

# Using Shared Priorities to Measure Shared Situation Awareness

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## ABSTRACT

Shared situation awareness is hard to measure, especially in operative environments such as crisis management. In this paper the purpose is to develop a novel method to measure to what extent the team has shared situation awareness that can be used in operations.

20 two person teams participated in a study where a dynamic and evolving tactical decision-making task was solved. Shared situation awareness, shared priorities, and team performance were assessed.

The results show that the shared priorities measure in this study did not relate to shared situation awareness. Several methodological concerns was identified which could have affected the results. The measure did relate to subjective ratings of cooperation which is very interesting and it is suggested that the measure captured aspects of teamwork.

The shared priorities measure was easy to employ, required little preparation, and is a promising addition to team research.

## Keywords

Shared situation awareness, Shared priorities, Team, Command and control

## INTRODUCTION

Shared understanding of operational goals, common operational picture, and team potential is considered important for effective command and control. Imagine being able to quickly and with minimal preparation measure to what extent a team has a shared understanding of a complex situation. Imagine having a computer based tool doing this for you, requiring no preparation and almost no prior knowledge to use. Imagine this taking very little time and affecting the task itself to such a small extent it could be employed in a real, time-stressed, situation such as crisis management. This study takes a small step towards that goal by developing and evaluating a new measure for assessing shared situation awareness, in the form of a shared priorities measure.

Having an easy to use, quickly employable measure with high user acceptance that can be used in the dynamic and stressful situations, that crisis management most often are characterized by, would be a big step towards actually measuring crisis management teams shared understanding. That would suggest results that could be related to how well the teams perform, and also used for developing decision support systems that actually supports the teams.

In conclusion, the purpose of this study was to develop a novel method to measure to what extent the team has shared situation awareness. It needed to be easy to employ (minimal amounts of time to prepare the measure before use), easy to use (both for respondent, and for data collectors), have high acceptance among the respondents. If these requirements were met it could be useful in real operations.

## THEORY

The most widely used definition of situation awareness (SA) is probably that of Endsley's (1995a): "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 and Jones (1997) define team SA as "The degree to which every team member possess the SA required for his or her responsibilities." and shared SA is

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defined as “The degree to which team members possess the same SA on shared SA requirements.” which are the definitions used in this paper. To phrase it differently, you could say that they consider team SA to be the sum of all the team members SA and shared SA as the overlap in SA between the different team members.

The most widely known and used model for SA is also probably Endsley’s (1995a) model, based on information processing. This model consists of three levels. Level 1 is Perception, where we perceive information about the situation, level 2 is Comprehension where we build an understanding of the situation and level 3 is Projection where we project what might happen in the near future. Each level represents a deeper understanding of the situation.

A lot of different approaches have been taken when it comes to measuring SA and shared SA. Pew (2000) differentiated between four main approaches to measuring SA. Direct System Performance Measures which are only useful when the performance of the system is mainly based on SA. Direct Experimental Techniques are the most commonly used and contains questions or probes as well as measures of information seeking. Verbal Protocols and Subjective Measures are the two other approaches Pew (2000) accounts for. To date there seems to be few or no measures specifically developed for shared SA or team SA. The measures that exist are adopted versions of measures intended for assessing individual SA and no measure has been properly validated and tested for shared SA or team SA (Salmon et al., 2006; 2007). Mainly three categories of team/shared SA measures can be identified, team probe-recall techniques, observer rating team SA techniques and team task performance-based SA assessment techniques. (Salmon et al., 2007)

“The concept of team or shared SA requires much further investigation in itself, which in turn requires the provision of reliable and valid measurement procedures. There are two potential solutions. The first solution would be to develop a novel approach to the assessment of SA, a daunting prospect, and one that requires a great deal of further investigation. The second solution would be to combine the most successful current SA measurement techniques in order to form a battery or toolkit of SA measures.” -Salmon et al. (2006)

The following study investigates the first potential solution by developing and evaluating a new way to measure shared SA.

## Research Questions

1. How is shared SA, in terms of a shared priorities measure, related to shared SA in terms of subjective assessments?
2. Can a shared priorities measure detect a change in shared SA?
3. Is a shared priorities measure easy applicable during a test?

## METHOD

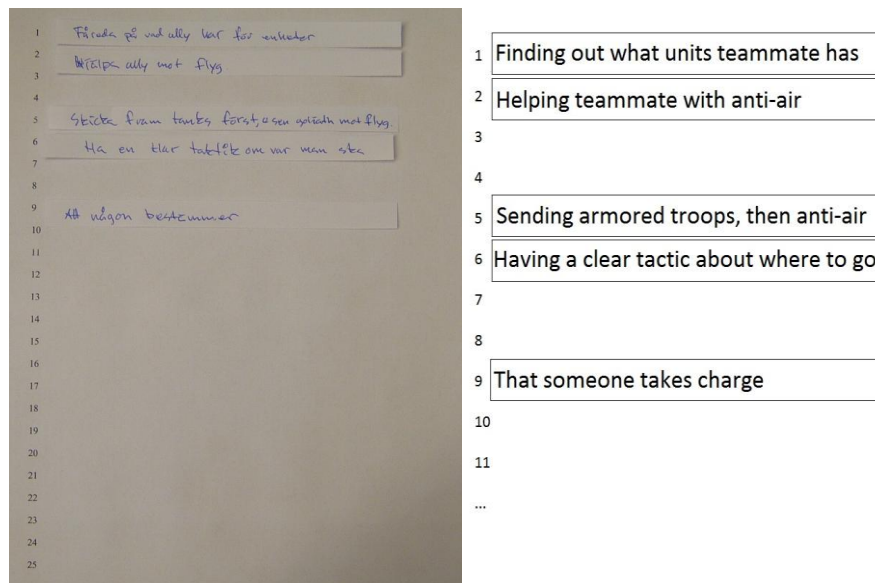
A novel measure to assess shared situational awareness in terms of a shared priorities measure was developed. This measure was then tested in an experiment using the computer game Starcraft, a real-time strategy game where one or more players control different types of units. The players represent decision-makers on a tactical level. In this study two players cooperated to stop enemy units.

Two conditions (shared vision vs not shared vision) were tested. That is, one where the teams had visual information about the other team member’s units and their locations. In the “not shared vision”-condition the participants could only see their own units, unless the other team member’s units were within the visual range of your units. For each condition there were three sequential goals that were constructed in a way that required cooperation within the team in order to be successful. After each goal the shared priorities measure was used and a questionnaire about self-rated performance, situational awareness and a few other concepts was answered. Because the scenarios used were custom built for the study, an objective performance measure was not available.

The two different conditions were scenariowise the same, with the same goals and the same encounters. The difference was that the maps were rotated. The conditions were balanced so that half the groups started with shared vision and half the groups started without shared vision. The 40 participants were between 20 and 35 years old with a mean of 23.85 years. 38 of the 40 participants were students at Linköping University.

The measure developed for the study was a shared priorities measure. Each participant came up with and rank-ordered what they thought was the five most important factors in the situation for the team to be successful. This rank-order was done visually on pieces of paper with the scale 1-25, the scale allowed measurement of relative

importance in addition to the definite order of priorities. The top item was always placed on 1 to have a fixed point. The factors were recorded and then scrambled and handed over to the other participant who also rank-ordered them. In summary, both participants created a list of factors and rank-ordered this list as well as the other participants list. An example is shown in Figure 1 below:



**Figure 1 - A shared priorities measurement with translations.**

A questionnaire was also used. It had 8 questions, each question with a 7-graded scale where every number was marked out. The endpoints of the scales had written descriptions so that they could range from, for example, “Very bad” to “Very good”. The questions were concerning their impression of both their own and the team’s performance, shared situation awareness, communication, their certainty of their teammate’s position, their mental workload, and the cooperation between the two participants.

Each list of priorities was rank ordered by both participants and the correlation between these two was computed. Two lists were created each event which led to two correlation values, the mean of these two values was used as the final score for the specific event. A correlation value of 0 indicated that the team did not share any of the priorities. A correlation value of 1 indicated that the team were in total agreement, and -1 meant that they had opposite opinions about the priorities. Since both participants rated subjective team performance and shared SA, the mean was used to get a team value for each event.

## RESULTS

To explore how shared SA, in terms of a shared priorities (SP) measure, was related to shared SA in terms of subjective assessments, a correlation test between the mean correlation of the SP measurements and the mean subjective rating of shared SA was done. The relation was almost non-existing ( $r=0.04$ , n.s.).

To then explore if the SP measurements was related to the subjective ratings of team performance (TP), a correlation test between the mean correlation of the SP measurement and the mean subjective rating of TP was done. The relation was very weak ( $r=0.09$ , n.s.).

These first two results show that on a team level, the SP measurements were not connected to the subjective ratings of the participants. The only variable the SP measure correlated with significantly was cooperation. The relation was weak ( $r=0.14$ ,  $p<0.05$ ).

Three different ANOVA-tests (shared vision/not shared vision) were computed with the mean correlation of the two participants SP measurements, subjectively rated shared SA and subjectively rated TP as the three different dependent variables. This was done to see if any of these variables differed between the two conditions and the results can be seen in Table 1 below.

	Shared Vision	No Shared Vision	ANOVA-results
Shared Priorities	0.27 (-)	0.30 (-)	$F_{(1,118)}=0.194$ , n.s.
Shared SA	5.38 (1.04)	4.72 (1.13)	$F_{(1,118)}=11.33$ , $p<0.01$
Team Performance	5.26 (0.95)	5.11 (0.94)	$F_{(1,118)}=0.75$ , n.s.

**Table 1 - Mean values and ANOVA-results for the team variables for the two condition (standard deviation is shown within the parenthesis).**

## DISCUSSION

As the results show, the shared priorities measure did not correlate with neither subjectively rated shared SA nor with subjectively rated team performance. The shared priorities measure did not change between the two conditions. The measure did not seem to measure what was intended, this might have stemmed from different methodological concerns. The measure did correlate weakly with subjectively rated cooperation. This might be of no interest since the correlation is quite weak, but some pointers in the data imply that the measure might have captured aspects of cooperation seeing how many written factors were concerning cooperation.

The quasi-experimental approach with repeated measures not only gives two different scenarios to work with, but also three different events within those scenarios, allowing for better generalization of any found results. Seeing how no properly validated measures of shared or team SA exists today, it seems like a good approach to test a new measure by using different conditions where you create a change in shared SA. If one can be sure about a large change in shared SA, a measure should obviously be able to pick this up, if it is indeed measuring what is intended. In this study, one of the largest methodological concerns is that the manipulated change in shared SA was arguably not very large. The offset intended by shared or not shared vision seemed to be countered by communication and the participants was able to find each other very quickly in the cases that required it, even when they did not have shared vision, probably ending up in no detectable difference at all. Because of the step-by-step nature of the tasks, very little planning ahead was possible. This means that the projection level of Endsley's (1995a) model of SA was probably not involved much at all, something that can also have affected the outcome.

Another issue was the priorities used by participants. The participants were put in a new situation which they had no knowledge about, with an unclear definition of what constituted good performance. This in combination with the fact that the participants did not seem to understand the given instructions in relation to the tasks led to them writing down priorities not closely connected to the team's performance in the current situation as was intended. When it comes to the questionnaires and subjective ratings, Endsley (1995b) argued that subjective ratings of SA are troublesome. The questionnaires were mainly included as a simple and effortless way of getting complimentary data to correlate to the shared priorities measure and might very well be unrelated to actual SA.

### The Shared Priorities Measure and its Practical Uses

The shared priorities measure has high face validity. If members of a team agree on what factors are important to be successful as a team in a specific situation and also agree on how important these factors are in relation to each other, it seems natural that they have the same awareness about the situation. Do note that it is not always important to have the exact same awareness about a situation seeing that people can have different roles and tasks to perform.

Because of the many methodological concerns, it is impossible to draw any conclusions on how the shared priorities measure relates to shared SA from this study, but several things have been learned about the measure. Because the users themselves determine the factors the measure requires virtually no preparation at all to adapt to a new situation. This is something that makes it very attractive for a dynamic field like crisis management where every situation is a new one. This study mainly used a theory-driven approach, choosing shared SA as the base concept to try to measure, but this does not have to be the case. A theory-begging approach not postulating any given concept is a very viable approach and a very interesting one at that. After all, it might be possible to measure a lot of different team variables this way, depending on the instructions and the factors used.

While this study was undertaken in an experimental setting hypothesizing a connection with shared SA, the measure was mainly designed to be of practical use in a dynamic and time-stressed field setting, such as in crisis management operations. With portable technology like PDAs the acquisition of the data could be location independent, effortless, and quick, especially if only one list of factors is created. A team leader could decide to create a list and send it out to the team. The team could then themselves prioritize the list whenever they could spare the few seconds it would take to prioritize the given factors. The team leader could then get a measure of how well the team agrees with the factors, also getting other data. Another approach could be to let each team member come up with one factor each, gather these factors in one list and then let every team member order these factors. This could also be an interesting way to quickly share information about prioritizations within the team. In crisis management a list of factors could range from high level goals and their prioritization, to low level actions and situation-specific information regarding solving a specific task most efficiently. Other possible uses could be in the training of a team or use the shared priorities measure to get a base-line of how things are understood and prioritized in ad-hoc teams to get them up to speed as an effective team.

Two ways forward can be identified. The first is further testing in an experimental setting, where care should be taken to further clarify the measure and its use to the participants. The use of scenarios with different conditions could prove to be the best approach. A theory-begging approach grounded in the measure itself, only later coupling it with theoretical concepts is suggested. The other way forward is evaluating the measures practical uses on experts in situations they are familiar with.

## CONCLUSION

The developed shared priorities measure initially seems like an interesting new way to measure shared team variables. This study's purpose was investigating the potential of the developed measure by comparing it to shared SA in terms of subjective assessed shared SA and by investigating if it could detect a change in shared SA as manipulated by the conditions in the experiment. The measure had no correlation with subjective assessments of shared SA and it did not change significantly between the two conditions, meaning it could not detect a change or that no significant change was manipulated. Possible explanations for this include several methodological issues as well as the possibility that the measure is not suitable for measuring shared SA. The measure did correlate significantly but weakly with subjectively rated cooperation.

The measure has potential for being able to measure shared SA, or other shared team variables, in a range of different scenarios while at the same time being easy to administer and requires almost no preparation. As such it is a promising addition to team research and deserves further investigation.

## REFERENCES

1. Endsley, M., R. (1995a). Toward a Theory of Situation Awareness in Dynamic Systems. *Human Factors*, 37(1), 32-64.
2. Endsley, M., R. (1995b). Measurement of Situation Awareness in Dynamic Systems. *Human Factors*, 37(1), 65-84.
3. Endsley, M., R., & Jones, W., M. (1997). *Situation Awareness Information Dominance & Information Warfare* (Technical Report). Belmont, MA: Armstrong Laboratories.
4. Pew, R., W. (2000). The State of Situation Awareness Measurement: Heading Toward the Next Century. In M. Endsley, R. & D. Garland, J. (Eds.), *Situation Awareness Analysis and Measurement* (pp. 33-47). Mahwah, New Jersey: Lawrence Erlbaum Associates, Publishers.
5. Salmon, P., M., Stanton, N., A., Ladva, D., Jenkins, D., P., Walker, G., H., & Rafferty, L. (2007). *Measuring Situation Awareness during Command and Control Activity: A Comparison of Measures Study: Human Factors Integration Defence Technology Centre*.
6. Salmon, P., M., Stanton, N., A., Walker, G., H., & Green, D. (2006). Situation Awareness Measurement: A Review of Applicability for C4i environments. *Applied Ergonomics*, 37(1), 225-238.