

Questionnaires for Distributed Assessment of Team Mutual Awareness

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Background and Application

Teams, by definition, perform interdependent tasks that require team members to coordinate their decisions and actions in order to achieve their shared goals (Orasanu and Salas, 1993). In order to successfully achieve the level of coordination that is required for successful interdependent performance, team members need a shared awareness of the situation, and of the roles, tasks, and actions of the other team members. The existence of this “shared mental model” among team members has been suggested as an explanatory mechanism for effective teams, and, as measured in various ways, has been shown to increase team performance (Cannon-Bowers, Salas, and Converse, 1993; Stout, Cannon-Bowers, Salas, and Milanovich, 1999).

Despite its importance, it is difficult to measure the extent to which team members are successful in developing and maintaining a shared, accurate awareness of the situation and of each other’s roles. For distributed teams, with members who are not co-located, it is especially difficult both to develop and maintain this awareness and to measure it.

The notion of team mutual awareness – the extent to which team members are informed of other team members’ behaviors – provides a measurable construct for assessing the presence of shared mental models. We propose a model, presented in Figure 1, that specifies three interrelated facets of team performance to provide a structure to assess team mutual awareness. Taskwork awareness refers to awareness of what tasks other team members are completing and how important these tasks are. Workload awareness refers to awareness of the loading that the Taskwork imposes on team members. Teamwork awareness, finally, refers to awareness of how well team members perform team-specific behaviors (i.e., coordination and back-up).

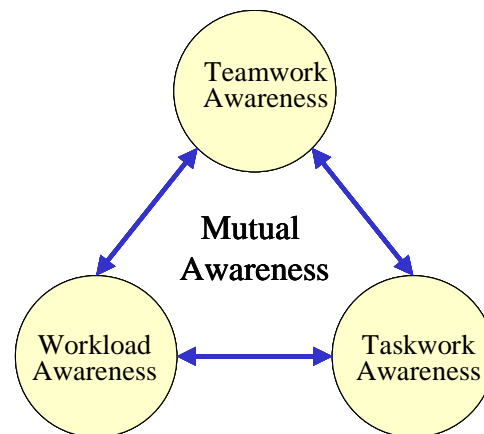


Figure 1. Team Mutual Awareness Model

We have developed a set of Mutual Awareness Questionnaires that are used to capture team level data for each component of our model. The *Task Mutual Awareness Questionnaire* asks team members to assess for themselves and for each of the other team members, the most important task that each team member is performing at selected points in time. The *Team Workload Awareness Questionnaire* asks for a subjective rating of the workload that each respondent is experiencing, and ratings for the workload that he or

she believes each of the other team members is experiencing. A third questionnaire, the *Teamwork Awareness Questionnaire* asks the team members to rate the team on four dimensions of teamwork processes. A critical feature of all these questionnaires is that the results can be used to assess mutual awareness—the congruence of the team’s perceptions about their workload and performance—not just the individual or team average levels of performance and workload.

Each of these questionnaires was originally developed and tested in a paper-and-pencil version for assessing the mutual awareness of co-located teams in order to identify factors that contribute to effective team performance (Entin, Entin, and Serfaty, 2000). More recently, we have implemented web-based versions of the workload and teamwork questionnaires for use in distributed team environments to simultaneously gather data from team members in multiple locations. Use of electronic collection methods greatly increases the utility of these measures because data collected with these questionnaires can be processed in near real-time and used to provide immediate feedback for self-correction during team training. For example, the extent of agreement between each team member’s rating of his or her own workload and the ratings provided by the other team members was recently used to provide the team an indication of the team’s mutual awareness as part of a system to train US Army soldiers for peacekeeping (Paley, Serfaty, Baker, Miller, Bailey, Ganberg, and Wan, 2002).

Procedure

Task Mutual Awareness: The task awareness questionnaire requires each team member to retrospect at the end of a scenario trial about one or more salient events that occurred during the scenario. Each event acts as a common time marker so that all team members are focused at the same time within the scenario. For each event, team members report the tasks they were performing (or just started to perform) when the event occurred and then report the tasks each of the other team members was performing during the same event. As originally implemented, the team members report the tasks they and their teammates were performing using a free-response format. A subject matter expert then classified the team members’ responses into task categories. An alternative to the free-response mode that has been used in subsequent administrations of this measure is to provide the team members with a list of task categories and have them check the category that represents the task they were performing. The former methodology has the advantage that it is not necessary to define the task categories ahead of time. The latter methodology, an example of which is shown in Figure 2, has the advantage of efficiency of response.

TASK AWARENESS QUESTIONNAIRE

Selection #	Category	Definition/Example
1	Hill	Attacking, taking, holding, etc.
2	Beaches	Attacking, taking, holding, etc.
3	Bridge	Blowing-up correct bridge, etc.
4	Airport	Attacking, taking, holding, etc.
5	Seaport	Attacking, taking, holding etc.
6	Ground Tasks	Includes mine clearing, clearing roads, attacking armor, etc.
7	Air Tasks	Includes AAW, CAS, engaging air threats, etc.
8	Sea Tasks	Includes mine clearing, gunfire support (NSFS), engaging PBs and Subs
9	Reconnaissance/ Identification	
10	Medevac	Calling for Medevac, launching Medevac helos
11	Don't Know	
12	Other (please specify)	Includes non-specific moving, coordinating, attacking, deploying, launching, etc.

Each of the categories listed above describes an important task or group of tasks that team members perform during the scenario. Use these categories to identify what you were doing and what you think others were doing at specific times in the scenario.

<p>1. Think back to when elements of the team had just completed taking the North Beach.</p> <p>a) What task were you performing (or had you just started to work on) at that time? Please select from the table above. Selection # (choose one) _____ Comments _____</p> <p>b) What tasks do you believe each of the other positions in your team were performing (or had just started to perform) when you began working on the task you selected in (2a)? <i>Select from the table above the category that best describes what each of the other positions were doing (omit yourself).</i></p> <table border="1" style="width: 100%;"> <thead> <tr> <th>Other Positions</th> <th>Selection #</th> </tr> </thead> <tbody> <tr><td>Flag</td><td></td></tr> <tr><td>Green</td><td></td></tr> <tr><td>Blue</td><td></td></tr> <tr><td>Purple</td><td></td></tr> <tr><td>Red</td><td></td></tr> <tr><td>Orange</td><td></td></tr> </tbody> </table>	Other Positions	Selection #	Flag		Green		Blue		Purple		Red		Orange		<p>2. Think back to when elements of the team were preparing to take the airfield.</p> <p>a) What task were you performing (or had you just started to work on) at that time? Please select from the table above. Selection # (choose one) _____ Comments _____</p> <p>b) What tasks do you believe each of the other positions in your team were performing (or had just started to perform) when you began working on the task you selected in (2a)? <i>Select from the table above the category that best describes what each of the other positions were doing (omit yourself).</i></p> <table border="1" style="width: 100%;"> <thead> <tr> <th>Other Positions</th> <th>Selection #</th> </tr> </thead> <tbody> <tr><td>Flag</td><td></td></tr> <tr><td>Green</td><td></td></tr> <tr><td>Blue</td><td></td></tr> <tr><td>Purple</td><td></td></tr> <tr><td>Red</td><td></td></tr> <tr><td>Orange</td><td></td></tr> </tbody> </table>	Other Positions	Selection #	Flag		Green		Blue		Purple		Red		Orange	
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Figure 2. Example of Task Mutual Awareness Questionnaire

Team Workload Awareness: We have extended the Task Load Index (TLX; Hart & Staveland, 1988), which provides a domain-independent assessment of individual team members' workload, to capture team as well as individual workload (Entin, Serfaty, and Kerrigan, 1998). We use a three-part questionnaire to assess individual and team workload. In the first part of the workload questionnaire, participants report their own workload in terms of five of the traditional items comprising the TLX: mental demand, temporal demand, performance, effort, and frustration (we omit the sixth item, physical workload, because it is not applicable in most simulation-based situations). In the second part of the questionnaire each participant provides an estimate of the overall workload

experienced by each of the other team members. In the third part of the questionnaire each participant responds to the five TLX items, but this time for the team as a whole (not just for themselves). The team workload questionnaire can be administered using a paper and pencil survey or as a web-based electronic survey. An abbreviated electronic version, used by Paley et al. (2002), is shown in Figure 3.

Team Workload and Organizational Awareness

Please use the following rating scales to evaluate your own workload experience during the trial just completed. Each scale is design to capture a different dimension (Component) of workload. Place an "X" on each scale to reflect your own experience.

Dimensions	Rate Your Own Workload
Mental	Very Low ----- ----- ----- ----- ----- ----- ----- ----- ----- Very High
Time Pressure	Very Low ----- ----- ----- ----- ----- ----- ----- ----- ----- Very High
Effort	Very Low ----- ----- ----- ----- ----- ----- ----- ----- ----- Very High
Frustration	Very Low ----- ----- ----- ----- ----- ----- ----- ----- ----- Very High

Others Workload

Using the scales in the right-hand column, mark an "X" to indicate your estimate of the overall workload experienced by each DM. Please rate your self , as well

Positions	Rate Overall Workload For Each Decision Maker(DM)
G3	Very Low ----- ----- ----- ----- ----- ----- ----- ----- ----- Very High
G2	Very Low ----- ----- ----- ----- ----- ----- ----- ----- ----- Very High
S3	Very Low ----- ----- ----- ----- ----- ----- ----- ----- ----- Very High

Submit Reset

Figure 3. Team Workload Assessment Survey

Teamwork Awareness: Entin and Serfaty (1995) initially developed the teamwork assessment measure as an instrument used by subject matter expert observers to capture the quality of a team’s teamwork processes on six dimensions of teamwork. Like the workload measure, the teamwork measure is independent of the task domain and mission objectives associated with any particular scenario. The teamwork measure has been used in a number of studies assessing team performance (Entin and Serfaty, 1999; Entin, Entin, and Serfaty, 2000). In the traditional application of this measure, observers rate

the team on each of the six dimensions using a behaviorally anchored 7-point scale. For each dimension, at one end of the scale are examples of behaviors indicating poor team process (for example, poor monitoring behavior), and at the other end are behaviors indicative of good team process on that dimension. During the scenario run, observers take notes on team processes, and at the end of the scenario they complete the behavioral ratings, based on their observations across the entire scenario.

We have recently instantiated this teamwork measure in a web-based format and used it as a way of assessing *team members'* mutual assessment of their teamwork processes (Paley, et. al., 2002). That is, the team members, not external subject matter experts, make subjective ratings of the team's performance. In this application, the team members rate the team on four teamwork behaviors: communication, back-up, coordination and information-management, and leadership/team orientation. Leadership score is related to team members' ability to agree on goals, tasks, and concepts involving the mission. Communication score is related to team members' ability to provide important information to others. Information Exchange score is related to team members' ability to pass critical information to the other members, thereby enabling them to accomplish their tasks. Back-up Behavior score is related to team members' ability to be aware of each other's workload buildup and react to adjust division of task responsibilities to redistribute workload.

An example of the web-based questionnaire is shown in Figure 4. Following the completion of a simulated training scenario, a web browser automatically presents a survey (see Figure 4) on the players' computer screens. After all the players have completed this survey and the workload survey presented in Figure 1, results are tabulated and fed back to the players as part of an after-action review (AAR) to support team self-correction.

Scoring and Measure Development

Mutual awareness of tasks performed: To develop the mutual task awareness measure, the task category representing what each team member said he or she was doing is compared to the task category representing what each of the other team members said that team member was doing. The number of category matches is counted and a percentage agreement (congruence score) computed for each team.

To calculate mutual awareness based on workload scores, we calculate a congruence measure that reflects the difference between each team member's self-reported workload and the estimates of his or her workload made by each of the other team members. To compute this measure: 1) the self-reported workload for an individual is subtracted from each team member's estimate of the workload for that individual; 2) these difference scores are squared, summed, and averaged for the team, and; 3) the square root of the average is taken.

Teamwork Assessment: In order for a team to achieve high levels of mission effectiveness, they must perform as an effective team. The intent of the Teamwork

Assessment Survey is to provide feedback to team members to support self-correction in four key teamwork components: leadership, communications, information exchange, and back-up behavior. This feedback can take two forms. The first is to simply provide a mean score of each rating across the team. This score, normalized on a 100-point scale, represents how well the team believes they are performing. The second feedback method is to calculate agreement scores within the team. This approach demonstrates to team members differences in perceived level of teamwork performance. In both feedback conditions, the objective is to stimulate conversation within the team as part of an AAR to foster self-correction.

TEAMWORK ASSESSMENT

Communication Behavior

1. To what extent did team members provide relevant information to another team member, in a pro-active way, without that team member having to ask for it?

1 2 3 4 5 6 7

- 7 Team members always provided important information to others without being asked.
- 1 Team members never provided information to others unless specifically asked.

Back-up Behavior

2. Did the team members adjust individual task responsibilities to prevent overload?

1 2 3 4 5 6 7

- 7 Team members were consistently aware of each other's workload buildup and reacted quickly to adjust division of task responsibilities to redistribute workload.
- 1 Team members were generally unaware of each other's workload buildup; little or no attempt was made to adjust the distribution of task responsibilities before significant compromises to mission safety or mission effectiveness occurred.

Coordination and Information-Management Behavior

3. To what extent was the team's behavior coordinated?

1 2 3 4 5 6 7

- 7 Good coordination behavior occurs when team members consistently pass critical information to the other members, thereby enabling them to accomplish their tasks. Team members appear very familiar with the relevant parts of one another's jobs and carry out individual tasks in a synchronized manner.
- 1 Poor coordination behavior occurs when team members consistently carry out their tasks ineffectively, leading to other team members' failing at their tasks; members carry out their tasks unpredictably, leading to delays in execution of critical tasks; members neglect to pass on critical pieces of information to one another, leading to breakdowns in team performance.

Leadership/Team Orientation

4. How congruent/similar were the commander's and the other team members' understanding of the mission?

1 2 3 4 5 6 7

- 7 The commander and other team members were completely in agreement (i.e., congruent) on goals, tasks, and concepts involving the mission.
- 1 The commander and other team members were rarely in agreement (i.e., congruent) on goals, tasks, and concepts involving the mission.

Figure 4. Teamwork Assessment Survey

Advantages

The mutual awareness questionnaires are quick and easy to complete, inexpensive to use, require little training of respondents, and can easily be collected at multiple points in time during a simulated mission or team training session without the need for trained observers. They provide information on a construct, the presence of mutual awareness

and a shared mental model, that has been shown to be important for team performance but is difficult to measure. If implemented in the web-based version, the questionnaire can quickly provide assessment data for self-correction in distributed team training.

Disadvantages

The data are subjective, based on self-ratings. The output measures the extent to which the team members have an internally consistent “picture” of what each person on the team is doing, how hard they are working, and how well the team is coordinating, but not whether that picture matches reality. The questionnaires assess team process, not team performance, although task mutual awareness has been shown to be correlated with team performance outcomes (MacMillan, Entin, and Serfaty, in press). Also, the importance of mutual awareness depends on the design of the team structure. In particular, the extent to which team members are performing inter-dependent tasks affects the extent to which they *need* mutual awareness of the other team members (MacMillan, Entin, and Serfaty, in press).

Example Output

Feedback can be provided to team members at the conclusion of a simulation session. Figure 5 illustrates two types of output that can be provided from the teamwork awareness questionnaire: (1) teamwork assessment mean scores across team members on teamwork dimensions (based on self assessment); and (2) teamwork awareness agreement scores for the team that show differences among team members in perceived levels of teamwork performance. The diagonal cells of the matrix represents a team member’s rating of his or her own performance. The other cells in the same row represent how the other team members rated his or her performance.

Teamwork Assessment	
Teamwork Score	75.0
Leadership Score	85.0
Communication Score	95.0
Information Exchange Score	70.0
Backup Behavior Score	50.0

Teamwork Score Interpretation

- 00-19% Fair
- 20-39% Moderately Good
- 40-59% Good
- 60-79% Very Good
- 80-100% Excellent

Teamwork Awareness				
	G3	G2	S3	Discrepancy
G3	40.0	30.0	50.0	10.0
G2	60.0	50.0	20.0	29.15
S3	80.0	80.0	75.0	3.53
			Overall Discrepancy	14.23

Teamwork Awareness Interpretation

- 00-19% Excellent
- 20-39% Very Good
- 40-59% Good
- 60-79% Moderately Good
- 80-100% Fair

Figure 5. Example Output for Team Mutual Awareness (1) Teamwork Assessment (2) Teamwork Awareness

Related Methods

The accuracy of mutual awareness affects how efficiently and effectively team members communicate to “push” and “pull” information, as measured by the team’s *anticipation ratio*—the ratio of the number of communications transferring information to the number of communications requesting information. The anticipation ratio measure has proved to be associated with effective team performance for a variety of different types of teams (Serfaty, Entin, and Johnston, 1998; Entin and Serfaty, 1999; Entin, 1999). More accurate awareness of each others’ roles and actions allows the team members to effectively push information, reducing the communication overhead for the team because only one message, rather than two, is needed for information transfer. This reduction in the time and resources required for communication is especially important when the team is experiencing periods of heavy task loading (Serfaty, Entin, and Johnston, 1998).

Standards and Regulations

Distributed assessment of the shared knowledge and team processes that lead to effective team performance is not yet covered by standards or regulations.

Approximate Training and Application Times

Several minutes of introductory training, which can be delivered through written materials, is needed to explain to respondents how they should complete the questionnaire. This training is needed only once in a data collection session, even if the questionnaire is administered several times during the session. Completion of the questionnaire requires less than five minutes for respondents, depending on the size of the

team. The workload assessment can typically be completed in under a minute. The mutual task assessment may take several minutes if open-ended questions are used.

Reliability and Validity

The validity of the mutual awareness measures is supported by their correlation to team performance (Entin and Entin, 2000; MacMillan, Entin, and Serfaty, in press) as well as their correlation to other process measures, such as the anticipation ratio, that have been shown to be associated with more effective levels of team performance (Entin, 1999; Serfaty and Entin, 1999; MacMillan, Entin, and Serfaty, in press). The measures also have considerable face validity as they focus directly on observable aspects of team performance which the team members themselves see as important.

Tools Needed

The paper-and-pencil version requires no special tools. The web-based version requires computers with internet connections and web browsers for respondents; and a web server to deliver the questionnaire and collect, analyze, and provide the results.

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