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An Exploratory Study of Transactive Memory System Development in a Geographically Distributed Temporary Organization

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# An Exploratory Study of Transactive Memory System Development in a Geographically Distributed Temporary Organization

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## Abstract

As part of measuring training effectiveness of distributed simulation based training and exploring the impact of communication condition on military organizing, we conducted an exploratory investigation of transactive memory system (TMS) development in a distributed temporary organization comprising one Control and Report Center (CRC) and two frigate Anti-Air Warfare (AAW) teams. The JADE II joint tactical training capability prototype facilitated this investigation.

TMS have been proposed as an important way in which organizations enable information processing. However, there is to our knowledge little research on TMS development in a military context. Specifically, whether exposing an organization to multiple training sessions in a short period of time would enhance a TMS were investigated in this study. Furthermore the impact of perceived task complexity, safety organizing and perceived media richness on TMS was investigated. The impact of TMS on mutual understanding and perceived situation awareness was also measured.

The tentative findings suggest that differences in routines and vocabulary between CRC and the AAW organization on joint tasks necessitated this kind of training. Being able to make unforeseen events and coordination problems into an occasion for learning and develop shared vocabulary and routines seem to be particularly important for this kind of temporary and distributed organizations.


**Keywords:** Joint Operations, Transactive Memory Systems, Distributed Organizations, Temporary Organizations, Safety Organizing, Task Complexity, Media Richness, Mutual Understanding, and Situation Awareness

## Introduction

Network Enabled Capabilities implies both possibilities for more flexible utilization of sensors and effectors as well as challenges in how these capabilities are utilized. Although information may be available, whether it is made into actionable information may still rest on the capabilities of the organization to process that information and on the basis of that process coordinate action (Smith, 2006).

Several structural and processual features of organizing may impact information processing and coordination; among the most prominent are organizational structure, the composition of the teams, and the complexity of the task environment. However these are features of organizing that to our knowledge is quite thoroughly discussed in a military context. On the other hand, the dynamic development of knowledge of others expertise is to our knowledge not discussed at length in a military setting. We believe however, that it is valuable to look into this particular mechanism as a way in which in particular ad hoc and distributed organizations enable information processing.

Knowledge of others expertise may facilitate task oriented communication rapidly as members of an organization have a common ground through their shared understanding of others expertise. Rapidly understanding information and messages as intended by the sender as well as understand work processes and facilitate coordination may be a positive outcome of such common ground. Shared knowledge of others expertise may also ensure that communication, shared sensemaking and development of shared situation awareness are enabled across geographic distances.

## The concept of transactive memory system and the research problem

Two geographically dispersed organizations were combined into one ad hoc organization through a simulated environment, and this context allowed us to explore one aspect of organizations that might positively influence information processing in a network enabled military organization: transactive memory system (TMS) (Rau, 2006).

TMS is defined as the shared division of cognitive labor with respect to encoding, storing and retrieving knowledge from different domains (Lewis, et al., 2007, p. 160). The idea underlying the concept of TMS is that if an organizational member know in principle what the other members expertise are, have trust in their knowledge, and have enabled good coordination, it is possible to direct critical issues to the right person having the right expertise. In this sense the existence of TMS may be seen as a structural and processual mechanism by which an organization easily may draw upon the different organizational members' cognitive resources but at the same time not overloading the members with requests to know in detail the expertise of every other member. TMS may also be part of the common ground that facilitates effective task oriented communication.

It is suggested that TMS takes time to develop in organizations and that some factors are more likely to impact the development of TMS, although it is not clear-cut which is most important in all settings (Lewis, et al., 2007). Furthermore, although TMS may have positive effect on performance, it is not clear whether TMS enables the kind of knowledge needed in a military organization. We therefore wanted to explore more in detail not only the antecedents but also the possible outcomes of TMS in military decision-making.

In particular we wanted to investigate TMS development in a distributed temporary military organization. Although the technical development, facilitates working distributed and joint, more knowledge is needed on what organizational capabilities facilitate working in such organizations (Alge, et al., 2003).

The aim of this study was thus to develop further an understanding of:

<u>What are the factors that may enhance TMS in a distributed temporary military organization?</u>

<u>What is the utility of TMS in a distributed temporary military organization?</u>

To explore the first question we wanted to investigate the impact of objective task characteristics and perceptions of task as well as task related communication and quality of communication condition on TMS development. We attempted to explore the second question by investigating whether situation awareness and mutual understanding were enhanced by TMS as these factors may influence military decision making positively.

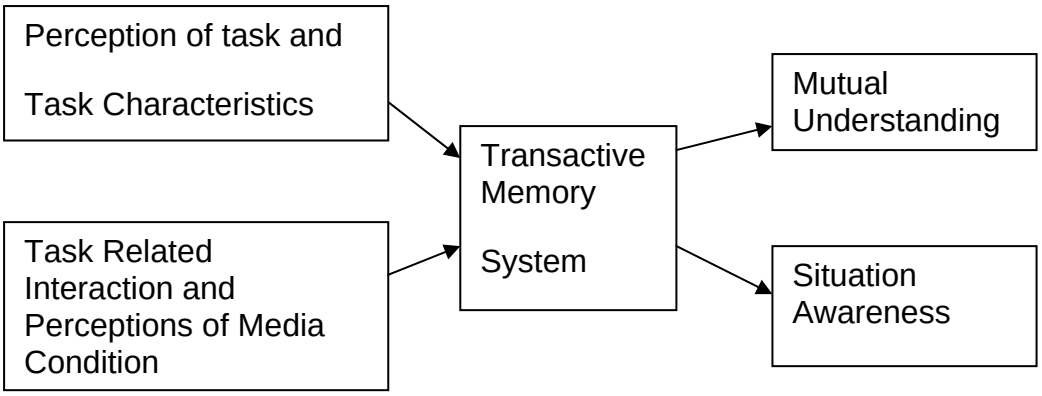


Figure 1. Antecedents and outcomes of transactive memory system.

In order to substantiate the discussion we collected data during two days of a distributed training and simulation of tactical decision making comprising cooperation between a Control and Report Center (CRC) and an Anti-Air Warfare (AAW) organization onboard two frigates (a maritime task group). The personnel at the CRC did not know the personnel on the two frigates before the simulation started so the organization was in that sense temporary (Bechky, 2006). Additionally, the collocated CRC and the two collocated frigates worked together geographically distributed (Boyer O`Leary & Cummings, 2007). The data were collected during the Joint Air Defence Training Simulation (JADE) II experimental held October 22-25 2007. ( For a detailed description see: Staal, et al., 2008).

We were not able to compare with a collocated only and non-temporary organization, so it cannot be claimed that the findings are typical of temporary distributed organization. We can only direct attention to what took place in this particular simulated temporary and distributed organization. Our analysis may provide knowledge that further the development of studies of collective knowledge in military settings, as well as give a background on what the factors are that may be crucial in the development of TMS and its utility. Additionally, it may contribute to knowledge of whether exercises like the one described in this study is a valuable way of achieving TMS in distributed temporary military organizations, Finally we hope to contribute to more detailed knowledge on how such training can be conducted.

## Theory: Antecedents and outcomes of TMS

Elaborating on the two research questions stated in the introduction and the factors shown in figure 1 we describe more in detail the assumptions underlying possible antecedents and outcomes of TMS.

### *Antecedents of TMS*

The theory of TMS suggests that knowledge of others expertise is an important component of this construct, as well as trust in others knowledge and quality of coordination. Although expertise may be defined in terms of roles that are superimposed on individuals (the military

rank system may be an example) expertise in the sense developed in the TMS literature also refers to situated expertise and the development of trust in coworkers in practice and the learning of specific ways of coordinating work. In particular two related conditions, may serve to enhance this development: Exposure and perceptions of task, and communicative activity that relates to the task.

*Exposure to multiple tasks and perceptions of task*

Exposing an organization to multiple tasks, which differ in objective surface characteristics but are functionally similar, may ensure the development of a more flexible TMS (Lewis, 2005). By interacting in different ways the expertise may be utilized in diverse ways and thus the knowledge of others expertise may be more comprehensive and generalizable.

However the subjective perception of the task is also known to be an important factor determining task related activity (Haerem & Rau, 2007). Drawing on theories and research of the effect of task complexity on organizational structure and processes it is suggested that perceptions of tasks as having high levels of complexity may trigger the need for more interaction among organizational members (Perrow 1967, Van de Ven, et al., 1976). Recent research suggests that in particular tasks that are perceived as having high variability and low analyzability (variability and analyzability being the dimensions of task complexity) may trigger more participation in certain group processes that are task-related (Chong & Johnson, 2007). One explanation might be that not knowing a task fully motivates search for information about the task and involvement of coworkers. Following the suggestion from Lewis, et al., (2005) task-related interaction may increase the knowledge of others expertise and thereby positively influence TMS development.

Thus we suggest that both objective factors such as number of tasks, which differ in objective surface characteristics but are functionally similar, and subjective factors such as perception of analyzability and variability of tasks, may influence TMS development.

*Communicative activity: Safety organizing and perceived media richness*

Interaction that exposes actors to the specific contributions that other make to a task, i.e. task related interaction, may be valuable in order to develop a TMS ( Majchrzak, et al., 2007). In particular task related interaction may enable TMS development as it may make visible what other contribute to the task as well as build trust in their capability of performing tasks. These theories are clearly linked with those focusing on task conditions described above, but focus more on the specific task related communicative interaction types as what may enhance TMS development.

A conceptualization of task related activities that are especially important in high reliability organizations, such as military organizations, is the concept of safety organizing (Vogus & Sutcliffe, 2007). Safety organizing is defined by the central behaviors that enable mindful organizing: preoccupation with failure, reluctance to simplify interpretations, sensitivity to operations, and commitment to resilience and deference to expertise (Vogus & Sutcliffe, 2007). This particular activity type may be especially important in developing the kind of TMS needed in a military setting as it relates to crucial behaviors in military decision making.

However the technological conditions may impact the quality of this communication (Weick & Sutcliffe, 2001). Based on media richness theory the ability of the media to support the

specific types of information exchange necessitated by the task conditions may impact the extent to which it supports group interaction (Daft & Lengel, 1986). Media richness refers to a mediums capacity to facilitate shared understanding (Daft, et al., 1987). Although media may have specific objective characteristics, users experience in using a media may impact their ability to utilize the media for communication purposes and these perceptions may enhance the richness of the media (Rice & Gattiker, 2001). In particular in geographically distributed organization knowledge of others expertise and trust as well as coordination may be impacted by perceptions of the media condition and the lack of face-to-face communication may hamper TMS development. Thus we suggest that both safety organizing and perceived media richness may impact the development of a TMS in a distributed temporary military organization.

*Outcomes of TMS*

Two factors that may be particularly relevant to temporary distributed military decision making is to achieve mutual understanding and situational awareness. These factors relate to information exchange and problem formulation, two crucial aspects of process performance within high reliability organizations (Waller, 1999). Mutual understanding may be important for information exchange and situation awareness may be crucial for problem formulation. Whether a TMS contribute to these factors may validate the utility of the concept in this particular setting.

*Mutual understanding and situation awareness*

Perceptions of whether mutual understanding was achieved may indicate to what extent the information exchange contributed positively to task related interaction (Katz & Te´eni, 2007). Mutual understanding, understanding of a message and awareness by the communication partner that they have understood the message, may be crucial if one wants to communicate task related information in highly interdependent work. If one already knows the expertise and have trust in the communication partner such mutual understanding might be easier to develop.

As pointed out by Weick & Sutcliffe (2001) one of the distinguishing features of high reliability organizations are sensitivity to operations. Situational awareness, the perception of the elements in the environment within a volume of space and time, the comprehension of their meaning, and the projection of their status in the near future ( Endsley, et al., 2003, p. 13), may be regarded as an important part of an ongoing shared sensemaking activity aimed at making continuous adjustments to unexpected events and maintain operational activity. Situational awareness is specifically important in a tactical task that involves continuous updating on the situation on the battlefield.

Furthermore, it is proposed that a richer set of mental representations may enhance the ability to make sense of a task environment (Weick & Sutcliffe, 2001). As a more fully developed TMS may function well for a diverse set of tasks that share the basic functional characteristic, but may differ in surface characteristics, it may be likely to see a more flexible TMS as consisting of richer mental representations of a task environment and therefore enhance situation awareness. Based on these considerations mutual understanding and situation awareness may be enabled by a TMS in a distributed temporary military organization.

*Control variables*

Drawing on previous investigations of TMS development, intragroup conflict may hinder task related activity and thus hamper the development of TMS (Rau, 2006). Additionally a geographically distributed organization poses specific challenges that may be influenced by experience of working geographically distributed (Bunderson, 2003). These variables should therefore be taken into account in the analysis of factors impacting TMS development.

## Method

*Research design*

We applied a combination of quantitative quasi-experimental design and qualitative observation of a training organization in order to obtain empirical data. For the quantitative quasi-experiment we ran one organization through two days of training and gave this group a questionnaire on background variables before the experiment started and a questionnaire with items relating to the variable of the research model and intragroup conflict after each day of training. In order to compare the scores on TMS with a group that were not exposed to the same type of tasks we gave the questionnaire on TMS to a group that received only one day of training with a less complex task. We were able to obtain some expert observations, although they did not cover all locations each day. Figure 2 summarizes the data we obtained.

| **Quantitative data** |
|---|
| •Control group (n=4: 2 at the Control and Report Center (CRC) and 2 at the AAW organization)<br><br>– Questionnaire on background variables before task -Test obtained after one day of training with low complexity task<br><br>•Pretest and post test of a training group (n=8: 4 at CRC and 4 at AAW organization)<br><br>– Questionnaire on background variables before task -Test obtained after 1st day of training with task of moderate complexity and after 2nd day of training with a task of higher complexity |
| **Qualitative Observation** |
| • Expert observation of the control group and the training group on day 1 and 2 at the AAW organization<br><br>•Observation by researchers of the training group on day 1 at CRC |

Figure 2. Data obtained

The level of analysis was the group level, although it should be emphasized that the low sample rate does not permit a strict statistical analysis at this level.

*Experiment organization*

The experiment organization in this experiment comprised one CRC and two frigate AAW teams. The CRC were collocated but the AAW organization worked distributed. The whole organization was thus distributed. For the training group there were 4 persons at each place who completed the questionnaire, in total 8 persons. However, there were additional personnel at both CRC and the AAW organization. In other words, we only obtained quantitative data from some of the members of the organization. However, the qualitative observations encompassed all the individuals in the organization.

*Research participants and tasks*

The participants were professional officers and civilian experts manning CRC and working on naval vessels as part of their daily job. Those responding to the questionnaires came from all the different functions that were manned, as well as were personnel with both senior and lower rank, and more and less expertise. Except for one, all the participants in the training group were male. All the participant in the control group were male.

Three *tasks that differ in surface characteristics* but which have the same functional characteristics were identified in the training program based on the guidelines outlined by Lewis (2005). Based on guidelines by experienced military instructors all the tasks were intended to train basic coordination and procedures and in this respect they are functionally similar. However, the different tasks ad in the number and intensity of incidents so that the first task is relatively simple, the second require more decisions, and the third exposes the participants to more events so as to ensure that the surface characteristics vary between the tasks.

*Measures*

The indicator of *TMS* was the fifteen items, five point scale; generic measure developed by Lewis (2003) reflecting specialization, credibility and coordination. *Safety organizing* was measured by the nine items, seven point scale, measure developed by Vogus & Sutcliffe (2007). *Perceived task variability* and *perceived task analyzability* were measured by the nine items, seven point scale, developed by Withey, et al., (1983). *Mutual understanding* was measured by the 8 point scale developed by Katz & Te´eni (2007). *Perceived media richness* was measured by an eight item, seven point scale (Dennis & Kinney, 1998). *Perceived situational awareness* was measured by the three items, seven point scale, developed by Eid, et al., (2004). *Intragroup conflict* was measured by an eight item, five point scale, instrument developed by Jehn (1995). Some minor adjustments of the wording were made to some of the measurements so as to adapt it to a military context.

The control variable *expertise working in a geographically distributed team* was measured by a five item instrument (figure 3), scored on a seven point scale ranging from 1 “not at all” to 7 to “a very great extent”, based on the characteristics of dispersion in teams as outlined by Boyer O´Leary & Cummings (2007). Face validity of the questions were ensured through discussion among the researchers, further pilot testing of the instrument ensuring the validity and reliability of the instrument should therefore be conducted and the results on the variable *expertise working in a geographically distributed team* should be seen as tentative.

| **Dimension of dispersion** | **Item** |
|---|---|
| Spatial: Geographic distance among team members | To what extent has it been a large geographic distance between you and other team workers working with you? |
| Temporal: Time difference among team members | To which extent do you have experience working with team members, located in other time zones than yourself? |
| Site (Configurational): Locations where team members work | To which extent do you have experience working with team members, located at other locations than you? |
| Isolation (Configurational): Locations where team members work alone | To what extent were you the only one at your location working with team members located elsewhere? |
| Imbalance (Configurational): Locations with uneven distribution of team members | If you have been participating in teams, which were geographically distributed, to what extent did your location have most of the team members? |

Figure 3. Experience working in a geographically dispersed team: items

*Distribution of questionnaires*

A questionnaire on the background variables were given prior to involvement in the tasks. The different other subjective measures were obtained once after each day: Twice for the training group, and once for the control group. The respondents were instructed to take into account the whole organization, both CRC and the maritime task group, and to consider the most recent day of training when answering the questionnaire after each day.

*Qualitative observation*

In order to get a broader view on what were the factors impacting TMS development and its use, we did qualitative observation. The main parameter guiding the observation was to notice whether there were changes in responses to unexpected events. These events posed special problems for the organization and we expected the way in which they were solving these problems could tell something about the way in which the knowledge of others were utilized, how this use came about and in what ways it contributed to the operation (Waller, et al., 2004).

## Results

As the low sample of this study does not permit a strict statistical analysis, the results should be viewed as tentative and only indications of what might be general tendencies. The following section provides a resume of the quantitative and qualitative results.

*Data screening and control variables*

According to the data analysis all variables measured had a normal distribution and none of the control variables correlated significantly with the variables in the research model. However it should be noted that motivation correlated positively with TMS trust, experience working distributed correlated with TMS coordination, and being an experienced user of information technology correlated negatively with TMS.

*Transactive memory system development*

We ran an within group interrater reliability analysis (r*wg*) in order to acquire knowledge on whether the respondents in fact agreed on their rating of TMS and a TMS developed (Lewis, 2005). The results indicated that for all indicators of TMS the value on interrater-agreement were above the required level of 0.7, ranging from 0.86 to 0.96, indicating that a TMS developed both in the training group and the control group. The mean values on the indicators of TMS ranged between 3.5 to 4.1 which was quite high considering the scale of TMS ranging from 1-5, with 5 as the highest score. When comparing the mean scores from the training group with that of the control group, only trust in others knowledge (credibility) was marginally significantly higher in the training group (independent sample t-test showing $p$= 0.06). However, scores on both knowledge of others expertise (specialization) and coordination were higher for the training group. The mean scores and interrater-agreement scores on TMS are presented in figure 4.

| | **Control group**<br><br>**day 1**<br><br>**(mean score/interrater - agreement)** | **Test after**<br><br>**day 1**<br><br>**(mean score/interrater - agreement)** | **Test after**<br><br>**day 2**<br><br>**(mean score/interrater - agreement)** |
|---|---|---|---|
| **TMS Specialization** | 3.7/0.96 | 3,8 / 0.95 | 3.9 / 0.93 |
| **TMS Credibility** | 3.7/0.93 | 4.0 / 0.95 | 4.1 / 0.98 |
| **TMS Coordination** | 3.5/0.94 | 3.5 / 0,86 | 4.1 / 0.95 |

Figure 4. Mean scores on the indicators of TMS and interrater -agreement values for the control group and the training group

*Factors affecting transactive memory system*

Having established that a TMS developed in the training group we investigated to what extent the factors thought to impact TMS development related to the indicators of TMS.

As the indicators of TMS was higher in the training group we may have an indication that exposure to multiple tasks with differences in surface characteristics but which is functional similar might enhance TMS development, in particular trust seemed to be enhanced by the training.

There were mixed results with regard to the impact of task analyzability. Perceiving the task to be analyzable in fact correlated negatively with knowledge of others expertise on day 1 of training, pointing in the direction of our initial assumption that being able to analyze the task does not necessarily lead to better knowledge of others expertise. However perceiving the task to be analyzable correlated positively with trust in others expertise and coordination on day 1 of training. The same indications were seen on day 2 of training. This suggests that task analyzability may have a mixed impact or relationship with TMS development. Knowing the task well is not necessarily a guarantee that one knows about others expertise, although knowing the task well seem to relate positively to trust in others expertise and perceptions of coordination.

For task variability the results were less marked and variability correlated negatively with knowledge of others expertise on day 1 of training and positively on day 2, similar results were found for trust and coordination on day 2.

With regard to task related interaction, safety organizing seem to relate positively with trust in others expertise and coordination on day one of training and negative relationship with knowledge of others expertise. However, this tendency did not last and safety organizing related negatively to all aspects of TMS on day 2 of training. Almost the same tendency was found with regard to perceptions of media richness. Initially perceptions of media richness as high, related positively to trust and coordination, however there were a negative relationship with knowledge of others. On day 2 of training media richness related negatively to both expertise of others and only marginally positively to trust in others knowledge.

*Influence of TMS on mutual understanding and situation awareness*

Knowledge of others expertise related positively to mutual understanding on day 1 of training. However, trust in others knowledge and coordination correlated negatively with mutual understanding on day 1 of training. On day 2 of training none of the indicators of TMS correlated positively with mutual understanding. On day 1 of training all of the indicators of TMS contributed negatively to perceived situation awareness. On day 2, however, knowledge of others expertise correlated positively, but very marginally with perceived situation awareness. All the other indicators of TMS had a negative relationship on day 2. The scores on both mutual understanding and perceived situation awareness remained high and did not change significantly from day 1 to day 2 of training. Summarized, knowledge of others expertise seem to influence mutual understanding and perceived situation awareness positively.

The appendix provides a correlation matrix and means and standard deviations on the variables in the conceptual model.

*Qualitative observation*

Summarized, the observations indicate that both knowledge of others expertise, trust in others knowledge and coordination developed somehow as part of the training. Most of the observations suggested that the training resulted in a more orderly and efficient coordination and that coordination were better on day 2 of training. Situation awareness in general was good according to the impression from the observers.

The observations revealed that faced with unexpected events the AAW organization compared to the CRC resorted to different routines. One incident showed that the organization at some points had problem coordinating as a result of the time lag initiated by the lack of coherence in routines. This incident pointed to limitations of knowledge of others expertise. AAW experts commented that it was difficult to know the vocabulary used by the personnel at the CRC. The observations revealed that negotiations and informal talk occurred when procedures were unclear; however these events for which there was no shared vocabulary posed some unrest with the organization. The training situation revealed such shortcomings and could be viewed as a possible arena for resolving these difficulties and developing new routines and modifying existing routines in the organization. Figure 5 below show the most important observations by the expert observers and the researchers.

| |
|---|
| **AAW organization expert 1 (every group and day):**<br><br>In general better coordination and less unrest with regard to decision making on day 2 compared to day 1 of training. Situation awareness and understanding the mission was less of a challenge, coordination most challenging. Misunderstanding between the frigates and the CRC due to different vocabulary on day 1 of training. (Lasting approx 5-10 min). Changed the organization from less specialized to more task based on the day of the control group contrary to NATO procedures. |
| **AAW organization expert 2 (every group and day):**<br><br>Coordination was better on day 2 of the training. Situation awareness was good. Both knowing the expertise and the vocabulary of the other team were difficult. NATO-procedures do not cover all the processes involved in these tasks. A lot of technical focus initially for the training group |
| **Researcher 1 (CRC day 1 of training):**<br><br>Coordination was best during the last vignette. Misunderstanding with the AAW organization regarding track and/or handover approx 10 min (a lot of confusion at CRC). During first vignette and during resolution of ambiguous task in later vignettes a lot of face-to-face communication at the CRC. A lot of jargon used and mostly very efficient use of modifications to this jargon to convey additional information not covered by keywords and/or known procedures. Some technical difficulties |

Figure 5. Qualitative observations of the training and control group.

## Limitations

This study has, as already mentioned, several limitations. First of all, the situation in which we sought to develop an understanding of TMS development in a military setting, and its effect were not specifically designed to collect data on these phenomena. It was also noted by the observers that especially initially on day 1 of training there were several technical difficulties that interrupted the vignettes in short time intervals.

In further research on TMS development, and its utility, more care should be taken to be able to systematically collect data, and to run several experiments that would permit more rigorous

statistical and qualitative analysis. Also the sensitizing effect of giving the same questionnaire to the same group should be controlled for by having control groups that only receive the questionnaire at the end of training.

The operationalizations used in this study should be reconsidered and modified in subsequent studies. TMS measurement as such may consider the specific context more in detail, and a combination of both generic and specific measurements may be important as well as extending the measurement of TMS to the measuring of memory repositories such as information services.

As to the independent variables emphasized in this study there could be several extensions. Manipulating more systematically the use of specific communicative styles and communication modes may increase the knowledge of communication. Exposing the organization to more tasks then those used in this training session may tell more about the utility of specific tasks in developing a TMS.

The full utility of TMS may better be viewed when seen in relation to more specific measures of process and outcome measures of performance (Waller, 1999). This may reveal more about the exact utility of the TMS concept in explaining performance.

Other constructs than the ones investigated here might be of interest, such as the importance of role knowledge and education and the ways in which communication takes place between teams. Additionally a more grounded qualitative approach might reveal a broader range of theoretical themes that might be interesting to consider with regard to TMS in a specific military setting.

## Discussion and conclusion

This exploratory study highlight some issues for further elaboration and study, rather than suggests specific guidelines for development of transactive memory system or suggesting in what way TMS may contribute in military decision making. However, some comments on the factors that might impact transactive memory system development and its utility can be made on the basis of our observations and quantitative data.

The study seems to indicate that going through the type of training described here, is developing trust in others knowledge to a larger extent than not going through it. Comparing the quantitative and qualitative results there seem to be indications that TMS improved during the training. The factor impacting it positively may have been the possibility of interacting in this simulated environment, as the observations to some extent revealed.

Although both safety organizing and perceived media richness had a positive impact on trust in others knowledge, there were no clear indication on their contribution to TMS development. There were no strong indications of the utility of TMS for mutual understanding and situation awareness, however knowledge of others expertise may contribute positively to these factors.

Task analyzability may have a differential impact on TMS development. As suggested by previous empirical work task analyzability did not relate positively to acquiring knowledge of others expertise; however, it related positively to trust in others knowledge and coordination.

We can not conclude what is cause effect in this relationship, and the findings remain highly tentative.

Task analyzability may initiate trust in other and coordination, but is not enough to gain knowledge of others expertise. A feeling of knowing less of the task may be necessary in order to engage in seeking knowledge of others expertise. The practical implication of this might be that the actors need to differentiate between knowing the task well enough to initiate trust building and coordination, and realizing that one does not know procedures in a joint task necessitating a need to engage in task related discussions with coworkers. Training programs aimed at developing TMS may gain from pointing out this fact early in the training. The positive value of lack of analyzability with regard to initiating information search, and in some instances through this process the acquiring of knowledge of others expertise, may be highlighted in such training programs. In particular with regard to the training of ad hoc teams such considerations can be valuable.

Developing ways in which these instances of low analyzability can be made into occasions of learning may be a great challenge. Availability of rich communication media and debriefing procedures could be particularly important to achieve this aim. Especially in distributed work, where rich communication conditions may not be present, special care should be taken to moderate the effect of distance between the organizational actors for instance by experimenting with new information and communication technology allowing more information sharing.

Importantly: new ways of sharing information may impact cooperation in ad hoc and distributed teams in ways that differ from the present case. Specifically the introduction of availability of sensor data as services and a possibility of less manual transfer of these data may ease the process of exchanging data. However in some cases the coordination of what areas sensors may cover may still rest on the capability of the organization to exchange viewpoints through human-to-human dialogue. Thus the availability of means of rich communication media may be essential allowing for feedback, sharing of viewpoints and building of relationships. However, possible trade offs in an operational setting between rich media and cognitive processing needs to be discussed.

In summary, we will emphasize the need to develop the knowledge of the role of TMS further. In particular it should be compared to other constructs of collective knowledge such as shared mental models. Additionally, studies aiming at determining what the crucial factors in TMS development are, should be designed to allow comparison between distributed and collocated organizations, comparison between specific training programs, more refined process and outcome measures of performance, and evaluations of the importance of the use of information and communication technology.

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**Appendix: Correlations and Descriptive Statistics for the Training Group.** n = 8 , * Correlation is significant at the 0.05 level (2-tailed)., ** Correlation is significant at the 0.01 level (2-tailed)

| | Mean | s.d. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. Safety Organizing Day 1 | 4,97 | ,46 | | | | | | | | | | | | | | | | | |
| 2. Safety Organizing Day 2 | 5,26 | ,56 | ,86 ** | | | | | | | | | | | | | | | | |
| 3. TMS Specialization Day 1 | 3,83 | ,41 | -,25 | -,34 | | | | | | | | | | | | | | | |
| 4. TMS Credibility Day 1 | 4,05 | ,40 | ,65 | ,71* | -,51 | | | | | | | | | | | | | | |
| 5. TMS Coordination Day 1 | 3,45 | ,64 | ,23 | ,48 | -,05 | ,60 | | | | | | | | | | | | | |
| 6. TMS Specialization Day 2 | 3,98 | ,47 | -,03 | -,18 | ,87 ** | -,42 | -,26 | | | | | | | | | | | | |
| 7. TMS Credibility Day 2 | 4,18 | ,23 | ,08 | -,22 | -,06 | ,40 | ,13 | -,22 | | | | | | | | | | | |
| 8. TMS Coordination Day 2 | 4,05 | ,40 | -,15 | -,24 | ,03 | ,35 | ,03 | -,05 | ,66 | | | | | | | | | | |
| 9. Task Variety Day 1 | 5,05 | ,67 | ,38 | ,52 | -,64 | ,34 | ,06 | -,27 | -,46 | -,47 | | | | | | | | | |
| 10. Task Analyzability Day 1 | 4,06 | 1,50 | ,43 | ,54 | -,03 | ,74 * | ,72* | ,09 | ,12 | ,20 | ,35 | | | | | | | | |
| 11. Task Variety Day 2 | 5,00 | ,93 | ,22 | ,11 | -,27 | ,39 | ,17 | ,01 | ,16 | -,06 | ,63 | ,61 | | | | | | | |
| 12. Task Analyzability Day 2 | 4,53 | 1,24 | ,29 | ,40 | -,47 | ,82* | ,56 | -,31 | ,27 | ,36 | ,51 | ,85 ** | ,72 * | | | | | | |
| 13. Sit. Awareness Day 1 | 5,13 | ,69 | ,30 | ,01 | -,01 | -,13 | -,32 | -,05 | ,15 | ,15 | -,31 | -,41 | -,44 | -,40 | | | | | |
| 14. Sit. Awareness Day 2 | 5,25 | ,46 | -,08 | -,25 | ,17 | -,60 | -,66 | ,12 | -,21 | -,08 | -,39 | -,81 * | -,72 * | -,82 * | ,78 * | | | | |
| 15. Mut. Understanding Day 1 | 4,33 | ,79 | ,17 | ,05 | ,28 | -,45 | -,04 | ,20 | -,37 | -,50 | -,11 | -,30 | -,33 | -,55 | ,64 | ,59 | | | |
| 16. Mut. Understanding Day 2 | 4,31 | ,47 | -,02 | -,40 | -,08 | -,50 | -,66 | -,06 | ,12 | -,19 | -,13 | -,71 | -,13 | -,55 | ,70 | ,71* | ,54 | | |
| 17. Perceived Media Richness Day1 | 4,63 | 1,25 | ,00 | ,19 | -,17 | ,26 | ,55 | -,31 | ,09 | -,42 | ,24 | ,28 | ,32 | ,26 | -,70 | -,68 | -,28 | -,40 | |
| 18. Perceived Media Richness Day2 | 4,94 | ,65 | -,33 | -,51 | ,14 | -,65 | -,52 | -,10 | ,11 | -,18 | -,54 | -,93 ** | -,64 | -,86** | ,47 | ,75* | ,40 | ,72* | -,13 |