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Transactive Memory in Organizational Groups: The Effects of Content, Consensus, Specialization, and Accuracy on Group Performance

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Previous research on transactive memory has found a positive relationship between transactive memory system development and group performance in single project laboratory and ad hoc groups. Closely related research on shared mental models and expertise recognition supports these findings. In this study, the author examined the relationship between transactive memory systems and performance in mature, continuing groups. A group's transactive memory system, measured as a combination of knowledge stock, knowledge specialization, transactive memory consensus, and transactive memory accuracy, is positively related to group goal performance, external group evaluations, and internal group evaluations. The positive relationship with group performance was found to hold for both task and external relationship transactive memory systems.

The widespread use of team-based structures in many of today's organizations has contributed to an increased interest about how teams can better coordinate and use their available expertise to solve unique and complex problems. Researchers have developed several theoretical frameworks of group knowledge processes in groups to help explain coordination and problem-solving dynamics within workgroups. Team mental models (Klimoski & Mohammed, 1994), information sampling models (Stasser & Titus, 1985), team learning (Edmondson, 1999), and transactive memory systems (Wegner, 1986) are some of the more active recent theoretical approaches to group knowledge. In their recent review of workgroup research, Kozlowski and Bell (2003) called for more research to disentangle the various approaches to measuring cognitive processes in groups and their effects on group performance. The present study starts to address this call by providing a detailed measurement approach designed to directly assess transactive memory systems in organizational groups and by connecting the transactive memory framework with previous research on team mental models and expertise recognition in groups.

Research on expertise recognition in decision-making groups suggests that work groups perform better when their members know who is good at what (Libby, Trotman, & Zimmer, 1987; Littlepage & Silbiger, 1992). The transactive memory framework provides an explanation for these findings. Wegner (1986) introduced the concept of transactive memory systems as a way to understand how couples coordinate to solve information problems. Wegner defined the transactive memory system as a combination of the knowledge possessed by each individual and a collective awareness of who knows what. He argued that this system provides individuals with access to a level of knowledge that no one member could hope to remember.

Transactive Memory in Workgroups

There have been a limited number of studies of transactive memory systems in workgroups. Current research relies on data from laboratory groups or newly formed groups. Hollingshead's (1998) research of retrieval processes in laboratory groups and Moreland's (1999) research on newly formed undergraduate workgroups provide compelling evidence that transactive memory systems exist in workgroups and that such systems affect group process and performance. Liang, Moreland, and Argote (1995) and Moreland, Argote, and Krishnan (1996) provided indirect evidence for transactive memory systems in workgroups. The researchers measured transactive memory by observing student groups as they assembled AM radios. The researchers looked for group dynamics that were suggestive of the existence of a transactive memory system. These dynamics included specialization of tasks, task coordination activities, and task credibility actions (evidence that group members trusted each other's expertise). These studies revealed that student groups trained as groups performed better than groups trained individually and that the relationship between training and performance was mediated by the indirect measure of transactive memory. Moreland (1999) described in a subsequent study that the indirect measures of transactive memory were highly correlated with direct measures of transactive memory. Lewis (2003) conducted the most significant field study of group transactive memory systems. In a study of 27 teams from several technology companies, she found that a 15-item self-report scale designed to measure specialization, credibility, and coordination was correlated with team and manager evaluations of team performance.

Most published transactive memory research to date has been done in groups assembled for the express purpose of studying transactive memory. These groups are generally asked to complete a single task and are disbanded when the task is complete. The connection between transactive memory and performance in ma-

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ture organizational groups has yet to be empirically tested. The present study addresses this research gap. Unlike the project groups described in previous research, continuing organizational groups face changing task demands. In an ever-changing task environment, groups need to be able to accurately identify and use a variety of expertise. However, certain group knowledge may generalize across tasks. A well-developed transactive memory system built around this generalized task knowledge may provide a group with a mechanism for identifying new task-specific knowledge. A strong transactive memory system may influence group performance in several ways. By enabling the group members to efficiently identify and use relevant knowledge, a strong transactive memory system will enable the group to generate higher quality solutions and move smoothly from task to task. This efficiency of process could also improve external perceptions of the group's competence because outsiders see the group's productivity. Group members may also form more positive opinions of their group because the accurate understanding of who knows what leads to more effective communication flows within the group.

Dimensions of Transactive Memory

Wegner's (1986) definition of transactive memory includes two parts: (a) a combination of individual knowledge and (b) interpersonal awareness of others' knowledge. The focus of recent studies on group transactive memory systems entails the second part of Wegner's definition—the interpersonal awareness of others' knowledge. Moreland (1999) identified three dimensions of interpersonal awareness of others' knowledge. These dimensions are accuracy, agreement, and complexity. Moreland described complexity in terms of specialization of expertise within the group and of the level of detail group members use when describing others' expertise. Other researchers concur that group member specialization is an important dimension of group transactive memory (Hollingshead, 1998; Lewis, 2003; Wegner, 1995). Building from these previous conceptualizations of group transactive memory, I conceptualize transactive memory as a combination of four dimensions. These dimensions are group knowledge stock (combination of individual knowledge), consensus about knowledge sources (agreement), specialization of expertise, and accuracy of knowledge identification. I describe each of these dimensions in more detail below.

Knowledge stock of a group captures the individual knowledge element of the transactive memory construct. If a group is trying to solve a problem using only knowledge available within the group, then the knowledge stock of the group is an important determinant of group success. Many laboratory studies of knowledge sharing in groups are designed to control for knowledge stock by providing the same information to each group (Stasser, Stewart, & Wittenbaum, 1995; Gruenfeld, Mannix, Williams, & Neale, 1996). In studies in which knowledge stock is not controlled, researchers often measure it by asking group members to answer questions individually to determine their expertise level (Libby, Trotman, & Zimmer, 1987; Littlepage & Silbiger, 1992; Henry, 1993).

Beginning with Wegner's original definition, consensus has been seen as an important component of transactive memory. Transactive memory consensus is the extent to which group members agree about who has what knowledge. The consensus component of transactive memory provides a link with research on team mental models. A team mental model is "an organized understanding of relevant knowledge that is shared by team members" (Mohammed & Dumville, 2001, p. 89). Transactive memory consensus is a team mental model about the distribution of knowledge within the group. The extent to which knowledge is shared—and the implications of this on team process and performance—is the central characteristic of the team mental model research. Team mental model similarity has been shown to affect team processes and performance (Mathieu, Heffner, Goodwin, Salas, & Cannon-Bowers, 2000; Stout, Cannon-Bowers, Salas, & Milanovich, 1999), although the strength and mechanism of this effect remains unclear.

Wegner (1995) proposed that knowledge specialization is greater in groups with well-developed transactive memory systems. Specialization enables a group to make better use of its individual members because each group member can build a deeper knowledge base in a narrowly defined area of expertise. Specialization may also enable transactive memory consensus and accuracy because it is easier to identify others' expertise in a group of specialists. Hollingshead's (1998, 2000) research on retrieval processes in transactive memory systems has shown that specialization can reduce repetition of effort and enable better access to a wide range of expertise.

Transactive memory accuracy involves the extent to which individuals identified by others in the group as possessing particular knowledge actually possess that knowledge. Libby et al. (1987) and Littlepage and Silbiger (1992) found that this type of group accuracy leads to better group performance on problem-solving tasks. Transactive memory accuracy is similar to Henry's (1993, 1995) concept of group judgment accuracy in which group member estimates of trivia test scores of their group mates are compared with actual test scores. In a study of newly formed student groups attempting to build AM radios, Moreland (1999) found that groups who trained together developed more accurate transactive memory systems. In addition, groups who trained together exhibited greater transactive memory consensus and specialization.

Relationships Among Transactive Memory Dimensions

Although the four dimensions of a group transactive memory system are derived from previous research, their relationships have not been empirically examined. To better understand the dynamics of these relationships, each element of the group transactive memory system is measured separately in the present study.

The three interpersonal dimensions of transactive memory grow from repeated interactions among group members and are likely to be strongly correlated with each other. Transactive memory consensus may grow as group members gain experience working with each other. Through group discussions, group members learn which other members have relevant knowledge for the task at hand. As the group works through multiple tasks together, transactive memory consensus may grow stronger as group members refine their understanding of member competencies. Knowledge specialization may also grow through repeated group interactions. If one group member demonstrates competence in a knowledge area, such as accounting, other group members may start relying on that group member to resolve problems involving accounting. As a result of this process, other group members may stop developing their own competence in accounting, leading to increased specialization within the group. Knowledge specialization and transactive memory consensus are likely to be highly correlated for two reasons. First, both are developed through repeated interpersonal interactions within the group. Second, in a group with a high degree of specialization, it is easier to identify group experts and thus it is likely that group members will more readily agree on who has relevant expertise.

The relationship between transactive memory accuracy and both consensus and specialization is more complex. Like consensus and specialization, transactive memory accuracy is developed through repeated interpersonal interactions. However, transactive memory accuracy does not require high levels of transactive memory consensus and specialization. If a group has multiple experts for relevant skills, the group members may disagree about which expert is “most expert,” leading to low transactive memory consensus. This group could still have moderate to high transactive memory accuracy if each group member is generally correct in their assessment of others’ expertise. Conversely, a group could have a high level of transactive memory consensus but overlook a group member with more expertise than the consensus group expert. In this case, high group transactive memory consensus is combined with low transactive memory accuracy. In general, transactive memory accuracy is likely to be correlated with transactive memory consensus and specialization, but this correlation may not be as strong as the correlation between transactive memory consensus and knowledge specialization.

Transactive Memory Content

The forms and use of knowledge structures are strongly driven by the knowledge content represented by those knowledge structures (Schank & Abelson, 1977; Walsh, 1995). As Walsh (1995, p. 285) stated, “one cannot investigate a knowledge structure without identifying it by the information environment it represents.” Groups can have multiple transactive memory systems dealing with separate knowledge domains. Previous transactive memory research has focused on task transactive memory, transactive memory systems made up of the skills and knowledge pertaining to the group task at hand. Because transactive memory research has focused on a single knowledge domain, it is unclear how the characteristics of transactive memory may vary based on knowledge content. Group member relationships with nongroup members are a second important group knowledge domain. For many years, social scientists have argued that awareness of social relationships influences collective dynamics (DeSoto, 1960; Krackhardt, 1987). The accuracy of an individual’s perceptions of interpersonal relationships influences, and is influenced by, interaction patterns and the individual’s power in his or her social network (Krackhardt, 1990). Group awareness of external relationships can be conceptualized as a type of transactive memory system that is separate from task transactive memory. Like task transactive memory, external relationship transactive memory may develop through repeated group member interactions. In groups characterized by frequent intragroup interaction, awareness of group member ties to nongroup members may grow as the group struggles to bring new information into the group to resolve new problems.

Transactive Memory and Group Performance

A well-developed group transactive memory system, characterized by high levels of knowledge stock, consensus, specialization, and accuracy is hypothesized to lead to increased group performance. Group performance is defined as the attainment of group goals, supervisor perceptions of group performance, and group member perceptions of group performance. In addition, the studies described in the preceding sections provide some initial evidence that each dimension of the transactive memory system will individually influence group performance. Although these dimensions are likely correlated with each other, each dimension is proposed to have a unique influence on performance. Group knowledge stock increases group performance by minimizing the group’s need to seek external assistance, transactive memory consensus increases group performance by reducing coordination miscues, knowledge specialization increases group performance by reducing knowledge search, and transactive memory accuracy increases group performance by enabling correct use of available knowledge resources.

> *Hypothesis 1a:* The greater a group’s task transactive memory system, the more successful the group will be at accomplishing its goals.

> *Hypothesis 1b:* The greater a group’s task transactive memory system, the more highly the group will be evaluated by external evaluators.

> *Hypothesis 1c:* The greater a group’s task transactive memory system, the more highly the group will be evaluated by its members.

> *Hypothesis 2:* Task knowledge stock, transactive memory consensus, knowledge specialization, and transactive memory accuracy will each explain unique variance in group performance.

Organizational groups do not exist in a knowledge vacuum, and as the groups address new tasks, they bring new knowledge into the group (Ancona, 1990; Ancona & Caldwell, 1992). Groups that are able to efficiently bring new knowledge into the group as it is needed increase their pool of available knowledge. Because individuals may act as agents of the group outside of group meetings (Eisenhardt, 1989), it is useful for each individual group member to have an accurate understanding of how to draw from external knowledge sources. Knowledge of group member relationships with nongroup members can provide this understanding. Every group member does not need to have strong external ties, but every group member would benefit from knowledge of the external ties of fellow group members.

Awareness of others’ external relationships is another type of transactive memory. Group members with close relationships to important external stakeholders provide the group with access to needed knowledge resources. Knowledge of external relationships is a form of group knowledge that can be used to attain group goals. External relationship transactive memory refers to knowledge of others’ relationships to relevant nongroup members. The effects of a strong external relationship transactive memory system on group performance would be similar to those of a strong task transactive memory system.

Hypothesis 3a: The greater a group's external relationship transactive memory system, the more successful the group will be at accomplishing its goals.

Hypothesis 3b: The greater a group's external relationship transactive memory system, the more highly the group will be evaluated by external evaluators.

Hypothesis 3c: The greater a group's external relationship transactive memory system, the more highly the group will be evaluated by its members.

Hypothesis 4: External relationship knowledge stock, transactive memory consensus, knowledge specialization, and transactive memory accuracy will each explain unique variance in group performance.

Research Site and Method

Research Site

The data for this project were collected from multiple surveys of continuing groups in a large apparel and sporting goods company. The company rapidly expanded its product offerings and as a result was competing against a variety of companies in a range of markets. In response to these concerns, executives began to reorganize the company around product lines. The first step in this direction was the creation of 27 groups oriented around product lines. Each group consisted of between 8 and 11 members (a total of 263 individuals). The groups were responsible for profit and loss of their products, determining purchasing and manufacturing levels for products, and making new product recommendations. These groups were the direct responsibility of a strategic management team made up of the functional directors who managed the departments represented in the groups. The senior management team mediated disputes between the groups and kept group plans in line with strategic objectives. The data gathered in this project were drawn from the 27 continuing groups with some initial survey design and evaluation data drawn from the senior managers. At the time of this study, the groups had been together for almost 2.5 years, and the average tenure in the groups was 1.9 years.

The data were collected with multiple surveys over a period of 5 months. The groups had participated in numerous team development exercises, and the surveys were introduced to them as a team development tool focusing on team expertise. The participants were informed that participation was voluntary and that individual responses would remain confidential. Participants were also promised group level feedback at the conclusion of the study to assist in further team development. This feedback was provided after all group performance data were collected. Surveys were completed during a team training session and before scheduled group meetings.

Measures

The four dimensions of transactive memory were calculated separately for task transactive memory and external relationship transactive memory. Appendix A outlines the process I used to calculate the measures and provides an example using a hypothetical three-person group.

I used a semistructured interview protocol to identify the skills and relationships that were relevant for work in the groups. I conducted interviews with nine group members and five organization members who frequently interacted with multiple groups. Using a free listing procedure outlined in Weller and Romney (1988), interviewees identified relevant skills and external relationships. The participants were encouraged to continue the list until they could not think of any more skills. Following Weller and Romney's procedure, I combined the responses from all of the interviews into a single list and weighted each skill by two criteria: (a) the number of respondents who identified the skill and (b) the listing position of the skill. Responses named earlier were given a higher weight. The free listing procedure generated a list of 11 skills and knowledge areas and 10 stakeholder relationships that interviewees identified as relevant to the groups. The interview questions and responses are listed in Appendix B. In addition, interviewees described recent problems the groups had encountered. These problem descriptions formed the basis for a set of problem scenarios used in a subsequent scenario assessment survey.

The expertise identification survey was administered 1 month after the preliminary interviews. The survey was administered to all group members during a daylong on-site training meeting. The response rate for that day was 95% ($n = 251$). I was able to follow up shortly thereafter with the 12 group members who were absent from the meeting and obtain a 100% response rate for this survey ($n = 263$).

The primary components of the survey were two sets of questions that requested information about perceptions of group member skills and external relationships. The group members were given a list of the 11 skills identified in the preliminary interviews and were asked to identify members of their group whom they felt had the most expertise in that particular skill or knowledge area. Respondents could select more than one expert. In the next part of the survey, the group members were asked to identify group members whom they felt had the closest work relationships with each of the 10 stakeholders identified in the preliminary interviews. Each group member was also asked to rate their own skills and relationships.

Group task knowledge stock. Appendix A includes details for calculating this measure. Group task knowledge stock was measured by first averaging each group member's self-evaluations of their expertise in the 11 group skills, generating an individual score with a range from 1 to 5. These individual scores were then aggregated into a group score. The group knowledge stock measure is a measure of resources available within the group. It is essentially an inventory of individual group member knowledge and as such aggregation is appropriate. Group task knowledge stock is the sum of the individual group member knowledge scores. Using aggregation to obtain a group score makes this measure sensitive to group size, reflecting the larger potential skill set available within a larger group. The self-report measure is consistent with Gollwitzer and Kinney's (1989) finding that although individuals often overestimate their abilities when performing tasks, individuals are able to realistically assess their level of skill when faced with decision tasks not requiring action. This measure has a possible range from 9 to 55 and the actual range was from 22 to 50.

To test the validity of the self-report measure of group knowledge stock, I calculated a second measure based on group member responses to problem scenarios. One month after completing the group expertise survey, group members were asked to complete a problem solving survey. The problem solving survey consisted of six scenarios describing problems that group members were likely to encounter on their job involving different combinations of the 11 group skills.[1] Individually, group members were asked to describe what they would do to resolve each of the six problems. A set of senior managers familiar with the work of the groups evaluated the quality of the responses to this questionnaire and assigned scores to the responses. Each group member received a problem-solving quality score. As with the self-report measure, these scores ranged from 1 to 5 and were aggregated to the group level. Further details for calculating this measure are included in Appendix A. Because the scenarios were designed to reflect the 11 identified group skills, a high correlation between group member self-report evaluations and scenario problem-solving evaluations demon-

[1] Copies of the six scenarios are available from John R. Austin on request.

strates convergent validity of the self-report measure. The correlation was .87.[2]

Group external relationship knowledge stock. Group external relationship knowledge stock was measured by aggregating group member self-evaluations of the strength of their relationships with the 10 identified group stakeholders. This measure has a possible range from 9 to 55 and the actual range was from 15 to 49.

Task transactive memory consensus. Appendix A includes details for calculating this measure. Task transactive memory consensus was calculated by measuring group consensus on who was the group expert for each of the 11 task skills. Groups whose members identified the same individual as an expert on a given skill have high task transactive memory consensus. Each group member's choice of expert for each skill was recorded. Standard deviation scores were calculated to measure group member consensus of expert identification for each skill. These 11 skill consensus scores were combined to create a single mean task transactive memory consensus for the group. A lower standard deviation score indicates greater group consensus. Transactive memory consensus is a dispersion variable (Chan, 1998) that is appropriately measured using standard deviation scores. Because some of the group scores fell outside of the accepted r_{wg} range of 0 to 1.0, the standard deviation provides a more appropriate dispersion measure for this data (Klein, Conn, Smith, & Sorra, 2001). The group standard deviation measure was reversed using a $1 - x$ transformation so that a high score would represent high transactive memory consensus. The scores ranged from .02 to .79. The internal reliability coefficient was .84, demonstrating that task transactive memory consensus tended to be consistent across skills.

External relationship transactive memory consensus. External relationship transactive memory consensus measured group agreement about which group member had the closest relationship with each of the ten external stakeholders. The group standard deviation measure was reversed using a $1 - x$ transformation so that a high score would represent high transactive memory consensus. The scores ranged from .11 to .76. The internal reliability coefficient was .80.

Task knowledge specialization. Appendix A includes details for calculating this measure. Task knowledge specialization was measured by comparing identified experts across the 11 task skills. Groups in which members tended to identify different individuals as experts for different skills had high levels of task specialization. For each individual group member, I calculated a standard deviation measure based on the number of times the member was identified as an expert by fellow group members across the 11 task skills. If task knowledge were specialized within a group, then individual group members would have high scores on some skills and low scores on other skills, leading to high standard deviation scores. For each group, the individual specialization scores were averaged to generate a group specialization score. The scores ranged from 1.56 to 2.58.

External relationship specialization. External relationship specialization was calculated using the same procedure as was used to calculate task specialization using the 10 group stakeholder relationships. The scores ranged from 1.80 to 2.70.

Task transactive memory accuracy. Appendix A includes details for calculating this measure. Task transactive memory accuracy was measured by connecting self and other reports of expertise. Accuracy was determined by matching group member identification of experts with self-report ratings of expertise. If the identified experts concurred with the group members—rated themselves as experts—then group transactive memory accuracy is high.

The task transactive memory accuracy measure was calculated by first calculating separate measures of perceived expertise accuracy for each group member. In addition to identifying experts in the 11 knowledge areas, each respondent provided a self-evaluation of his or her own expertise in those knowledge areas. Perceived expertise accuracy was determined by matching group member identification of expertise with self-report ratings of member expertise. For example, if Jim identified Mary as an expert in financial planning, and Mary evaluated her financial planning expertise as 4 (on a 5-point scale), then Jim's score of perceived expertise accuracy for financial planning is 4 (Mary's self-evaluation). This procedure was done for each of the 11 skills. For each group member, the scores were combined into a single mean score of awareness of interpersonal knowledge resources. The reliability score for this individual level measure was strong, with a Cronbach's alpha of .83. This reliability score indicates that individuals tended to have relatively consistent perceived accuracy scores across the 11 measured knowledge areas. These individual-level perceived expertise accuracy scores were averaged to the group level to create the group transactive memory accuracy score. This measure has a possible range from 1 to 5 and the actual range was from 2.78 to 4.69.

A second measure of transactive memory accuracy was calculated to test the validity of the self-report measure of accuracy. The second measure of transactive memory accuracy drew from responses to the problem-solving scenarios given by the identified experts. If the identified experts had high problem-solving scores on the scenarios that drew from that expertise, then group transactive memory accuracy is high. This measure has the advantage of linking transactive memory accuracy with specific problems. This measure has a possible range from 1 to 5 and the actual range was from 2.34 to 5.00.

The correlation between the self-report and the scenario measures of transactive memory accuracy was .82 ($p < .05$). The high correlation demonstrates convergent validity and supports the use of either measure of transactive memory accuracy. In addition, both measures had high intraclass correlations (.80 and .76, respectively), supporting their use as group level measures (Myers, DiCecco, & Lorch, 1981). The self-report measure was selected for this study because it is consistent with past research on self-report of ability and is easier to replicate for future studies of transactive memory.[3]

External relationship transactive memory accuracy. External relationship transactive memory accuracy was calculated using the same procedure as was used to calculate task transactive memory accuracy using the 10 group stakeholder relationships. The scores ranged from 3.35 to 4.97.

Dependent Variables

Group goal attainment. The group goal attainment measure was obtained 2 months after the completion of the study. Every year, an evaluation team assesses the groups on their ability to attain the financial and development goals set for them 1 year earlier. Three managers completed these evaluations with the assistance of an internal team development specialist. This group worked together to calculate all group performance scores. Groups were assigned a score from 1 to 10 based on the percentage of group goals met during the previous year. A score of 1 means the group met 10% of its goals, 10 means the groups met 100% of goals, and so forth. Actual group scores ranged from 4.44 to 9.45.

External group evaluation. Members of the strategic management team evaluated each group based on the groups' success at fulfilling the company objectives set forth during the creation of the merchandising groups. These goals were to (a) increase company responsiveness to changing market demands for their products and (b) improve cross-functional communication in the merchandising process. The managers assigned each group a score from 1 (*poor*) to 5 (*excellent*). Group scores ranged from 2.2 to 5.0, and the interrater reliability coefficient was .78.

Internal group evaluation. Group members evaluated their group's performance using the same goals used for the external group evaluation. Group scores ranged from 3.0 to 4.6, and the interrater reliability coefficient was .80.

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[2] Using the scenario-based measure does not significantly change the results of the study. The scenario-based measures are included in Table 1.

[3] Copies of the six scenarios are available from John R. Austin on request.

Control Variables

Group size. The groups ranged in size from 8 to 11 members. Group size can influence transactive memory by affecting communications within the group and by changing the amount of information needed to maintain a high level of group expertise (Wittenbaum, Vaughan, & Stasser, 1998); larger groups require each group member to remember information about more people.

Results

Table 1 reports the means, standard deviations and bivariate correlations for all the variables. The content of the transactive memory being measured does appear to play a role in the relationships among the dimensions. As expected, the four dimensions of the external relationship transactive memory system are significantly correlated with each other. The four dimensions of the task transactive memory system are not highly correlated. Task transactive memory consensus and task knowledge specialization are strongly correlated, but other task transactive memory correlations are insignificant or marginally significant. However, the significant correlations between some of the task and external relationship transactive memory dimensions do support the idea that transactive memory systems partially generalize across content areas. In particular, transactive memory consensus and specialization in the groups is consistent across the task and external relationship measures.

Goal attainment is highly correlated with external evaluation but not with internal evaluation. Internal and external group evaluations are not significantly correlated and appear to capture different aspects of group performance. With the exception of task knowledge stock and external relationship knowledge specialization, each individual dimension of the task and external relationship transactive memory systems is significantly correlated ($p <$ .05) with goal attainment. External relationship knowledge specialization is correlated with goal attainment at the .10 level of significance. These significant bivariate correlations are consistent with the results of previous research studies that found evidence that transactive memory was related to group performance in laboratory groups. All of the external relationship transactive memory dimensions are also significantly correlated with internal evaluation. Of the task transactive memory dimensions, only transactive memory accuracy is significantly related to internal evaluations.

Multiple regression analysis was used to test the hypotheses. Tables 2 and 3 report the results of the regression analysis for each of the three group performance measures. Table 2 shows the results for task transactive memory. The relationship between task transactive memory, as captured in the full model, and all three group performance measures is positive and significant. Thus Hypotheses 1a, 1b, and 1c are all supported. The results for the individual dimensions of transactive memory are less clear and do not support Hypothesis 2. Task transactive memory accuracy is significantly related to all three group performance measures. Task knowledge specialization is significantly related to external and internal evaluations. Task knowledge stock is significantly related to internal evaluation at the .10 level. However, the task knowledge stock–group performance relationship is opposite of the expected direction.

Table 1
Means, Standard Deviations, and Correlations

Variable	*M*	*SD*	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1. Goal attainment	7.19	1.54														
2. Ext evaluation	3.57	0.81	.82***													
3. Internal evaluation	3.78	0.51	.35*	.26												
4. Task knowledge stock (self-report)	36.00	8.58	.24	.22	−.09											
5. Task knowledge stock (scenario)	34.20	7.22	.39**	.38*	.12	.87***										
6. Task TM consensus	0.53	0.22	.52***	.30	.15	.08	.03									
7. Task knowledge specialization	2.10	0.30	.39**	.43**	.30	.17	.10	.65***								
8. Task TM accuracy (self-report)	3.80	0.57	.69***	.60***	.43**	.38*	.33	.34*	.18							
9. Task TM accuracy (scenario)	3.56	0.97	.72***	.69***	.24	.29	.47**	.39**	.33	.82***						
10. Ext relationship knowledge stock	27.36	9.06	.53***	.45**	.40**	−.15	−.16	.39**	.35*	.29	.37*					
11. Ext relationship TM consensus	0.42	0.15	.43**	.38*	.48**	−.09	−.09	.60***	.65***	.27	.33	.67***				
12. Ext rel knowledge specialization	2.25	0.25	.38*	.39**	.40**	.25	.34**	.28	.70***	.38**	.35*	.23	.57***			
13. Ext relationship TM accuracy	4.13	0.50	.58***	.56***	.56***	.01	.19	.25	.40**	.49**	.49**	.62***	.63***	.49**		
14. Group size	9.78	0.51	.25	.19	.20	−.01	.15	−.15	−.13	.33	.34	.32	−.11	.03	.08	

Note. N = 27. TM = transactive memory; Ext = external; rel = relationship.
* $p <$ .10. ** $p <$ .05. *** $p <$ .01.

Table 2
Regression Results for Task Transactive Memory and Group Performance

Variable	Goal attainment	External evaluation	Internal evaluation
Group size	.14	.01	.01
Task knowledge stock	−.01	−.08	−.37*
Task transactive memory consensus	.27	.23	.35
Task knowledge specialization	.14	.49**	.48**
Task transactive memory accuracy	.53***	.63***	.61***
F	6.02***	4.28***	2.71**
R^2	.59	.51	.40
Adjusted R^2	.49	.39	.25
N	27	27	27

Note. Standardized regression coefficients are reported.
* $p < .10$. ** $p < .05$. *** $p < .01$.

Table 3 shows the results for external relationship transactive memory. The relationship between external relationship transactive memory, as captured in the full model, and group goal attainment and internal evaluation is positive and significant at the .05 level, and for external evaluation it is significant at the .10 level. Thus, the data provide support for Hypotheses 3a and 3c and marginally support Hypothesis 3b. The results for the individual dimensions of external relationship transactive memory suggest a balanced contribution to the full model and do not provide support for Hypothesis 4. With the exception of a marginally significant relationship between transactive memory accuracy and internal evaluation, none of the individual external relationship transactive memory dimensions demonstrate a significant relationship with the group performance measures.

I conducted several post-hoc analyses to clarify how the transactive memory dimensions interact to influence the three performance measures. The results indicate that interactions among the transactive memory dimensions are sensitive to selection of performance measure and content of transactive memory. After centering the main effect variables (Aiken & West, 1991), I added interaction terms to the regression equations. Because of the small sample size, I ran separate analyses for the different interaction terms. The effect of task transactive memory accuracy remained a significant predictor for all three measures of group performance after the addition of all interaction terms. None of the task transactive memory interaction terms were significant predictors of goal attainment. Task Knowledge Specialization × Task Transactive Memory Accuracy was a significant predictor of external evaluation and internal evaluation ($p < .05$, external evaluation $\Delta\text{Adj}R^2 = .08$, internal evaluation $\Delta\text{Adj}R^2 = .05$). This result suggests a synergistic interaction between task knowledge specialization and task transactive memory accuracy.

The post-hoc analysis of the external relationship transactive memory dimensions revealed a different pattern. The three-way interaction term for external relationship knowledge stock, external relationship knowledge specialization, and external relationship transactive memory accuracy was a significant predictor of goal attainment and external evaluation. The addition of this interaction term to the regression equations led to a significant change in R^2 (goal attainment $\Delta\text{Adj}R^2 = .13$, external evaluation $\Delta\text{Adj}R^2 = .09$). The External Relationship Transactive Memory Consensus × External Relationship Transactive Memory Accuracy term was a significant predictor of internal evaluation ($\Delta\text{Adj}R^2 = .04$), indicating a synergistic interaction between external relationship transactive memory consensus and accuracy as predictors of internal evaluation.

Discussion

Task and external relationship transactive memory systems are positively related to all three measures of group performance.

Table 3
Regression Results for External Relationship Transactive Memory and Group Performance

Variable	Goal attainment	External evaluation	Internal evaluation
Group size	.12	.06	.26
Ext relationship knowledge stock	.28	.23	−.19
Ext relationship transactive memory consensus	.06	.15	.37
Ext relationship knowledge specialization	.17	.23	.02
Ext relationship transactive memory accuracy	.35	.40	.42*
F	3.07**	2.46*	2.74**
R^2	.42	.37	.40
Adjusted R^2	.29	.22	.25
N	27	27	27

Note. Standardized regression coefficients are reported. Ext = External.
* $p < .10$. ** $p < .05$.

These results expand current understanding of transactive memory by combining four separate dimensions of transactive memory systems in a single study and by demonstrating a positive effect on performance in continuing organizational groups. Of the four dimensions, transactive memory accuracy is shown to be the most significant predictor of group performance. The dynamics of how the other dimensions influence the transactive memory accuracy–group performance relationship are sensitive to the content of the transactive memory being measured. Knowledge specialization plays a more significant role in predicting group performance when measuring the task transactive memory system, whereas transactive memory consensus plays a stronger role when measuring the external relationship transactive memory system.

The present study makes three significant contributions to current research on organizational groups. First, this research provides empirical evidence for a link between two separate types of transactive memory systems (task and external relationship) and group performance. Second, this study clarifies how the different dimensions of the transactive memory system construct interact to influence group performance. Third, this study validates the use of self-report measures of transactive memory accuracy in continuing organizational groups.

Previous studies have shown the positive relationship between transactive memory systems and group performance (Moreland, 1999; Moreland & Myaskovsky, 2000; Lewis, 2003). The present study extends our understanding of the performance effects of transactive memory in several important ways. Previous research linking transactive memory with group performance has focused on indirect measures of transactive memory systems such as group member perceptions of knowledge specialization, credibility, and coordination (Lewis, 2003) or observations of group behaviors that indicate higher levels of specialization, credibility, and coordination (Moreland, 1999). The measures presented in this study offer a more direct approach to measuring transactive memory systems by capturing patterns of group member mental models of expertise. Future research should clarify the relationship between the direct and indirect measures of transactive memory systems. The procedures outlined in this article, in combination with Lewis (2003) validated measures, provide the tools for such a project. The direct approach outlined in this article offers a clear link between transactive memory research and recent field research on team mental models (Cannon-Bowers & Salas, 1998; Rentsch & Klimoski, 2001). Further linkages between transactive memory and team mental model research are possible through the combination of transactive memory theory and network analysis in group settings.

External relationship transactive memory exhibits the same positive relationship with group performance as does task transactive memory. This finding may indicate that the group processes that contribute to the development of transactive memory systems are generalizable across knowledge domains. If transactive memory development is not limited to knowledge of current skills (task) but also involves the awareness of where to go to access new skills (external relationship), then transactive memory may play an important role in enabling group learning and improving performance on unique tasks. In addition, evidence that the transactive memory system's influence on group performance is not limited to the task transactive memory system supports the use of generalized survey measures of transactive memory systems, such as Lewis's (2003) Transactive Memory Scale. However, comparisons between the task and external relationship results indicate that the individual dimensions of the transactive memory systems do not demonstrate consistent patterns of influence on group performance. Content specific measures of transactive memory, such as those used in this study, can shed further light on the differential effects of transactive memory dimensions on group performance. In future studies, researchers should take care to specify the content of transactive memory measured and to justify their decisions to use generalized or content specific measures of transactive memory.

Recent reviews of organizational group research have highlighted the link between transactive memory and other research streams, such as shared mental models and expertise recognition as an area that could benefit from further research (Kozlowski & Bell, 2003; Mohammed & Dumville, 2001). By developing separate measures for the four dimensions of transactive memory, the present study provides some data on this link. Shared mental models of group member knowledge (transactive memory consensus) and group expertise recognition (transactive memory accuracy) are correlated with each other and together partially explain the significant relationship between transactive memory and group performance.

The bivariate correlations reveal other interesting patterns. The knowledge specialization that previous researchers have theoretically linked with more developed transactive memory systems (Hollingshead, 1998; Lewis, 2003; Wegner, 1995) appears to be more tied to transactive memory consensus than with transactive memory accuracy. The causal link between consensus and specialization is unclear and could be examined in future research. Task transactive memory consensus is also strongly correlated with external relationship transactive memory consensus. This finding supports the notion that shared mental models of expertise may generalize across content domains. Further research could examine this relationship. Task and external relationship transactive memory accuracy exhibit similar characteristics. The high correlations may suggest that similar group processes are involved in generating consensus and accuracy around the identification of task and external relationship expertise.

By offering multiple measures of group performance, this study provides fairly robust support for the hypothesis that well-developed transactive memory systems positively affect group performance. The selection of performance measures is an important consideration in group research. In a study of software development teams, Faraj and Sproull (2000) found that expertise coordination within teams affected some performance measures but not others. The present study finds that task transactive memory has a greater effect on goal attainment and external evaluation than on internal evaluation. External relationship transactive memory appears to have a relatively consistent influence on all three measures of group performance. The bivariate correlations reveal a similar pattern for the individual transactive memory dimensions. In the analysis of all three performance measures and for both types of transactive memory, the accuracy dimension has the strongest influence on group performance. The analysis of interaction terms reinforces this result. Choice of performance measure determines which of the other transactive memory dimensions exhibits synergistic interactions with accuracy but does not change the conclusion that, of the four transactive memory dimensions, transactive memory accuracy has the strongest effect on group performance.

The scenario-based measure of transactive memory accuracy provides convergent validity for self-report measures of transactive memory accuracy in continuing teams. Self-report accuracy may be the result of the multitask demands and high level of team autonomy characteristic of continuing self-managed teams. Henry (1995) found that groups are good at identifying their most accurate member after task-oriented group discussions. Such discussions were common in the groups studied. In addition, the group members had an average group tenure of 1.9 years. The groups had completed numerous budgetary cycles and new product launches over the span of 2 years and group members had ample opportunities to assess their personal strengths and weaknesses. Self-report measures may be most appropriate for situations when individuals have had the opportunity to repeatedly assess their skills. This study indicates that self-report measures of transactive memory can be appropriately used in the context of continuing cross-functional groups.

Although the present study provides useful information about the role of transactive memory systems in organizational groups, it is based on a small number of groups in a single organization. Because transactive memory is so closely tied to the context, groups need to be found that are facing similar issues. At the same time it is essential that the data set exhibit enough between group variance so that group level relationships can be examined. Conducting research on groups within a single organization addresses the first issue (context similarity) but may limit the variance between groups. Furthermore, the groups in this study were self-managed teams in which leadership was negotiated within the group. In groups with defined leaders who act as gatekeepers, the importance of member external relationships may be diminished and play a lesser role in group performance.

The surveys used in this study may have acted as a process intervention in the groups and influenced group performance. However, all groups followed a similar protocol in completing the surveys in order to reduce bias. None of the groups were provided any process discussion of the results until after the performance evaluations. The measure of group goal attainment was determined from an annual group evaluation process completed 5 months after the completion of the expertise survey. The group goals that made up the content of the performance evaluation had been determined before the start of the study. The performance evaluation was administered by a different set of people not part of the initial survey administration. External evaluations were obtained after the completion of the study but before the goal attainment scores. Internal evaluations were obtained at the start of the study as part of the expertise survey. The long time lag between internal evaluation and the other two performance measures (3 and 5 months) may partially explain the low correlation between these measures. The time lag between goal identification, expertise surveys, and performance assessment minimized the potential intervention effect.

This study provides strong evidence of the role of transactive memory as a driver of performance in continuing groups. The surveys used in this study provide a rich source of data to guide future research. The use of time-ordered, multiple surveys, and separate measures of group performance address some of the concerns about single source bias inherent in survey research. The correlated self-report and scenario measures of transactive memory accuracy and group knowledge stock further validate the conclusions of this study.

The research described in this article provides evidence that accurate transactive memory is important for the effective functioning of continuing organizational groups. Generating group capabilities involves more than simply assembling a group of individuals with a wide range of specialized knowledge. Although this knowledge base may establish a strong foundation for a successful group, actual group performance depends upon how well the individual members are able to tap into the assembled knowledge base and how well the individual members are able to reconfigure this knowledge base in new situations. Transactive memory, a group's awareness of the location of knowledge resources distributed throughout the group, provides a promising approach for future study of knowledge and expertise in groups.

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(*Appendixes follow*)

Appendix A

Calculations and Examples of Measures for Three-Person Team

1. Group Task Knowledge Stock (Self-Report)

Self-report survey question:

For each skill/area of knowledge, please record the number that corresponds with your evaluation of your ability in that skill/area of knowledge.

1	2	3	4	5
Very Low	Low	Average	High	Very High

Step 1: Skill self-report scores are averaged to create a single individual skill score.

Step 2: Individual skill scores are aggregated to create a group task knowledge stock score.

Table A1
Skill Self-Report Scores

	Skill				
	1	2	3	4	*M*
Person A	4	5	5	3	4.25
Person B	5	2	4	4	3.75
Person C	3	3	2	3	2.75

Group task knowledge stock = 4.25 + 3.75 + 2.75 = 10.75.

2. Group Task Knowledge Stock (Scenario)

Scenario Survey Question:

Many of the problems that cross-functional teams deal with originally surface as problems that individual team members encounter. For each of the problems below, please respond to the questions as if *you were the first member of your team to be made aware of the problem.*

[Scenario Description]

List the steps you would take to resolve this problem.

Step 1: The quality of individual scenario responses are assessed by senior managers.

Scenario Response Quality Assessment Question (completed by senior managers):

As part of a team development project, each member of the merchandising teams was asked to respond to six scenarios. Their responses to one scenario are listed below. Please evaluate the effectiveness of the response using the scale to the left of the response. Some of these responses have been modified to maintain the anonymity of the team member.

[Scenario Description]

1	2	3	4	5
Poor	Below Average	Acceptable	Above Average	Excellent

Step 2: Scenario response quality scores are averaged to create a single individual response quality score.

Step 3: Individual response quality scores are aggregated to create a group task knowledge stock score.

Table A2
Scenario Response Quality Scores

	Scenario				
	1	2	3	4	*M*
Person A	4	5	4	5	4.50
Person B	3	4	3	4	3.50
Person C	3	2	2	3	2.50

Group task knowledge stock = 4.50 + 3.50 + 2.50 = 10.50.

3. Transactive Memory Consensus

Transactive Memory Survey Question:

For each skill or area of knowledge listed below, write the name of the team member(s) that you believe is most knowledgeable in that particular skill or area.

Table A3a
Identified Experts

	Skill			
	1	2	3	4
Person A	Person B	Person C	Person A	Person A
Person B	Person B	Person A	Person A	Person C
Person C	Person B	Person A	Person A	Person B

Step 1: For each skill, responses are recorded by assigning a number for each unique identified expert (Table 3b). The most frequently identified expert for that skill is coded as 1, the next most frequently identified expert is coded as 2, and so forth. Note that this coding strategy transforms the categorical variable into an ordinal variable.

Step 2: A standard deviation score is calculated for each skill, indicating group consensus on identification of group experts for that skill.

Step 3: Skill consensus scores (standard deviation measures) are averaged to create a single group consensus score.

Step 4: The group consensus score is transformed using a $1 - x$ transformation; thus, a higher score indicates greater group consensus.

Table A3b
Skill Expertise Ranking Scores

	Skill			
	1	2	3	4
Person A	1	2	1	1
Person B	1	1	1	2
Person C	1	1	1	3
SD	0.00	.58	0.00	1.00

Group consensus score = (0 + .58 + 0 + 1)/4 = .395.

Transactive memory consensus = 1 − .395 = .605.

4. Task Knowledge Specialization

Step 1: Start with the information in Table 3a. For each skill, the number of times each person is identified as an expert is counted (Table 4).

Step 2: A standard deviation score of counts across skills is calculated for each individual.

Step 3: Individual specialization scores (standard deviation scores) are averaged to create a group specialization score.

Table A4
Expert Identification Count

	Skill				
	1	2	3	4	*SD*
Person A	0	2	3	1	1.29
Person B	3	0	0	1	1.41
Person C	0	1	0	1	0.58

Group task knowledge specialization = (1.29 + 1.41 + 0.58)/3 = 1.093.

5. Transactive Memory Accuracy (Self-Report)

Step 1: Self-report expertise scores (Table 1) are linked with identified expert scores (Table 3a) to create accuracy of identified experts scores for each individual and skill. See Table 5 and explanation below.

Step 2: For each individual, skill accuracy scores (Table 5) are averaged to create a single individual expertise accuracy score.

Step 3: The individual expertise accuracy scores are averaged to create a group transactive memory accuracy score.

Table A5
Accuracy of Identified Experts

	Skill				
	1	2	3	4	*M*
Person A	5	3	5	3	4.00
Person B	5	5	5	3	4.50
Person C	5	5	5	4	4.75

Person A identified Person B as expert at Skill 1 (Table 3a). Person B rated his own expertise at Skill 1 as a 5 (Table 1). Person A's accuracy score for Skill 1 is 5 (Person B's self-rated expertise for Skill 1; Table 5).

Transactive memory accuracy = (4.00 + 4.50 + 4.75)/3 = 4.42.

6. Transactive Memory Accuracy (Scenario)

Scenario Weighting Survey Question (completed by senior managers): [Scenario Description]

Please classify the relevance of the following skills/areas of knowledge to the effective handling of this scenario.

0	1	2	3	4
Not Important	Slightly Useful	Useful	Somewhat Important	Essential

Table A6a
Scenario-Skill Weights

	Skill			
	1	2	3	4
Scenario 1	.7	.2	.3	0
Scenario 2	0	.6	0	0
Scenario 3	.3	0	0	.9
Scenario 4	0	.2	.7	.1

Step 1: Weighted scenario response scores (see Tables 2 & 6a) are linked with identified expert scores (Table 3a) to create accuracy of identified experts scores for each individual and skill (Table 6b). See table and explanation below.

Step 2: For each individual, skill accuracy scores are averaged to create a single individual expertise accuracy score.

Step 3: The individual expertise accuracy scores are averaged to create a group transactive memory accuracy score.

Table A6b
Accuracy of Identified Experts

	Skill				
	1	2	3	4	*M*
Person A	3.0	2.4	4.7	4.1	3.55
Person B	3.0	4.8	4.7	2.1	3.65
Person C	3.0	4.8	4.7	3.1	3.90

Person A identified Person B as expert at Skill 1 (Table 3a). Person B's scenario response quality scores (Table 2) for Scenarios 1 and 3 are used to calculate their expertise for Skill 1. Scenarios 1 and 3 are used because these two scenarios were identified as requiring expertise in Skill 1 (Table 6a). Person A's accuracy score for Skill 1 is 3 (Person B's weighted scenario quality scores for Scenarios 1 and 3; [.7 × 3] + [.3 × 3] = 3).

Transactive memory accuracy = (3.55 + 3.65 + 3.90)/3 = 3.70

(*Appendixes continue*)

Appendix B

Skills/Knowledge Areas and Relationships Identified in Preliminary Interviews

Skills/knowledge areas	Relationships
1. Knowledge of the competitor's products	1. Suppliers
2. Budgeting and financial planning	2. Strategic process management team
3. Knowledge of company's product history	3. Senior vice president of merchandising
4. Scheduling across functions	4. Creative department
5. Knowledge of the supplier's production process	5. Call center director
6. Product testing	6. Training and development department
7. Crisis management	7. Budget director
8. Written communication	8. Public relations department
9. Creative/layout	9. Lakeland distribution center
10. Team coordination	10. Retailer support department
11. Product process training	

Relevant interview questions:

1. Tell me what makes a merchandising team successful? In other words, what kinds of skills are necessary for a team to fulfill its objectives?

   Prompts for clarification of "skill": competencies, expertise, abilities, proficiencies, capabilities

2. Who do you think are the groups and individuals—that are not a part of the team—that are essential to a merchandising team's success?

   Prompt for each one: Why are they essential?

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