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Transactive Memory Systems: Current Issues and Future Research Directions

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Transactive memory system (TMS) theory has been popularized in recent research on groups and other collectives. In this essay we outline current issues in TMS research and develop propositions that can be tested in future research. We describe issues concerning how researchers define and conceptualize TMSs, interpret the relationship between TMS measures and the TMS concept, and attend to the role of task type in TMS research. The potential to advance TMS research by incorporating multilevel and social network perspectives, reconsidering the role of information technology in supporting TMSs, and developing frameworks suited to complex, multiactivity tasks is considered.

Key words: transactive memory; group cognition; tasks
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Introduction

Research on transactive memory systems provides compelling evidence that group cognition influences collective performance. A transactive memory system (TMS) is the shared division of cognitive labor with respect to the encoding, storage, retrieval, and communication of information from different domains that often develops in close relationships (Hollingshead 2001, p. 1080). Although initially conceptualized as a theory to explain the implicit division of cognitive labor that develops in intimate couples (Wegner 1986, Wegner et al. 1985), TMS theory and research has expanded to explain the cognitive processes in groups, the factors that affect those processes, and the group performance outcomes that result. TMS has been studied in a wide variety of groups and teams, including laboratory groups (e.g., Liang et al. 1995), product development teams (Akgün et al. 2005), global sales teams (Yuan et al. 2010a), air traffic control teams (Smith-Jentsch et al. 2009), top management teams (Rau 2005), consulting teams (Lewis 2004), daycare groups (Peltokorpi and Manka 2008), anesthesia teams (Michinov et al. 2008), software development teams (Faraj and Sproull 2000), and emergency response teams (Majchrzak et al. 2007). TMSs are thought to improve performance in workgroups because they facilitate quick and coordinated access to specialized expertise, ensuring that a greater amount of high-quality and task-relevant knowledge is brought to bear on collective tasks.

The published research on TMS has grown appreciably in the last five years.[1] With increased interest in applying TMS theory in new ways and in new settings, however, comes increased variety in how researchers conceptualize TMSs, design TMS research, and interpret TMS findings. Through our experiences studying TMSs and reviewing and editing TMS research, we identified three key issues in TMS research that arise from this increased variety: (1) discrepancies in the definition of a TMS, (2) misinterpretation of TMS measures as indicative of the composition of a TMS, and (3) inattention to the ways that different task types might affect the applicability or relevance of TMSs. In raising these issues, our aim is not to criticize but rather to learn from this variety where additional clarity is needed and to establish common ground on which researchers can build. We develop propositions that can be tested in future research and discuss possible solutions for addressing current research issues with the hope of stimulating new thinking about the ways that TMS theory can be advanced.

TMS Research: A Brief Review

In the Liang et al. (1995) study of TMSs in laboratory groups performing an electronics assembly task, groups whose members were trained together were better able to collectively remember and apply task knowledge, coordinate members' actions, and perform at higher levels than were teams whose members were trained individually. The positive effects of group training were attributed to the development of a TMS. Since that seminal study, laboratory and field research has consistently shown a positive relationship between TMSs and workgroup performance (e.g., Austin 2003; Kanawattanachai and Yoo 2007; Lewis 2003, 2004; Moreland et al. 1996, 1998; Zhang et al. 2007). TMSs have also been linked to other group outcomes, including learning (Akgün et al. 2005, Lewis et al. 2005) and creativity (Gino et al. 2010).

Other research has emphasized antecedents to TMS development in dyads and workgroups. Hollingshead (2001) found that task incentives to remember different rather than similar information influenced whether dyads divided the responsibilities for learning, remembering, and communicating different aspects of the task; Hollingshead and Fraidin (2003) found that individuals used gender stereotypes to infer the relative knowledge of their partners, which then affected the division of responsibilities in a dyad's TMS. Laboratory research on groups performing a command-and-control task has shown that certain environmental stressors enhance (challenge stressors) or inhibit (hindrance stressors) TMS development (Pearsall et al. 2009), that the assertiveness of a team's critical member is positively related to a group's TMS (Pearsall and Ellis 2006), and that role identification behaviors (requesting information about other members' roles and responsibilities, and providing information about one's own roles and responsibilities to other members) are related to TMS development (Pearsall et al. 2010). Prichard and Ashleigh (2007) found that teams that had received team-skills training in problem solving, interpersonal relationships, goal setting, and role allocation were more likely to develop a TMS than were nontrained teams, suggesting that team-skills training might facilitate TMS development.

Findings from field research investigating the antecedents of a TMS show that team member familiarity (Akgün et al. 2005, Lewis 2004) and communication volume and frequency (Jackson and Moreland 2009, Kanawattanachai and Yoo 2007, Lewis 2004, Peltokorpi and Manka 2008) are positively related to TMS development. Zhang et al. (2007) found that team characteristics such as task interdependence, cooperative goal interdependence, and support for innovation were also related to higher TMSs in workgroups. TMS development was found to be hampered, however, in geographically distributed teams with strong subgroups and among subgroups with a numerical minority of team members (O'Leary and Mortensen 2010).

Although much of the TMS research focuses on the benefits of TMSs, some research suggests that TMSs can, under some circumstances, be detrimental to group outcomes. Skilton and Dooley (2010) argued that repeat collaboration among team members—which promotes TMS development—can generate creative abrasion, thwarting new idea generation, reducing information exchange, and causing members to quickly converge on suboptimal solutions when performing creative tasks. Central to Skilton and Dooley's argument is the idea that group cognition can create rigidity in members' knowledge and perceptions and in a group's routines and processes. Lewis et al. (2007) found evidence of such rigidity in their laboratory study of groups that experienced membership change. Groups that developed a TMS and then later lost and received one member tended to rely on obsolete TMS structures and processes to the detriment of collective performance on an assembly task. When these groups were coached to pause to reflect about the group's knowledge, however, the rigidity symptoms of membership change were eliminated, and groups performed better than groups that experienced no membership change.

A few recent studies challenge the assumptions underlying TMS theory. For example, Jarvenpaa and Majchrzak (2008) argued that when individual experts in a group have incongruent goals, the experts might not share the useful knowledge that they possess. An implicit assumption in TMS research has been that members are motivated to share the information they possess to the benefit of group performance. Results from a study of security professionals suggest that policies and practices that encourage dialogic communication, define rules for knowledge ownership, and specify protocols for knowledge dissemination can stimulate the development of TMS in organizational contexts in which individuals might not otherwise be motivated to divulge information or use information they receive. The emergent response groups described by Majchrzak et al. (2007) provide another example of groups achieving high levels of coordination and performance without the features typically found in groups with a well-developed TMS. The researchers argue that the unique qualities of these groups—such as unstable task definition, changing and potentially conflicting goals, and fluid membership—necessitate extensions to current TMS theory.

TMS Research: Issues and Solutions

The relatively recent proliferation of TMS research has led to increased variety in how researchers define and conceptualize TMSs and how they interpret research results. Below, we describe three key issues that result from this increased variety and develop related propositions that can be tested in future research. We emphasize issues related to the definition of TMS, the distinction between TMS measures and the theoretical components of a TMS, and the importance of task type for understanding the applicability or relevance of a TMS.

Defining a TMS: More Than a Shared Understanding

A TMS has been defined by researchers in different ways (e.g., see the descriptions of a TMS by Austin 2003, Hollingshead 2001, Lewis 2003, Moreland 1999). One of the more frequently applied characterizations of a TMS is as "a shared understanding of who knows what." Although this characterization accurately represents a TMS as a type of socially shared cognition, it is deficient because it fails to capture important qualities of a TMS. We see this simplified definition of a TMS as concerning because it could easily result in the misspecification of research (for example, studies that claim to examine TMSs but do not), invalid measurement of TMSs (for example, measures that capture shared knowledge only), and misconstrued results (for example, interpreting TMS structure as a definitive marker of a TMS). As we explain below, this oversimplified characterization of a TMS fails to incorporate three important qualities of a TMS that are articulated in TMS theory and that distinguish a TMS from other forms of socially shared cognition: (1) differentiated knowledge; (2) transactive encoding, storage, and retrieval processes; and (3) the dynamic nature of TMS functioning.

First, defining a TMS in terms of a shared understanding of who knows what ignores the *differentiated* knowledge aspect of a TMS. Differentiated knowledge, along with shared knowledge, is integral to a TMS (Wegner 1986, Wegner et al. 1985). Differentiated group knowledge is created from a division of knowledge responsibilities, whereby each member is responsible for unique knowledge. Differentiated group knowledge is thought to be useful because it provides the group with diverse, specialized knowledge that can be applied to the group's task. Shared knowledge—similar knowledge that members hold in common—is thought to be useful because it helps all members quickly locate the specialized expertise possessed by different members of the group. Empirical research supports both of these claims, suggesting that the performance benefits of a TMS stem from members sharing a common understanding of how the group divides the cognitive labor for the group's task and coordinates differentiated knowledge (e.g., Fraidin 2004, Hollingshead 1998b, Liang et al. 1995, Sharma and Yetton 2007, Wegner 1995).

We advocate that authors define a TMS to take into account both the shared and differentiated aspects of TMS knowledge because the available conceptual and empirical evidence suggests that the usefulness of a TMS depends not only on a shared understanding of who knows what but also on the degree to which a group's knowledge is differentiated. Comparing the effects of group cognition defined merely in terms of shared knowledge with the effects of a TMS (defined as incorporating both shared knowledge and differentiated knowledge), we predict the following.

Proposition 1A. *Compared with groups in which group cognition is limited to a shared understanding of who knows what, groups with a TMS will have higher performance.*

Proposition 1B. *This higher performance by groups with a TMS will be attributed to the degree to which the group's knowledge is differentiated, evidenced by the diversity and depth of knowledge possessed by members and applied to the group's task.*

A second problem with defining a TMS only in terms of shared knowledge is that this definition emphasizes the structural component of a TMS to the exclusion of the *process* component of a TMS. According to Wegner et al. (1985), a TMS has two components: an organized store of knowledge (TMS *structure*) and a set of knowledge-relevant transactive *processes* (encoding, storage, and retrieval processes) that occur among members. The TMS structure is a knowledge representation of members' unique and shared knowledge (including members' shared understanding of who knows what). TMS processes are the mechanisms by which the group coordinates members' learning and retrieval of knowledge, so that the knowledge can be applied to group tasks. TMS processes were a principal focus of a study by Lewis et al. (2007), who found that errors in TMS processes, rather than faults or gaps in the TMS structure, accounted for low levels of performance among groups experiencing membership change. This empirical evidence underscores the importance of considering transactive processes in TMS research and of not limiting conceptualizations of a TMS by defining it merely in terms of a knowledge structure.

Third, defining a TMS as a shared understanding of who knows what ignores the *dynamic* nature of TMS functioning, which is reflected in the ongoing and reciprocal impact of TMS structure on transactive processes, and vice versa. As defined by Wegner et al. (1985), the structure and process components of a TMS are intertwined, with TMS structure influencing the nature and efficiency of transactive encoding, storage, and retrieval processes, and those same TMS processes in turn updating and refining the TMS structure. This dynamic interplay occurs as members communicate, interact, and perform the group's task. One result from the dynamic interplay between TMS structure and processes is that members' understanding of who knows what becomes more refined and more similar. Mutual reliance on one another to be responsible for different but complementary expertise allows individual members to develop deeper expertise in specialty areas. Over time, this results in group knowledge that is progressively more differentiated.

Another result from the dynamic interplay is the creation of new collective knowledge. Wegner et al. (1985) described this new knowledge in terms of *integrations* produced by TMS processes: "Integrations result when members discover links between members' knowledge and create new knowledge that no member had previously possessed" (Lewis et al. 2005, pp. 583–584). Evidence from Lewis et al. (2005) suggests that new collective knowledge that developed in groups with prior task experience and a TMS helped those groups transfer prior learning to different tasks. New knowledge developed through transactive processes is probably helpful to groups performing many different types of tasks, but it is likely to be especially helpful when a task requires substantial amounts of learning. Comparing the effects of group cognition defined in terms of a shared understanding of who knows what, with the effects of a TMS (defined as incorporating transactive processes), we predict the following.

Proposition 2A. *Compared with groups whose members have a shared understanding of who knows what, groups with a TMS will demonstrate greater learning.*

Proposition 2B. *This greater learning in groups with a TMS will be attributed to integrations, evidenced by new collective knowledge that no member had previously possessed.*

In sum, we encourage researchers to define, measure, and conceptualize a TMS in a way that is consistent with TMS theory by capturing ideas about shared and differentiated knowledge and the dynamic processes that create and retrieve that knowledge.

TMS Components and TMS Measurement

A second issue in TMS research arises from mistakenly interpreting indirect indicators of a TMS as if they were TMS components. As described in the preceding section, the components of a TMS include an organized store of knowledge (TMS structure) and a set of transactive processes. Interpreting indirect indicators of a TMS to be meaningful representations of TMS components can lead researchers to draw invalid conclusions about TMS development, functioning, and effects.

In some settings, TMS structure and processes can be assessed directly (Hollingshead 1998a, 1998b; Wegner et al. 1991). Direct measures enable researchers to draw valid conclusions about TMS structure and processes and about TMSs as a whole. Indirect measures of a TMS allow one to infer that a TMS exists without measuring the TMS itself. An indirect measure is useful in settings where tasks cannot be tightly specified and understood, or when TMS structure and processes cannot be easily measured. One indirect measure of a TMS is the scale developed by Lewis (2003), based on the observational indicators used by Liang et al. (1995) to infer that a TMS was operating in groups performing an electronics assembly task. The Lewis (2003) measure is represented as a latent variable model, where a TMS is an unobservable (latent) construct indicated by three observable (measurable) manifestations (or *indicators*) of a TMS (Liang et al. 1995): the differentiated structure of members' knowledge (specialization); members' reliance on other members' knowledge (credibility); and effective, orchestrated knowledge processing (coordination). These manifest variables represent features that one would expect to observe in a group, if the group had developed a TMS. The formal assumptions underlying this latent variable model (Bollen 2002, Borsboom et al. 2003, Edwards and Bagozzi 2000) imply that (1) it is by these manifest variables that we can *infer* that a TMS is operating in a group; (2) the reason that specialization, credibility, and coordination are observed together is because a TMS is operating in the group (i.e., specialization, credibility, and coordination scores covary as a *function* of a TMS); and (3) the manifest variables are *independent* after controlling for a TMS (i.e., apart from the explanation that a TMS is operating, there is no theoretical reason for the specialization, credibility, and coordination variables to be related).

One implication of these assumptions is that we cannot interpret these manifest variables as if they were components of a TMS. The manifest variables (specialization, credibility, and coordination) do not map onto the TMS structure and process components, and they therefore cannot be interpreted as either indicative of, or as measuring, TMS components. For example, it would be incorrect to draw conclusions about the efficiency of transactive encoding, storage, and retrieval processes from the coordination variable score or to make inferences about the development of a TMS by examining the change in means on the specialization variable over time.

A second implication of the assumptions of the latent variable model is that the three manifest variables cannot be meaningfully analyzed or interpreted in isolation. Considered separately, the specialization, credibility, and coordination variables do not imply that a TMS exists. To illustrate, imagine a group with exceptionally high scores on the coordination measure. It would be incorrect to interpret the high coordination score as indicative that a TMS exists in the group; it would also be incorrect to compare that group's coordination score to another group's score and infer that the group with the higher score has a more well-developed TMS. High coordination scores could be indicative of something other than a TMS—high coordination scores might be observed in a group that follows structured plans and schedules or that is structured as a formal hierarchy (Okhuysen and Bechky 2009). We can meaningfully interpret coordination scores as indicative of a TMS (as opposed to indicative of other causes of coordination) if and only if coordination is observed in the presence of the other manifest variables, specialization and credibility.

The choice of an appropriate TMS measure—direct or indirect—should be made based on considerations about study design (e.g., laboratory or field) and on the research questions of interest. For example, if one is interested in research questions about the development or functioning of TMS structure, transactive processes, or their interplay, then direct measures of TMS structure and processes should be used (see examples by Hollingshead 1998a, 1998b, 2001; Lewis et al. 2007). If one is interested in predicting the existence of a TMS or predicting the effects of a TMS, then using an indirect measure of a TMS is appropriate. An indirect measure, such as the latent variable model described above, is also appropriate in settings where a TMS is difficult to observe or measure directly, provided that results-based inferences are made in accord with that model's assumptions.

TMS and Task Type

A third issue in the TMS literature concerns the lack of consideration of task type in TMS research. Our earlier review of the literature illustrates the wide range of groups, tasks, and settings that have been examined in TMS research. Researchers typically explain that a TMS is relevant when group tasks require the processing of large amounts of knowledge and information (indeed, we have used this explanation in our own research; see Lewis et al. 2005, 2007). That explanation is unsatisfactory for at least two reasons. First, it implies that a TMS is useful for virtually all types of tasks performed by workgroups in knowledge-based organizations. Yet there is evidence that a TMS might not operate the same way (or have the same performance effects) for every type of knowledge-intensive task (e.g., Jarvenpaa and Majchrzak 2008, Rau 2006). Second, it assumes that workgroups perform a single "type" of task. Yet software development teams, new product development teams, consulting teams, and other ongoing workgroups—all of which have been examined in TMS research—certainly engage in varying types of tasks in the course of accomplishing their work.

We consider the inattention to task type in TMS research to be an issue because it limits our ability to interpret research findings and to compare results or draw conclusions across studies. In addition, failure to distinguish among the different types of activities in which ongoing workgroups engage, or among the different activities inherent in project-based work, limits our ability to diagnose problems and develop interventions to improve group outcomes. In this section, we discuss the role of task type in TMS theory and develop propositions that can be examined in future research. Our analysis provides insight into the task types where a TMS is likely to be most beneficial and explains how engaging in different types of tasks affects the development and functioning of a TMS.

Before analyzing the role of task type in TMS theory, we first consider how tasks can be categorized according to their elementary activities and structural characteristics. The approach we use for categorizing tasks draws upon more than 30 years of group task research aimed at describing and classifying tasks involved in group work (e.g., Hackman 1968, Larson 2010, Laughlin 1980, McGrath 1984, Shaw 1963, Steiner 1972). Although our categorization is not exhaustive, it does reflect key task activities and characteristics described in prior group task research, and it represents the vast majority of tasks that organizational workgroups might encounter. We categorize tasks in terms of three elemental *processes* (produce, choose, and execute) and three *structural qualities* of the task, relating to task demands (divisible versus unitary), the underlying goal structure of the task (cooperative versus conflictual), and the evaluative specificity of group outputs (intellective versus subjective).

Task Processes (Produce, Choose, and Execute). Produce tasks are those tasks that involve generating ideas or images (Hackman 1968). Produce tasks include tasks described by McGrath (1984) as planning tasks and creativity (brainstorming) tasks, as well as tasks that require groups to generate alternative courses of action or processes of implementation (Hackman 1968). *Choose* tasks in our categorization include tasks that require the group to render an answer or solution to a problem or challenge (Larson 2010, McGrath 1984). This category includes problem-solving tasks and decision-making tasks (Steiner 1972, Laughlin 1980), both of which require groups to make choices among alternatives to reach a solution. Finally, *execute* tasks are those tasks that involve the actual performance or execution of operations to achieve a group goal (Hackman 1968) or to meet a standard of excellence (McGrath 1984). Examples of groups that are largely engaged in execute activities are sports teams, air traffic control crews, surgical teams, and combat groups.

Task Structural Qualities. We further categorize tasks in terms of three elemental *structural qualities* of the task, relating to task demands (divisible versus unitary), the underlying goal structure of the task (cooperative versus conflictual), and the evaluative specificity of group outputs (intellective versus subjective). We categorize tasks based on task demands according to the divisible–unitary continuum described by Steiner (1972). Divisible tasks are those tasks with a subtask structure, where different subtasks can be performed by different individuals with different skills and abilities (Larson 2010). Unitary tasks are those that cannot be meaningfully subdivided into separate activities and are accomplished by different members engaging in the same activities, using the same skills and abilities. Another structural quality relates to the goal structure inherent in the task. For some tasks, members share a common goal and cooperate to achieve group performance outcomes (McGrath 1984). Other tasks involve competing goals, with members' motives being more competitive than cooperative in nature (Laughlin 1980). The third structural quality relevant to our categorization describes the extent to which the outcome of the task can be specified. Intellective tasks are those tasks for which the correctness of a solution can be readily demonstrated (Laughlin 1980), either by appealing to authority, logic, or feedback (Shaw 1963). We categorize tasks as more subjective than intellective if the task has more than one correct solution (Shaw 1963) or no demonstrably correct solution (Laughlin 1980).

Categorizing tasks by elemental processes and structural qualities allows us to systematically analyze the role of task type in TMS theory and to pinpoint more precisely the types of tasks for which a TMS is most useful, and why. In the sections that follow, we analyze how the processes and structural qualities of different types of tasks affect the *relevance* of a TMS for group outcomes and how engaging in a particular task might help *develop* a TMS.

TMS Relevance. We define TMS *relevance* in terms of the strength of the relationship between a TMS and performance on a task. There is evidence in the literature that for some tasks (e.g., production and assembly tasks), the strength of the TMS–performance relationship is quite strong (Lewis 2003, Liang et al. 1995, Moreland and Myaskovsky 2000). For other types of tasks, however, the strength of the TMS–performance relationship appears to be relatively weak (e.g., Rau 2006). Understanding the features and outcomes of a well-developed TMS (characterized by a functional TMS structure and efficient transactive processes) should help us predict the types of tasks for which a TMS will be more or less relevant.

A functional TMS structure provides members with a directory of member-expertise associations and ready access to a greater diversity and depth of knowledge than any single member could possess. This provides the group with a large amount of specialized and task-relevant knowledge that can be brought to bear on the group's task. Efficient transactive processes, however, are needed to store, retrieve, and coordinate that knowledge so that it can be applied to the group's task. Transactive processes are efficient when information processing in the group "occurs more completely, quickly and with a minimum of confusion and unnecessary effort" (Lewis et al. 2007, p. 165). Efficient transactive processes ensure that new information entering the group is allocated to the member most capable of being responsible for it and that relevant knowledge already possessed by a member is quickly retrieved, communicated, and integrated with other task-relevant knowledge. The dynamic interplay between TMS structure and processes can produce individual specialized learning and new collective knowledge that can be applied to the group's task.

Based on the above description of the features and outcomes of a well-developed TMS, the tasks that are likely to benefit from a TMS are those for which performance depends on access to diverse knowledge, access to deep and specialized knowledge, access to credible and correct knowledge, the recognition of which members possess what expertise (expertise recognition), a division of the cognitive labor for the task, the complete application of knowledge to the task, combining and integrating members' knowledge, efficient coordination of members' activities, and new learning that occurs during task processing. For what types of tasks does performance depend on these features and outcomes?

Produce tasks, which include idea-generation tasks and tasks that require developing alternatives or creating plans of action, are likely to benefit especially from access to knowledge that is diverse, because that diversity can lead to a greater quantity of ideas (Larson 2010). Recognizing expertise helps members elicit information from the person most likely to contribute ideas that are useful. Produce tasks also benefit from integrations created by transactive processes, because combining members' ideas might lead to new or better ideas.

Choose tasks, which include problem-solving and decision-making tasks that require the group to choose among alternative solutions or decisions, are apt to benefit from a division of cognitive labor. Dividing the cognitive labor for the task will help members cope with the high cognitive demands of choose tasks, which require cycles of reviewing evidence, creating hypotheses, and probing for new evidence (Larson 2010). Knowing who knows what will help members to identify the person most likely to possess the correct solution or to come up with a superior alternative for the group to consider. Transactive processes that help members recall and discuss all available information and that help pool expertise that is distributed across members increase the chance that the group will find a solution or make a good decision on a choose task (Stasser and Stewart 1992). Also helpful to performance on choose tasks is the individual and collective learning produced by transactive processes, which can increase the possibility that new solutions and ideas emerge out of task processing.

Execute tasks benefit especially from group knowledge that is diverse, specialized, and credible and that is completely accessible from known experts, because the more that high-quality knowledge, skills, and abilities are brought to bear on execute tasks, the better the performance. Execute tasks benefit especially from the efficient and coordinated combination and integration of members' knowledge, skills, and abilities made possible by efficient transactive processes. Execute tasks also tend to involve physical activities, making efficient coordination of members' actions especially important to performance. Because execute task performance depends on harnessing all available resources (and not on those resources that are not directly and precisely relevant to the task), a well-developed TMS is more important for execute tasks than for other task process types.

In all, our analysis suggests that tasks categorized under all three of the task process types benefit from the group having a TMS, for slightly different reasons. Execute tasks, however, capitalize on all of the features of a well-developed TMS (and a greater number of the features than do produce or choose tasks), suggesting that a TMS is especially relevant for the performance of execute tasks. Thus, we propose the following.

Proposition 3A. *A TMS is relevant for task activities that involve produce processes, choose processes, or execute processes.*

Proposition 3B. *The relevance of a TMS for activities that involve execute processes is higher than for activities that involve produce or choose processes.*

The relevance of a TMS to task performance also differs depending on a task's structural qualities. For instance, when the task demands are more divisible than unitary, a TMS is likely to be more relevant to task performance. Highly divisible tasks require that groups coordinate and integrate the different skills and abilities of members. The greater the diversity and depth of members' task-relevant knowledge, and the more members can orchestrate the integration of that knowledge, the better a group's performance on divisible tasks. In contrast, the performance of unitary tasks does not depend on the application of diverse and specialized knowledge, nor on combining and integrating that knowledge.

Considering the underlying goal structure of a task, cooperative tasks benefit from both the division of cognitive labor created with a TMS and the combination and integration of members' knowledge afforded by efficient transactive processes. Although a goal structure that is more conflictual than cooperative might benefit from the expertise recognition facilitated by a TMS (because using this information a member could elicit information from known experts or avoid eliciting information, according to that member's motives), expertise recognition is unlikely to benefit the group as a whole when members' goals are in conflict.

Finally, for tasks with a demonstrably correct solution (intellective tasks), a TMS is likely to be very useful. A TMS helps members identify the member most likely to possess the correct solution or most likely to find it. Members might be better able to persuade others of the correctness of a solution if members with diverse information can corroborate evidence supporting the solution. Thus, the diversity of expertise characteristics of a well-developed TMS might benefit performance on intellective tasks. When the specificity of the task outcome is more subjective, however, a TMS is liable to be less helpful for performance. In the case of subjective outcomes, the diversity of expertise associated with a TMS might exacerbate the disagreement that is common when tasks outcomes are not clearly understood (Larson 2010), rather than assist with convergence on an optimal solution. Together, the analysis above suggests the following.

Proposition 4A. *A TMS is more relevant for tasks where task demands are divisible rather than unitary.*

Proposition 4B. *A TMS is more relevant for tasks where the underlying goal structure is cooperative rather than conflictual.*

Proposition 4C. *A TMS is more relevant for tasks where the task output is intellective rather than subjective.*

TMS Development. Just as the relevance of a TMS differs by task type, the degree to which performing a task encourages the development of a TMS is also likely to differ. A TMS begins to develop when members learn something about one another's expertise. This initial learning forms the basis for a TMS structure. As members interact during task processing, more information about the depth and validity of members' knowledge can be obtained, helping members' understanding about who knows what to become more refined, more accurate, and more similar across members. Performing a task can also increase the efficiency of transactive processes by providing members with diagnostic feedback about the functioning of retrieval and communication activities and by helping to establish routines for interacting in the future. Performing a task can be thought of as "learning by doing," which can help establish and strengthen the TMS structure and processes (Lewis et al. 2005).

Task types differ by the extent to which performing the task helps refine the TMS structure (by creating accurate member-expertise associations and a shared understanding of who knows what) and create efficiencies in transactive processes (by establishing effective routines for interacting, and for allocating, eliciting, and sharing information). As we explained above, produce, choose, and execute tasks each benefit from the features of a well-developed TMS. As these features are exercised during task processing, they might become even more developed. For example, produce and choose tasks involve activities that emphasize identifying expertise and depend on using and building upon expertise. Performing those tasks is likely to reveal information about members' true expertise and about the credibility of member-expertise associations, thereby helping to refine and further develop the TMS structure. In comparison, execute tasks emphasize the use of established routines for applying information and depend on utilizing expertise from an already developed TMS structure. As a result, learning during the performance of execute tasks focuses especially on refining knowledge structures and transactive processes. In comparison, produce and choose tasks provide members with opportunities to explore new combinations and integrations of knowledge, expanding knowledge structures in unanticipated ways. Moreover, because produce and choose tasks are not refined through repetition the way execute tasks are, they allow for the emergence of new routines and patterns of interacting, leading potentially to greater learning and TMS development. We propose the following.

Proposition 5A. *Engaging in activities that involve produce, choose, or execute processes will help a TMS to develop.*

Proposition 5B. *TMS development will be higher when activities involve produce or choose processes than when activities involve execute processes.*

The structural qualities of a task might also encourage a TMS to develop and strengthen. For example, tasks that are more cooperative than conflictual are likely to motivate members to learn about other members' knowledge and to take responsibility for learning, remembering, and communicating knowledge in their respective knowledge domains. Divisible tasks, more so than unitary tasks, are likely to provide the opportunity for group members to explore the best ways to assign responsibilities and to manage the division of cognitive labor based on the knowledge, skills, and abilities revealed during task processing. Intellective tasks, more so than subjective tasks, reinforce member-expertise associations because the demonstrable nature of the task makes it obvious which members possess (and do not possess) relevant knowledge. In each case, engaging in the task is likely to strengthen and refine the TMS structure and create new efficiencies in transactive processes. Therefore, we propose the following.

Proposition 6A. *TMS development will be higher when the task's demand structure is divisible rather than unitary.*

Proposition 6B. *TMS development will be higher when the task's underlying goal structure is cooperative rather than conflictual.*

Proposition 6C. *TMS development will be higher when the task's output is intellective rather than subjective.*

Our analysis explains how tasks with different characteristics might be affected by a TMS in different ways. Although execute tasks seem to benefit most from a TMS, a TMS is also relevant for choose and produce tasks, as well as for tasks where the underlying structure is cooperative, divisible, or intellective. These same task structural qualities are also likely to help a TMS to develop, because performing tasks with those qualities tends to strengthen the TMS structure and increase the efficiencies of transactive processes. TMS development is apt to occur while engaging in activities involving execute processes, but it is most likely to occur with produce and choose processes because those activities encourage refinements and updates to the TMS structure, and they allow for new routines and patterns for interacting to emerge.

Considering task type in TMS research can help researchers better interpret significant findings as well as nonsignificant findings, which might be observed because the study tasks are those for which TMS relevance is low. In addition to considering task type when analyzing TMS research, it would be useful to consider task type when designing TMS studies. For example, it would be wise to include assessments of task type as part of a study so that the effects of task type can be distinguished from the effects of other variables of interest, including TMSs.

Future Research Directions

Research on TMSs promises to increase our understanding of group functioning and performance in contemporary organizations. TMS theory goes beyond other theories on group cognition in that it explains not only the cognitive structures needed for group performance but also the group processes that define how group cognition emerges and functions. The cognitive process aspects of TMS theory have not been emphasized in previous research, something that is perhaps explained by the research issues described in this essay. For example, if researchers define a TMS in terms of cognitive structures but not processes, then the learning, recall, and communication activities so distinctive to TMS functioning and impact are unlikely to be investigated. If researchers do not recognize that TMS structure and process can be implicated differently in different types of tasks, then predictions and inferences about the effects of a TMS will lack a useful specificity that TMS theory would otherwise allow. Based on our analysis of previous TMS research and current issues, we encourage three directions for TMS research that capitalize on the richness of TMS theory.

New Perspectives on Collectives

Research by Yuan and her colleagues (Yuan et al. 2005, 2010b) suggests that the processes that account for TMS functioning might best be examined at both the individual and collective levels. Characterizing a TMS as a multilevel phenomenon is consistent with TMS theory and yet offers new insights about the conditions under which TMSs develop and function. Multilevel explorations model more closely the fact that social interactions are nested, and multilevel approaches avoid problems arising from inferring collective properties from aggregated individual data, or vice versa. Thus, multilevel techniques offer the possibility of exploring TMSs beyond traditional techniques, which have examined TMSs by measuring individual cognition (e.g., Hollingshead 1998b) or by focusing on collective properties (e.g., Lewis 2003).

Although there is certainly room for traditional treatments in future TMS research, multilevel approaches might be especially useful when research questions focus on the mechanisms underlying TMS effects. For example, future research could help identify the features of interactions that are more or less likely to create collective knowledge and the features of collective knowledge that are more or less likely to encourage functional and efficient interactions between members. Yuan et al. (2010b) found that the strength of communication ties between individual members influenced processes and outcomes at both the individual and group levels. Some other factors that might be investigated include the motives of members, group leader behaviors, group structure, and the nature of activities (task type) in which the members are engaged.

A related stream of research examines TMSs using social networks. Similar to multilevel approaches, social network approaches allow for the examination of TMSs in the context of nested social interactions (Monge and Contractor 2003). Network approaches enable the study of interactions between members of the same group (Palazzolo 2005), between group members and outside others (e.g., Austin 2003), and across larger collectives such as the organization as a whole (e.g., Garner 2006). An advantage of evaluating a TMS using a social network approach is that it allows researchers to simultaneously examine TMS structure and processes at the individual, dyadic, and network levels. For example, researchers might examine the nature of communications between members aimed at eliciting information or providing information, or the patterns of information exchange among network actors that are most likely to affect a TMS (Palazzolo 2005). Network approaches also allow us to conceptualize a TMS at the organization level (Moreland and Argote 2003), where an organization-wide TMS can be defined in terms of multiple group-based networks, linked by one or more members (Garner 2006).

Network approaches offer many avenues for new research, including research that examines how variations in the nature, frequency, or efficacy of interactions by members of the same group might affect TMS functioning. Another possibility is to examine the effects on collective structures and processes of the distribution of members' knowledge, whether it is uniformly distributed among group members or concentrated among only a few members. Perhaps different distributions are effective for different types of tasks. A third avenue for future research, relating to network structure, is research examining the different roles played by different members of a group. Some members might focus on information exchanges relating to domain knowledge, whereas other members might focus on TMS-related information such as maintaining the group's directory of member-expertise associations (Garner 2006).

Technology Substitutes

In many organizations, information technologies in the form of intranets, search engines, and knowledge repositories are used to support knowledge management practices (Alavi and Leidner 2001). Some information technology systems might perform as substitutes for TMSs by providing workers access to specialized knowledge possessed by experts across the organization (Gray 2000). Information systems can encourage communication among coworkers—whether person-to-person, or via online discussion boards or groupware tools—that is similar to the type of communication that occurs as part of TMS development and functioning. Although these TMS-related benefits remain largely unexplored, information technology has the potential to offer many of the benefits of a TMS (knowledge sharing, knowledge storage, access to specialized knowledge) across a large number of colocated or geographically distributed workers simultaneously.

Research on TMS and information technology shows that technologies such as information repositories or directories that point users to the location of expertise can enhance workers' understanding of who knows what within the organization (Yuan et al. 2007) and can help to develop a TMS among collaborating workers (e.g., Choi et al. 2010, Schreiber and Engelmann 2010). However, there is also evidence that technology substitutes do not explain performance outcomes (Child and Shumate 2007, Schreiber and Engelmann 2010). Considering these findings in light of the points made in this essay, we suggest that technology substitutes such as repository-based systems and systems that predominately locate expertise are deficient (and will not reliably predict performance or other outcomes observed in the TMS literature) because these systems do not effectively emulate or facilitate transactive processes. Transactive processes refine information in the TMS structure and produce individual and collective learning that is useful for performance. Technology substitutes that do not consider transactive processes, their effects, and their dynamic interplay with TMS structure are therefore very unlikely to explain individual or collective performance.

Incorporating the functions of transactive processes in information technology involves modeling the transactive aspects of learning, storage, and retrieval (i.e., cognitive activities that result from interactions between people, or between a person and a system). A technology substitute for TMS also needs to account for the interplay between these processes and TMS structure, whereby processes update and refine structure. Finally, an effective technology substitute would need to facilitate and capture new learning that occurs as a result of transactive processes. Future research could be aimed not only at designing and testing such systems but also at comparing their effects with TMSs in colocated groups, in geographically distributed (or virtual) groups, and in larger collectives.

Complex, Dynamic Tasks

TMS provides an ideal—albeit underutilized—lens through which to consider the performance and development of groups engaged in complex, dynamic tasks.

Multitask activities are a form of dynamic complexity where group processes and the knowledge and skill demands of tasks change throughout the life cycle of the group's work. Many organizational workgroups engage in tasks characterized by dynamic complexity, performing activities that do not fall clearly into one type of task (Marks et al. 2001). For example, projects are multitask activities that are common in modern organizations. Projects involve a set of coordinated activities that are time-bound, with specific start and completion dates, and that proceed in a series of phases that together form a project life cycle.

Although some TMS research has examined groups that are certainly engaged in multiactivity tasks (e.g., Akgün et al. 2005, Austin 2003, Lewis 2004, Yuan et al. 2010a, Zhang et al. 2007), such research has viewed group activities holistically, without considering that these activities are varied or that activities vary over time. Future research could examine how multiactivity tasks and the sequencing of activities within those tasks affect a TMS and its role in group performance. Laboratory research testing the task-type propositions we present in this essay could be valuable for launching field-based investigations that examine multiactivity tasks. Granted, considering dynamic complexity in organizational workgroups, which themselves might vary, is extremely difficult and often impractical. For those reasons, investigating dynamic complexity using computational modeling techniques might be helpful in advancing TMS research. Computational modeling offers the possibility of investigating how TMSs develop and evolve over time and of better understanding the complex set of factors that might affect that evolution (Palazzolo et al. 2006, Ren et al. 2006). Hypotheses that are developed from computational models can then be tested in laboratory and field settings.

In describing some of the issues in TMS research, developing testable propositions, and outlining opportunities for future research, we endeavored to address topics that are likely to be most impactful to the advancement of TMS theory and research. We encourage thoughtful and intelligent expansions of TMS theory into new and unanticipated arenas, with the hope that the TMS will become an even more compelling means for understanding group cognition, functioning, and performance.

Endnote

[1]A search of published journal articles and proceedings papers from ISI Web of Science (performed on December 31, 2010) using the topic keywords "transactive memory" retrieved 198 articles published between 2000 and 2010, with 77% of those published after 2005.

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