Communication and performance in teams
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Citation for published version (APA):

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6 TEAM INFORMATION, TEAM KNOWLEDGE, COMMUNICATION, AND PERFORMANCE

In this chapter, we describe an experiment in which the effect of a written instruction containing team information is investigated on members' team knowledge, communication, and performance. The results show that teams that receive team information improve their communication on several points. Less information was exchanged, whereas the percentage of necessary information exchange was higher than in the teams that did not receive team information. The provision of team information resulted also in better team knowledge that was, in turn, positively correlated with communication. Surprisingly, the improved communication did not result in better performance.

6.1 Introduction

As described in chapter 5, the research concerning cross training as a method to improve communication and performance shows conflicting results. In Experiment 1 and 2, and experiments of other researchers (McCann et al., 2000; Schaalstal & Bots, 1997), training in each other's task had no effect upon implicit coordination and performance. In only one experiment, this resulted in better performance (Cannon-Bowers et al., 1998). Team members of these teams had also better team knowledge and provided more information in advance of requests. Nevertheless, there were no correlations between these measures, and the provision of information in advance of requests was not correlated to performance. Hence, the performance improvement in this experiment cannot be explained by the improvement of team member's communication because of having better team knowledge. Referring to the first research question of this thesis, the question remains how communication and performance can be improved by fostering the knowledge in the mental models of team members.

Two studies might give an answer to this question. First, the Schaalstal and Bots (1997) study shows that communication and performance improves when team members are explicitly instructed on the interdependencies in the team. Second, in another study, team members that watched a videotape and received a written instruction with information about each other's tasks, roles, responsibilities, and informational needs, provided more information in advance of requests and performed better (Volpe et al., 1995). Both studies show that the provision of explicit instructions is effective to improve communication and performance in teams. The Schaalstal and Bots study shows that this was even better than training in each other's tasks. In both studies, it was hypothesized that the communication and performance improvement could be ascribed to the development of team knowledge. Nevertheless, because there were no measures of the knowledge of the team members in these studies, this could not be confirmed.

Two other studies show that training methods directly aimed at the development of team knowledge lead to improvements. In one study, a team interaction training resulted in improved coordination behaviors (Minionis et al., 1995). However, the teams that received the team interaction training did not communicate or perform differently than the teams that did not receive such a training. There was also a measure of whether teams developed mental models containing team interaction knowledge. The results
show that the extent of similarity in these mental models is positively correlated to coordination and performance. However, there were no correlations between mental model similarity and the number of statements in any of the communication categories. A problem with interpreting these results is the way communication is classified. This classification includes communication categories such as planning, execution, and group regulation. It is not clear how this teamwork is influenced by shared mental models. For example, these types of categories do not reflect implicit coordination. It is therefore possible that a relationship between team interaction training and communication could not be established.

In another study, an experiment is performed in which team members received an instruction of how to interact effectively as a team (Marks et al., 2000). In this experiment, team mental model similarity as well as accuracy was measured. The quality of teamwork was measured by rating the communication in several categories such as assertiveness, decision making, and adaptability. The results show that teams that received a team interaction training had more similar and accurate mental models. Nevertheless, whereas mental model similarity was positively associated with the quality of teamwork, mental model accuracy was not associated with the quality of teamwork at all. The quality of teamwork was positively associated with performance. This study shows that a team interaction training improves team members' mental models with respect to the teammates' tasks and the sequences of activities. However, because this was not measured, no relationships could be established between such a training and implicit coordination or the effectiveness and efficiency of communication.

The above-described studies show that training methods directly aimed at the development of team knowledge are promising for the improvement of communication and performance in teams. These studies have shown that team training improved communication and performance (Schaafstal & Bots, 1997; Volpe et al., 1995) or improved coordination (Minionis et al., 1995) and teamwork in general (Mathieu et al., 2000). In the studies of Mathieu et al. (2000) and Minionis et al. (1995) there is also support that this was mediated by the knowledge team members developed in a mental model. Nevertheless, there have been no studies that investigated the effect of a team training (i.e., a training that is directly aimed at the development of team knowledge) to team knowledge, implicit coordination in terms of effective and efficient communication, and performance.

In the present experiment we operationalize a team training by giving team members a written instruction that contains explicit information about each other's tasks, roles, and responsibilities. We also highlight the informational interdependencies among team members and the timing of each other's activities and when information exchange is necessary. Our reasoning is that team members, when receiving such team information, will gain a detailed understanding of how and when to communicate. Therefore, we expect that teams will communicate more effectively (i.e., more necessary information exchange in time and in advance of requests) and efficiently (i.e., less information exchange in general and a higher proportion of necessary information exchange). In turn, we expect that this has a positive impact on team performance.

In contrast to other studies (Blickensderfer et al., 1997c; Cannon-Bowers et al., 1998; Entin & Serfaty, 1999; Schaafstal & Bots, 1997; Stout et al., 1996; Volpe et al., 1995), implicit coordination in the present experiment is not only measured by the provision of information in advance of requests. In our opinion, this is just one measure of implicit coordination, but not the only one. In chapter 2 (see section 2.3.1, Table 2.1), we described several other communication measurements including the total amount, timeliness, and number of requests that measures implicit coordination more precisely. It is possible that in other studies (Cannon-Bowers et al., 1998; Stout et al., 1996) the relationship between the shared mental model measures and implicit coordination (measured by the provision of information in
advance) could not be established because this measure was too limited. For that reason, we measure implicit coordination more precisely in the present experiment.

A measure to assess team members’ knowledge is also included in the present experiment. Based on the cognitive team task analyses described in chapter 4, we developed a questionnaire that team members had to answer after the experimental session. Besides a team measure, we included a heterogeneous accuracy measure (see also Cooke et al., 2000b) for the answers that are unique for each team member’s role and two similarity measures for the answers that are similar for both team members. One measures similarity regardless of whether it was accurate, the other measures similarity for the accurate answers only. We also defined a priori which answers comprise knowledge of each other’s tasks and procedural knowledge about the timing of interaction. This way, we attempt to get a better picture of the knowledge team members need to coordinate implicitly and to what extent this needs to be shared. By our knowledge, there are no studies yet in which knowledge type and heterogeneous measures as well as similarly measures are related to implicit coordination and performance.

6.2 Experiment 3

6.2.1 Hypotheses

The experiment described in this chapter addresses the question whether the provision of team information improves members’ team knowledge, communication, and team performance. A comparison is made between teams that receive team information and teams that receive no team information. Figure 6.1 represents the dimensions and the relationships that are under investigation in Experiment 3.

![Figure 6.1](image)

**Figure 6.1:** Hypothesized relationships between team information, team knowledge, communication, and performance under investigation in Experiment 3

Given the expected value of team information on the development of team knowledge in the mental models of the team members, communication, and performance, the following hypotheses are put forward:

1. We expect that the teams that receive team information develop better team knowledge than the teams that receive no team information
2. We expect that the teams that receive team information coordinate more implicitly and therefore communicate more efficiently and effectively (i.e., less communication, more necessary information, more necessary information in advance of requests, less requests, answering more requests, more necessary information in time, and answering more requests in a shorter time notice) than the teams that receive no team information.

3. We expect that the teams that receive team information perform better than the teams that receive no team information.

4. We expect that team knowledge is positively correlated with communication.

5. We expect that team knowledge is positively correlated with performance.

6. We expect that communication is positively correlated with performance.

6.2.2 Method

Participants

The data for Experiment 3 were obtained from 80 students of Utrecht University in 40 teams of two participants. The distribution of participants with regard to sex was as follows: 12 female, five male, and three mixed teams. Participants that formed the team were not acquainted to each other. The participants were paid Dfl. 70, = for their contribution.

Design

In order to test the hypotheses, two experimental conditions were designed. In the team information condition, team members received a written instruction that contained team information. In the no team information condition, team members did not receive team information.

Task

In Experiment 3, Version 3 of the fire-fighting task as described in section 3.3.2 was used.

Manipulation

Team information was manipulated as follows. For the teams that received team information, a separate section in the instructions was included in which important team knowledge in the fire-fighting task was described. Based on the cognitive team task analysis described in chapter 4, we determined what important team knowledge was. All knowledge important to perform teamwork in the restricted condition was explicitly described in the instruction. This included a description of the teammate's task and timing and sequences of the teammate's activities. The instruction also highlighted the necessary interactions between team members. It was not only described what information was necessary to exchange but also in which periods. Team members that did not receive the team information were instructed on their own tasks only. This included information of the tasks and the timing and sequences of activities. In contrast to the team information instruction, this was geared completely to team members' own taskwork. The taskwork description in the instruction was identical in both conditions.

Measurements

Knowledge. To assess the team knowledge of the team members, a 12-item questionnaire was developed. The questionnaire was based on the cognitive team task analysis described in chapter 4. As with the development of the instructions concerning team information, we used the cognitive team task analysis to determine what important team knowledge was in the fire-fighting task. This helped us in
developing the items that should be included in the questionnaire. The questions are listed in Table 6.1 (translated from Dutch).

Table 6.1: Knowledge measurement; overview of the questions

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer observer</th>
<th>Answer dispatcher</th>
</tr>
</thead>
</table>
| 1. Which information was necessarily needed by your teammate to accomplish the tasks? | 1 Changes in the number of units  
2 Large building in danger | 1 Changes in the allocation of units  
2 Changes in the amount of units present in the station |
| 2. In which period had the units to be withdrawn to be on time?          | Period 6                                              | Period 6                                                |
| 3. What is the most important task of your teammate?                    | Allocation of units                                   | Detecting fires                                         |
| 4. How many periods was a message relevant?                             | Maximal 2 periods                                     | Maximal 2 periods                                       |
| 5. What are the two most important messages you had to give to your teammate? | 1 Changes in the number of units  
2 Large building in danger | 1 Changes in the allocation of units  
2 Changes in the amount of units present in the station |
| 6. In which period had the message of the large building in danger to be sent at least? | Period 7                                              | Period 7                                                |
| 7. Give two of your teammate's tasks that were the most important to perform accurately | 1 Allocation of units  
2 Providing information about the allocation of units | 1 Detecting fires  
2 Providing information about the detected fires |
| 8. How many periods were needed to withdraw units, reallocate, and effectively extinguish fires | 4 periods                                              | 4 periods                                                |
| 9. From which information is your teammate dependent to accomplish the tasks accurately? | 1 Allocation of units  
2 Providing information about the allocation of units | 1 Detecting fires  
2 Providing information about the detected fires |
| 10. In which period had units to be allocated to be on time for the large building in danger? | Period 7                                              | Period 7                                                |
| 11. How could your teammate obtain information about the fires in the city? | Messages containing a question mark                   | Clicking buildings on the map in the city               |
| 12. In which period was the building in danger known?                    | Period 6                                              | Period 6                                                |

The odd numbered questions were developed to tap team members' task knowledge about each other's tasks, roles, responsibilities, and informational needs. The even numbered questions were developed to tap team members' procedural knowledge about the timing and sequences of activities. Each question that was accurately answered was scored with one point. For the questions where team members were asked to provide two answers (i.e., Question 1, 5, 7, and 9) one accurate answer was rewarded with half a point and two with one point. In total, each team member could earn 12 points.

Several scores were calculated. The team score was the average score of both team members of all accurate answers. The heterogeneous score was the score of all accurate answers of both team members that are unique for each team member's role (all accurate answers on the odd questions). Note that the heterogeneous score is concerned with the questions that were developed to tap team members' declarative task knowledge about each other's tasks, roles, responsibilities, and informational needs. The procedural score was the score of all accurate answers of both team members on the questions that were developed to tap team members' knowledge of the timing of activities and interaction needed (all accurate answers on the even questions). The similarity score was the score of all answers that both team members could have and had similar (all answers on the even questions that were similar). The similarity and accuracy score was the score of all answers that both team members could have and had similar, and were accurate (all answers on the even questions that were similar and accurate).

Communication. As with Experiment 1 and 2, team members could only communicate by using the standardized electronic messages. The messages were time-stamped and saved in a computer log file for analysis. The same communication measures of Experiment 1 and 2 were used to determine whether
teams coordinated implicitly and therefore communicated efficiently and effectively (see section 5.2.2, Table 5.1). These measures were based on the communication features of implicit coordination in the fire-fighting task that we established with the help of the cognitive team task analysis of chapter 4 (see section 4.2.2, Table 4.7).

We added one communication measure. The percentage of scenarios in which the message of the large building in danger was sent and read in time. In the scenarios that were used in Version 3 of the fire-fighting task, it was highly important that this message is sent and read before Period 7 finishes. If team members are not able to perform this in time, then it is not possible to allocate units to the large building in danger and save a large number of potential casualties. We believe that this is an important measure of implicit coordination. It measures whether team members have provided the necessary information on the time in the teammate’s task sequence that this information is needed. Moreover, this measure indicates whether team members have declarative team knowledge of what information is necessary to exchange (i.e., the large building in danger), and procedural knowledge of when this information must be provided (i.e., before Period 7 finishes).

**Performance.** Performance was measured by the percentage of casualties saved out of the total number of potential casualties that could be saved in a scenario.

**Procedure**

An experimenter assigned the participants randomly to the role of dispatcher and observer and told them to read the instruction. Participants were placed in separate soundproof rooms and communication between the participants was made possible by sending and receiving the standardized electronic messages. They were told not to speak to each other about the experiment and the experimenter was always present in situations where participants were together in the same space. Participants were allowed to ask questions at any point during reading.

The instruction first explained the fire-fighting task in general, followed by instructions specific for each role. This included a systematic instruction on how to manipulate the interface, accompanied by small tasks that had to be carried out by the participants. Subsequently, there was a training session of five scenarios. After this first training session, participants were asked to continue to read the instruction. In this instruction, it was explained how participants could predict, based on a pattern in a series of small fires, the location, type, and time of a large fire later in the scenario. In addition, the participants in the team information condition had to read the section in which team knowledge was described.

After the training, the experimental session started. Participants were presented with 20 scenarios that consisted of 11 periods of 15 seconds each. Each team was presented with identical scenarios in a fixed order.

In the last part of the experiment, participants answered the questionnaire. The questions were presented one by one on a computer screen. Participants were asked to give the first answer they could think of. Time to answer each question was limited and participants could not go back to a previous question. This way we attempted to avoid that participants reasoned their answers and forced them to give answers that were on top of their heads. In total, an experimental session lasted about four hours.
6.2.3 Results

Knowledge

In order to test Hypothesis 1, a Mann-Whitney U-test was performed to find out whether there are differences in the scores on the team knowledge questionnaire. The results of the test are shown in Table 6.2.

Table 6.2: Mean score for each condition on the team knowledge questionnaire

<table>
<thead>
<tr>
<th>Knowledge score</th>
<th>No team information</th>
<th>Team information</th>
<th>U =</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Team score (maximum 12)</td>
<td>3.2</td>
<td>5.2</td>
<td>38***</td>
</tr>
<tr>
<td>2. Heterogeneous/declarative score (maximum 12)</td>
<td>4.6</td>
<td>6.7</td>
<td>81***</td>
</tr>
<tr>
<td>3. Procedural score (maximum 12)</td>
<td>1.9</td>
<td>3.8</td>
<td>55***</td>
</tr>
<tr>
<td>4. Similarity score (maximum 6)</td>
<td>4.2</td>
<td>3.5</td>
<td>139*</td>
</tr>
<tr>
<td>5. Similarity and accuracy score (maximum 6)</td>
<td>0.0</td>
<td>0.6</td>
<td>100***</td>
</tr>
</tbody>
</table>

*Note. *p <.10, ***p < .01

Hypothesis 1 predicted that teams that receive team information have better team knowledge than teams that receive no team information. As can be seen in Table 6.2, this hypothesis is supported by the results. Teams that received team information gave more accurate answers on all questions, and on the declarative and procedural questions than team members that did not receive team interaction information. There are no differences on the similarity score. For the answers that both team members could have and had similar, there is a tendency that the teams that did not receive team information scored higher than the teams that did receive team information. The similarity and accuracy measure shows a floor effect. In both conditions, team members had almost no answers that were accurate and similar for both team members. The procedural score and the similarity and accuracy score were calculated for the same set of questions (i.e., the odd questions). The difference is that the procedural score counted the number of accurate answers for both team members, whereas the similarity scores counted the number of answers that were similar. Therefore, the results indicate that in the team information condition, the teams had better procedural knowledge than in the no team information condition. This knowledge, however, was distributed among team members and not held in common.

Communication

In order to test Hypothesis 2, an analysis of variance using repeated measures for each scenario was performed. The repeated measures design consisted of 20 scenarios. Exceptions were Measure 6 (percentage of questions answered) and 9 (time between request and answer) for which we performed an analysis of variance without repeated measures. This was done because in several scenarios team members did not provide answers, which resulted in several missing values. The results of the analysis are shown in Table 6.3 in which the means for each scenario can be found.
Hypothesis 2, which predicted that teams that receive team information coordinate more implicitly and therefore communicate more efficiently and effectively than teams that receive no team information, is partially supported by the results. As can be seen in Table 6.3, the teams in the team information condition communicated more efficiently than teams in the no team information condition. These teams sent fewer messages, whereas the percentage of necessary messages was higher. However, the teams in the team information condition did not communicate more effectively. There were no differences between the conditions on the percentage of necessary messages of the total number of necessary messages that could be sent.

With respect to the provision of information in advance of requests, there is a tendency that the teams in the team information condition did this more than the teams in the no team information condition. Team members that received team information had fewer questions than team members that did not receive team information. However, the percentage answers did not differ between the conditions. With respect to the timing of the provision of necessary information, there is a tendency that the teams that received team information were more often in time (i.e., more often in two periods) than the teams that did not receive team information. However, there are no differences between the conditions on the time between a request for information and receiving an answer.

The last communication measure was defined as the percentage of scenarios in which the building of the large building in danger was sent and read in time. In each scenario, team members could be either in time or too late (i.e., when the message was not sent at all, this was considered as too late). The scores can be found in Table 6.4.

Table 6.4: Communication measure; total number of scenarios in which team members were in time with sending and reading the message about the large building in danger \((N = 800)\)

<table>
<thead>
<tr>
<th>Condition</th>
<th>Message</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In time</td>
</tr>
<tr>
<td>No team information</td>
<td>251</td>
</tr>
<tr>
<td>Team information</td>
<td>277</td>
</tr>
</tbody>
</table>

To test the differences between the conditions, a Chi-square for the two-way table was calculated and tested. It appeared that the teams in the team information condition were more often in time with sending and reading the message about the large building in danger (69%) than teams in the no team information condition (63%), \(\chi^2(1, N = 800) = 3.77, p = .05\).
Performance

In order to test Hypothesis 3, which states that teams that receive team information perform better than teams that receive no team information, we performed an analysis of variance using repeated measures for each scenario. The repeated measures design consisted of 20 scenarios. Hypothesis 3 did not receive support. There was no performance difference between the team information condition (45% potential casualties saved) and the no team information condition (40% potential casualties saved), $F(1,38) < 1$.

Team knowledge, communication, and performance

As a final step, the relationships between the knowledge, communication, and performance were examined. The correlations can be found in Table 6.5.

Hypothesis 4 predicted that team knowledge is positively associated with communication. As can be seen in Table 6.5, a moderate positive relationship appeared between the team score and the percentage of necessary messages sent of the total number of messages that was sent, $r = .39$, $p < .05$, the provision of information in advance of requests, $r = .39$, $p < .05$, and the percentage of scenarios in which the building of the large building in danger was sent and read in time, $r = .36$, $p < .05$. We also took different sets of questions of the questionnaire that were created to measure declarative and procedural team knowledge respectively. As can be seen in Table 6.5, there are several moderate positive correlations between the heterogeneous/declarative score and the communication measures. Positive relationships appeared between the heterogeneous/declarative score and the percentage of necessary messages sent of the total number of messages was sent, $r = .47$, $p < .01$, the percentage of necessary messages sent of the total number of necessary messages that could be sent, $p = .35$, $p < .05$, the provision of information in advance of requests, $r = .50$, $p < .01$, the percentage of necessary messages sent of the total number of necessary messages that could be sent in two periods, $p = .34$, $p < .05$. With respect to the procedural score, a moderate positive relationship appeared with the percentage of scenarios in which the building of the large building in danger was sent and read in time, $r = .32$, $p < .05$. Finally, with respect to the similarity measure and the similarity and accuracy measure, there are no relationships with exception of a negative relationship between the similarity score and the percentage of scenarios in which the building of the large building in danger was sent and read in time, $r = -.33$, $p < .05$. Note that the similarity score measured the number of answers that both team members had the same, regardless of whether the answers were accurate. This may explain the negative relationship. Similarity in the knowledge that is inaccurate is negatively associated with the timing of communication.
<table>
<thead>
<tr>
<th>Measure</th>
<th>N</th>
<th>M</th>
<th>SD</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
<th>12</th>
<th>13</th>
<th>14</th>
<th>15</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Team score</td>
<td>40</td>
<td>4.2</td>
<td>1.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2. Heterogeneous/declarative score</td>
<td>40</td>
<td>5.6</td>
<td>2.1</td>
<td>.87**</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>3. Procedural score</td>
<td>40</td>
<td>2.8</td>
<td>1.6</td>
<td>.78**</td>
<td>.38**</td>
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<td></td>
</tr>
<tr>
<td>4. Similarity score</td>
<td>40</td>
<td>3.9</td>
<td>1.3</td>
<td>-.55**</td>
<td>-.30*</td>
<td>-.68***</td>
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</tr>
<tr>
<td>5. Similarity and accuracy score</td>
<td>40</td>
<td>0.3</td>
<td>0.6</td>
<td>.42**</td>
<td>.19</td>
<td>.57**</td>
<td>.21</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>6. Number of messages</td>
<td>40</td>
<td>24.1</td>
<td>7.6</td>
<td>-.22</td>
<td>-.21</td>
<td>-.16</td>
<td>-.01</td>
<td>-.17</td>
<td></td>
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</tr>
<tr>
<td>7. Percentage necessary messages sent of the total number of messages that was sent</td>
<td>40</td>
<td>57.7</td>
<td>15.2</td>
<td>.39**</td>
<td>.47**</td>
<td>.14</td>
<td>-.13</td>
<td>.04</td>
<td>-.72***</td>
<td></td>
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<td></td>
</tr>
<tr>
<td>8. Percentage necessary messages sent of the total number of necessary messages that could be sent</td>
<td>40</td>
<td>46.4</td>
<td>7.8</td>
<td>.24</td>
<td>.35**</td>
<td>.01</td>
<td>-.11</td>
<td>-.04</td>
<td>.43**</td>
<td>.17</td>
<td>-.05</td>
<td>.50**</td>
<td>.51***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Number of necessary messages provided in advance of requests</td>
<td>40</td>
<td>12.5</td>
<td>4.3</td>
<td>.39**</td>
<td>.50**</td>
<td>.13</td>
<td>-.04</td>
<td>.17</td>
<td>-.05</td>
<td>.50**</td>
<td>.51***</td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Number of questions asked</td>
<td>40</td>
<td>3.4</td>
<td>4.5</td>
<td>-.28*</td>
<td>-.28*</td>
<td>-.17</td>
<td>.08</td>
<td>-.15</td>
<td>.59***</td>
<td>.63***</td>
<td>.06</td>
<td>.50***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11. Percentage of questions answered</td>
<td>36</td>
<td>77.3</td>
<td>22.5</td>
<td>.27</td>
<td>.25</td>
<td>.17</td>
<td>-.09</td>
<td>.15</td>
<td>-.14</td>
<td>.34**</td>
<td>.23</td>
<td>.50***</td>
<td>.64***</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12. Percentage of necessary messages sent in one period of the total number of messages that could be sent</td>
<td>40</td>
<td>39.3</td>
<td>7.9</td>
<td>.12</td>
<td>.23</td>
<td>-.05</td>
<td>-.16</td>
<td>-.18</td>
<td>.50***</td>
<td>.09</td>
<td>.92***</td>
<td>.49***</td>
<td>.07</td>
<td>.16</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13. Percentage of necessary messages sent in two periods of the total number of messages that could be sent</td>
<td>40</td>
<td>44.0</td>
<td>9.0</td>
<td>.21</td>
<td>.34**</td>
<td>-.02</td>
<td>-.03</td>
<td>.02</td>
<td>.34**</td>
<td>.29*</td>
<td>.90***</td>
<td>.66***</td>
<td>.15</td>
<td>.26</td>
<td>.87***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14. Time between request and answer (seconds)</td>
<td>36</td>
<td>16.6</td>
<td>8.0</td>
<td>-.02</td>
<td>.04</td>
<td>-.09</td>
<td>.11</td>
<td>-.07</td>
<td>-.10</td>
<td>-.13</td>
<td>.11</td>
<td>-.35**</td>
<td>-.08</td>
<td>-.19</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15. Percentage of scenarios in which the message of the large building in danger was sent and read in time</td>
<td>40</td>
<td>66.0</td>
<td>29.4</td>
<td>.36**</td>
<td>.28*</td>
<td>.32**</td>
<td>-.33**</td>
<td>.11</td>
<td>-.02</td>
<td>.07</td>
<td>-.05</td>
<td>.17</td>
<td>-.40**</td>
<td>.56***</td>
<td>.04</td>
<td>.01</td>
<td>-.28*</td>
<td></td>
</tr>
<tr>
<td>16. Percentage of potential casualties saved</td>
<td>40</td>
<td>42.4</td>
<td>22.5</td>
<td>.26</td>
<td>.19</td>
<td>.21</td>
<td>-.12</td>
<td>.15</td>
<td>-.08</td>
<td>.04</td>
<td>-.08</td>
<td>.08</td>
<td>-.26*</td>
<td>.46***</td>
<td>.12</td>
<td>-.01</td>
<td>-.14</td>
<td>.64***</td>
</tr>
</tbody>
</table>

Note: *p < .10, **p < .05, ***p < .01
With respect to Hypothesis 4, it can be concluded that a better score on the team knowledge questionnaire is positively correlated with several communication measures. This indicates that the better the team knowledge, the better the communication. It appears further that the amount of accurate answers on the questions that were developed to tap team members’ declarative knowledge of each other’s task (i.e., the heterogeneous/declarative score: different answers for each team member about the teammate’s tasks and informational needs) is positively associated with communication. Procedural knowledge is only correlated positively with a communication measure that measures the timing explicitly (i.e., the percentage of scenarios in which the message of the large building is send and read in time). There are no positive correlations found on both similarity measures, indicating that the better communication in this experiment was dependent on the knowledge each team members held individually.

Contrary to Hypothesis 5, which predicted that team knowledge would be positively associated with performance, there are no significant correlations. A theoretical important assumption of the shared mental model construct is that the relationship between knowledge and performance is mediated by communication. To conclude that communication mediated the influence of team knowledge on performance, we must first demonstrate that team knowledge is correlated with performance (Baron & Kenny, 1986). Since there are no correlations between the knowledge scores and performance, we could not confirm mediation.

Hypothesis 6 predicted that communication is positively associated with performance. As can be seen in Table 6.5, a moderate positive relationship appeared between the percentage of answers provided and performance, $r = .46$, $p < .01$. This indicates that the more team members answered each other’s requests for information, the better the performance. The percentage of answers accounted for approximately 21% of the variance in the performance. A positive correlation also appeared between the percentage of scenarios in which the message of the large building in danger was sent and read in time and performance, $r = .64$, $p < .01$. This indicates that the more often team members were in time with sending and reading the message about the large building in danger, the better the performance. This accounted for approximately 41% of the variance in the performance.

6.3 Discussion

Our goal in Experiment 3 was to demonstrate that team information, which explicitly describes team member’s tasks and informational needs, improves performance as a result of better communication. In contrast to our hypothesis, there was no performance improvement when team information is provided. This is surprising because the teams that received team information improved their communication on several points. The teams communicated less, whereas the percentage of necessary information was higher than the teams that did not receive team information. The teams also requested less information from each other, and the results indicate that they provided more information in advance of requests. Finally, the teams were more often in time with exchanging the necessary information. In short, the teams that received team information were more effective and efficient in their communication. Less communication was needed to exchange the same amount of necessary information in time. Based on these communication improvements, we would expect a performance increase.

An explanation for the lack of performance improvement is that while the provision of team information improved communication, other factors may have weighed more into performance. One of these factors is the individual taskwork of each team member. It is possible that although the teamwork skills were
improved, team members’ taskwork skills lagged behind. The results provide some evidence for this explanation. Team members in the team information condition provided more often a crucial piece of information. With the help of this information it was possible to obtain a high performance. In other words, the conditions to perform well, as a result of good teamwork, were more often present in the team information condition than in the no team information condition. The fact that performance did not differ between the conditions must have been due to team members failing to perform well on their taskwork. In this case, while having all the information they needed, dispatchers were still too late with allocating units. This echoes the ideas of several researchers that team performance depends on task as well as teamwork factors.

The findings of the present experiment provide support for the hypothesis that team knowledge improves when members receive team information. The knowledge questionnaire shows that team members had better declarative knowledge of each other’s tasks and informational needs, and better procedural knowledge about the moments that the necessary information had to be exchanged. In other words, team information consisting of an explicit instruction about team member’s tasks and informational needs fosters team knowledge. However, the results must be interpreted with caution. Although there were differences in the scores on the knowledge test depending on whether teams received team information, the scores were relatively low. Even in the condition with the highest scores, only half of the questions were answered accurately. This indicates that in both conditions, team members had not fully developed team knowledge. Although the provision of team information is a good start for developing team knowledge, longer practice or better training methods may be needed to develop full team knowledge. A combination of an explicit team instruction and a systematic training that is geared to the acquisition of efficient and effective communication strategies is a possible candidate for that matter.

Another point of interest is the way knowledge is distributed among team members. One set of questions was created to tap team member’s procedural knowledge. Regardless of the role that team members had in the task, the answers on these questions could have been the same. Thus, the number of similar answers of both team members indicates the extent of similarity in their procedural knowledge. When viewing the total number of accurate answers on these questions for each team (i.e., the sum of accurate answers of the observer and the dispatcher), the results show that the teams that received team information had better procedural team knowledge than the teams that did not receive team information. However, there were practically no accurate answers on the procedural questions that were the same for both team members. This leads us to conclude that although the procedural knowledge of the teams in the team information condition was better, this knowledge was distributed among team members, not held in common.

The other set of questions of the knowledge questionnaire was created to tap team member’s declarative knowledge. The accurate answers were different depending on the role team members had. It can be argued that, because different knowledge seems to be tapped, this knowledge is also distributed among team members. Given that the provision of team information led to better scores on the declarative questions, it seems that the better team knowledge (procedural and declarative) in the team information condition is totally distributed among the members. Note, however, that if one team member has knowledge of the teammate’s task, this might be similar to the knowledge that the teammate has about his or her own task. In this sense, it is possible that there is overlap in the declarative knowledge of each other’s task and informational needs. However, we have not measured this overlap.

We hypothesized that communication improvements would be affected by having team knowledge. The correlations between the scores on the knowledge questionnaire and the communication measures give
some evidence that supports this hypothesis. Especially declarative knowledge appears to have a positive effect on communication. Knowledge of each other's tasks and informational needs is positively correlated with the percentage of necessary information that was exchanged of the total amount that took place and was possible respectively. There is also a positive correlation with the exchange of information in advance of requests. Finally, procedural knowledge is correlated positively with the percentage of scenarios in which a crucial piece of information was passed and received in time. Taken together these results are consistent with the shared mental model theory; the better the team knowledge, the better the communication.

Whereas teams differed in the amount of communication depending on whether they received team information, there was no correlation with team knowledge. Therefore, the provision of team information directly influenced the amount of communication, independent of having team knowledge.

Several researchers assert that it is the degree of overlap in team member's knowledge that accounts for better communication strategies (Cannon-Bowers et al., 1993; Converse et al., 1991; Kleinman & Serfaty, 1989). Based on the results of Experiment 3, this assertion cannot be confirmed. There are no positive correlations found between the degree of similarity in team member's knowledge and the communication. Moreover, similarity, regardless of the accuracy, was even negatively correlated with one communication measure. For a large part this is due to a floor effect. There were hardly any teams in which this knowledge was accurate and similar among both members. Given the positive relationships we did find with communication, we conclude that knowledge overlap is not necessarily needed for better communication. With respect to the shared mental model theory, this indicates that it is the individual knowledge content that is important, not the similarity.

Although we expected that communication would be positively associated with performance, there were practically no significant correlations. The lack of relationship may be caused by the previously mentioned explanation that the influence of team member's taskwork on performance might have outweighed the influence of teamwork. The most important correlation we did find was the timely exchange of a crucial piece of information. The exchange of this information accounted for 40% in the variance of the performance. This is solid support for the hypothesized relationship between better communication and performance. The timely exchange of necessary information within a teammate's task is basically what effective communication is about. Exchanging this information in advance of requests may be preferable because no additional communication is needed. However, not exchanging this information at all or too late is, with respect to performance, unacceptable. Therefore, we view the obtained relationship between this communication measure and performance as evidence for the hypothesized positive relationship between communication and performance.