Organizing distributed knowledge for collaborative action: Structure, functioning, and emergence of organizational transactive memory systems

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APPENDIX 1. TMS ANTECEDENTS, MODERATORS, AND EFFECTS

Although findings of one unit of analysis may not be applicable to other units of analysis, many insights of TMS studies at dyad, tryad, and team level have been referred to in the three empirical research projects of this dissertation. At the same time, an extensive overview of these details has not been included in the introductory chapter (Chapter 1), as it would distract the reader too much from the core interest of this dissertation, which is at the organization level. Hence, these details are provided in this appendix. The appendix is structured as follows:

Section 1: Emergent characteristics of TMS
Section 2: Higher order contextual features and effects

Emergent Characteristics

In Table 1 an overview is presented of emergent characteristics that have been identified in the literature. In the following text each row is being discussed.

As Hollingshead (1998) noted, a TMS will only develop if actors perceive cognitive interdependence with others. This characteristic, which may change in time, may be expressed by the level of specialization found in the network (Moreland and Myaskovsky 2000). Whether the TMS is effective depends on the level of task credibility and task coordination (Moreland and Myaskovsky 2000). Using slightly adjusted constructs, Kanawattanachai and Yoo (2007) who studied TMS in virtual teams, found that expertise location and task cognition-based trust (task credibility) both increase task-knowledge coordination.

Distinguishing between initial, developing, and well developed TMS, Kanawattanachai and Yoo (2007) found that in the first two phases task-oriented communication has a positive impact on virtual team performance. In well-developed TMS task-knowledge coordination, defined as “the team’s ability to develop overlapping mental representations of how the task can be divided and the relationships
between subtasks and team members” (Kanawattanachai and Yoo 2007:786), does positively influence virtual team performance.

<table>
<thead>
<tr>
<th>Emergent characteristic</th>
<th>Definition</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specialization Expertise</td>
<td>the level of memory differentiation within a team, or, differently formulated; the extent to which team members know who on the team knows what</td>
<td>Moreland and Myaskovsky ’00; Lewis ’03; Kanawattanachai and Yoo ‘07</td>
</tr>
<tr>
<td>Task credibility; Cognition-based trust</td>
<td>team members’ beliefs about the reliability of other members’ knowledge and their ability to carry out the task</td>
<td>Moreland and Myaskovsky ‘00 Kanawattanachai and Yoo ‘07</td>
</tr>
<tr>
<td>Task coordination; Task-knowledge coordination</td>
<td>the ability of team members to work together efficiently; the team’s ability to develop overlapping mental representations of how the task can be divided and the relationships between subtasks and team members</td>
<td>Moreland and Myaskovsky ‘00 Kanawattanachai and Yoo ‘07</td>
</tr>
<tr>
<td>Accuracy</td>
<td>the degree to which group members’ perceptions about others’ task-related expertise are accurate</td>
<td>Brandon and Hollingshead ‘04</td>
</tr>
<tr>
<td>Sharedness</td>
<td>the degree to which members have a shared representation of the TMS</td>
<td>Brandon and Hollingshead ‘04</td>
</tr>
<tr>
<td>Validation</td>
<td>the degree to which group members participate in the TMS</td>
<td>Brandon and Hollingshead ‘04</td>
</tr>
</tbody>
</table>

Table 1: Emergent characteristics of TMS in the literature

Depicting the development of a TMS on a continuum ranging from highly divergent to highly convergent, convergence is the optimal state of TMS development, reflecting high levels of accuracy (degree to which perceptions about group members are accurate), sharedness (degree to which perceptions of group members are shared by all group members), and validity (degree to which group members actually make use of group members’ expertise) (Brandon and Hollingshead 2004).
Emergent social phenomena are highly complex and influenced by contextual factors at higher societal levels (Klein and Kozlowski 2000). Following one of the principles of Klein and Kozlowski for studying multi-level phenomena, ‘the relevant contextual features and effects from higher order levels should be incorporated into the theoretical models’, as they do have ‘either direct or moderating effects on lower-level processes and outcomes’ (Klein and Kozlowski 2000:15).

**Introduction to Higher Order Contextual Features and Effects**

In this section an overview is given of higher order contextual features that have been identified in the literature. To this end I extend the work of Ren and Argote (2011) and Lewis and Herndon (2011), who both conducted an extensive TMS literature review. Following the work of Ren and Argote (2011) a distinction is made between antecedents (table 2) and moderators (table 3). Antecedents are factors that condition the development of TMS. Moderating factors condition its outcome and performance.

Ren and Argote (2011) identify three types of antecedents, i.e. antecedents related to individual members (who participate in the team), related to the team, or related to the organization. Building on this classification I add three classes. First, following Brandon and Hollingshead (2004), who stipulated the importance to identify task as a factor next to people and expertise, I include a class of contextual features related to task. Second, I include a miscellaneous class for features not specifically related to one of the former categories. And third, as the level of TMS development is the only contextual feature that is recursively related to TMS development, I include this TMS characteristic as a special class.

**TMS Antecedents and Effects**

In Table 2 an overview is presented of emergent characteristics that have been identified in the literature. In the following text each row is being discussed.
<table>
<thead>
<tr>
<th>Contextual feature type</th>
<th>Contextual features</th>
<th>Effects</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual member characteristics</td>
<td>Surface, or diffuse cues (e.g. gender, age, ethnicity) and specific cues (e.g. experience, certificates)</td>
<td>Both are related to perceived experience. Only specific cues have intra-group influence</td>
<td>Bunderson and Sutcliff 2003; Wegner et al. 1991</td>
</tr>
<tr>
<td>Critical team member dispositional assertiveness</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With increasing expertise mental representations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>become increasingly abstract and decreasingly reliant on superficial features of a task</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Task characteristics interdependence</td>
<td>Cognitive</td>
<td>Most critical prerequisite for TMS development.</td>
<td>Brandon and Hollingshead 2004; Wegner et al. 1985</td>
</tr>
<tr>
<td>Task and goal interdependence</td>
<td></td>
<td>Both positively affect team performance. Both effects are mediated by TMS</td>
<td>Zhang et al. 2007</td>
</tr>
<tr>
<td>Team characteristics</td>
<td>Virtuality expressed in distances in terms of space, time, organizational boundaries, and culture; Use of technology mediated communication</td>
<td>May hinder ability to coordinate actions; lack of mutual knowledge; may be larger and more divers, and have less opportunity to train together</td>
<td>Bell and Kozlowski 2002; Bjorn and Ngwenyama 2008; Cramton 2001; Griffith and Neale 2001</td>
</tr>
<tr>
<td></td>
<td>Group training</td>
<td>Members of groups with highly developed TMS declare domains of</td>
<td>Moreland et al. 1996; Ren and Argote 2011; Rulke 2017</td>
</tr>
<tr>
<td>Contextual feature type</td>
<td>Contextual features</td>
<td>Effects</td>
<td>References</td>
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<td>-------------------------</td>
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<tr>
<td>Team member familiarity; group experience</td>
<td>Team member familiarity related to task may or may not result in higher expert recognition and utilization (if not related to task it does not). Ren and Argote (2011) speculate that the effect may depend on whether TMS processes are affected as well.</td>
<td>expertise during earlier periods of group interaction, while the frequency with which members evaluated others’ expertise and competence increases over time; TMS mediates the relationship between training and performance;</td>
<td>Akgün <em>et al.</em> 2005; Jackson and Moreland 2009; Littlepage <em>et al.</em> 1997; Michinov and Rulke and Rau 2000; and Argote (2011)</td>
</tr>
<tr>
<td>Task experiences</td>
<td>Direct task experience leads to higher ability;</td>
<td></td>
<td>Gino <em>et al.</em> 2010; Littlepage <em>et al.</em> 1997</td>
</tr>
<tr>
<td>Communication</td>
<td>Volume and frequency are both positively related to TMS development</td>
<td></td>
<td>Jackson and Moreland 2009, Kanawattanachai and Yoo 2007, Lewis 2004, Peltokorpi and</td>
</tr>
<tr>
<td>Contextual feature type</td>
<td>Contextual features</td>
<td>Effects</td>
<td>References</td>
</tr>
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<td>-------------------------</td>
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<tr>
<td>ICT mediated communication can be detrimental to TMS development if not accompanied with frequent face-to-face communication</td>
<td></td>
<td>Manka 2008; Lewis 2004</td>
<td></td>
</tr>
<tr>
<td>Organizational characteristics interdependence (mixed motives); Reward interdependence</td>
<td>need to share or withhold information</td>
<td>Jarvenpaa and Majchrzak 2008; Zhang et al. 2007</td>
<td></td>
</tr>
<tr>
<td></td>
<td>shared rewards lead to improvements in information allocation and reductions in social loafing</td>
<td>Pearsall and Ellis 2010</td>
<td></td>
</tr>
<tr>
<td></td>
<td>ineffectiveness of ICT, lack of common ground, and breakdowns in information flow</td>
<td>Less effective coordination</td>
<td>Reddy et al. 2009</td>
</tr>
<tr>
<td>Miscellaneous characteristics Acute stress due to time pressure or danger</td>
<td>reduced TMS related communication</td>
<td>Ellis 2006</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Stress due to challenge or hindrance</td>
<td>challenge stressors positively affect team performance and transactive memory, while hindrance stressors affect them negatively. In combination they lead to the lowest levels of performance and TMS</td>
<td>Pearsall et al. 2009</td>
</tr>
<tr>
<td>TMS development level</td>
<td>Level of convergence, specialization,</td>
<td>Different stages require different forms and accents of</td>
<td>Brandon and Hollingshead 2004; Littlepage et al.</td>
</tr>
<tr>
<td>Contextual feature type</td>
<td>Contextual features</td>
<td>Effects</td>
<td>References</td>
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<tr>
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</tr>
<tr>
<td>cognitive-based trust, and task-knowledge coordination</td>
<td>communication</td>
<td>In integrative knowledge structure knowledge overlap is larger than in differentiated knowledge structures; Explicit encoding schemes may negatively infer with existing implicit encoding schemes</td>
<td>2008; Kanawattanachai and Yoo 2007; Ren and Argote 2011; Wegner 1986</td>
</tr>
</tbody>
</table>

**Table 2: TMS antecedents and effects in the literature**

*Antecedents related to individual member characteristics.*

Wegner *et al.* (1991) identify three learning methods through which distributed expertise may become known, i.e. through stereotyping, perception and self-disclosure, and through knowledge of actors’ access to information. In their work they describe how people gain almost instant knowledge about someone’s capabilities through stereotyping, such as inferences from uniforms, posture, age, or sexe (Hollingshead and Fraidin 2003). Perceptions are further developed by self-disclosure of traits, skills, past activities, preferences, and emotions. The final method, knowledge about the actor’s access to information, includes facts like knowing who accessed the source, accessed it the longest time, or most recently. This type of knowledge is then used to infer which actor may have more, or more recent knowledge then oneself (Wegner *et al.* 1991). Where stereotyping is based on what Bunderson (2003) calls 'diffuse cues', perception and self-disclosure, and knowledge of actors’ access to information rely more on specific cues, such as experience and certificates.
One of the personality characteristics that does positively influence the development of TMS, and thus performance, is critical team member dispositional assertiveness (Pearsall and Ellis 2006). Critical team members are those with access to information that is vital for task completion (Brass 1984). It is perceived that dispositional assertiveness of critical members aids to team performance, as these persons ‘tend to be decisive, outspoken, forceful, and direct (Deluga 1988) and share ideas and information in a clear, confident manner (Hayes 1991).

Lewis et al. (2005) found that with specialization, individual representations of tasks become increasingly abstract and procedural (rather than declarative) in nature. This allows experts to recognize the structural qualities of tasks and contexts that are similar to the ones they have experience with. Thus, TMS developed within one context may positively impact TMS development in other (task) settings.

**Antecedents related to task characteristics**

One of the most critical prerequisites of TMS development is cognitive interdependence for completing a shared task (Hollingshead 1998; Wegner et al. 1985). Other researchers have examined the related concepts of task and goal interdependence (Zhang et al. 2007) and found that these, too, positively contribute to TMS development, and thus team performance.

**Antecedents related to team characteristics**

One important contextual feature influencing TMS development is the degree of virtualness, which may be defined as the degree of distribution of group members in time or space (Griffith and Neale 2001). To overcome these distances teams rely on technologically mediated forms of communication to coordinate their activities (Bell and Kozlowski 2002; Cordery and Soo 2008). Thus, virtual teams are defined as ‘groups of geographically and/or organizationally distributed participants who collaborate towards a shared goal using a combination of information and communication technologies (ICT) to accomplish a task’ (Bjorn and Ngwenyama 2008:2). Technologically mediated forms of communication
may impede communication cues (intonation and paralanguage), and visual cues, such as style of dress, gender, age, and behavior (Griffith and Neale 2001; Hollingshead 1998). Moreover, geographically distributed teams may experience a lack of mutual knowledge, which may render information retrieval coordination problematic (Cramton 2001). Other reasons why virtual teams may experience more difficulty to coordinate knowledge include the facts that they are often more diverse in nature, may be larger in size, making it more difficult to know who knows what, and there may be less opportunity to train together (Griffith and Neale 2001). Alavi and Tiwani (2002) and others (e.g. Griffith et al. 2003) assert that these difficulties may be mitigated by technology or organizational systems that support the development of TMS. Concrete examples include the fostering of a psychological safe communication climate (Cordery and Soo 2008); the use of ‘yellow pages’ and searchable repositories, such as bulletin boards where actors can pose and answer questions; and the construction of feedback mechanisms (Alavi and Tiwana 2002).

Moreover, Moreland et al. (1998) found that training together aids tackling the problem of fleeting membership in virtual teams, which is found to be as effective as priming, defined as providing actors in the network with a description of the capabilities of new actors (Moreland and Myaskovsky 2000). Other measures include the standardization of templates and methodologies across the network and the use of rich communication media, such as teleconferencing, complemented with occasional face-to-face contact (Oshri et al. 2008). The latter two are especially useful for moderating the difficulties in integrating information in virtual teams, by allowing actors to ‘develop a shared understanding of the task goals and the current state of accomplishment’, and which provide them with opportunities to organize monitoring, feedback, and evaluation (Curșeu et al. 2007:645).

Training may help to increase team performance through developing its TMS (Liang et al. 1995; Moreland et al. 1996). This is due to the fact that members of groups with highly developed TMS declare domains of knowledge in earlier periods of interaction then groups with less developed TMS, while the frequency with which members evaluate
other’s expertise and competence increases over time (Ren and Argote 2011; Rulke and Rau 2000).

Research findings with respect to the effect of team familiarity are mixed. In their analysis of TMS literature Ren and Argote speculate that familiarity may only have a positive influence on TMS development if TMS processes are affected as well (Ren and Argote 2011). Experience with the task, however, always has a positive effect on TMS development (Littlepage et al. 1997), and direct experience more so than indirect (through the experience of others) (Gino et al. 2010).

Frequency and volume of communication are positively related to TMS development (Lewis 2004; Peltokorpi and Manka 2008), as it provides members with the opportunity to demonstrate what they know and to learn to know what others know (Jackson and Moreland 2009). Moreover, communication is important in the early phases of TMS development when it is task oriented, and in mature TMS when it is oriented at task-knowledge coordination (Kanawattanachai and Yoo 2007). Frequent face-to-face communication is important in the initial TMS development phase, as well as for TMS to become more mature (Lewis 2004). ICT mediated communication did not influence TMS development during the initial TMS development phase, but it was found to be detrimental for TMS maturing if not accompanied with frequent face-to-face communication (Lewis 2004). Jackson and Moreland (2009) nuanced this finding. They found that face-to-face communication was particularly important in the early phases of TMS development, but less so in the later development phases. In contrast with these studies, Kanawattanachai and Yoo (2007) found that TMS may develop in virtual teams that solely rely on ICT mediated communication. The difference between these two findings may be explained by the differences in study context (Ren and Argote 2011). Where students involved in the first study had the opportunity to meet face-to-face, the students involved in the study of Kanawattanachai and Yoo could not.

Where Lewis et al. (2005) found that individual specialization facilitates knowledge transfer to new TMS settings, the ordering of individual contributions to organizational tasks in organizational routines
serves a similar purpose. That is, TMS developed in relation to one routine may aid the development of TMS in other settings, as long as the individual expert domains are recognized across task domains.

**Antecedents related to organizational context**

People work together in all kinds of organizational contexts, ranging from stable business units to temporal projects, and from startups to aged organizations. Such characteristics condition TMS development. Hence, in empirical studies these conditioning factors may be found as control variables (e.g. Jarvenpaa and Majchrzak 2008) or archetypes (e.g. Fiol and O’Connor 2005). In cooperation between (non) profit organizations, or organizations with convergent yet different motives, for example, the need to share information is balanced with the need to withhold information, because it may cause harm, or because its possession or access is restricted by law (Jarvenpaa and Majchrzak 2008). As a consequence, (informal) TMS structure is likely to reflect (formal) organizational structure (Wegner 1986).

Pearsall and Ellis (2010) studied the impact of reward interdependence on TMS development. Where individual reward systems may reduce individual information sharing (Johnson *et al.* 2006), shared reward systems reduce personal accountability (Karau and Williams 1993). Pearsall and Ellis found that hybrid reward systems outperformed individual and shared reward systems, by minimizing the risks of reduced information allocation (individual) and social loafing (shared reward systems).

Reddy *et al.* (2009), who studied coordination among teams in crisis situations, found that coordination is negatively affected by the ineffectiveness of information and communication technologies, the lack of common ground, and breakdowns in information flow.

**Miscellaneous antecedents**

Psychological stress may be related to personal factors, team factors, organizational factors, or environmental or other external factors. Psychological stress related to job-demand and control is often additive
Teams under stress, caused for example by time pressure of danger, tend to become more cohesive (Drabek and McEntire 2003), but also more closed, as the cost of coordinating new actors may be higher than their potential contribution (Moynihan 2009; Provan and Kenis 2008). In his study about the vulnerability of transient teams during crisis, Weick (1990; 1993) found that stress may result in several tendencies, which together may result in a functional breakdown of the team. That is, actors tend to regress to simpler mental models, become more self-centered, centralize command, and ignore data, which is not consistent with the conditions as perceived. Ellis (2006), who studied the relation between acute stress and the role of TMS and mental models, found that acute stress affects the levels of communication, especially those related to the processes of directory updating, information allocation, and retrieval coordination, thus disrupting transactive memory. The literature proposes several measures to mitigate the problems related to stress in transient teams, all aimed at increasing control. Measures include: previous working relationships (Moynihan 2009); cross-functional training (Ellis 2006); the development of shared mental models; the stimulation of active communication aimed at sense making; the cultivation of interpersonal skills and norms of trust and openness about stress and doubt; the over-learning of newly required skills (to reduce the likelihood of regression); by increasing the awareness of the conditions under which actors are vulnerable for false hypotheses (i.e. when they expect, want, or finish something, or when they are preoccupied); the generous distribution of discretion (Weick 1990); and the restructuring of teams towards more divisional structures (broad and independent) rather than functional structures (narrow and specialized) (Hollenbeck et al. 2002).

**Antecedents related to TMS development level**

With respect to stage of TMS development, Wegner et al. (1991) identify three progressively sophisticated learning methods through which distributed expertise may become known, i.e. through stereotyping, perception and self-disclosure, and through actual knowledge of actors’
access to information. In their work they describe how people gain almost instant knowledge about someones capabilities through stereotyping, such as inferences from uniforms, posture, age, or sexe (Hollingshead and Fraidin 2003). Perceptions are further developed by self-disclosure of traits, skills, past activities, preferences, and emotions. The final method, knowledge about the actor’s access to information, includes facts like knowing who accessed the source, accessed it the longest time, or most recently. This type of knowledge is then used to infer which actor may have more, or more recent knowledge than oneself (Wegner et al. 1991). These increasingly sophisticated learning methods suggest that TMS mature in an iterative manner. Within these cycles Brandon and Hollingshead (2004) identify three returning phases, i.e, construction, evaluation, and utilization. Through these phases useful links among task (T), expertise (E), and persons (P) emerge. During the iterations TEP-combinations are being ordered in useful hierarchies of nested knowledge domains that structure the TMS (Brandon and Hollingshead 2004:638).

Kanawattanachai and Yoo (2007), who studied TMS development in MBA-student project teams, distinguish between before midpoint (of early phase), midpoint, and after midpoint of project life. Looking at expertise location, task-knowledge coordination, and cognition-based trust, they found that the impact of these behavioral dimensions of TMS on team performance change over time. In the early stages of a project, task-oriented communication played an important role in the development of expertise location and cognitive-based trust, thus laying the foundation for team performance. Once expertise location and cognition-based trust have been formed, however, communication related to task-knowledge coordination becomes more important, mediating the development of expertise location and cognitive-based trust, and performance. This finding is consistent with the work of Littlepage et al. (2008). In their attempt to better understand the role of communication, they too, distinguish between a development and utilization of a TMS. Based on an experiment with collocated pairs of coworkers, they suggest that ´for intact work groups with a history of working together, additional communication at the time of task allocation [i.e. task-oriented
communication] over and above the background level of communication
that naturally occurs does not improve performance’ (Littlepage et al.

Wegner (1986) describes knowledge structures as ranging from
highly integrated to highly differentiated. Integrated knowledge structures
are those in which ‘the same items of information are held in different
individual memory stores and the individuals are aware of the overlap
because they share label and location information as well’ (Wegner,
1986:204). Differentiated knowledge structures are those in which
‘different items of information are stored in different individual memory
stores but the individuals know the general labels and locations of the
items they do not hold personally’ (Wegner, 1986:204). Hence, as
differentiated TMS allow for more specialization and provide access to a
larger pool of knowledge, differentiated TMS are more beneficial to
groups operating on complex tasks (Akgün et al. 2005). Knowledge
structures in TMS, including forms of coordination, may be both tacit and
explicit. Where the first is based on expectations, the latter is based on
explicit communication (Vaughan 1996; Wittenbaum et al. 1998). With
respect to the latter Wegner (1991) suggests that (new) explicit encoding
schemes may negatively infer with implicit encoding schemes that exist in
established TMS (Ren and Argote 2011).

**TMS Moderators and Effects**

In Table 3 an overview is presented of emergent characteristics
that have been identified in the literature. In the following text each row is
being discussed.

*Moderators related to task characteristics*

One of the task characteristic that is identified in TMS literature
that moderates the relation between the existing TMS and its performance,
is task complexity (Ren and Argote 2011). Akgün et al. (2005) describe
task complexity in terms of routine (routine or non-routine) and
knowledge (existing or novel solutions). They conclude that non-routine
work and work involving novel bodies of knowledge benefits more from
TMS than routine work or work that can be executed using existing bodies of knowledge. The reason is that novelness and variation may require the involvement of more people to deal with new information and knowledge, thus requiring more cooperation and coordination between team members.

<table>
<thead>
<tr>
<th>Moderator type</th>
<th>Moderators</th>
<th>Effects</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>task characteristics</td>
<td>Task complexity; task type</td>
<td>Non-routine work benefits more from TMS than routine work, because more variation may require the involvement of more people to deal with new information and knowledge</td>
<td>Gupta and Hollingshead 2010; Akgün et al. 2005</td>
</tr>
<tr>
<td>team characteristics</td>
<td>Team composition; diversity Fleeting membership (stability)</td>
<td>need for TMS fragmented memory; larger pool of knowledge</td>
<td>Moreland et al. 1996; Wegner 1986; Cordery and Soo 2008; Lewis et al. 2007; Moreland et al. 1996; Wegner 1986; Ren et al. 2006</td>
</tr>
<tr>
<td>Group size</td>
<td>Task and knowledge volatility</td>
<td>TMS are more beneficial in environments with high task volatility and knowledge volatility</td>
<td>Ren et al. 2006</td>
</tr>
<tr>
<td>Miscellaneous characteristics</td>
<td>New product technologies; customers preferences</td>
<td>Weakening relationship between TMS and team learning as well as lower speed-to-market</td>
<td>Akgün et al. 2006; Ren et al. 2006</td>
</tr>
</tbody>
</table>

**Table 3: TMS moderators and effects in the literature**

Gupta and Hollingshead (2010), who studied two types of task, i.e. recall and intellective, found that task type does moderate the relationship between TMS knowledge structure and group performance. Where most TMS researchers studied the effect of differentiated...
knowledge structures compared to the absence of knowledge structures, Gupta and Hollingshead (2010) are among the first to compare differentiated knowledge structures with integrated knowledge structures. Studying performance of (very) small work groups (3 members) they found that teams with more integrated TMS performed intellectual tasks faster and more accurate than groups with more differentiated TMS.

Recall tasks were performed faster by groups with differentiated TMS, yet less accurate, thus evidencing a decreased cognitive load. The conclusion Gupta and Hollingshead (2010) draw is that the advantage of a reduced cognitive load in differentiated TMS has to be weighted against the advantage of correcting errors in integrated TMS. Another argument to weigh these two alternatives stems from the work of Rau (2005). In her study on the moderating role of conflict and trust on TMS performance in top management teams, she cautiously concludes that too much diversity in top management teams operating in relatively stable environments may cause conflict, resulting in lower team performance. As a consequence she advises that ‘teams may need to trade off between the positive and negative effects of having different types of expertise on the team’ (Rau 2005:766-767).

Lewis and Herndon (2011) use two dimensions to categorize tasks. First, they distinguish between three procedural task characteristics, i.e. produce, choose, and execute. Second, they distinguish between three structural characteristics, i.e. task demands (divisible vs unitary), underlying goal structure (cooperative vs conflictual), and evaluative specificity of group outcomes (intellective vs subjective). Based on these dimensions they draft a number of propositions. They speculate that TMS relevance will be higher for execute tasks than for choose and produce tasks; when tasks are divisible rather than unitary; when the goal structure is cooperative rather than conflictual; and when task output is intellective rather than subjective. Moreover, they speculate that TMS development (thus, not moderating, but antecedently) will be higher when activities involve choose and produce tasks, rather than execute tasks, when tasks are divisible rather than unitary; when the goal structure is cooperative
rather than conflictual; and when task output is intellective rather than subjective.

**Moderators related to team characteristics**

A high levels of specialization may not only indicate the presence of a TMS (Moreland and Myaskovsky 2000), it also signifies that the team may benefit more from the development of a TMS by facilitating specialization and access to a larger pool of knowledge (Hollingshead 1998; Wegner, 1997).

Fluctuating team membership may impede TMS in two ways (Cordery and Soo 2008). First, it takes time to incorporate new members. Moreover, new members tend to adapt their specialization to substitute for members that have left. Although as a consequence TMS structure remains largely the same, TMS processes may be affected negatively (Lewis *et al.* 2007). This may be mitigated by asking old group members to “formally consider ways in which their collective knowledge structures might be leveraged, and even more importantly, how their own and others’ roles might be adapted prior to task execution” (Lewis *et al.* 2007:175). Second, access to leaving members may be restricted, rendering the related meta-knowledge fragmented (Moreland *et al.*, 1996; Wegner 1986).

Team size in most TMS-related studies focus on dyads and small groups (up to 5) (e.g. Hollingshead 1998, 1998a, 2000, 2001; Michinov and Michinov 2009; Jackson and Moreland 2009) to groups up to 20 members (Palazzolo *et al.* 2006). Ren *et al.* (2006) forms an exception, studying groups ranging from 3 to 35 members. They found that although groups of all sizes benefit from established TMS, TMS were more beneficial to larger groups in terms of efficiency and speed, while TMS in smaller groups tend to be more beneficial in terms of decision quality. This finding is confirmed by the work of Palazzolo and colleagues (2005, 2006). They found that network size is negatively related to the average number of communications within the network, which negatively affects both the process of differentiation and the accuracy of expertise recognition.
Task volatility (frequency at which tasks change) and knowledge volatility (speed at which knowledge decays) render some individual knowledge obsolete and force individuals to search for knowledge in the rest of the team. Consequently, TMS become more valuable with high task or knowledge volatility (Ren et al. 2006).

**Miscellaneous moderators**

A final class of features that moderate the performance of TMS is environmental turbulence. Akgün et al. (2006) distinguish between turbulence caused by market dynamics and turbulence caused by technological development. High turbulence renders some team knowledge obsolete, old-fashioned, and misleading, and forces the team to search for new knowledge to address the change. As a consequence Akgün et al. (2006) conclude that TMS are less useful within high turbulent environments. This finding seems inconsistent with the conclusion Ren et al. (2006) with respect to task volatility. According to Ren and Argote (2011) the explanation can be found in the level at which the knowledge becomes obsolete. Where in environmental turbulence team knowledge may be affected, in task volatile environments individual knowledge may become obsolete.