Australian Government
Department of Defence
Defence Science and
Technology Organisation

An Empirical Study of the Relationship Between Situation Awareness and Decision Making

Melinda Stanners and Han Tin French

Land Operations Division
Systems Sciences Laboratory

DSTO-TR-1687

ABSTRACT

It is assumed that good situation awareness (SA) leads to good decision making, which is then expected to result in a good outcome. Despite increasing reliance on this assumption by the land force, little research has been undertaken to validate it. This study attempts to address this deficiency. SA was assessed using the Direct Questioning Technique, which elicits SA through direct questioning during play. This is an adaptation of the Situation Awareness Global Assessment Technique. Responses to SA questions were compared against the ground truth of the scripted scenario. A relationship was found between SA and decision making, such that participants with a high degree of SA made high quality decisions. SA was also related to planning. However, other factors also contributed significantly to decision quality and performance.

RELEASE LIMITATION

Approved for public release

Published by

DSTO Systems Sciences Laboratory
PO Box 1500
Edinburgh South Australia 5111 Australia

Telephone: (08) 8259 5555
Fax: (08) 8259 6567

AR 013-336

Submitted: October 2004
Published: February 2005

APPROVED FOR PUBLIC RELEASE

An Empirical Study of the Relationship Between Situation Awareness and Decision Making

Executive Summary

Situation awareness (SA) is a term that has become relatively familiar in military research. Basically, it refers to a state of understanding what is going on around you, and consists of three levels: perceiving elements in the environment, comprehending their meaning in the context, and predicting the state of the situation in the future.

It is assumed that good SA leads to good decision making, which is then expected to result in a good outcome. Despite increasing reliance on this assumption by the land force, little research has been undertaken to validate it. This study attempts to address this deficiency through examining whether there are differences in the quality of decisions made by people of varying degrees of SA. This was done using a computer simulated reconnaissance mission, to provide the researcher with a high degree of control, and to reduce the interference of variables such as hunger and fatigue in the decision-making process. The role that planning before entering the situation plays in decision making and SA quality was also of interest.

Twenty-four participants aged 18-40, from the South Australian Air Field Defence Squadron and DSTO, volunteered to engage in a scenario using the commercial-off-the-shelf game 'Operation Flashpoint'. This is a military-based tactical first-person shooter game that has been lauded as the most realistic first-person war game available. It is also scriptable, allowing the custom design of a scenario appropriate to the study. A reconnaissance scenario was scripted with the aid of a subject matter expert. It was tightly constrained such that although the participant had the freedom to choose their course of action, they had no more than three options to choose from at each decision point.

Planning was assessed by administering a short questionnaire after providing the participant with the appropriate information. The questionnaire garnered their knowledge of such things as their rules of engagement, their mission statement, and possible courses of action.

SA was assessed using the Direct Questioning Technique (DQT), a question and answer technique that elicits SA through direct questioning at natural breaks during play. The DQT involves asking questions from all three levels of SA, and the questions related to elements of the game environment, such as enemy locations, convoys observed, and perception of time passed. The DQT is an adaptation of the Situation Awareness Global Assessment Technique.

Decision making was assessed through a scoring system that attributed 'points' according to whether the chosen course of action was optimal, average, or poor. Loosely based on the Anti-Aircraft Performance Index, an optimal decision would earn five 'points', an average decision would earn three, and a poor decision would earn one. The points were then averaged to provide a mean decision-making score out of five.

Responses to SA questions were compared with the programmed reality of the scripted scenario. Decision making was assessed indirectly through the actions performed in the game. It was assumed that people's actions would be in alignment with decisions made, such that once a course of action was decided upon, the participant would be able to act on that course of action.

A relationship was found between SA and decision making, such that participants with a high degree of SA made high quality decisions. SA was also related to planning. However, other factors also contributed significantly to decision quality and performance, such as game-play skills. Future studies would need to provide more comprehensive training in the use of the game, to reduce the game-play experience effect. Additionally, these results are not necessarily transferable to a live environment, as the skills required to complete a computer simulated reconnaissance mission are not necessarily the same skills required to complete a live reconnaissance mission.

Authors

Melinda Stanners
Land Operations Division

Melinda Stanners completed a Bachelor of Arts, majoring in Psychology, in 2003, and in 2004 undertook an Industry-Based Learning placement in Land Operations Division at Defence Science and Technology Organisation. During her time there, Melinda was involved in human factors research in the Human Sciences Discipline, specifically in the area of Infantry Situation Awareness. Melinda returns to the University of Adelaide in 2005 to complete her honours year in Psychology, in affiliation with the Human Systems Integration Group in Command and Control Division.

Han Tin French
Land Operations Division

Dr Han Tin French obtained her PhD from the University of New England, Armidale NSW, in the field of Physical Chemistry. She joined DSTO in 1988, working in Weapons Systems Division in the research area of blast overpressures from weapons. Since moving to Land Operations Division in 1997, she has conducted research in the human factors field, specifically collective training in the Army and infantry situation awareness. She is the Head of the Human Sciences Discipline in LOD.

Contents

1. Introduction

Recognised as being crucial to military success, Situation Awareness (SA) has received an increasing amount of attention over the last twenty years. A variety of tools and displays have been developed in an attempt to enhance the quality of SA in many military arenas, from pilots to infantry. Superior infantry SA is expected to promote information dominance, improve security and survivability and optimise lethality [1], while poor SA has been found to lead to catastrophic errors [2]. The American Civil War Battle of Chancellorsville, where the Confederate Army of Northern Virginia was outnumbered by Union troops of the Army of the Potomac, provides historical evidence of the disastrous impact that poor SA can have in a military operation. Despite possessing a larger army and doctrinally superior plans, Hooker's mental model of the situation was inaccurate and inflexible, and as a result he experienced an utter loss of SA and was defeated by the Confederate Army [3].

The relationships between SA and decision making, and SA and outcomes have been examined in the aviation domain, particularly in the areas of air traffic control and combat piloting. Both Endsley [4] and Durso [5] have used simulations to investigate this relationship, with Endsley finding a positive relationship between SA and performance. Durso et al [5] found that two out of four SA procedures (the Situation Present Assessment Method and the Situation Awareness Global Assessment Technique (SAGAT)) were able to predict the performance of air traffic controllers. Despite increasing reliance on SA in land operations, however, little empirical research has been undertaken to establish that better SA results in better decisions, and hence more favourable outcomes, within the land domain.

In the current study the relationship between SA and decision making will be assessed using the Direct Questioning Technique (DQT), a method based on the Situation Awareness Global Assessment Technique [6]. The purpose of this work is to validate the assumption that superior SA results in better decisions, and better outcomes.

Additionally, the relationship between planning and SA will also be assessed, using a questionnaire based on Infantry planning protocols. This is designed to discover the extent of the participant's understanding of the situation, based on the briefing information. It is expected that those who have greater understanding in the planning stage will also possess superior SA within the game.

The primary hypothesis is that high decision quality will be related to high SA, reflected in a positive correlation between SA and decision-making scores. A subsidiary prediction is that there will be a positive relationship between the mean SA scores and the mean planning scores.

This study is not intended to fully represent actions in the field, but is rather an attempt to empirically establish a theoretical concept through an abstraction of a dynamic environment designed to minimise confounding variables.

2. Situation Awareness

2.1 Definition

There is no universally accepted definition of 'situation awareness'. At the most basic level, SA is generally agreed as being understood to mean 'knowing what is going on around you' [7].

The definition suggested by Endsley [8] is widely accepted by the research community in various domains. Endsley defines SA as consisting of three levels: perceiving elements in the environment within a volume of space and time; comprehending what they mean in context; and predicting their status in the near future [8].

Level one, the level of the lowest cognitive sophistication, involves perceiving elements or cues in the environment. Level two involves the integration of this perceptual information with other information, and comprehending what it means. Level three, the most cognitively sophisticated level of SA, involves predicting or anticipating future events based on current ones.

2.2 Model

On the basis of this hierarchy, Endsley developed a model of dynamic decision making with SA at the core [6]. The model is graphically described in Figure 1.

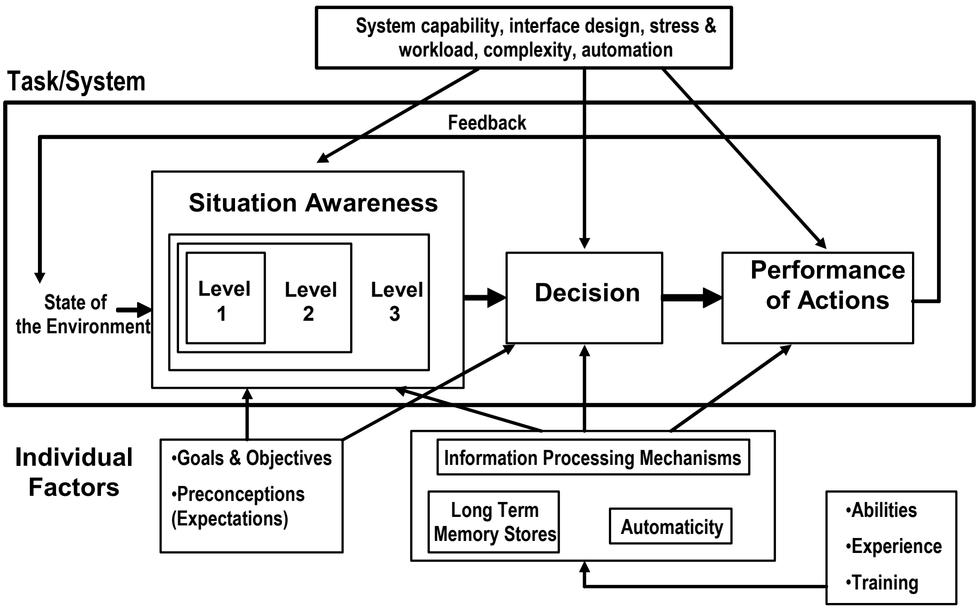

Figure 1: Model of SA in dynamic decision making[10]

The model demonstrates that SA is built from external cues and is separate from, and the prerequisite for, decision making. Decisions are then made on the basis of the SA, and actions are taken that produce an outcome. Good SA leads to good decision making, which is then expected to result in a good outcome.

All of the three steps in the dynamic decision-making process are influenced by a range of factors, including task and individual factors. The latter may include such things as abilities, stress, hunger, fatigue, boredom, experience and training. The interplay of factors affecting the dynamic decision-making process means that good performance is not secured by good SA alone. Endsley [9] expresses the relationship between SA and decision making as a 'probabilistic link,' whereby 'Good SA should increase the probability of good decisions and performance, but does not guarantee it'.

2.3 SA Measures

Guille and French's 2004 report [11] provides a thorough dissertation on both the objective and subjective measures of SA available. However, a closer look at the objective measures of the SAGAT and the DQT is worthwhile for this report.

2.3.1 The Situation Awareness Global Assessment Technique

The SAGAT [12] is an electronically based objective measure of SA, designed to assess an individual's SA level through questions relating to their task. Through eliciting information about their knowledge regarding the situation, an objective measure of SA can be obtained by comparing it with the real situation. Although the SAGAT was originally developed for use in the aviation domain, [12] it has been modified to apply to other domains such as infantry [13], automotive [14], nuclear [15] and medicine [16] The SAGAT was designed for use in a simulated environment, but has also been modified for use in live field exercises [17].

A pool of questions is prepared, covering all three levels of SA, and contextualised to the scenario. The simulation is then frozen at random intervals, while the participant is asked a series of randomly selected questions about the current situation. Randomisation is required to counter any possible learning effects.

These intervals must be kept as short as possible, to prevent memory decay and minimise intrusiveness. On completion of the simulation, the participant's answers are then scored on the basis of the reality of the situation.

The SAGAT is useful for providing an unbiased and objective assessment of SA[18], measuring SA directly by asking for information about the simulated environment. It also has high content validity, where the questions asked pertain to the related field of knowledge, as they were created on the basis of the SA requirements analyses.

However, the perceived intrusiveness of pausing the simulation to collect data is its chief disadvantage. It has also been suggested that, due to the participant's reliance on memory, this technique might not provide a real reflection of their SA.

2.3.2 The Direct Questioning Technique

The DQT is a modified version of the SAGAT originally designed for use in a live exercise, as opposed to a computer simulation [17]. Apart from the different context of use, there are three main differences between the SAGAT and the DQT.

Firstly, the DQT is paper-based instead of electronically administered. Secondly, the comparison of the real and perceived situation is performed with the aid of a Subject

Matter Expert (SME), instead of comparing participants' answers to data collected from the computers. Finally, the exercise is paused at naturally occurring breaks, instead of at random.

The DQT was used in the current study because, despite the computer-based nature of the experiment, it was more suitable than the SAGAT for a number of reasons.

The DQT allowed for paper-based data collection, which was the collection method most readily available.

The comparison of the real and perceived situation did not require an SME. The scenario was designed by the experimenter with the aid of two SMEs, who provided the experimenter with domain knowledge prior to experimentation. The SME also provided guidance in designing the scenario to be as realistic as possible, and provided guidance with designing constraints so as to limit the number of decision options within the context of the scenario. This meant that the ideal courses of action were known prior to data collection.

Finally, there existed three naturally occurring breaks in the game where questioning was considered to be less intrusive. In the current study, it was important for the same questions to be administered at the same point in the simulation for every participant, in order for them to be relevant at the time they were asked. Relevance was a significant factor in designing the DQT questions, because the simulation was composed of different events and choices. One could not ask questions randomly about things that had not happened yet.

3. Decision making

3.1 Decision-making Models

Over the years, a number of different models have been designed to try to explain human decision processes. It is useful to examine various decision-making models in order to gain a better understanding of the phenomenon of decision making, particularly in a dynamic context. A brief outline of some of the more dominant models follows.

3.1.1 Unbounded Rationality – Expected Utility Theory

In order to solve a problem using expected utility theory, one would have to determine all possible options available, and determine all possible consequences of each option. Subjective probabilities would then have to be attached to each of the consequences, and their expected utility would then have to be assessed. Each utility would have to be multiplied by its associated probability, and summed across each option. The option with the highest expected utility would then be chosen. [19]

Needless to say, although this theory is convenient for mathematical modelling, this is not how real people make decisions, faced as we often are with limited time, knowledge and computational capacity [19]. The unnaturalness of the theory outweighs its convenience in decision-making research relating to the decision-making processes of real people.

3.1.2 Optimisation Under Constraints

Closely related to unbounded rationality theory, optimisation under constraints involves a limited information search, which involves some kind of stopping rule such as 'stop search when costs outweigh benefits'[19]. However, this does not simplify the matter. After each consequence is established, and probabilities and utilities are estimated, it must then be calculated whether the benefits of continuing the information search would outweigh the costs before other consequences can be considered. Not only must the utility associated with each benefit be calculated, but the costs associated with continuing the process must be calculated. This is no more realistic than expected utility theory.

3.1.3 Bounded Rationality: Satisficing

Satisficing is not identical to optimisation under constraints. It takes into account '…the limitations of the human mind, and the structure of the environments in which the mind operates'[19]. Because of human limitations, 'approximate methods' are used to manage most decision-making tasks [20]. This theory acknowledges the importance of recognition processes, which provide heuristics to guide both the search for information and when it should end. It also emphasises the importance of simple heuristics being adapted to the environment. Gigerenza [19] calls these 'fast and frugal' heuristics.

Satisficing sets an adjustable aspiration level, where the search is ended as soon as one alternative is found that exceeds the aspiration level [19], meaning that as soon as an acceptable possibility is found, no other alternatives are considered. One does not go on looking for the most optimal option.

While satisficing is a very reasonable model, it has not been applied in the current study because a different model, discussed below, was considered more appropriate for use in situations where the participant is considered to be an expert.

3.1.4 Naturalistic Decision making – the Critical Decision Method

In contrast to the previously discussed 'classical' decision theories, which focused on human decision makers' failings, naturalistic decision making concentrates on the way in which human decision makers actually make decisions, every day [21]. Klein [21] suggests that humans do not perform exhaustive analyses – rather, they look at the situation and apply some kind of general heuristic based on previous experience. If the situation appears similar to one encountered previously, the pattern is recognised, and the course of action is obvious. This use of a kind of 'situation template' has come to be known as 'recognition-primed decision making' (RPD) [21].

A naturalistic decision-making situation setting consists of the following elements: time pressure (relative to the task); high stakes; experienced decision makers; inadequate information (for performance in uncertain situations); unclear outcome goals; poorly defined procedures; cue learning (where patterns are perceived within ambiguous stimuli); a larger context inclusive of higher-level goals and background conditions;

dynamic conditions where the situation is constantly changing; and team coordination in decision making [21].

Klein [21] cites a number of time pressurised situations, such as those in fire fighting and emergency services, where people handle a large number of decision points, but don't spend a lot of time on any of them. In a contrast to classical decision-making theory, he opposes the conventional sources of decision-making 'power', or abilities, such as logical deductive thinking, probability analysis and statistical methods. Instead, he favours the importance of intuition, mental simulation, metaphor and storytelling as sources of power in dynamic real world situations. Intuition allows one to size up the situation, mental simulation allows the visualisation of potential courses of action, metaphor allows one to draw on previous experience by presenting parallels between the cases, and story telling helps to consolidate the experiences to make them available for the future. Naturalistic decision making is also flexible, and the heuristics applied adjust as the situation changes.

3.2 Decision-making measures

It is very difficult to measure decision quality, as it is impossible to get inside people's heads and find out exactly what they are thinking. Instead of measuring decision making directly, therefore, it must be inferred from performance, whereby the participant's actions are assumed to reflect the choice that they have made. This is the approach taken in this study.

There are a number of decision-making questionnaires available, but many of them relate to assessing decision-making style, as opposed to the decision making itself. The Anti Air Performance Index (ATPI) is one decision-making measure that assesses the quality of decisions made.

3.2.1 The Anti-Air Performance Index

The ATPI [22] was designed to assess how well a certain task was performed by a team across each event in the task, while in training. It is a behaviourally-based table, consisting of one row for the events that will occur, one for the time at which they will occur, and a scale of 0 to 3 with specific outcome anchors for scoring, to ensure consistency across instructors. For example, a score of 0 might equate to 'Fired missile at target; fired other weapons', and a score of 3 might equate to 'Does not shoot at targets'. Examination of actions across events highlights the types of situations that a team struggles with.

The ATPI can also be used to assess individual outcomes that contribute to team outcomes. The format is very similar to that used to assess team decision making.

The ATPI is advantageous for use in assessing team decision making, but only caters for individual decision making in the context of a team environment. It was inappropriate in its current form for use in this study, but provided a base for a variation of decision-making measurement to be created. The variation is discussed in Section 4, *Method*.

4. Method

4.1 Operation Flashpoint

One way to examine the real relationship between SA and decision making is to assess it in an environment where as many factors as possible are controlled. If the confounding factors are minimised, it is possible to get a clearer view of the phenomenon itself, and thus gain a greater insight into the decision-making process. The current study uses the Commercial-Off-The-Shelf computer game 'Operation Flashpoint' to do just this. The same motivation prompted other researchers to utilise a virtual environment to study the role of infantry platoon leaders' SA in decision making [23]. In other domains, simulation was used to examine the relationship between SA, decision and performance for combat pilots [4] and air-traffic controllers [5].

Computer simulations have been used successfully in military endeavours, particularly in training [24]. 'Operation Flashpoint', a military-based tactical first-person shooter game, has been lauded as the most realistic first-person shooter game available [25]. It can be scripted and constrained, has a realistic game engine, gives players modern 'equipment', and has been assessed in relation to the Australian Army as being a good training tool [25]. Furthermore, within Land Operations Division a number of other experiments have been carried out using 'Operation Flashpoint', which have provided information and expertise [26]. These considerations made it the most suitable choice for the current study.

4.2 Operation Flashpoint Scenario

The 'Operation Flashpoint' scenario involved the participant entering the game at their insertion point, making a number of decisions in order to reach a road suspected of being an enemy Main Supply Route, and setting up an observation post at one of three appropriate areas. They were then required to perform reconnaissance, recording on a tally sheet the vehicles that traversed the road, and in particular watch for the Musorian Senior Commander. When the commander's presence had been confirmed, they were to move to exfiltration point Alpha. They then had a number of choices, based on information gleaned from previous decisions, about how to reach Alpha. Depending on their decisions, they gained extra information that allowed them to choose to go to exfiltration point Bravo instead. The scenario took participants between fifty and ninety minutes to complete.

The development of the scenario was guided by two SMEs, both Army Non Commissioned Officers with extensive infantry experience. Within the limitation imposed by the game, care was taken to ensure that the scenario was realistic in terms of reconnaissance activities and constraints placed to limit the number of decision options within the context of the scenario.

4.3 Participants

Twenty-four volunteers participated in this study. Ten were civilians from DSTO, four of whom had some military experience in the Reserves or Infantry. The remaining fourteen were members of 1 Air Field Defence Squadron.

Demographic information, including age, presence and extent of military experience, and experience with playing computer games, was collected, in order to examine the impact, if any, that military training and gaming skill would have on the data.

Subjects' ages ranged from 19 to 52 years (Median = 28.5). Military experience ranged from participation in the Army Reserves (8.3%) and Air Force logistics (12.5%) to the Australian Army (54.2%), with overall military experience ranging from 3 to 35 years (Median = 6-12 years). Gaming experience, measured on a 5-point scale of 'often played' to 'rarely played,' averaged at 'somewhat regularly,' but the median for playing first person shooter games was 'Rarely'. 83.3% had never played 'Operation Flashpoint' before.

4.4 Experimental Protocol

The study consisted of one reconnaissance scenario. Before commencing the study, participants were informed of the aims and methods of the study, before their consent was obtained. They were then required to provide demographic information pertaining to their age, rank, military division, and their experience with computer games.

Each participant participated in a ten minute training exercise before performing the trial proper, in order to become accustomed to the game and the use of the questioning technique employed in this study. They were then provided with a mission brief, and additional information, and were requested to fill out a planning form addressing such things as potential routes to the observation area, their mission statement, and their rules of engagement. All participants played the same mission.

4.5 Data Collection

4.5.1 Planning

Of subsidiary interest was the role of planning and knowledge in SA. After being given time to read the brief, and being provided with additional information, participants were asked to prepare a plan of action in their minds. Informational aids were then removed, and participants were required to fill out a questionnaire regarding their understanding of the situation prior to their entry into the game.

The questions were developed with the aid of an SME, who advised on the type of questions that were appropriate and the wording of questions, and provided additional documents pertaining to military planning procedures. The questionnaire asked them for their understanding of the mission statement, the specified and implied tasks they were required to complete, their equipment, their rules of engagement, and their strengths. They were also asked to detail on a map provided for the purpose their infiltration point and a route to it, three possible OPs, and their extraction point and a route to it.

4.5.2 Situation Awareness – DQT

4.5.2.1 Question Development

A Goal Directed Task Analysis [9] was carried out on the scenario. The players' goals, subgoals, decision points and the SA requirements for each decision were identified.

Analysis of these elements was carried out with the aid of an SME. Particular care was taken to identify and separate tasks from goals, as goals consist of the ultimate desired outcome, which can be achieved through different tasks.

Particular care was also taken to ensure that the questions would not pre-empt certain actions – that is, that the questions would not cue the player to attend to certain elements in their environment more than others. It was vital for us to ensure that the questioning process did not interfere with the way in which participants played the game.

4.5.2.2 DQT Application

SA was gathered using the DQT as discussed above. The game was paused at three preselected times, during which six SME-approved questions were verbally asked of each participant. The first set of questions was not asked until more than five minutes had elapsed, in alignment with Endsley's research on required immersion time [9]. Aids in the room such as maps and information sheets were removed prior to questioning. The participant recorded answers on a sheet of paper, which was then taken away and scored by the experimenter.

Each question was worth one point. Decimal scores were attributed when answers were incomplete or only partially correct. The scores were then averaged, and converted into a percentage to provide a wider range, and greater accuracy, for the scores.

4.5.3 Decision making

4.5.3.1 The Action-Inference Decision Tree (AIDT)

In the current study, decisions were inferred on the basis of the actions taken, much like the ATPI. It is assumed that decisions would not be confounded by a lack of skill in performing the actions. Unlike the ATPI, the AIDT does not require detailed information regarding the specific errors performed, as it is used for assessment purposes, and not training and correction.

The AIDT is a flow chart that branches at each option, and the potential options resulting from them, permitting the experimenter to plot the path of the participant's actions.

The AIDT is highly context dependent, and must be custom designed to cover every possible choice that the participant may make. Decisions are plotted on a flow chart by the experimenter as the participant performs actions reflecting them, and are attributed scores of 1, 3 or 5. An optimal decision earns a score of 5, a mediocre decision a score of 3, and a poor decision a score of 1.

Figure 2 shows a section of the decision tree used in the current study. The selection of OP1, the optimal observation post (OP) option, leads to other decisions relating to events occurring in the game. The three options branching from this decision are attributed scores according to their optimality. An SME advised on the optimality of each option, on the basis of the real situation as written into the scenario. When option S1c is selected, this leads to two further options.

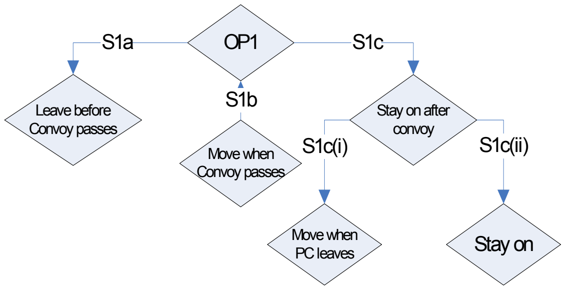

Figure 2: Section of decision tree used

If a player chose OP1 (5 points), then option S1b (5 points), their score for this decision point would be five, the highest possible score. If they chose OP1 (5 points), option S1c (3 points) and option S1c(i), their score would be 4.33 ((5+3+5)/3 = 4.33). Thus, scores are averaged to the number of decisions made.

In the current study, the decision tree decomposed naturally into four sections, where the participants arrived at the same decision points irrespective of their previous actions. Therefore, the scores of the decisions that they made in each block were averaged to provide a section score, and the scores of each section were then averaged to provide an overall decision-making score.

5. Results

Overall, participants had a moderately high level of SA, decision-making scores and planning scores, as displayed by Table 1.

Table 1: Table of overall means and standard deviations (SD) of SA, planning and decision-making (decision) scores

	Mean	SD
SA (%)	70.33	9.44
Decision	3.45	0.58
Planning	7.58	1.95

5.1 SA and Decision making

Pearson's *r* correlations were performed to test the predictions that SA scores would be related to decision-making scores. As graphically demonstrated in Figure 3, positive correlations were found between SA and decision making, $r = 0.47$, $p < .05$.

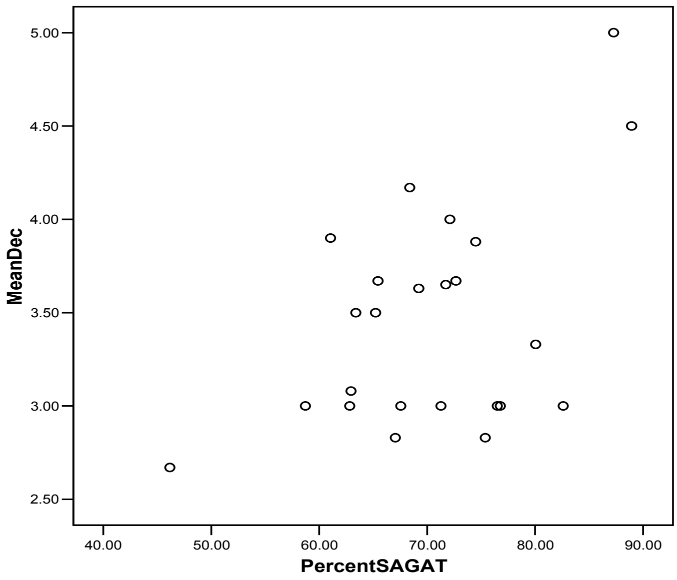

Figure 3: Scatterplot of mean decision scores and SA percentage scores

5.2 SA and Planning

Pearson's *r* correlations were also performed to test the predictions that SA scores would be related to planning scores. Figure 4 shows that positive correlations were found between SA and planning scores, $r = 0.43$, $p < .05$.

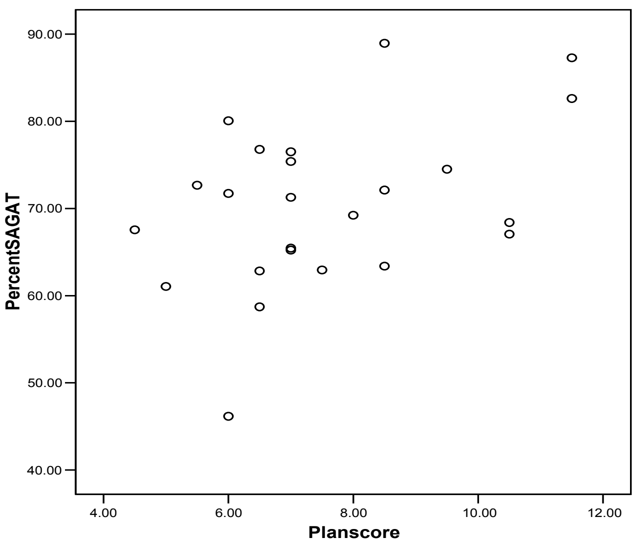

Figure 4: Scatterplot of SA percentage and mean planning scores

SA accounted for 22 % of variability in decision making and 18 % of variability in planning.

6. Discussion

This study found that SA was related to both planning and decision making, providing empirical support for Endsley's model of dynamic decision making [9]. On the whole it would appear to support the assumption that there is a positive relationship between SA and decision making, and SA and planning.

It is important to mention that three cases came close to falling outside three standard deviations from the mean, but did not quite classify as outliers (see Figure 3). Until this study can be replicated with a larger number of participants, the results remain somewhat ambiguous. A larger number of participants will reveal whether the cases in question are a part of the main data set, or whether they are actually outliers. The small number of cases available renders the conclusion not very robust.

As it was, the relationship between SA and decision making was of medium strength ($r = 0.47$, $p < 0.05$), suggesting that other factors might play an important role in decision making.

As shown by Endsley's model [9] many factors contribute to each of the steps in dynamic decision making, namely SA, decision and performance of actions. These factors include abilities, experience, training, expectations, and workload. In the current study the effect of game-play skill was examined more closely.

The current study was undertaken to show a relationship between SA and decision making. The quality of the decisions was not measured directly, but was inferred from the actions taken by the player. The underlying assumption was that the players had the skills to execute any actions based on the decisions taken. In other words, once the player made a decision, he or she should be able to act in accordance with the decision; skills or the lack thereof should not be a confounding factor. It was possible, however, that skills in game-play might have an effect on decision making and actions taken during the scenario.

Despite the training provided on the game scenario as part of the experimental protocol, it was observed during data collection that there was considerable variation in game-play skills among the participants, as well as in their confidence with playing the game. The relationship between decision scores and experience in game-play revealed a correlation ($r = 0.42$, $p < 0.05$), but the correlation between SA and game-play experience was not significant. This suggested that familiarity with computer games had some effect on the decision scores, which as mentioned previously were measured through the actions. Therefore the initial assumption that skills were not a contributing factor did not appear to be entirely valid.

Partial correlation was employed to examine the relationship between SA and decision making while controlling for game-play experience. (Game-play experience was measured by requiring the players to provide a subjective rating of their experience from 1 to 5.) It was found that general game-play experience had only a modest effect on the strength of the relationship between SA and decision making (r was reduced from 0.469 to 0.395) accompanied by an increase in p value from 0.021 to 0.062. Given the subjective nature of game-play experience measure and the small sample size, the increase in p value to above 0.05 was not considered to be an issue.

Although game-play experience is expected to assist players in getting through the game, it does not necessarily give them all the skills required to execute their decisions. The nature of the scenario was different to those offered in the commercial games that participants may have played. Whereas many first person shooter games generally focus on players having to evade and shoot the enemies, the scenario presented in this study required them to observe their surroundings, be aware of environmental cues, navigate in the virtual terrain assisted by a compass and a map, and achieve goals that did not involve shooting. This required a different mindset from the usual first person shooter scenario. It might take some time for the players to be accustomed to and fully immersed in the game. It was therefore possible that a learning effect might be present during the game. The current study provided participants with a ten-minute training exercise, which might not be adequate.

The role of training is an important issue in the military environment. The more skill and/or experience (training) a person has, the larger their repertoire of available responses. Consequently, their level of both SA and decision-making skills should arguably increase. Future studies should provide the participants with a more structured training session that ensures that all participants are comfortable with the task prior to commencement of the experimental session, in order to equalise the playing field.

A repeated measures study would allow examination of the extent of the impact of game-play experience on SA and decision making. Having participants with no computer game experience play through the scenario, and then returning some time later and playing a different, but comparable, scenario with the same game, would achieve this. If game-play experience does impact on the relationship between SA and decision making one would expect the relationship between these two factors to be larger for the second exposure to the game.

A limitation of the current scenario is the lack of SA stimuli, caused by the constraints imposed by the game, the need to maintain realism in terms of a military scenario, and restriction on the decision options available to the players. As a consequence, the number of stops for probing the players' SA and the number of questions that could be asked during each stop were limited. As it was, six SA questions, two at each level, were asked at each of the three stops.

Due to insufficient movement constraints, which led to unpredictability in player behaviour, players sometimes answered questions at a different level of SA than that which the question was framed to reflect. For example, when a participant had only just looked at his watch previous to being asked the level 3 question, 'Are you ahead of, behind or on schedule?' the question elicited level 2 information. As a result of this, there were insufficient level 3 (prediction) questions.

Participants also missed vital SA cues as a result of taking unexpected courses of action. Some participants chose optimal courses of action without knowledge of the SA cues related to those courses of action, and therefore the decisions made, and scores given, are misleading, as the decisions were not made on the basis of programmed SA cues. For example, some participants chose to move to the alternative exfiltration point, Bravo, for reasons such as 'I took the wrong path and didn't want to waste energy moving to Alpha' and 'Bravo is closer' (to the OP area).

It was also observed that, when a crucial decision point arose, the information provided by the brief was not taken into account by a number of players. When informally asked about their choices, participants cited infantry protocol that the researchers had not been aware of. In the future, input from several SMEs would be valuable, as their pooled understanding of infantry practices might prevent similar misunderstandings arising.

There is a strong possibility that motivation may have played a key role in the players' performances here. In a computer simulation the stakes are low, with no real risk to the participants. Therefore participants took risks that in a live situation they might not have. For example, players were advised to remain on the tracks outlined in the map, because they were areas that had been cleared for mines. Regardless of this warning, many participants ventured off the paths to circumnavigate enemy troops, instead of taking the safer, and more strategically sensible, options provided. It is unclear whether the information was ignored or forgotten. Such a response may stem from inexperience, as participants may not have encountered a similar situation before, and therefore have no comparable situations in their memory [21].

It is worth mentioning that although the naturalistic decision-making model was the basis for our understanding of decision making, in this situation it was not observed to come into play. Because of the mixed nature of the participant pool (consisting of air force logistics staff as well as infantry), and the use of the unfamiliar, simulated environment, naturalistic decision making was not observed to occur. The recognition primed decision model came partially into play, with participants applying elements of their trained protocol to the situation, but their inability to integrate new and more urgent information into their situational model jeopardised their safety. This was made particularly clear in the case of path selection mentioned in the previous paragraph. This shows a lack of expertise, and an absence of naturalistic decision-making heuristics such as intuition and mental simulation.

However, it cannot be overlooked that many of them were operating in a new context in which they were not experts. It was unfair to expect participants to apply naturalistic decision-making heuristics in an unfamiliar context, particularly a context in which they had not previously applied such skills. They might have behaved more in accordance with naturalistic decision making had we given them a scenario in the field.

There is also a possibility that the model applied was not the right model to use in this situation. The naturalistic decision model appeared to be the most appropriate for use with the intended participant pool out of all of the possible models considered. Additionally, we had originally designed the experiment for use with experts, those being members of the infantry, and had believed that the game-play effect would be minimised by the training course provided. Since the participants were not all infantry members, and the training was insufficient to counter the skill effect for the task, further studies should use participants solely from the infantry, and a closer look must be taken at the game-play effect, before altering the model. Further research should take a closer look at the satisficing model, as it may prove more appropriate for use with non-experts.

Because of individual and unexpected idiosyncrasies in play, questions did not always relate to the participant's activity of the moment, and so were not always appropriate. Future studies need to ensure that decision options are carefully constrained to decrease the likelihood of data being jeopardised by unanticipated behaviour.

To ensure that there are sufficient questions that relate to each SA level, future studies also need to ensure that the questions are not only appropriate to each SA level but also are highly internally consistent. These questions must also be appropriate to the activity undertaken at – or prior to – SA question administration.

A further consideration is that findings of the current study may not necessarily translate to the field, due to the reliance on computer game-play. It may well be the case that the relationships between SA, decision making and planning are different in live exercises, though it is acknowledged that even live exercises are only a simulation of the real situation. A challenge for researchers is to investigate whether findings in live exercises are applicable to real operations.

7. Conclusion

Although this exploratory study has provided support for the assumption that the quality of SA predicts the quality of the decisions made, this support must be qualified.

Despite attempts to control for it, game-play skills appeared to impact on relationships found. This emphasises the role that external variables play in the SA-decision-performance of actions relationship. A closer look at the impact of familiarity with the simulation environment would be useful.

The results of this study cannot be applied to dynamic decision making in live operations, as the gaming skills and familiarity with the game context are not the same skills and familiarity required for live exercises. These skills may not be transferable across environments, and this highlights the importance of contextual knowledge as an external variable.

This study is a base on which further research into the SA-decision making relationship can be built. A positive relationship was found between SA and decision making, however, other factors contributed significantly to the relationship.

8. Acknowledgements

The authors would like to acknowledge and thank the following: members of 1 AFDS for the participation in the experiment, and Peter Boyd, CAPT William Boland, WO2 John Williams, and especially Diane Pomeroy, for their contributions to the experiment.

9. References

1. Endsley, M.R., Holder, L.D., Leibrecht, B., C., Garland, D., J., Wampler, R., L., and Matthews, M., D., *Modelling and Measuring Situation Awareness in the Infantry Operational Environment*. 2000, U.S. Army Research Institute for the Behavioural and Social Sciences: Alexandria, Virginia. p. 1-104.
2. *Land Warfare Doctrine LWD 0-1-5, Situational Awareness Developing Doctrine.* 2001.
3. Bolia, R.S., Nelson, W.T., Vidulich, M., and Taylor, R.M., *From chess to Chancellorsville: Measuring Decision Quality in Military Commanders*, in *Human performance, situation awareness, and automation: Current research and trends*, P.A. Hancock, Editor. 2004, Lawrence Erlbaum Associates, Inc: Mahway, NJ. p.269-273.
4. Endsley, M.R. *Predictive utiliy of an objective measure of situation awareness.* In *Proceedings of the Human Factors Society annual meeting*. 1990. Santa Monica, California: Human Factors Society.
5. Durso, F.T., Hackworth, C.A., Truitt, T.R., Crutchfield, J., Nikolic, D., and C.A., M., *Situation Awareness as a Predictor of Performance in En Route Air Traffic Controllers*. 1999, DOT/FAA/AM-99/3 National Technical Information Service: Springfield, VA.
6. Endsley, M.R. *Situation Awareness Global Assessment Technique (SAGAT)*. in *IEEE National Aerospace & Electronics Conference, 1988.* 1988. Dayton, OH.
7. Endsley, M.R., *Theoretical Underpinnings of Situation Awareness: A Critical Review*, in *Situation Awareness Analysis & Measurement*, M.R.G. Endsley, D.J., Editor. 2000, Lawrence Erlbaum Associates: Mahwah, New Jersey. p. 3-33.
8. Endsley, M.R. *Design and Evaluation for Situation Awareness Enhancement*. in *Human Factors Society 32nd Annual Meeting - 'Riding the Wave of Innovation'*. 1988. Anaheim, California: HFES.
9. Endsley, M.R. and Garland, D.J., eds. *Situation Awareness Analysis and Measurement*. 2000, Lawrence Erlbaum Associates: Mahwah, NJ. 367.
10. Endsley, M.R., *Toward a Theory of Situation Awareness in Dynamic Systems.* Human Factors, 1995. **37(1)**: p. 32-64.
11. Guille, M. and French, H.T., *Toward A Methodology For Evaluating the Impact of Technologies on Infantry Situation Awareness*. DSTO-TR-1628, 2004, DSTO: Edinburgh.
12. Endsley, M.R., Kiris, Esin O., *Situation Awareness Global Assessment Technique (SAGAT) TRACON Air Traffic Control Version User Guide*. 1995, Texas Tech University, Department of Industrial Engineering.: Lubbock, Texas. p. 1-41.
13. Endsley, M.R., Holder, L. D., Leibrecht, B.C., Garland, D.J., Wampler, R.L. and Matthews, M.D., *Modeling and Measuring Situation Awareness in the Infantry Operational Environment.* 2000, U.S. Army Research Institute for the Behavioural and Social Sciences: Alexandria, VA. pp. 1-104.
14. Gugerty, L. and Tirre, W. *A PC-based Simulator for Assessing Situation Awareness*. in *Human Facotrs and Ergonomics Society 41st Annual Meeting*. 1997: HFES.
15. Hogg, D.N., Torralba, B. and Volden, F.S., *A situation awareness methodology for the evaluation of process control system: Studies of feasibility and the implication of use*. 1993, OECD Halden Reactor Project: Storefjell, Norway.
16. Gaba, D.M., Howard, S.K. and Small, S.D., *Situation awareness in anesthesiology*. Human Factors, 1995(37): pp. 20-31.
17. Guille, M. and French, H.T. *Toward a Methodology for Evaluating the Impact of Solider Combat System Technologies on Situation Awareness*. in *Land Warfare*

Conference 2003: Projected Forces, Protected Forces. 2003. Adelaide, South Australia: DSTO.

18. Endsley, M.R., *Direct Measurement of Situation Awareness: Validity and Use of SAGAT*, in *Situation Awareness Analysis and Measurement*, M.R. Endsley, & Garland, D.J., Editor. 2000, Lawrence Erlbaum Associates: New Jersey. p. 147-174.
19. Gigerenza, G., Todd, P.M., and Group, A.R., *Simple Heuristics That Make Us Smart*. Evolution and Cognition, ed. S. Stich. 1999, New England, Oxford: Oxford University Press.
20. Simon, H.A., *Rational decision-making in business organisations*, in *Advances in Behavioural Economics*, J.H. Kagel, Editor. 1987, Ablex: Norwood, New Jersey. p. 18-47.
21. Klein, G., *Sources of Power: How people make decisions*. 1998, Cambridge, Massachusetts: The MIT Press.
22. Johnston, J.H., Smith-Jentsch, K.A., and Cannon-Bowers, J.A., *Performance Measurement Tools for Enhancing Team Decision-Making Training*, in *Team Performance Assessment and Measurement: Theory, Methods and Applications*, C. Prince, Editor. 1997, Lawrence Erlbaum Associates: New Jersey.
23. Pleban, R.J., Eakin, D.A., Salter, M.S., and Matthews, M.D., *Training and assessment of decision-making skills in virtual environments*. 2000, US Army Research Institute for the Behavioural and Social Sciences: Fort Benning, Georgia.
24. Ricci, K.E., Salas, E., and Cannon-Bowers, J.A., *Do computer-based games facilitate knowledge acquisition and retention?* Military Psychology, 1996. **8**(4): p. 295-307.
25. Barlow, M., Morrison, P., and Easton, A., *1st Person tactical Shooters: COTS games with military training potential?* 2002, University of NSW at ADFA, ACT: Australian Capital Territory.
26. French, H.T., Clarke, E., Pomeroy, D., Seymour, M., and Clark, C.R. *Psychophysiological Measures of Situation Awareness (Summary Report)*. in *Proceedings of Human Factors of Decision-making in Complex Systems Conference*. 2003. Dunblane, UK.

Appendix A: Materials

A.1. Information Provided to the Participants

Both the brief and information sheet were available to the participant during play, but were removed during the planning session and the administration of the DQT questions.

A.1.1 Brief

Due to heightening tensions fuelled by disagreements over oil reserves off the coast of Australia, the Musorian Government has sent an expeditionary force into the Kidman Enclave and has taken control of the major infrastructure. Australia was asked to assist in restoring control back to the Government and responded by sending a security force to oust Musorian forces and return control of the enclave to the local Government.

There are still elements of the Musorian Armed Forces (MAF) in the Area of Operations (AO). They are conducting destabilising tactics against the local populace and infrastructure. They are using the Shylock Rd as their Main Supply Route (MSR) to move around the area and to move stores and troops. They remain relatively confident of their actions and as such are moving by both day and night.

Latest intell is as follows:

1. The senior commander has been active in the AO marshalling the local troops.
2. He is moving around the AO in a staff car (UAZ) with armoured protection.
3. Latest reports suggest that he will be escorted from his firm base in the North down to the forward areas today.
4. The MAF are conducting clearing patrols of the AO to the North.

You are to ensure that you do not compromise the operation by being contacted.

You are Reconnaissance Sect Commander of 12 RAR. Your Battalion is part of a security Force to assist in restoring security to the Kidman Enclave. You have been tasked with conducting an Observation Post (OP) over the MSR to gather information on the amount of troop movement that the MSR is used for. Your Recon group will consist of yourself.

<u>MAF Opposing Forces (OPFOR)</u>

1 Light Infantry Battalion;
1 Transport Tp;
1 Light Armoured Tp (Possible, TBC); and
Dress: MAF is Cams, web kit.
Wpns: AKMs , RPKs
Morale: as reported is high due to success so far.
Tactics: They will conduct aggressive actions to any contact or possible sighting.

Civilians
There are civilians in the area. Most are sympathetic to the Australian Government's actions; they should be treated with some caution but are willing to give information of local troop movements.

Mission: You are to conduct an Observation Post (OP) of the Main Supply Route to gather intelligence about Enemy movement.

Execution: Infiltration at designated Drop point. Move East and establish a OP, Loc vicinity Shylock Road, then move to extraction point Alpha when info gathered. Points to note:

- Stay on the marked tracks as there have been reports of mines in the AO;
- Boundaries for the Location of the OP are;
- ROE do not engage any hostiles unless it is absolutely necessary;
- Reach target area undetected;
- Locate ideal hide and conduct Observation of Shylock Road;
- Withdraw. To Alpha
- If at anytime your are compromised you are to move to alternate extraction point Bravo
- At completion of task radio in for helo pickup.

Time out 0600h
Time in 1800h
Your Call Sign is 60A

A.1.2 Additional Information Provided

The document that follows contains information that is elementary and perhaps arbitrary to infantry members, but the participant pool contained non-infantry participants. It was considered prudent, in the interests of ensuring that they understood their task, that it be included for their benefit.

DQT

The DQT (direct questioning technique) is a method of working out an individual's situation awareness, situation awareness being how much the person knows about what is going on around them. We ask questions about what's going on to elicit your situation awareness, and we compare it to an ideal state of situation awareness as established by the programmed cues in the game.

When we ask about your current/future task, we are asking about the activity that you are performing in order to reach the overall goal – the task is a sub-goal.

GAME

You are performing a reconnaissance mission. That requires covert behaviour, moving quietly within the game and avoiding detection by the enemy forces. That is why you must only engage with the enemy if you are under attack.

You must find an observation post – this must be a concealed position from which the area can be observed. It should provide cover, a covered withdrawal route, with a clear view to the area. It should not be on a likely enemy patrol route.

You are the only Australian soldier in this scenario. You can therefore be confident that any other soldier you encounter is a member of the MAF.

The enemy will only appear on your map when he is within your field of view. Do not assume that just because you can't see him on the map, he isn't there.

Please note that although you are observing the traffic on the Shylock Rd, you are really looking for the senior commander. Once you have confirmed his presence and the direction in which he is travelling, you have obtained the necessary information.

The original exfiltration point is Alpha, the alternate exfiltration point is Bravo. To call the helicopter, press 0, 0, and then select the appropriate site that you need it to land at. **Delta** is to be selected if you need the helicopter to abort pick-up.

Don't call the helicopter until you're near the exfil site.

<u>Miscellaneous Information</u>

- Stick to the paths depicted on the map. They have been cleared for mines.
- There is a map of the area, marked with important locations, above the screen.
- Use your map. I repeat, USE YOUR MAP – it is vital to keeping you on track.
- You enter the game at 0730. Aim to reach the OP area by 0750 or before.
- Controls are displayed in the table at your left.
- Screenshots of vehicles you may see are also on your left.
- The tally sheet to your right is for your recon task. Record the vehicles. encountered and the number of them on this sheet. It need not be in the format provided, you may list them as they come past if you prefer.

A.2. Demographic Questionnaire

Participant No:

Age:

Have you had any military experience?

Yes / No

If you answered yes to the previous question, how long did you / have you served in the armed forces, and in what capacity (ie Reserves, Infantry, Communications etc)?

How regularly do you play computer games? 1=often, 5=rarely

1 2 3 4 5

How regularly do you play first person shooter games? 1=often, 5=rarely

1 2 3 4 5

Have you ever played 'Operation Flashpoint'?

Yes / No

If you answered 'Yes' to the previous question, how frequently do you play it? 1=often, 5=rarely

1 2 3 4 5

A.3. Planning Questions

1. What is the mission statement? (Who, what, when, where, why.)

2. What are the tasks you need to complete?
    a. Specified
    b. Implied

3. What equipment do you have?

4. What ROE are you operating under?

5. What are two of your strengths?

6. Detail infiltration point and possible route to observation point on the map.

7. Indicate three possible OPs on the map.

8. Indicate your extraction point and a potential route to it on the map.

A.4. DQT Questions

PAUSE 1

1) Mark on the map 3 locations where there is suspected enemy activity (use the information provided and your own observation).

2) Indicate your current position on the map.

3) Walking in the cleared paths involves some risks. What are two measures you could take to minimise the risks.

4) Was the MAF's behaviour consistent with the information you have received about the morale of the MAF? Explain your answer.

5) Do you think you are ahead of, behind, or on schedule for performing your reconnaissance task?

6) Given your mission, list two important characteristics of your OP.

PAUSE 2

1) How many convoys passed during your recon?

2) How many hills were there in the observation site?

3) List one advantage and one disadvantage of an OP in the southern area.

4) Based on your observation of the convoys list two strengths of the MAF.

5) Describe the highest risk that you face in completing your mission.

6) In relation to that risk, what are two measures you could take to minimise it?

PAUSE 3

1) Mark on the map where you met the civilian / Indicate your position on the map

2) How many track junctions have you passed since you left your OP?

3) To what extent do you trust the information provided by the civilian? Why? / What is your current task?

4) Mark on the map all known or suspected MAF locations.

5) Describe your next course of action.

6) Why have you chosen this particular course of action?

Because the participant's experience was contingent on the choices that they made, there were two possible questions to be used for questions 1 and 3 at Pause 3. These were selected according to the experiences of the participant within the game, ie where the participant has not met the civilian, it is useless to ask him whether he trusts him.

A.5. Other Aids - Map

An A4 sized copy of this map was provided to each participant for answering planning questions 6, 7 and 8, and DQT questions 1.1, 1.2, 3.1 and 3.4.

Appendix B: Results

B.1. Data

B.1.1 Demographic data

Subject	age	militexp	degmilexp	gameplay	FPshooter	OFPplayed	OFPfreq
1	29.00	1.00	2.00	5.00	5.00	2.00	6.00
2	37.00	1.00	2.00	1.00	2.00	1.00	2.00
3	20.00	1.00	3.00	4.00	4.00	2.00	6.00
4	40.00	1.00	3.00	5.00	5.00	2.00	6.00
5	34.00	1.00	3.00	4.00	5.00	2.00	6.00
6	23.00	1.00	4.00	5.00	5.00	2.00	6.00
7	21.00	1.00	4.00	2.00	3.00	2.00	6.00
8	25.00	1.00	4.00	2.00	5.00	2.00	6.00
9	39.00	1.00	5.00	1.00	1.00	1.00	2.00
10	26.00	1.00	5.00	2.00	3.00	2.00	6.00
11	30.00	1.00	5.00	3.00	5.00	2.00	6.00
12	28.00	1.00	5.00	2.00	2.00	1.00	2.00
13	28.00	1.00	5.00	5.00	5.00	2.00	6.00
14	26.00	1.00	5.00	1.00	2.00	2.00	6.00
15	33.00	1.00	6.00	5.00	5.00	2.00	6.00
16	36.00	1.00	6.00	5.00	5.00	2.00	6.00
17	52.00	1.00	6.00	5.00	5.00	2.00	6.00
18	46.00	1.00	6.00	3.00	1.00	2.00	6.00
19	23.00	2.00	1.00	4.00	5.00	2.00	6.00
20	19.00	2.00	1.00	2.00	3.00	2.00	6.00
21	27.00	2.00	1.00	1.00	1.00	2.00	6.00
22	23.00	2.00	1.00	2.00	4.00	1.00	5.00
23	38.00	2.00	1.00	3.00	5.00	2.00	6.00
24	35.00	2.00	1.00	3.00	5.00	2.00	6.00

<u>Numeric Codes</u>

Military experience: 1 = yes, 2 = no
Degree of military experience: 1 = Not Applicable, 2 = Reserves, 3 = Air Force, 4 = Australian Army 0-5 years, 5 = Australian Army 6-12 years, 6 = Australian Army 13+ years

Game play experience, first person shooter (FPShooter), and Operation Flashpoint playing frequency (OFPfreq): 1 = Often, 2 = Regularly, 3 = Somewhat Regularly, 4 = Every now and Then, 5 = Rarely
Have played Operation Flash Point (OFPplayed): 1 = yes, 2 = no

B.1.2 SA and Planning scores

Subject	Planscore	DQT1	DQT2	DQT3	SumDQT	meanDQT	PercentDQT
1	6.50	4.91	3.91	5.00	13.82	4.60	76.78
2	5.50	4.58	3.50	5.00	13.08	4.36	72.67
3	5.00	3.83	3.91	3.25	10.99	3.66	61.06
4	10.50	3.91	3.91	4.25	12.07	4.02	67.06
5	8.50	3.41	4.25	3.75	11.41	3.80	63.39
6	4.50	4.66	4.00	3.50	12.16	4.05	67.56
7	6.00	4.66	3.75	4.50	12.91	4.30	71.72
8	6.50	5.41	2.45	3.45	11.31	3.77	62.83
9	11.50	5.16	5.55	5.00	15.71	5.24	87.28
10	6.00	5.16	5.25	4.00	14.41	4.80	80.06
11	7.00	4.66	4.00	4.91	13.57	4.52	75.39
12	7.00	3.58	5.25	4.00	12.83	4.27	71.28
13	7.00	3.83	3.75	4.16	11.74	3.91	65.22
14	8.00	4.41	3.30	4.75	12.46	4.15	69.22
15	7.00	5.16	3.71	4.90	13.77	4.59	76.50
16	7.50	3.58	3.50	4.25	11.33	3.78	62.94
17	7.00	3.83	4.50	3.45	11.78	3.93	65.44
18	8.50	5.16	5.50	5.35	16.01	5.34	88.94
19	6.00	2.08	3.08	3.15	8.31	2.77	46.17
20	9.50	4.16	4.25	5.00	13.41	4.47	74.50
21	8.50	4.58	4.15	4.25	12.98	4.33	72.11
22	6.50	3.66	3.41	3.50	10.57	3.52	58.72
23	11.50	5.16	5.80	3.91	14.87	4.96	82.61
24	10.50	3.91	3.25	5.15	12.31	4.10	68.39

Game play experience, first person shooter (FPShooter), and Operation Flashpoint playing frequency (OFPfreq): 1 = Often, 2 = Regularly, 3 = Somewhat Regularly, 4 = Every now and Then, 5 = Rarely
Have played Operation Flash Point (OFPplayed): 1 = yes, 2 = no

B.1.3 Decision scores

Subject	DecSet1	DecSet2	DecSet3	DecSet4	MeanDec
1	3.00	3.67	2.33	3.00	3.00
2	1.00	3.67	5.00	5.00	3.67
3	5.00	5.00	3.00	2.60	3.90
4	3.00	3.00	2.33	3.00	2.83
5	3.00	4.00	4.00	3.00	3.50
6	1.00	3.00	4.00	4.00	3.00
7	3.00	3.60	3.00	5.00	3.65
8	3.00	2.00	4.00	3.00	3.00
9	5.00	5.00	5.00	5.00	5.00
10	5.00	4.33	3.00	1.00	3.33
11	3.00	3.00	2.33	3.00	2.83
12	1.00	3.00	3.00	5.00	3.00
13	3.00	3.00	4.00	4.00	3.50
14	5.00	1.50	3.00	5.00	3.63
15	3.00	3.00	3.00	3.00	3.00
16	1.00	4.33	3.00	4.00	3.08
17	1.00	5.00	3.67	5.00	3.67
18	3.00	5.00	5.00	5.00	4.50
19	1.00	5.00	3.00	1.66	2.67
20	5.00	3.00	3.50	4.00	3.88
21	3.67	2.33	5.00	5.00	4.00
22	1.00	3.00	4.00	4.00	3.00
23	1.00	3.00	4.00	4.00	3.00
24	3.67	3.00	5.00	5.00	4.17

Game play experience, first person shooter (FPShooter), and Operation Flashpoint playing frequency (OFPfreq): 1 = Often, 2 = Regularly, 3 = Somewhat Regularly, 4 = Every now and Then, 5 = Rarely
Have played Operation Flash Point (OFPplayed): 1 = yes, 2 = no

B.2. Correlations

B.2.1 Correlations of mean planning score, mean decision score and DQT percentage

Correlations

		Planscore	PercentDQT	MeanDec
Planscore	Pearson Correlation	1	.427*	.386
	Sig. (2-tailed)		.038	.062
	N	24	24	24
PercentDQT	Pearson Correlation	.427*	1	.469*
	Sig. (2-tailed)	.038		.021
	N	24	24	24
MeanDec	Pearson Correlation	.386	.469*	1
	Sig. (2-tailed)	.062	.021	
	N	24	24	24

*. Correlation is significant at the 0.05 level (2-tailed).

B.2.2 Correlations of mean planning score, mean decision score and DQT percentage, controlling for game-play skills.

Control			Percent DQT	Mean Dec	Plan score
gameplay	PercentDQT	Correlation	1.000	.395	.399
		Significance	-	.062	.060
		(2-df)	0	21	21
	Mean Dec	Correlation	.395	1.000	.351
		Significance	.062	-	.101
		(2-df)	21	0	21
	Plan score	Correlation	.399	.351	1.000
		Significance	.060	.101	-
		(2-df)	21	21	0

B.2.3 Range, mean and standard deviation for planning scores, DQT percentage scores and decision scores

Descriptive Statistics

	Minimum	Maximum	Mean	Std. Deviation
Planscore	4.50	11.50	7.5833	1.94862
PercentDQT	46.17	88.94	70.3264	9.44124
MeanDec	2.67	5.00	3.4504	.58360

DISTRIBUTION LIST

An Empirical Study of the Relationship Between Situation Awareness and Decision Making

Melinda Stanners and Han Tin French

AUSTRALIA

DEFENCE ORGANISATION

	No. of copies
Task Sponsor	
Chief LOD	Doc Data Sheet& Dist List
S&T Program	
Chief Defence Scientist FAS Science Policy AS Science Corporate Management Director General Science Policy Development	shared copy
Counsellor Defence Science, London	Doc Data Sheet
Counsellor Defence Science, Washington	Doc Data Sheet
Scientific Adviser to MRDC, Thailand	Doc Data Sheet
Scientific Adviser Joint	1
Navy Scientific Adviser	Doc Data Sht & Dist List
Scientific Adviser - Army	1
Air Force Scientific Adviser	Doc Data Sht & Dist List
Scientific Adviser to the DMO	Doc Data Sht & Dist List
Systems Sciences Laboratory	
Research Leader Human Systems Integration	1
Task Manager (Han Tin French)	1
Author:	
Melinda Stanners (via Tin French)	1
DSTO Library and Archives	
Library Edinburgh	1 & Doc Data Sheet
Defence Archives	1
Capability Systems Group	
Director General Maritime Development	Doc Data Sheet
Director General Land Development	1
Director General Capability and Plans	Doc Data Sheet
Assistant Secretary Investment Analysis	Doc Data Sheet
Director Capability Plans and Programming	Doc Data Sheet
Director Trials	Doc Data Sheet

Chief Information Officer Group

Deputy CIO — Doc Data Sheet
Director General Information Policy and Plans — Doc Data Sheet
AS Information Strategies and Futures — Doc Data Sheet
AS Information Architecture and Management — Doc Data Sheet
Director General Australian Defence Simulation Office — Doc Data Sheet
Director General Information Services — Doc Data Sheet

Strategy Group

Director General Military Strategy — Doc Data Sheet
Director General Preparedness — Doc Data Sheet
Assistant Secretary Strategic Policy — Doc Data Sheet
Assistant Secretary Governance and Counter-Proliferation — Doc Data Sheet

Navy

Director General Navy Capability, Performance and Plans, Navy Headquarters — Doc Data Sheet
Director General Navy Strategic Policy and Futures, Navy Headquarters — Doc Data Sheet
Maritime Operational Analysis Centre, Building 89/90 Garden Island Sydney NSW
Deputy Director (Operations)
Deputy Director (Analysis) — shared Doc Data Sht & Dist List

Army

ABCA National Standardisation Officer, Land Warfare Development Sector, Puckapunyal — e-mailed Doc Data Sheet
SO (Science) - Land Headquarters (LHQ), Victoria Barracks NSW — Doc Data & Exec Summ
SO (Science), Deployable Joint Force Headquarters (DJFHQ) (L), Enoggera QLD — Doc Data Sheet

Air Force

SO (Science) - Headquarters Air Combat Group, RAAF Base, Williamtown NSW 2314 — Doc Data Sht & Exec Summ

Joint Operations Command

Director General Joint Operations — Doc Data Sheet
Chief of Staff Headquarters Joint Operations Command — Doc Data Sheet
Commandant ADF Warfare Centre — Doc Data Sheet
Director General Strategic Logistics — Doc Data Sheet

Intelligence and Security Group

DGSTA Defence Intelligence Organisation — 1
Manager, Information Centre, Defence Intelligence Organisation — email pdf
Assistant Secretary Corporate, Defence Imagery and Geospatial Organisation — Doc Data Sheet

Defence Materiel Organisation

Deputy CEO — Doc Data Sheet
Head Aerospace Systems Division — Doc Data Sheet

Head Maritime Systems Division	Doc Data Sheet
Chief Joint Logistics Command	Doc Data Sheet
PMAWD	Doc Data Sheet
Defence Libraries	
Library Manager, DLS-Canberra	Doc Data Sheet
OTHER ORGANISATIONS	
National Library of Australia	1
NASA (Canberra)	1
State Library of South Australia	1
UNIVERSITIES AND COLLEGES	
Australian Defence Force Academy	
Library	1
Head of Aerospace and Mechanical Engineering	1
Serials Section (M list), Deakin University Library, Geelong, VIC	1
Hargrave Library, Monash University	Doc Data Sheet
Librarian, Flinders University	1

OUTSIDE AUSTRALIA

INTERNATIONAL DEFENCE INFORMATION CENTRES	
US Defense Technical Information Center	emailed pdf
United Kingdom - Dstl Knowledge Services	2
Canada - Defence Research Directorate R&D Knowledge & Information Management (DRDKIM)	1
NZ Defence Information Centre	1
ABSTRACTING AND INFORMATION ORGANISATIONS	
Library, Chemical Abstracts Reference Service	1
Engineering Societies Library, US	1
Materials Information, Cambridge Scientific Abstracts, US	1
Documents Librarian, The Center for Research Libraries, US	1
SPARES	5

Number of copies:	**Printed**	**30**	
	PDF	**2**	
	Total		**32**

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION DOCUMENT CONTROL DATA	1. PRIVACY MARKING/CAVEAT (OF DOCUMENT)

2. TITLE	3. SECURITY CLASSIFICATION (FOR UNCLASSIFIED REPORTS THAT ARE LIMITED RELEASE USE (L) NEXT TO DOCUMENT CLASSIFICATION)
An Empirical Study of the Relationship Between Situation Awareness and Decision Making	Document (U) Title (U) Abstract (U)
4. AUTHOR(S)	5. CORPORATE AUTHOR
Melinda Stanners and Han Tin French	Systems Sciences Laboratory PO Box 1500 Edinburgh South Australia 5111 Australia

6a. DSTO NUMBER	6b. AR NUMBER	6c. TYPE OF REPORT	7. DOCUMENT DATE
DSTO-TR-1687	AR 013-336	Technical Report	February 2005

8. FILE NUMBER	9. TASK NUMBER	10. TASK SPONSOR	11. NO. OF PAGES	12. NO. OF REFERENCES
2004/1084277	LRR 03/205	Chief LOD	15	26

13. URL on the World Wide Web	14. RELEASE AUTHORITY
http://www.dsto.defence.gov.au/corporate/reports/DSTO-TR-1687.pdf	Chief, Land Operations Division

15. SECONDARY RELEASE STATEMENT OF THIS DOCUMENT

Approved for public release

OVERSEAS ENQUIRIES OUTSIDE STATED LIMITATIONS SHOULD BE REFERRED THROUGH DOCUMENT EXCHANGE, PO BOX 1500, EDINBURGH, SA 5111

16. DELIBERATE ANNOUNCEMENT

No Limitations

17. CITATION IN OTHER DOCUMENTS Yes

18. DEFTEST DESCRIPTORS

Decision making
Situation awareness
Operational readiness

19. ABSTRACT
It is assumed that good situation awareness (SA) leads to good decision making, which is then expected to result in a good outcome. Despite increasing reliance on this assumption by the land force, little research has been undertaken to validate it. This study attempts to address this deficiency. SA was assessed using the Direct Questioning Technique, which elicits SA through direct questioning during play. This is an adaptation of the Situation Awareness Global Assessment Technique. Responses to SA questions were compared against the ground truth of the scripted scenario. A relationship was found between SA and decision making, such that participants with a high degree of SA made high quality decisions. SA was also related to planning. However, other factors also contributed significantly to decision quality and performance.