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Communication in Theory and Research on Transactive Memory Systems: A Literature Review

Vesa Peltokorpi,[a] Anthony C. Hood[b]

[a]*School of Management, Operations and Marketing, University of Wollongong*
[b]*Department of Management, Information Systems and Quantitative Methods, Collat School of Business, University of Alabama at Birmingham*

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Abstract

Transactive memory systems (TMS) theory has attracted considerable attention in the scholarly fields of cognitive, organizational, and social psychology; communication; information science; and management. A central theme underlying and connecting these scholarly fields has been the role of interpersonal communication in explaining how members of dyads, groups, and teams learn "who knows what," specialize in different information domains, and retrieve information from domain experts. However, because theoretical and empirical evidence is scattered across related, yet distinct scholarly fields, it is difficult to determine how and why communication influences TMS and related outcomes. Thus, this paper reviews literature on the relationships between communication, TMS, and outcomes in dyads, groups, and teams, and proposes avenues for future research.

Keywords: Communication; Transactive memory systems

1. Introduction

Transactive memory systems (TMS) theory (Wegner, 1986, 1995; Wegner, Giuliano, & Hertel, 1985) has attracted increased attention in various scholarly fields (for literature

Correspondence should be sent to Vesa Peltokorpi, Faculty of Business, School of Management, Operations and Marketing, University of Wollongong, Northfields Avenue, Wollongong, NSW 2522, Australia. E-mail: vesa@uow.edu.au

reviews, see Hollingshead, Gupta, Yoon, & Brandon, 2012; Lewis & Herndon, 2011; Peltokorpi, 2008, 2012; Ren & Argote, 2011). A TMS is a specialized division of cognitive labor that develops within dyads, groups, and teams with respect to the encoding, storage, and retrieval of task-related information from different domains (Lewis, 2003). TMS theory highlights the tendency for people in dyads, groups, and teams to share the work of remembering certain types of shared information (Wegner, 1986; Whelan & Teigland, 2013). When one person needs information in another's area of expertise, they can ask for (retrieve) it from other members rather than spend time and energy searching for and learning it on one's own (Whelan & Teigland, 2013). Well-functioning TMS provide numerous benefits (Peltokorpi, 2008; Wegner, 1986). For example, people are able to specialize by relying on other members as their external memory aids. This specialization reduces knowledge overlaps, allowing members to gather and apply a greater amount of task-related information.

Interpersonal communication—an exchange of information, occurring through verbal/nonverbal channels, between two or more people—has been central to theory and research on TMS. For example, Wegner (1986, p. 186) described TMS as "a set of individual memory systems in combination with the communication that takes place between individuals." Similarly, several other scholars have argued that TMS are developed and function in dyads, groups, and teams largely through communicative interactions over time, allowing individuals to assess the quality, value, relevance, and accessibility of expertise possessed by others (e.g., Hollingshead & Brandon, 2003; Su, 2012; Yuan, Fulk, & Monge, 2007). In this way, the interpersonal communication indicative of TMS enables members to know who knows what, develop an interdependent cognitive division of labor in which all members specialize in different information domains, and retrieve information from domain experts (Hollingshead, 1998a; Hollingshead & Brandon, 2003; Littlepage, Hollingshead, Drake, & Littlepage, 2008; Palazzolo, 2005; Su, 2012; Wegner, 1986, 1995).

This paper, by reviewing theory and research on communication in TMS development, functioning, and outcomes in dyads, groups, and teams, contributes to the TMS literature and to the broader cognitive science community in three important ways. First, despite its centrality in TMS theory, the accumulated evidence of communication in TMS is scattered across various scholarly fields. This makes it is difficult to determine how and why communication influences TMS and related outcomes. In contrast to prior TMS reviews (Hollingshead et al., 2012; Lewis & Herndon, 2011; Peltokorpi, 2008, 2012; Ren & Argote, 2011), we provide a comprehensive, multidisciplinary review of communication in TMS. Second, in contrast to limited amounts of research on the antecedents of TMS, a considerable amount of research focus has been placed on various outcomes of TMS such as creativity (Gino, Argote, Miron-Spektor, & Todorova, 2010), innovation (Peltokorpi & Hasu, 2016), and performance (Liang, Moreland, & Argote, 1995). Thus, we have a more comprehensive understanding of the impact of TMS on outcomes than of the factors that encourage or impede its development and functioning. Our review seeks to illuminate ways in which communication affects the individual and collective (e.g., group) memory functions that govern performance outcomes. Third, we encourage more cross-disciplinary investigations of TMS by integrating research from various scholarly fields. Before describing the process of our literature search and reviewing theory and research on communication and TMS, we provide a brief overview of TMS theory.

2. TMS theory

Despite being originally developed to describe ways in which intimate couples divide and share responsibility for processing information (Wegner, 1986; Wegner et al., 1985), TMS theory has been extended to groups, teams, and organizations (Hollingshead et al., 2012; Lewis & Herndon, 2011; Peltokorpi, 2008, 2012; Ren & Argote, 2011). A TMS consists of two interrelated components that enable members in collective entities (in this case, groups) to divide and share responsibility for processing information: "(a) an organized store of knowledge that is contained entirely in the individual memory systems of the group members, and (b) a set of knowledge relevant transactive processes that occur among group members" (Wegner et al., 1985, p. 256). While transactive memory is an individual-level construct that exists in the mind of just one person, TMS is a collective-level construct that exists among individuals as a function of their individual transactive memories (Lewis, 2003; Wegner, 1986).

Wegner (1986) theorized TMS development and functioning to occur through three overlapping phases—*encoding*, *storage*, and *retrieval*. TMS development begins when people learn something about other members' domain of expertise. Such expert inferences can be made through stereotypes, self-disclosure, observations, explicit expert indications (e.g., diplomas), written communication, expertise assignments, and third-party comments (Wegner, 1986). Well-functioning TMS can be developed if all members accept responsibility for the encoding, storage, and retrieval of information related to their expertise domain (s). Acceptance of different expertise domains and shared expertise awareness enables members to support each other's expertise by allocating tasks and directing new information to the right people (e.g., assigning statistical analyses to a member who has published quantitative research in top-tier journals). Because each member specializes in certain areas of expertise, the expertise overlap within the group is reduced and all members are able to access a larger pool of information across different expertise domains. Transactive retrieval occurs when two or more people work together to retrieve uniquely held information. People are able to retrieve the needed information by identifying an expert via appropriate location information, that is, remembering who knows what (Wegner, 1986).

Wegner (1995) also described TMS development and functioning to occur through the complementary processes of *directory updating* (i.e., learning who knows what in the group), *information allocation* (i.e., assigning memory items to group members), and *retrieval coordination* (i.e., planning how to find items in a way that takes advantage of who knows what). TMS is most commonly measured using three indicators: *credibility* (i.e., beliefs about the reliability of other group members' knowledge), *specialization* (i.e., the level of expertise differentiation within the group), and *coordination* (i.e., effective, orchestrated knowledge processing) (Lewis, 2003).

3. Literature search

For this review, we searched for journal articles published in the English language in the Web of Science® database with the topic words "transactive memory" and "communication" through November 2017. Thus, our search did not include 24 papers published in conference proceedings and one journal article published in Spanish. Our search yielded 213 hits. We then checked these articles, including those with words "transactive memory" and "communication" in titles/abstracts. Based on these criteria, we excluded 159 articles. Among the 54 included articles, 20 were conceptual/literature reviews/simulation studies (shown by asterisk* in the reference section), and 34 were empirical (experiments/field studies) (shown in Table 1). In the following section on communication in TMS theory, we included book chapters and empirical works with theoretical focus on communication.

4. Communication in TMS theory

From the seminal works of Daniel Wegner (1986; Wegner et al., 1985), communication has played an integral role in TMS theory. For example, Wegner et al. (1985, p. 191) described TMS as a group-level memory system that "involves the operation of the memory systems of the individuals and the processes of communication that occur within the group." What is theorized to make TMS "transactive" are the communicative interactions among group members that make possible the encoding, storing, retrieving, and updating of information from individual memory systems (Gomez & Ballard, 2015; Hollingshead & Brandon, 2003; Palazzolo, 2005; Palazzolo, Serb, She, Su, & Contractor, 2006; Singh, Dong, & Gero, 2013; Spraggon & Bodolica, 2017; Su, 2012). Building on Wegner (1995), Lewis, Belliveau, Herndon, and Keller (2007) went a step further by arguing that TMS has a structure- (i.e., directory of who knows what) and a process component (i.e., transactive communication), emphasizing the importance of communication in TMS development and functioning. Communication is also conceptualized as the initial building blocks in a TMS structure (Brandon & Hollingshead, 2004; Pearsall, Ellis, & Bell, 2010); that is, knowing who knows what in groups occurs through communicating directly with a second person and indirectly by communicating with other group members who have their perceptions of the second person's expertise. TMS is further described as a group information-processing system that is made up of the memory systems of individual members and the communication that links individual memory systems together (Lee, Bachrach, & Lewis, 2014).

Communication is theorized to have an especially important role in TMS encoding and retrieval phases (Hollingshead & Brandon, 2003). During the encoding phase, communication helps group members move from simple, often inaccurate stereotypical notions to more accurate, sophisticated expertise attributions. Group members can also use communication to demonstrate their expertise, which in turn allows for greater precision in

Table 1
Communication in transactive memory systems (TMS) research (alphabetical order)

Theme	Study	Sample	Context/Task	Main Findings
Communication frequency and quality	Akgun et al. (2005)	69 New product development project teams	New product development	Frequency of formal team communication had a positive effect on TMS specialization, but no significant effect on TMS credibility, TMS coordination, and cumulative TMS. Frequency of informal team communication had no significant effect on any of these TMS dimensions.
	Chen et al. (2013)	95 Open source software project teams	Various	Communication quality mediates the positive relation between TMS credibility and technical achievement.
	Hsu et al. (2012)	236 Information system project employees	Information system projects	TMS mediates the positive relation between team communication effectiveness and team performance.
	Jackson and Moreland (2009)	63 Groups, 209 undergraduate students	Group project	Communication had a positive effect on TMS, which in turn had a positive effect on group performance.
	Kotlarsky et al. (2015)	174 Employees	Various	Syntactic (differences in lexicon) and pragmatic (differences in interests) knowledge boundaries negatively affect TMS development.
	Liao et al. (2015)	126 Multidisciplinary hospital teams, 882 healthcare professionals	Various	Team identification moderates the positive relation between perceived communication quality and TMS.
	Peltokorpi and Manka (2008)	33 Daycare work groups, 157 employees	Various	TMS mediates the positive relation between interpersonal communication and group performance.

(continued)

Table 1. (Continued)

Theme	Study	Sample	Context/Task	Main Findings
	Tang (2015)	86 Software development teams	Various	Benevolence- and competence-based trust mediates the positive relation between communication quality and TMS; TMS has a positive effect on team performance.
	Zhang et al. (2016)	40 Student groups, 137 students	Collaborative group project (research report)	TMS mediates the positive relation between social connection, information processing, communication quality, and task performance.
Communication medium and group development	Chung et al. (2015)	309 Individuals who share travel information on social media	Sharing travel information through social media	TMS mediates the positive relation between formal/informal communication and travel information sharing
	Hollingshead (1998a)	88 Couples, 176 undergraduate students	Memory recall task	Dating couples recalled more words than strangers when not able to communicate during learning
	Hollingshead (1998b)	49 Couples, 98 undergraduate students	Memory recall task	Dating couples recalled more words than strangers when not able to communicate during learning
		34 Couples, 68 undergraduate students	Memory recall task	Dating couples scored better when they had access to nonverbal or paralinguistic cues than when they had access to neither
	Lazzara et al. (2015)	32 Healthcare providers	Interaction with patients at a trauma center	The use of telemedicine did not change TMS over time.
	Lewis (2004)	64 Consulting groups, 261 MBA students	Consulting project	Communication and initially distributed expertise had a positive impact on TMS.

(continued)

Table 1. (Continued)

Theme	Study	Sample	Context/Task	Main Findings
	Littlepage et al. (2008)	36 Clerical staff members (18 dyads)	Collaborative job knowledge quiz	Explicit communication in intact dyads with extensive history of communication does not enhance their ability to utilize an existing TMS effectively. Dyad performance was higher when members differed in ability and when they allocated more work to the more proficient member.
	Moreland and Myaskovsky (2000)	63 Groups, 189 undergraduate students	AM radio assembly	Training together promoted TMS development, largely because of the opportunity to determine team-member specialization.
	O'Leary and Mortensen (2010)	62 Teams, 372 undergraduate students	Student project (8–10 pages written report)	Social categorization in teams with geographically based subgroups (two/more members per site) triggers weaker team identification, less effective TMS, more conflict and coordination problems. Further, imbalance in the size of subgroups (i.e., the uneven distribution of members across sites) invokes a competitive, coalitional mentality that exacerbates these effects; subgroups with a numerical minority of team members reported poorer scores on identification, TMS, conflict, and coordination problems. In contrast, teams with geographically isolated members (i.e., members who have no teammates at their site) reported better scores on the

(continued)

Table 1. (Continued)

Theme	Study	Sample	Context/Task	Main Findings
				same four outcomes than both balanced and imbalanced configurations.
	Oertel and Antoni (2015)	33 Student project teams, 100 students	Student project (e.g., designing and conducting an experimental study)	Knowledge-based team learning processes (storage, retrieval) have a stronger effect on TMS during early stages of project-based team work; communication-based team learning processes (reflection, co-construction) have a stronger effect on TMS during latter stages.
	Peltokorpi (2004)	111 Employees	Various	TMS directories mediate the positive relation between electronic communication and service capital.
	Rulke and Rau (2000)	11 Groups, 33 undergraduate students	AM radio assembly	In groups with high TMS, group members declared domains of expertise during earlier than later periods of group interaction, and the frequency with which members evaluated others' expertise and competence increased over time.
	Tang et al. (2014)	272 New product development teams, 1643 employees	New product development	TMS has a positive effect on new product team performance. Task exploration and exploitation positively moderate the relation between four types of communication (informal-, formal-, face-to-face-, and computer-mediated communication) and TMS.
	Kanawattanachai and Yoo (2007)	38 Groups, 146 MBA students	Business simulation game	Early communication volume on performance decreased as groups develop TMS.

(continued)

Table 1. (Continued)

Theme	Study	Sample	Context/Task	Main Findings
Communication styles	Neff et al. (2014)	25 Groups, 144 students	Student project	Individual directory development, individual positive effect, team directory development, and team positive affective valence had positive effects on information seeking
	Pearsall and Ellis (2006)	64 Groups, 268 undergraduate students	Command and control simulation	TMS moderated the positive relation between critical team member dispositional assertiveness and team performance/team satisfaction.
	Pearsall et al. (2010)	60 Student groups, 240 undergraduate students	Distributed dynamic decision-making simulation	Team mental models and TMS mediated the positive relation between role identification behaviors and team performance.
	Yoon and Hollingshead (2010)	57 Dyads, 114 undergraduate students (58 white European, 56 Asian descent)	Learning task	When not able to communicate, cultural diverse dyads used cultural stereotypes for task assignments, which resulted in fewer coordination errors and better performance when compared to culturally similar dyads. When able to communicate, culturally similar dyads performed as well as cultural diverse dyads, and the influence of cultural stereotypes persisted for culturally diverse dyads.
	Yuan et al. (2013)	130 graduate Students, 67 Americans and 63 Chinese	Non-eureka-type intellective decision-making task	Individual actual expertise and task-oriented communication has positive effects on recognition of expertise.

(continued)

Table 1. (Continued)

Theme	Study	Sample	Context/Task	Main Findings
Communication networks	Jarvenpaa and Majchrak (2008)	104 Security personnel in the private and public sectors	Various	Level of network's TMS development moderates the positive relation between dialogic practices, knowledge dissemination protocols, clarity of knowledge ownership, and combinative capabilities.
	Lee et al. (2014)	132 Teams, 528 undergraduate students	Glo-Bus simulation game	A negative direct effect of closure over time on TMS development and a simultaneous positive indirect effect of closure over time on TMS development driven by a transitive triadic social network structure.
	Palazzolo (2005)	12 Teams (academic, consulting, management, etc.)	Various	Emergent communication patterns partially matched TMS theory predictions and were related to members' perceptions of others, expertise.
	Su (2012)	17 Organizational groups, 208 individuals	Various	Group member's accuracy in expertise recognition was positively influenced by one's degree centrality in the communication network and negatively influenced by the extent to which one's work was done remotely.
	Whelan and Teigland (2013)	21 Members of research and development teams in two pharmaceutical companies	Research and development	To reduce information overload, one set of individuals specialized in filtering external information into the group while another set specialized in filtering that information for internal use.

(continued)

Table 1. (Continued)

Theme	Study	Sample	Context/Task	Main Findings
	Yuan et al. (2007)	179 People, 15 project teams	Various	Individual actual usage of organizational repositories mediates the positive relation between individual perceived usage of organizational repositories and individual access to information.
	Yuan et al. (2010)	18 Organizational teams, 218 individuals	Various	At the individual level, the relationship between directory development and expertise exchange was mediated by communication tie strength and moderated by shared task interdependence. Individual expertise exchange occurred more frequently in teams with well-developed team-level expertise directors and with higher team communication tie strength and shared task interdependence.

determining who knows what (Hollingshead & Brandon, 2003). Group members can also make expert inferences through face-to-face and virtual communication with third parties. Communication is further intricately related to transactive retrieval. To retrieve information from domain experts, members can either rely on their own inferences or engage in a transactive information search (i.e., retrieval process by relying on other people to locate experts) with other group members. The latter retrieval process can occur through collaborative remembering through conversations with other group members. Transactive information search processes also occur mainly through communicative interactions. Communication during transactive retrieval processes can lead to novel and shared interpretations of the information that arise through the collaboration (Hollingshead & Brandon, 2003). Scholars have further emphasized the benefits of knowledge management systems and information and communication technology systems in TMS development and functioning (Alavi & Tiwana, 2002; Chung, Lee, & Han, 2015).

Communication is theorized to have a more important role in TMS development than utilization (Hollingshead, 1998c; Hollingshead & Brandon, 2003; Lewis, 2004); a conceptual model suggests that the duration and complexity of the communication involved in TMS retrieval increases as the accessibility and availability of information needed for collective decisions decreases (Hollingshead, 1998c). During the early phases of group development, frequent communication enables members to develop accurate, shared perceptions of member-expertise associations by providing them with opportunities to explicitly establish who knows what. During early interactions, group members can describe their qualifications, state their lack of expertise in certain domains, respond to questions, and solicit information from other members (Hollingshead, 1998c; Lewis, 2004). If teams have developed efficient TMS in which task-expertise-people (TEP) are aligned (Brandon & Hollingshead, 2004), subsequent communicative interactions can be geared toward retrieval of information from domain experts. As explained by Brandon and Hollingshead (2004, p. 635), "A TEP unit relates a conception of a task to hierarchically organized domains of knowledge (i.e., expertise), and then to a person(s) (i.e., a location)." For example, knowing that statistical analyses in a group are handled by a statistician named John represents a full TEP unit (statistical analyses-statistician-John), which guides a group member to the person who is likely to have expert knowledge on statistics. Regarding communicative interactions, Liao, Jimmieson, O'Brien, and Restubog (2012) conceptualized that not only the frequency of communication, but also the quality of communication influence TMS development. Communication frequency is the volume of communication which occurs among team members; communication quality is the extent to which communication adequately distributes pertinent information among team members as needed (Marlow, Lacerenza, Paoletti, Burke, & Salas, 2018).

Communication networks are theorized and demonstrated to influence TMS directory updating, information allocation, and information retrieval. Using a computer model, Palazzolo et al. (2006) demonstrated that the rate of task communication was positively related to expert recognition accuracy and knowledge differentiation networks with a higher initial level of expert recognition accuracy had a higher task communication density, and that smaller networks had a higher communication density than larger networks.

Frequent communicative interactions are particularly important for directory updating when people do not know one another (Palazzolo, 2005), suggesting that communication is more important in the early stages of network-based collaboration. Scholars have further proposed that compared to those in sparsely connected networks, those in highly dense communication networks more accurately identify other members' expertise domains and allocate new information to and retrieve information from members with requisite domain expertise (Palazzolo, 2005; Palazzolo et al., 2006; Yuan, Fulk, Monge, & Contractor, 2010). Communication density represents the amount of communication among team members. Network size is also argued to have a negative impact on communication, which in turn leads to inaccuracy in expertise recognition and information allocation (Palazzolo et al., 2006).

5. Communication in TMS research

As shown in Table 1, we organize our review on communication in TMS research around four topics: communication frequency and quality, communication medium and group development, communication styles, and communication networks. Despite some overlaps, these four topics provide a sufficient differentiation of the most important areas of communication in TMS research.

5.1. Communication frequency and quality

Nine studies have examined communication frequency and quality in TMS. Depending on the focus of investigation, the frequency and quality of communication has been found to have positive, negative, and nonsignificant associations with TMS and outcomes. Starting with the positive effects, two studies show that TMS mediates the positive relationship between communication frequency and performance in work groups (Peltokorpi & Manka, 2008) and student groups (Jackson & Moreland, 2009). Furthermore, TMS and TMS credibility, respectively, are found to mediate the positive relationship between communication quality and performance in student groups (Zhang, Chen, de Pablos, Lytras, & Sun, 2016) and technical achievement in software project teams (Chen, Li, Clark, & Dietrich, 2013). In the study by Chen et al., TMS differentiation was not significantly related to communication quality and technical achievement. Using TMS as an independent variable, Hsu, Shin, Chiang, and Liu (2012) further found that communication effectiveness mediates the positive relationship between TMS and performance in information system development teams. Another study in software development teams shows that benevolence- and competence-based trust mediates the positive relationship between communication quality and TMS (Tang, 2015). Liao, O'Brien, Jimmieson, and Restubog (2015), in turn, found that team identification mediates the positive relationship between communication quality and the level of TMS in multidisciplinary teams. Taken together, these studies suggest that TMS is both an antecedent and outcome of communication frequency and quality.

Moving to the negative and nonsignificant effects receiving less attention in TMS research, Kotlarsky, van den Hoooff, and Houtman (2015) found that syntactic knowledge boundaries (i.e., differences in vocabulary and lexicon) act as a barrier to communication frequency and quality between team members. Because communication about domain expertise is hampered by a lack of a shared syntax (i.e., terminologies, codes, protocols, routines, or other means of expression), expertise recognition is less accurate and there is lack of consensus across team members regarding who knows what. Pragmatic knowledge boundaries between team members also had a negative effect on TMS development. Pragmatic knowledge boundaries refer to differences in interests, existing practices, goals, and other aspects that have become common sense specific knowledge domains. Due to these boundaries, the quality and frequency of communication is negatively influenced, which in turn negatively impact TMS development. Furthermore, a study in new product development teams shows that while the frequency of formal team communication had a positive effect on TMS specialization, it had no significant effect on TMS credibility, TMS coordination, and cumulative TMS of three TMS dimensions (Akgun, Byrne, Keskin, Lynn, & Imamoglu, 2005). In this study, the frequency of informal team communication had no significant effect on any TMS dimensions.

5.2. Communication medium and group development

Thirteen studies have examined the influence of communication medium and group development on TMS. Two of these studies focus on the influence of group training on TMS development. To untangle communication from TMS, Moreland and Myaskovsky (2000) found that groups trained together performed no better than groups that did not train together but were given specific information on individual group member's expertise. While training together was an antecedent of TMS development, Moreland and Myaskovsky concluded that the underlying mechanism was not communication per se, but the opportunity to get to know each group member's expertise. Written information about group members' expertise can thus produce TMS that are as helpful as those developed through shared experience. Rulke and Rau (2000) found that student groups with the most efficient TMS and best performance had conversations about individual expertise early in the group's life and continued to have these conversations over time. These results suggest that TMS development follows a pattern of initial expertise declaration, followed by expertise evaluation by the group and expertise coordination for group execution. Although these two studies show that face-to-face communication facilitates TMS and performance by helping members to make expertise inferences, specialize in different expertise domains, and retrieve knowledge from experts, they also show that expertise inferences can be established through written communication. Taken together, these studies highlight the importance of promoting specific forms of communication that promote or refine expert inferences.

Hollingshead conducted two experiments on the influence of communication and communication medium on TMS development and functioning. First, Hollingshead (1998a) examined communication during learning and collective recall in dating and artificial couples (non-dating couples). While dating couples not allowed to communicate performed better than artificial couples, this effect was reversed when communication was allowed; communication helped artificial couples to compensate for the performance advantages that accrued to dating couples, due to their use of TMS. Although communication had a positive overall effect on TMS, it was still unclear how different communication media influenced information encoding and retrieval. In another experiment (Hollingshead, 1998b), dating couples communicating face-to-face performed better than ones communicating through computers and better than artificial couples communicating face-to-face. The dating and artificial couples' performance did not differ in computer-mediated communication, suggesting that dating couples are better at using information through face-to-face communication. Because these differences could be caused by more efficient usage of nonverbal/paralanguage by dating couples, Hollingshead examined their impact on TMS. Dating couples with access to nonverbal/paralinguistic cues performed better than artificial couples in a similar task. The results of these studies suggest that dating couples are more effective at using their collective information than artificial couples and that non-verbal and paralinguistic channels facilitate information exchange.

Scholars have also examined the influence of communication contexts and modes on TMS. In new product development teams, task exploration and task exploitation moderated the positive association between four communication types (i.e., informal-, formal-, face-to-face-, and computer-mediated communication) and TMS (Tang, Mu, & Thomas, 2014). Tang et al. defined task exploration as searching for and experimenting to find new knowledge, and task exploitation as capitalizing on existing knowledge. Formal communication adheres to common rules/regulations through pre-established plans; informal communication is spontaneous and rich. Peltokorpi (2004) found that TMS directories (i.e., knowing who knows what) mediated the positive relationship between electronic communication and service capital (i.e., the ability to provide high quality customer service). In the same study, interpersonal communication had a positive effect on TMS directories but not on service capital. In social media, TMS coordination, credibility, and specialization are further found to mediate the positive relationship between formal communication and travel information sharing (Chung et al., 2015); TMS credibility and coordination mediated the positive relationship between informal communication through social media and travel information sharing. To understand the influence of communication on TMS more fully, Littlepage et al. (2008) argued that it is important to make a distinction between TMS development and utilization. While communication between group members plays an important part in TMS development, Littlepage et al. argued that its impact is not as critical in utilization of an existing TMS. In line with this argument, they found that explicit communication is not critical to the utilization of an existing TMS.

Scholars have further tested the influence of communication on TMS development and functioning over time. Testing the influence of communication media during two phases of team development, Lewis (2004) found a positive effect of face-to-face communication frequency on TMS formation during the team planning phase. Communication through email/telephone had no significant effect. Similarly, a study in healthcare settings showed that the use of telemedicine did not have a significant effect on TMS over time (Lazzara et al., 2015). In virtual teams, however, task-oriented communication (i.e., messages on web pages and emails) had a positive effect on members' initial beliefs and trust about others' expertise (Kanawattanachai & Yoo, 2007). The discrepancy in findings can be due to collocated teams in Lewis's study; teams in Kanawattanachai and Yoo's study were in different countries and thus had no face-to-face communication. Another study in global virtual teams divided across two geographic locations suggests that the influence of geographical distribution on TMS development depends on the configuration or number of members in each location (O'Leary & Mortensen, 2010). Totally dispersed teams with only one member in one location and four members in another location developed more efficient TMS than teams with two or more members in each location. Further, an unequal number of members per location led to more negative outcomes (i.e., conflicts, coordination problems, weak team identification) than balanced subgroups. These findings suggest that if the geographic dispersion allows for subgroup formation, groups tend to have weaker TMS. Finally, Oertel and Antoni (2015) found that knowledge-based processes (i.e., storage and retrieval) play a more important role during early stages of project-based teamwork, followed by a shift to a higher relevance of communication-based processes (i.e., reflection and co-construction) in later stages.

5.3. Communication styles

Five studies have examined the relationship between communication styles, TMS, and outcomes. Pearsall and Ellis (2006) found that TMS mediated the positive relationship between critical team member assertiveness (i.e., the capacity to effectively communicate in interpersonal encounters by sharing ideas clearly and directly) and team performance and team satisfaction. In this study, critical team members were described to have access to and control of vital information that without which other team members are not able to perform their tasks. In another study, Pearsall et al. (2010) found that role-identification behaviors (through which team members share information on their expertise with the rest of the team) facilitates TMS development. As hypothesized, TMS also mediated the positive relationship between role-identification behaviors on team performance. Yuan, Bazarova, Fulk, and Zhang (2013) in turn tested how communication styles influence expert recognition in multicultural student groups. Controlling for actual expertise, Yuan et al. found that confidence affected perceived influence (not expertise recognition); task-oriented communication had a positive impact on expertise recognition and perceived influence; and talkativeness and dominance did not predict expertise recognition or perceived influence. In another study of student groups, Neff, Fulk, and Yuan (2014) found that individual- and group-level positive affect (i.e., high energy, full concentration, and pleasurable engagement) were positively related to individual volume of transactive communication. More specifically, Neff et al. found that affective homogeneity among group members had a significant relationship with information sharing (but not with information seeking), and the interaction between affective homogeneity and group-level positive affect did not impact either transactive communication process. A related study shows that culturally diverse dyads formed convergent expectations about expertise consistent with cultural stereotypes and also assigned knowledge categories to each partner based on those stereotypes regardless of whether or not they were allowed to communicate (Yoon & Hollingshead, 2010).

5.4. Communication networks

Seven studies have focused on communication networks and TMS. In line with TMS theory, Palazzolo (2005) found that team members retrieve information from perceived experts and from experts on a given topic. When people do not know one another, Palazzolo argued that frequent communicative interactions are particularly important for directory updating, suggesting that communication is more crucial in the early stages of network-based collaboration. Another study shows that dialogic practices (semi-structures that describe rules of conversation) mediate the positive relationship between the use of multiple channels for communication (phone calls, emails, face-to-face meetings) and the extent of the network's TMS development (Jarvenpaa & Majchrak, 2008). In line with TMS theory, a mixed method study (social network analysis, interviews) in research and development teams also shows that central connectors (members with external networks) in teams gained a reputation for ensuring that relevant external information reaches the appropriate members and that members also gave careful consideration to the communications from these connectors (Whelan & Teigland, 2013). To reduce information overload, the same study provides evidence that one set of individuals specialized in filtering external information into the group, whereas another set specialized in filtering that information for internal use.

Furthermore Yuan et al. (2007) compared the relationships among team members' access to information from organizational information repositories and access through a team TMS. They found that development of individual expertise directories affected individual direct information exchange with team members and that perceived usage of organizational information repositories by team members influenced actual usage. Yuan et al. (2010), in turn, found that the strength of communication network ties (operationalized by the frequency of communication among team members) was related to group members' expertise awareness. In another study, Su (2012) found that a team member's accuracy in expert recognition was positively influenced by one's degree centrality in the communication network (i.e., frequency of communication with every other team member) and negatively influenced by the extent to which one's work was done remotely. In this study, there was also an interaction effect between work remoteness and use of digital knowledge repositories (e.g., database) such that the negative influence of work remoteness on expert recognition was weaker when team members used digital knowledge repositories. Finally, mutual connections among three members in closed triads are found to have a positive impact on TMS development (Lee et al., 2014). Based on Lee et al., network density represents inefficient/redundant information exchanges, reflected by information sharing in overlapping expert areas and the propagation of conventional ideas.

6. Future research directions

Although the reviewed theory and research on communication in TMS development, functioning, and outcomes in dyads, groups, and teams show great promise, we recommend several potential areas for future research and theory extensions. More specifically, we propose that more research is needed to address (a) combined effects of communication frequency and quality on TMS over time, (b) the impact of frequency of communication on expert inferences, (c) the effects of task, relationship, and process conflict on TMS-related communication, (d) the impact of language and cultural differences on TMS-related communication, and (e) the impact of network size on TMS-related communication. We discuss these future research directions in turn below.

While our review shows that communication frequency and quality are antecedents, parts, and outcomes of TMS, little is known of their combined effect on TMS over time. Building on the reviewed research, we expect that communication frequency and quality can have different effects and that their effects change as TMS mature and become differentiated (i.e., increasing specialization to different expertise domains among group members). Specifically, we expect that communication quality is more strongly related to TMS development and functioning. In some support, cognitive load theory (Van Merrienboer & Sweller, 2005) suggests that a large volume of communication leads to difficulties in accurately remembering/comprehending more relevant, previously received information. In TMS research, Austin (2003) also argued that it is not frequency of communication interaction patterns themselves that improve accuracy of expertise inferences in teams, but rather the frequency of specific types of interactions, such as communication for problem solving with fewer redundant ties. Thus, communication quality enables team members to more effectively learn who knows what. We also expect that the frequency of communication decreases over time as team members develop more accurate expertise inferences and accept expertise roles. At the same time, quality of communication increases as team members use each other as external cognitive aids in interdependent tasks. These assumptions can be tested through a longitudinal research design.

Reviewed research also shows that communication frequency and quality have positive effects on TMS, but it does not explain to what extent communication helps group members to know who knows what. The hidden profiles paradigm (Stasser & Titus, 1985) suggests that discovering uniquely held information can be difficult because group members disproportionately discuss more common than unique information. Such patterns of communication hinder group members from making correct expert inferences. For example, a meta-analysis of studies using the hidden profile paradigm shows that groups mentioned two standard deviations more pieces of common information than unique information (Lu, Yuan, & McLeod, 2012). Further, communication behaviors, such as speaking forcefully without hesitation, a greater frequency and longer durations of talking, may not be strongly related with true expertise (Hollingshead, Brandon, Yoon, & Gupta, 2010). Members with relevant expertise can also hesitate to participate and display a lack of assertiveness when speaking with a higher status person. Low levels of communication and feedback from other group members can further prevent individuals from creating accurate expertise inferences (Hollingshead et al., 2010). While communication is critical in facilitating expertise inferences, Hollingshead et al. (2010) also argued that group members are not always diligent or motivated to communicate their expertise or learn others' expertise, especially in autonomous and short-term groups. Thus, future research can examine how and when communication has negative effects on TMS development, functioning, and outcomes.

While given scant attention in the TMS literature, we suggest that more research is also needed on the effects of task, relationship, and process conflict on TMS-related communication. Task conflict—disagreements in opinions and ideas—can include communication that create intellectual friction (Jehn, 1995). We expect task conflicts to improve TMS by increasing communication and expertise credibility among group members. In contrast, we expect that relationship conflicts disturb TMS development and functioning because of non-tasks related disputes. In contrast to non-personal differences related to what should be done (i.e., task conflict), process conflict refers to disagreements regarding how tasks should be accomplished. Process conflicts thus involve communications related to discrepancies over role assignments, scheduling or resource allocation (Jehn, 1997). Communications borne from process conflict can be beneficial for TMS by helping members to make new TEP associations or renegotiate or correct inaccurate or suboptimal ones (Goncalo, Polman, & Maslach, 2010). We expect that task, relationship, and process conflict influence all areas of TMS research reviewed in this paper.

While the reviewed research shows that nationality-based differences in communication influence TMS development in international student teams, culture-related communication style differences are subject to considerable individual variation and should thus be examined at the individual level (Merkin, Taras, & Steel, 2014). Future research can also test the impact of a broad array of cross-cultural communication styles on TMS encoding, storage, and retrieval processes. Interestingly, although language is a medium of communication and language differences are shown to have a strong impact on knowledge transfer and sharing activities (Peltokorpi & Vaara, 2014), there is no research on the influence of team members' shared language proficiency (e.g., English) on TMS development and functioning. Clearly, members with limited proficiency in dominant team language are constrained in their capacity to know who knows what and to retrieve information.

Relatively little is also known about how network size affects communication in TMS. In larger networks, people can have fewer chances to communicate and establish strong network ties with all members, which influence TMS development and functioning in terms of expert inferences, specialization among network members, and ability and willingness to retrieve information from domain experts. In support, the law of N-squared suggests that the number of potential links in a network increases geometrically with the number of people (Krackhardt, 1994). The number of potential links grows so fast that the number of people to which each person could be linked quickly exceeds each member's cognitive and communicative capacity. Indeed, as stated by an informant in a study on organizational TMS (Peltokorpi, 2014, p. 458): "it used to be easy to call appropriate people when staffing projects because I used to know almost all employees by their names and faces. But as the company gets bigger, it becomes harder to know all employees." Since network size influences how much can be known about, transferred to, and received from others in the network, more research on structural effects on TMS development and functioning is needed.

7. Conclusion

This paper described the key role of communication in TMS theory, theory extensions, and empirical research, and it provided suggestions for future research. Although communication is theorized and shown to be related to TMS development, functioning, and outcomes, it is still unclear whether communication should be conceived as an antecedent, outcome, or integral component of TMS. We contend that this lack of clarity could be reduced by innovative research collaboration across disciplinary boundaries (e.g., communication, neuroscience, organizational behavior, psychology, and sociology). We hope that our review stimulates more interdisciplinary research on communication in TMS development, functioning, and outcomes in dyads, groups, and teams.

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