, London, ON
Lecturer for *The Psychology of People, Work, & Organizations* 2007-Present
Prepared lectures and exams on material covering such topics as the history of psychology, research methods, job analysis, recruitment, selection, training, performance appraisal, work teams, leadership, motivation, and occupational health. Met with students to discuss the course material and conversed with students about their progress in the course.

University of Western Ontario, London, ON
Teaching Assistant for *Applications of Psychology; Research Methods & Statistical Analysis in Psychology; Research Methods in Psychology; Psychology of People, Work, and Organizations; Social Psychology; Introduction to Psychology* 2003-2005, 2007, 2009
Met with students to review exams, responded to student e-mails, proctored and scored exams. Prepared and taught weekly tutorials.

Related Experience

St. Joseph's Health Care, London, ON
Psychometrician & Research Assistant 2010
Conducted neuropsychological testing and assisted with research projects at the Cognitive Neurology and Alzheimer's Research Centre.

University of Western Ontario, London, ON
Psychology Research Assistant 2003-2006
Performed literature searches, composed ethics protocols, and collected and analyzed data.

Robarts Research Institute, London, ON
Biology Research Assistant 2001-2003
Performed literature searches, learned western blotting, cell culturing, and immunoprecipitation techniques, and developed and presenting a cell biology project.

Publications and Papers

Jesso, S., Morlog, D., **Ross, S.**, Pell, M., Pasternak, S., Mitchell, D., Kertesz, A., & Finger, E. *The Effects of Oxytocin on Social Cognition and Behaviour in Frontotemporal Dementia: A Randomized, Double-Blind, Placebo Controlled, Cross-Over Challenge Study*. Submitted to Brain.

Stanley, D.J., Allen, N. J., Williams, H., & **Ross, S.J.** Examining workgroup diversity effects: Does playing by the (group-retention) rules help or hinder? Accepted at Behavior Research Methods.

Ross, S. J., & Allen, N. J. (2010). What do we know about "who knows what"? *Public Sector Digest*, March 2010.

Allen, N. J., Stanley, D.J., Williams, H., & **Ross, S.J.** (2007). Assessing dissimilarity relations under missing data conditions: Evidence from computer simulations. *Journal of Applied Psychology, 92*, 1414-1426.

Allen, N. J., Stanley, D.J., Williams, H., & **Ross, S.J.** (2007). Assessing the impact of non response on work group diversity effects. *Organizational Research Methods, 10*, 262-286.

Kendall, S. E., Battelli, C., **Irwin, S.**, Mitchell, J. G., Glackin, C. A., Verdi, J. M. (2005). NRAGE mediates p38 activation and neural progenitor apoptosis via the bone morphogenetic protein signaling cascade. *Molecular and Cellular Biology, 25*, 7711-7724.

Ross, S. J. (2005). *Evaluating shared mental model measures.* Unpublished master's thesis, University of Western Ontario, London, Ontario, Canada.

Conference Presentations

Ross, S. J., & Allen, N. J. (2010, June). *Assessing shared mental models: Do great minds think alike?* Poster session presented at the 2010 Canadian Psychological Association Annual Convention, Winnipeg, MB.

Ross, S. J., & Allen, N. J. (2007, July). *Examining the convergent validity of shared mental model measures*. Paper presented at the Interdisciplinary Network for Group Research (INGRoup) Second Annual Conference, Lansing, MI.

O'Neill, T., Allen, N., Klammer, J., **Ross, S.**, & Lundberg, E. (2007, June). *Personality in teamwork: An empirical evaluation of Big Five factors versus facets*. Poster session presented at the 2007 Annual Convention of the Canadian Psychological Association, Ottawa, ON.

Parfyonova, N., **Ross, S. J.**, Tal, T., & Allen, N. J. (2006, June). *Capturing individual definitions of teams: Relative importance of task and outcome interdependence, communication, and complementary skill*. Poster session presented at the 2006 Annual Convention of the Canadian Psychological Association, Calgary, AB.

Ross, S. J., & Allen, N. J. (2006, May). *Evaluating shared mental model measurement.* Poster session presented at the 21st Annual Society for Industrial and Organizational Psychology Conference, Dallas, TX.

Allen, N. J., Stanley, D. J., Williams, H., & **Irwin, S.J.** (2005, April). *Assessing "dissimilarity from the group": Evidence from computer simulations*. Poster session presented at the 20th Annual Society for Industrial and Organizational Psychology Conference, Los Angeles, CA.

Irwin, S.J., & Allen N.J. (2004, June). *Performance beliefs about recall memory: Do you think you remember better in a group?* Poster session presented at the 2004 Canadian Psychological Association Annual Convention, St. John's, NL.

Memberships

Society for Industrial and Organizational Psychology
Canadian Psychological Association