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The Use of the Janus Wargame Simulation to Investigate Naturalistic Decision-Making: A Preliminary Examination

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DSTO-TR-1372

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Taryn Chapman[1], Vanessa Mills[1], Monique Kardos[1], Christina Stothard[1] and Douglas Williams[2]

[1]Land Operations Division
Systems Sciences Laboratory

[2]Air Operations Division
Systems Sciences Laboratory

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ABSTRACT

The Janus wargame was assessed as a means of investigating naturalistic decision-making (NDM). A further aim was to establish the generality of previous research that uses non-military simulation. Participants were divided into hierarchically structured teams of 3 (one military team, and three civilian teams). Each team was tested using open and restricted communication architectures. In line with predictions, open communication was more effective than restricted communication. In addition, military personnel out-performed civilian participants. No linear or quadratic patterns were found regarding the development of expertise. It was concluded that Janus was an effective means of examining NDM. In addition, the data indicated that non-military simulation can generate valid data in relation to communication architectures, but not in relation to the development of military expertise.

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Fax: (08) 8259 6567

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Executive Summary

Over recent years there has been an increase in the introduction of Information Technology (IT) to military headquarters (HQ). To achieve effective and efficient functioning in the Defence Force it is important for research to be conducted that identifies the following factors: a) the development of expertise; and b) how communication facilitates situation awareness. It is also important to identify an appropriate context for testing these processes. Consequently the aim of this research was to assess the use of the Janus wargame simulation as a means of investigating the impact of IT on naturalistic decision-making (NDM). There was also an examination of the development of expertise and the role of communication architecture in facilitating situation awareness. A further aim was to establish the generality of results from research that uses non-military microworlds (eg. *Networked Fire Chief (NFC)*).

Janus models realistic conditions and presents the user with pressures similar to those found in a real world NDM situation (i.e. time pressure, uncertainty, and high stakes). In the current study, it was networked with a situation awareness tool to simulate a simplistic command and control (C2) hierarchy. Experiment participants were divided into hierarchically structured teams of 3 (one military team, and three civilian teams). One team member acted as the commander, while the other two played the ground force controller and the support force controller. The teams were instructed to work together to accomplish the goals defined in an intent statement. This involved an initial planning session, followed by the wargame, where participants were tested under the following conditions:

- ***Open communication:*** All team members hear all communication.
- ***Restricted communication:*** Communication is limited to the commander and one of his subordinates at any one time. No one else in the team can hear the transmission.

Participants communicated via radios to coordinate their actions. Testing was conducted over three days, and involved 8 Janus trials, each lasting a maximum of 1½ hours.

Janus performance scores were calculated in terms of the loss exchange ratio (number of enemy kills divided by total losses). Team interactions were also monitored to provide a measure of communication problems, and behaviours that assist in the maintenance and development of situation awareness. Questionnaires were used to collect demographic information and to assess the participant's perception of their own progress.

In summary, the data indicated that:

- Open communication was more effective than restricted communication;
- The majority of participants preferred using open communication;
- Military personnel outperformed civilian participants;
- Military participants used substantially more acknowledgments and update reports than civilians, communication that facilitates teamwork and situation awareness;
- The development of expertise across trials showed no clear pattern;
- Participants felt their situation awareness and level of expertise increased over the trials; and
- Due to lack of expertise, civilian participants did not know which information to filter out, so were requesting more than was necessary for optimal performance.

In summary, Janus was an effective means of examining IT and NDM. In addition, the data indicated that NFC generates valid data in relation to communication architecture and military performance. However, the data suggests that expertise is domain specific, so NFC may not be an appropriate method of examining the development of military expertise.

Authors

Taryn Chapman
Land Operations Division

Taryn Chapman completed a Bachelor of Arts with Honours in Psychology in 2000. She joined DSTO in November 2000, working in the HSI discipline. She is tasked to the Human Factors battlefield command support system (BCSS) evaluation task. Specifically her role is to research human factors issues, such as decision modelling, decision error, and human biases in decision-making. She has presented work at various national conferences, such as the Land Warfare Conference (2001), and the Australasian Social Psychology Conference (2002). She is currently studying towards a PhD at Adelaide University, undertaking research in the field of naturalistic decision-making.

Vanessa Mills
Land Operations Division

Vanessa Mills graduated from the University of Adelaide in 1994 with a Bachelor of Arts degree and Honours in Psychology. Vanessa has since worked at the University of Adelaide, Department of Psychology, lecturing in the areas of Learning, Environmental Psychology, and Animal Behaviour. She completed her PhD in 1998, and in 1999 joined the Department of Defence. where she is employed within the Human Systems Integration discipline.

Monique Kardos
Land Operations Division

Monique Kardos completed a Bachelor of Science with Honours in Psychology in 1994, and a PhD(Psychology) in the field of Animal Learning and Behaviour at Adelaide University in 1999. She has taught Psychology to undergraduates and undertaken research field trips with both the Department of Environment and Natural Resources, and the Adelaide Zoo. She joined DSTO as a research scientist in March 2000, working in the HSI discipline. She currently works on the Force Operations Analysis and Battlespace Awareness tasks, focusing on the analysis of current operations, examining HMI issues as part of the development of SA tools and evaluating the effects of these tools on Army operations, and contributing to the evaluation of ARH tenderers' responses as part of the AIR 87 acquisition project. In East Timor she examined both the MGI capability and information management issues in 2nd Battalion Group during their deployment.

Christina Stothard
Land Operations Division

Christina Stothard graduated from the University of Adelaide in 1991 with a Bachelor of Arts degree and Honours in Psychology. Christina has since worked at the University of Adelaide at the Departments of Community Medicine, Clinical and Experimental Pharmacology and Psychiatry, as well as the University of South Australia in the School of Social Science. In 1998 Christina joined the Department of Defence and has had a key role in developing performance measures of operational Army headquarters, and reviewing the problems of introducing digital systems into a workplace. As part of the C2 team evaluating the operation of the BCSS in the Army she has interviewed 1 Brigade (Darwin), 7 Brigade (Brisbane) and 9 Brigade (Adelaide). Christina is currently employed as a Professional Officer with the Human Systems Integration discipline, and tasked to Optimising C4ISR Systems Integration Task.

Douglas Williams
Air Operations Division

Douglas Williams graduated from the University of New South Wales in 1997 with a Bachelor of Aerospace Engineering degree. After working for over 12 months in data management on the London Stock Market he joined the Combat Evaluation discipline in Land Operations Division in support of the Restructuring The Army Phase 2 (RTA Phase 2) knowledge management process. In 1999 he joined the DSTO contribution to the Headline series of Experiments as a Janus Analyst for the Army Experimental Framework task until his departure in 2001. Douglas currently works in the Air Vehicles Division (formerly Airframes and Engines Division) providing technology costing and analysis to the AIR6000 RAAF Fighter Replacement Study.

Contents

Glossary

BCSS	Battlefield Command Support System
Bde	Brigade
C2	Command and Control
DICE	Distributed Interactive C3I Effectiveness
DSTO	Defence Science and Technology Organisation
IT	Information Technology
NDM	Naturalistic Decision-Making
NFC	Networked Fire Chief
RPDM	Recognition Primed Decision-Making

1. Introduction

Over recent years there has been a vast increase in the introduction of Information Technology (IT) to the workplace. For example, the Australian Army has been introducing the Battlefield Command Support System (BCSS) to the various Brigades (Bde). BCSS is a suite of software tools designed to assist command decision-making in the Australian Army. Despite the promise offered by new technology difficulties in the use of IT systems have emerged (Mills, 2000; Huf, 2001). Some of these difficulties relate to providing new technology to users with varying levels of expertise. In addition, IT systems have the potential to enhance or interfere with team decision-making and situation awareness (Mills, 2000; Huf, 2001). To achieve effective and efficient functioning in the Defence Force, it is therefore important for research to be conducted that identifies the following factors: a) the development of expertise; and b) how communication facilitates situation awareness. It is also important to identify an appropriate context for testing these processes. Consequently, this report details an assessment of communication architecture and previous experience in relation to decision-making using a simulated wargame. It also describes the results of an investigation of the development of expertise.

2. Naturalistic Decision-Making

Research on naturalistic decision-making (NDM) is a relatively recent research area in psychology. It is currently being applied in practical situations, such as interface design (Hopple, 1988), the production of appropriate decision-making tools, and team training (Zsambok & Klein, 1997). NDM theory is concerned with decision-making in dynamic, uncertain, fast paced environments. It acts as an alternative explanation to classical decision theory for decision-making tasks that do not fit "into the rather limited mould that classical decision theory provides" (Beach and Lipshitz, 1993, p. 23).

2.1 The Classical Decision-Making Model

Edwards (1954) introduced the concept of classical decision-making to the field of psychology. The model is used to investigate everyday decision-making processes. Classical theory suggests that people collect and analyse information, eventually selecting an optimal solution from a range of alternatives. This is done by evaluating the advantages and disadvantages of each possible outcome and choosing the one most appropriate to achieve the desired outcome goal. This decision is regarded as optimal (McDaniel, 1993).

Classical decision-making research investigates the quality of the decision by comparing it with a normative statistical model. It relies on laboratory experiments to examine how a decision-making outcome differs from the optimal solution (Brehmer, Jungermann, Lourens & Sevon, 1985). Thus, rather than studying how people actually make decisions, classical decision theory focuses on how the optimal decision should be reached.

A potential problem with this approach is that it does not take contextual factors into account. Classical decision theory has been found to encounter problems when variables such as time pressure, uncertainty, complexity and high stakes are involved in the decision-making process. Needing to evaluate such a large number of alternatives in a short period of time could produce cognitive overload. This could result in serious errors. In such circumstances, there are grounds for querying the adequacy of the classical decision model.

2.1.1 Defining Naturalistic Decision Making (NDM)

The search for a more appropriate model of decision-making under these conditions has seen the development of NDM theory (Cannon-Bowers, Salas & Pruitt, 1996). Zsambok (1997) defines NDM as

> *how experienced people, working as individuals or groups in dynamic, uncertain, and often fast paced environments, identify and assess their situation, make decisions and take actions whose consequences are meaningful to them and to the larger organisation in which they operate (p. 5).*

In other words, NDM research investigates how people use experience to make decisions in naturalistic environments (eg. under time pressure, shifting conditions, unclear goals, degraded information and within team interactions). Cannon-Bowers, Salas and Pruitt (1996) suggest that NDM theory represents a more appropriate model for decision-making in naturalistic environments, as it takes into account the real world pressures. Figure 1 illustrates the circumstances under which the two decision-making models are suitable.

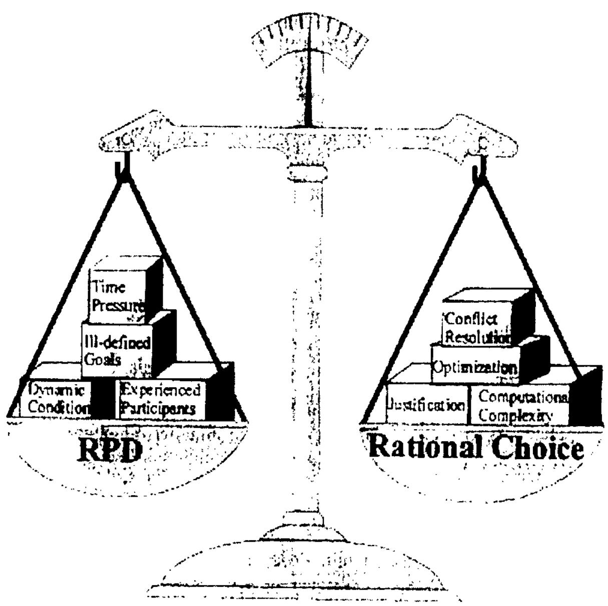

Figure 1. Comparing the NDM model with classical decision-making (Klein, 1997)

2.1.2 Naturalistic Decision-Making Processes: Klein's RPDM Model

Based on research on decision-making in natural environments, Klein (1989) formed the recognition primed decision-making (RPDM) model. The model was based on interviews and observations of fire ground commanders working in difficult and challenging circumstances (Klein, Calderwood & Clinton-Cirocco, 1986). It was thought that under complex, time-pressured circumstances, the commanders would make limited comparisons between possible outcomes. However, it was revealed that they were making no comparisons at all. In fact, 80% of decisions made in this task were made in less than one minute. From this, Klein et al. (1986) identified the following issues:

1. The commanders drew on their previous experience to recognise a typical action to take;
2. They did not have to find an optimal solution, merely a workable one; and
3. Once they arrived at a suitable course of action, they would mentally simulate it first to ensure it would work.

Consequently, Klein (1989) suggested the RPDM model of NDM. The RPDM model implies that experienced decision-makers:

1. Usually consider a workable option and do not need to generate a large set of alternatives;
2. Generate and evaluate options one at a time, instead of comparing the advantages and disadvantages of all options; and
3. Evaluate an option by imagining the outcome, and by finding ways to avoid problems that may arise from its implementation.
4. Focus on assessing the situation and looking for familiar cues.
5. Emphasise acting quickly and not sustaining analysis.

The RPDM model describes how people make decisions without comparing outcomes (see Figure 2). The decision-maker initially assesses the situation, looking for familiar patterns or prototypes. This allows him/her to know which goals make sense, what relevant cues to expect, and what action should be appropriate. A series of options is then generated. The first solution may not be optimal, but it will usually be workable. This model also shows that action can be taken quickly, which is important in crisis management (Klein, 1997). The RPDM model has been replicated and is seen as a viable explanation of the cognitive processes underlying NDM (Kaemf, Wolf, Thordsen, & Klein, 1996; Mosier, 1990; Pascual & Henderson, in press; Randel, Pugh, Reed, Schuler & Wyman, 1994).

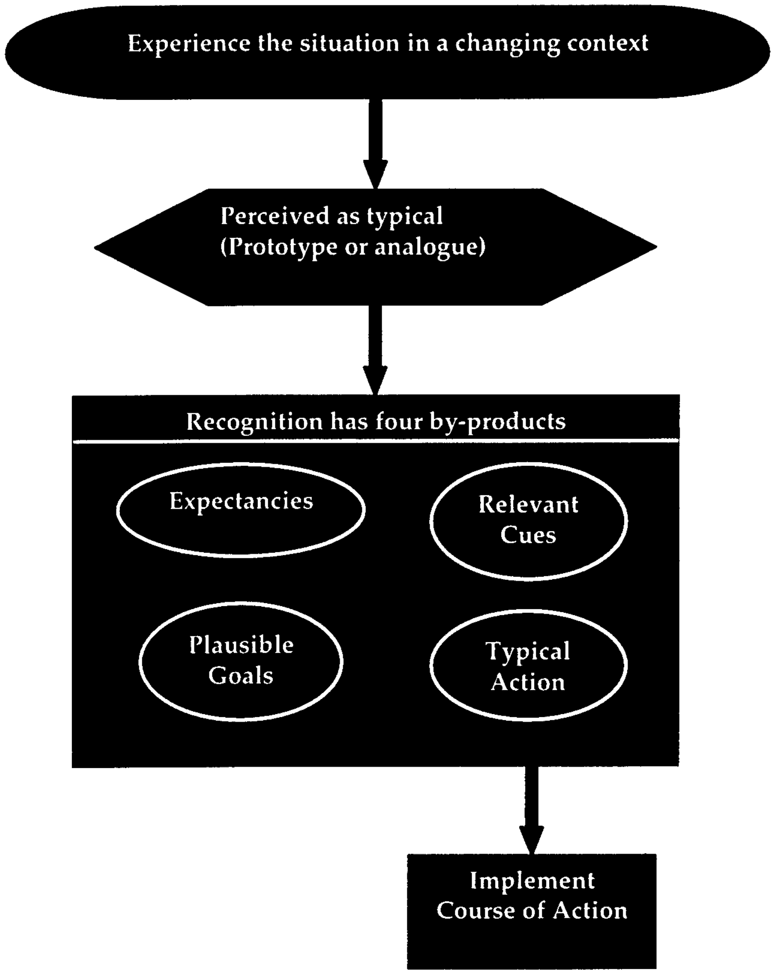

Figure 2. The RPDM model (Klein, 2000)

2.1.3 NDM Themes

According to Zsambok (1997) NDM has four main themes:

1. The tasks and setting involve poorly structured problems, uncertain and dynamic environments, shifting or ill defined goals, action feedback loops, time pressure, high stakes, teamwork, and organisational goals and norms;
2. The process of decision-making relies on developing situation awareness, diagnosis and plan generation rather than focusing on a moment of choice;
3. Decision-makers draw on previous experience to make current decisions; and
4. The aim of NDM research is primarily to describe more accurately and understand the decision-making processes people use, rather than investigating how people's decisions differ from statistically generated optimal solutions.

Brehmer (1997) reinforced Zsambok's description of a naturalistic environment, suggesting that the characteristics include complexity, feedback quality, delay, rate of change, how the environment is affected by the decision, and the extent of delegation that is used. Some examples of areas in which NDM research has been applied are during military operations, fire fighting, in operating theatres, nuclear power plants and oil rigs.

2.1.4 Situation Awareness

Klein and Calderwood (1991) describe NDM as continual situation assessment. This contrasts with singular moments of choice described in the classical decision-making model. NDM often requires a series of decisions that are interdependent. The decision-maker must constantly monitor the environment that will be spontaneously changing, as well as changing because of each decision. Continual assessment produces situation awareness. The initial part of the RPDM model outlines recognition of a situation. The rest of the decision-making process depends on correct judgement of the situation.

George, Kaempf, Klein, Thorsden and Wolf (1996) found that "awareness of the situation enabled officers to recognise appropriate actions from published procedures, and past experience" (p.220). They identified the following methods of arriving at situation awareness:

1. 87% of participants used a feature matching strategy. This is where the decision-maker sees the situation as familiar, and arrives at situation awareness through a series of recognised cues;
2. 12% of participants used story generation. When the environment does not provide enough information to be recognised as familiar, the decision-maker constructs a story to explain the information and to arrive at greater situation awareness; and
3. 1% of cases did not fit into either of these main categories.

Developing good situation awareness is an important part of NDM. It allows decision-makers to project the environment's status into the future (Artman, 1998). They can predict at time *t* what the situation will be like at time *t+1* (Brehmer, 1990). As such, research on the processes surrounding situation awareness could assist in a number of areas, including the design of appropriate decision-making aids and interfaces.

2.1.5 Previous Experience and NDM

Related to the development of situation awareness, is expertise (Dreyfus, 1997). In a summary of the great military blunders throughout history, David (1997) notes that a "typical handicap seems to be a lack of command experience. Naivety tends to promote vacillation and overcaution, resulting in lost opportunities and ultimately disaster" (p. 1). NDM theory suggests that people draw on previous experience to make sense of current situations. Experts establish situation awareness by relying on familiar stimulus cues. It has been suggested that with experience, people learn which cues to attend to, and what information to filter out (George, et al., 1996).

DeGroot (1965/1978) and Chase and Simon (1973) compared the performance of chess masters and novices. They found that they did not differ significantly on memory abilities, depth of planning or other similar areas. Instead, the difference seemed to be that the expert players could look at the entire complex chess display and condense it into "meaningful chunks", where the novices tried to understand the whole display. (Means, Salas, Crandall & Jacobs, 1993, p. 310). Means and Gott (1988) suggest that expert and less expert decision-makers apply the same rules but to a different content. Less expert decision-makers may experience cognitive overload more rapidly because they attend to all information, and do not filter irrelevant pieces (Randel, Pugh & Reed, 1996). As expertise grows, individuals use tacit knowledge, and see the world through categories (Means, Salas, Crandall & Jacobs, 1993). Experts acquire the ability to chunk information, recognise familiar patterns, and attend to critical indicators. This is referred to as the proceduralisation of declarative knowledge. (Means, Salas, Crandall & Jacobs, 1993). When a situation is recognised from previous experience, it can directly stimulate an appropriate course of action (Rasmussen, 1983).

A cognitive explanation looks at how previously solved problems are stored in memory (reference problems). Each reference problem can be broken down into three constitutive features:

- **Objective features:** This part of the memory characterises the problem and its objectives.
- **Action features:** This details the steps that are involved in solving the problem.
- **Environmental features:** This part compiles the cues that were present in the past problem scenario. These cues may suggest a problem solution that is likely to work.

There are also thought to be levels of abstraction in memory involved in the NDM process. The first is concerned with concrete features (specific observable events or objects). The second level involves abstract features that help generalise the problem type and solution method. Thirdly are environmental cues that may indicate a similar related problem.

This cognitive model allows recognition-based solutions of new problems that resemble but are not necessarily identical to those previously experienced (Cohen, Freeman & Wolf, 1996). During situation assessment, the reference problems that match the current situation are activated. The "problem solution...associated with those in memory become candidate actions "(Noble, 1993, p. 305).

Noble (1993) states that "matching observed and reference features may sometimes entail considerable sophisticated information processing requiring general world knowledge"(p. 290). Frequently, a decision-maker is forced to make a decision with incomplete information. In such circumstances, the abstract level of memory facilitates NDM. Lipshitz (1989) found that Israeli army officers seemed to make decisions by matching situations to an associated action. The nature of their experience, and consequently the patterns recognised, affect the decisions they make (Means, Salas, Crandall & Jacobs, 1993).

In summary, experts and novices differ in how they use their domain knowledge, and not in their ability to use particular problem solving methods or decision rules (Means, Salas, Crandall & Jacobs, 1993; Drillings and Serfaty, 1997). Beach et al. (1997) support the idea that decision-making events require decision-makers to use a "broad range of contextual knowledge in both situation analysis and problem solving in order to arrive at a decision"(p. 33). Therefore, expertise is speculated to be domain specific, because general problem solving skills are not used. It is also proceduralised, meaning that decision-making is directly linked to action and the conditions of its applicability. (Means et al., 1993) This may explain why decision-making can seem intuitive to the decision-maker.

2.2 Distributed Decision Making: NDM in a Team Environment

As well as involving expertise, many NDM tasks are too complex to be handled by individuals. Instead, teams form to achieve goals beyond the reach of individual members (Brannick, Roach & Salas, 1993). Known as distributed decision-making, the task is distributed between team members who must have shared situation awareness and who work towards a common goal. Each person is only required to perform part of the whole task. This is essentially the means by which the Command and Control (C2) of a defence force functions.

C2 is the process by which a commander exercises authority and direction over the team in order to accomplish a specified mission. This is achieved by arranging personnel, equipment, and communications facilities, as well as using procedures that are crucial to direct, control, coordinate and monitor the team. Situation awareness in this setting is important. Drillings and Serfaty (1997) state that effective commanders are encouraged to visualise the battlefield, asses risk, and visualise change while forming plans. Every action focuses on achieving the specified mission (McCann & Pigeau, 1999). It follows that achieving a good understanding of the processes behind distributed decision-making is important in a military setting.

2.2.1 Communication

A fundamental problem in distributed decision-making is knowing how best to organise the communication architecture so that team members have shared situation awareness (Brehmer, 1998). Stout, Cannon-Bowers, Salas and Milanovich (1999) found that "communication strategy alone affected the degree of coordinated performance attained by teams during periods of increased workload" (p.61). It is particularly important in hierarchical organisations that the most efficient and effective communication architecture is used, so that orders can be understood and thus successfully carried out.

Artman (1999) argues that "it is important for researchers and organisations to understand how different information architectures affect the process and outcome of controlling dynamic systems" (p. 1404). He examined parallel and serial communication architectures in a hierarchical organisation. The aim was to enhance teamwork by investigating which communication technique was the most appropriate in a dynamic environment. For parallel communication, participants received the same information. With serial communication, information was filtered down a chain of command. This contrasts information rich communication with a limited window of communication. Artman also examined fixed communication (where participants were told to use a specific style), and non-fixed communication (where participants were left to change between styles as they pleased). There was a significant difference between fixed and non-fixed communication styles, but not between parallel and serial communication.

Chapman (2000) expanded on this and examined open versus restricted communication architecture. In distributed decision-making, co-ordination of team members is difficult because everybody has a limited perspective of the task. Therefore, information-rich communication, where all information regarding the task is revealed to every team member, may lead to a greater understanding of the situation. In contrast to this, Artman (1999) states that, "communication must be relevant in order to support team situation awareness" (p. 1406). Hearing all information regarding the task, particularly that which is not relevant, may lead to information overload and cognitive fatigue. This may decrease decision-making performance.

2.3 Studying NDM

Previous research in NDM has focussed on several applied areas. For example, Klein et al. (1986) investigated decision-making in fire fighters. Serfaty, Macmillan, Entin and Entin (1997) carried out research into the nature of battle command decision expertise. Fiedler and Link (1994) investigated leader intelligence, interpersonal stress and task performance among military officers. Gaba (1991) studied the way anaesthesiologists make decisions in teams. These types of investigation advance understanding of cognitive processes, and aid in the design of interfaces and decision support systems. Other domains, such as nuclear power plants, oilrigs and aviation have also been subject to NDM research (Klein, 1997). In all of these situations, human error can result in death of oneself or another.

2.3.1 The Use of Microworlds and Computer Simulations

Because of its complexity, it is difficult to study naturalistic decision-making in a real world environment. As a result, the use of microworlds and other computer simulation techniques has become prevalent. A microworld is where "we select the important characteristics of the real system and create a small and well controlled simulation system with these characteristics" (Granlund, 1998, p. 91). The advantage of this type of research is that it allows researchers to set a relevant complexity level in a controlled research environment.

2.3.2 Networked Fire Chief

The microworld used by Chapman (2000) was a computer simulation called *Networked Fire Chief* (NFC). It requires the operator to make decisions under continually changing conditions. Participants are required to fight fires that spontaneously break out on a map, thus providing an element of uncertainty. Also, the tasks involved in successfully fighting a fire require the co-ordination and co-operation of a team of people. An advantage of the NFC program is that it can be networked, so that hierarchical organisation structures can be examined.

Variations in weather are represented by wind direction and wind speed. The participants are required to use the appliances to extinguish the fires. The appliances have some of the same limitations as their real world equivalents. The decision-maker is also required to prioritise areas when allocating resources to fight the fires. The order of priority established on NFC is: 1) residences, 2) pastures, 3) national park, and 4) grassland. The purpose of this variety in landscape is to create a more complex and realistic goal. Performance scores show the percentage of landscape left after a designated period of time had elapsed, taking land priority into consideration.

It should be noted that NFC does not mirror everything that occurs in a military context. Rather, it is a tool used to investigate the NDM theory. It brings the sort of variables into play that would be involved in NDM such as uncertainty, complexity, and feedback loops. Currently, NDM is an umbrella theory for all situations displaying these characteristics. Brehmer (1994) noted that like emergency target systems, air traffic, and military enemy force manoeuvres, the forest fire is a complex, dynamic, autonomous system (Brehmer, 1994). Therefore, it should be possible to refine the theory by using any of these appropriate contexts. A criticism, however, is that fire fighting is very different to military operations. The major way in which it is different is that military personnel are working with an intelligent enemy, whereas fires do not think. To that extent, fires could be argued to be slightly more predictable. Therefore, it is important to work towards finding whether the results using NFC are context specific.

2.3.3 The Use of Wargame Simulations

The use of wargames in military research has started to increase. According to Chaloupka, Coelho and Borges-Dubois (1991) "the importance of war gaming to military planners lies in its ability to explore the dynamic interactions of players". However, one must be critical of their application and be particular as to what is concluded from simulation results. Wargaming is useful for investigating processes but not calculating outcomes (Perla, 1991).

Thompson (1991) suggests that where wargames seem to mirror a real battle is in the decision-making process. Players monitor the environment, make a decision, and live with it. Therefore, similar to other microworlds, wargame simulations should be valuable tools for investigating NDM. An appropriate wargame should create a sense of danger, exertion uncertainty and chance. The simulation used in this study, Janus, creates this, and combats many criticisms that have been made towards simulation wargames.

2.3.4 Janus: A Computer Wargame Simulation

Janus is an interactive simulation wargame that allows multi-sided combat, under realistic simulation conditions. The view on the screen is a two-dimensional map with grid lines. However, to the weapon systems the terrain is three-dimensional (with elevation and contour lines). This affects manoeuvrability and line of sight. Unless the enemy is in the line of sight, each player can only see their own forces. When an enemy enters the line of sight of a friendly unit, it is spotted and identified. The units then automatically engage with the enemy, making decisions about what type of ammunition they will use (this decision is programmed into the computer's database).

Janus models real world phenomena, including natural and man made obstacles, the requirement for route planning, direct and indirect fire engagements, planned fire missions, and tactical decision-making as the game progresses. The tasks require the co-ordination and co-operation of a team of people. Similar to NFC, Janus allows a team of three or more participants. One participant can act as a battle commander, while others can act as sub-unit leaders. This sets up a requirement for distributed decision-making. A communication system can also be used between the team members.

2.4 The Current Study

2.4.1 Overview

As was mentioned, to achieve effective and efficient functioning in the Defence Force, it is important for research to be conducted that identifies the following factors: a) the development of expertise; and b) how communication facilitates situation awareness. It is also important to identify an appropriate context for testing these processes, and to determine whether results obtained using a simulation war game, representing an area similar to the expert participants area of experience, are consistent with those found by Chapman (2000) using a context removed from the expert's area of experience. In her study, Chapman (2000) investigated the effects of management structure, communication architecture and previous experience (military) on NDM performance using NFC. A comparison was made between information rich (open) and restricted communication.

- ***Open communication:*** All communications were heard by all team members.
- ***Restricted communication:*** Communication was limited to the commander and one of his subordinates at any one time. No one else in the team could hear the transmission.

Chapman (2000) also compared military personnel with civilian subjects. A limitation in this study was that the micro-world did not closely represent the area in which the expert participants had gained their experience. Although past experience can be used in an abstract way, and generalised to previously experienced reference problems, it may be the case that the difference in context between a fire fighting scenario, and a military scenario is too great. As was mentioned, a major criticism is that military personnel are working with an intelligent enemy, whereas fires do not think, and are seen as less predictable. If previous experience is context specific, testing should be performed in an appropriate context.

As a consequence, the current study will use the computer war game simulation, Janus. A comparison will be made between experienced participants (military) and inexperienced participants (civilian DSTO employees). Participants will be tested with the two communication architectures, defined in Chapman's experiment (2000). To investigate the development of expertise in the military and civilian participants, learning effects will be monitored. This should also help determine whether NDM performance is context specific.

2.4.2 Hypotheses

The hypotheses for the current study are:

1. Military personnel will outperform civilian subjects.
2. Open communication architecture will facilitate situation awareness, thereby producing higher performance outcomes.
3. Participants will perform better in Janus trials as they have more experience with the system.

3. Method

3.1 Participants

Fifteen participants took part in the study. Their mean age was 40 (sd=8.28). They comprised two groups:

- ***Military personnel*** (6 participants in 2 teams)
- ***Civilian subjects*** (9 participants in 3 teams)

The two groups were divided into teams consisting of three members. A description of their ages is shown in Table 1. There were fourteen male participants, and one female. The civilian participants were recruited by advertising the experimental opportunity on a DSTO Salisbury site mailing list. The Army personnel were recruited through Major Simon Harvey. Interested respondents were scheduled according to availability.

Table 1. Participants' mean ages across teams (M= military group, C= civilian group)

Group 1 (M)		Group 2 (C)		Group 3 (C)		Group 4 (C)		Group 5 (M)	
M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
30.67	*6.51*	*44.33*	*2.89*	*37.67*	*11.59*	*35.67*	*8.50*	*41.33*	*7.57*

3.2 Apparatus

3.2.1 Information, Data Sheets and Questionnaires

- Information Sheet: All interested participants were sent an information sheet via e-mail. This sheet provided a schedule for their participation in the experiment. It also outlined the study aims and described the experimental procedure over the three days (see Appendix A, A.1).
- Demographic Information Questionnaire: This questionnaire aimed to uncover confounding factors that might influence results. It included age, sex and job title, previous experience with NDM, recency of this experience, use of computer simulation, and amount of experience with this simulation (see Appendix A, A.2).
- Notes to the Commander/Sub-unit Leaders: These sheets outlined the roles expected of the different team members. It also contained information specific to roles, and rules of engagement (see Appendix A, A.3 & A.4).
- Weapon Unit Guide: This spreadsheet gave information to the participants on the full name of the combat elements involved in the scenario (both blue force, and suspected red force). It also provided weapon range, sensor range and maximum speed for each of the units (see Appendix A, A.5).
- "What weapon units look like in Janus" sheet: This illustrated what each of the weapon units looks like on the Janus screen (in a visual form).
- Casualty Sheet: This sheet listed the weapon units controlled by each blue team member, and left a space to mark down any losses (see Appendix A, A.6).
- Radio Protocol: The radio protocol outlined efficient protocol for transmitting information across a radio network. It also listed team member names and experimental roles (see Appendix A, A.7).
- Training Protocol: The training protocol outlined the capabilities of Janus, and included tactical information needed to make decisions. It described the experimental architecture, the participant's role in the experiment, including the functions they were expected to carry out. It then outlined general information regarding the Janus war game. This included information on game time, the zoom, and the communication requirements. It then described the terrain (topographical features, man made and natural obstacles), the movement capabilities (route planning, tracked, wheeled, foot and flyers) line of sight (obscuration by smoke, vegetation and terrain) and direct and indirect fire engagements and planned missions (Appendix B).
- Mission Planning Guide: This was a guide on the basics of mission planning, based on observations of a group of three military participants involved in planning for a Janus scenario. This was written into a suggested planning protocol (see Appendix C).
- Intent Statement: The intent statement described the goals for both of the scenarios (see Appendix D).
- Planning Tools: A large paper map of Kamaria was laid on a table (this corresponds to the landscape represented on Janus). A plastic overlay and markers

were provided to aid in route planning. A video camera was used to record all planning sessions.

- Communication Check-sheet: The communication check-sheet was used to record the frequency of desirable and non-desirable events during radio transmissions. It listed behaviours that may indicate communication problems, and those that might assist in the maintenance and development of situation awareness (see Appendix A.8).
- Post Trial Questionnaire: Following testing, a post trial questionnaire was filled in by participants. This enquired about their changing perceptions of situation awareness, development of expertise and preference for communication architecture. It used a 5-point scale for data encoding. This scale included responses ranging from strongly agree to strongly disagree (Appendix E).

3.2.2 Janus and Networked Computers

Four computers running Janus were networked in the experimental set up. They were all physically isolated from each other. Two computers represented the units under control of the friendly team sub-unit leaders. The enemy team used one monitor and the remaining monitor was set up as a "God screen". This monitor showed all units from both sides, providing an overall picture of what was happening.

As well as Janus, the current study used the BCSS and DICE[1]. DICE acts to link the action happening on the Janus screen with a BCSS monitor. It allows the positioning of the weapon units moving in Janus to be represented on the BCSS monitor. The system updates the positions of weapon units controlled by both sub-unit leaders on the BCSS map. Friendly units that were destroyed would cease to move on the BCSS screen.

Enemy sightings did not appear on the BCSS screen. Rather, the commander needed his/her sub-unit leaders to radio through enemy coordinates. These could then be updated by the commander, using markers on the transparency overlay covering the BCSS screen. There was also a colour printout of the Janus screen located below the BCSS screen. This allowed the commander to be more aware of what the sub-unit leaders were seeing.

3.2.3 The Whiteboard/Recording material

A whiteboard was provided for the commander to use if desired. In addition, all participants were supplied with paper and pens to copy down any transmissions they felt necessary.

3.2.4 Communication System

Participants communicated under both communication architectures using a set of radios. These could be used on the same frequency to simulate an open communication, or two different frequencies to simulate restricted communication. During restricted communication, the commander would have two radios on different frequencies to pick up the two sub-unit leaders. High level commands were issued by the commander who had a picture on BCSS of where all of the blue forces were. Feedback was required from the sub-unit leaders.

[1] Distributed Interactive C3I Effectiveness simulation capability.

The experimenters heard all transmissions by team members through the master radios.

3.2.5 Scenarios

Two scenarios of equivalent complexity were used. Both scenarios had the same weapon units, but were set in different areas. One was used for open communication, while the second was used for restricted communication. This was alternated for teams.

The scenarios ran for 1½ hours, and were set in the fictional land of Kamaria. Participants were instructed to attempt to accomplish the goal specified in the intent statement.

3.2.6 The Interactors

Because of time constraints, training each participant to use Janus was not possible. Therefore, Janus interactors were trained, and used to implement commands given by the sub-unit leaders. The interactor linked the participant to the action happening on the computer screen. This interactor was responsible for translating any of their participant's commands to the weapons units on the Janus screen. The interactors were instructed to act efficiently on commands given to them by the participants, and to explain any information regarding the useability of Janus. They were instructed not to act on their own initiative, or make any tactical suggestions that may influence the overall performance scores.

To assess whether this was adhered to, the experimenters used a check-sheet to record desirable and non-desirable interactor behaviour. This data was used to determine whether interactors were non-discriminatory, or whether they actively participated in the experiment and possibly influenced results (Appendix A.9).

3.3 Procedure

3.3.1 Participant Groups

Participants were randomly allocated into groups of three (within their level of expertise groups). One team member acted as the commander, while the other two were his/her subordinate sub-unit leaders (one was responsible for the ground force and the other for the support force). The groups of three people in this study represent a simplistic hierarchy, similar to that used in NFC. Roles within each team were randomly allocated.

3.3.2 Pre-Trial Information

At the start of the experimental session, participants were given a folder containing an information sheet, a demographic information questionnaire, a Janus training protocol, an information sheet for their designated role in the experiment, a casualty sheet, a weapon unit guide, a radio protocol, and a "what weapons look like" diagram.

3.3.3 Training

After reading the required information, each team took part in a training session to familiarise them with the specialised set up of Janus. Firstly, participants were asked to read through the training protocol. They were then taken through a practical demonstration of the program that closely followed the training protocol. During this time, any questions were answered to make the participants confident that they had

enough knowledge to effectively command an interactor to perform actions using the Janus war game. This practical demonstration lasted approximately 45 minutes.
Civilian participants were also given a lesson in the basics of mission planning. This was done by means of a pamphlet explaining the phases used by the military in planning exercises.

3.3.4 The Trials

The schedule for each of the 8 trials is illustrated in Figure 3.

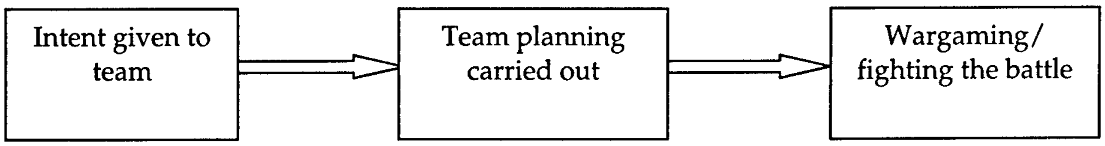

Figure 3. The schedule for the wargaming trials

Once training was complete, participants went through three days of Janus trials. This equated to 8 trials, each lasting up to 1½ hours. The criteria for ceasing a trial was one of:

1. The mission was accomplished (i.e. all enemies were defeated, and the goal was reached);
2. One of the teams surrendered; or
3. Game play had lasted 1½ hours (this length of time was needed for Janus to generate meaningful outcome data).

To control for learning effects, the two scenarios were alternated for each trial. Out of the eight trials, four were performed with each communication architecture. To control for order effects, each day and team started with different a communication architecture than the previous day or team.

3.3.5 The Planning Stage

In this phase, participants were read the intent statement. They were then given 20 minutes to work together to plan their mission. To assist with planning routes and tactics, they were provided with a map of Kamaria, a plastic overlay, and some transparency markers.

3.3.6 The Simulation Stage

Following planning, participants performed the wargame. Interactors were introduced to participants and team members were physically isolated from each other. A radio check was then performed to ensure that all radios were working correctly.

Each participant was positioned in front of a computer screen showing a map of Kamaria, with weapon units ready to fight. Participants were given 5-10 minutes before beginning game play for instructing their interactor on how to organise the movement routes of these weapon units.

During game play, the experimenters did three things:

1. Observed interactor/participant interactions (filling in check-sheets);

2. Watched the overall battle picture on the Janus screen and made observational notes; and
3. Listened to the radio transmissions and filled in communication check-sheets.

3.3.7 Post-Trial Procedure

At the end of the trial, participants were invited to the planning room to discuss their battle. No limits were put on this discussion. After the final trial, they were given the post-trial questionnaire.

4. Results

It should be noted that because this is such a new area of research, the current study is largely exploratory. Rather than supplying definitive conclusions, it should be valuable in providing insights into future research areas and methods.

As was mentioned, the design of the experiment was based on eight trials (four trials under each communication condition) (see Table 2). However, due to time and resource constraints, an equal number of trials for each group was not possible. All three of the civilian groups participated in eight trials. One military group was involved in experimental refinement, so their results have been excluded from final analysis. Due to time constraints, the second military group participated in only four trials.

Due to small sample size and unequal groups, the following is a descriptive analysis of results. It should reveal trends that could be pursued in further research, rather than finding significant effects.

Table 2. The experimental design

	Military	Civilian
Open communication	2 trials	4 trials
Restricted communication	2 trials	4 trials

4.1 Description of Participants

The demographic questionnaire revealed individual differences as shown in Table 3.

Table 3. Individual differences

	Frequency of Positive Response	Percent of Total
Have you previously used Janus?	4	23.5%
Have you worked with your team mates before?	6	35.3%
Have you ever played a computer game or simulation?	14	82.4%

Among those who had previously used a computer game or simulation, the frequency of usage was generally not high. Table 4 indicates the amount of simulation exposure participants have had before commencing the trials. This table shows that out of the participants who answered affirmatively to having previously played a computer game, the mean amount of time since they had played was approximately 2 years. The majority (35.3%) of respondents indicated that they had played for more than three hours. However, the infrequency of their game or simulation usage indicates that their expertise in game play would be minimal.

Table 4. Exposure to computer simulations or games

	Minimum (days)	Maximum (days)	Mean (days)	SD (days)
When was the last time you played a computer game and/or simulation?	0	4745	741	1344.31
When was the time before that you played a computer game?	1	1095	200.54	339.23
		Frequency of Response (%)		
	Less than 30 mins	30 mins to 1 hour	1 to 3 hours	More than three hours
How long did you spend on your last game or simulation?	0	23.5	23.5	35.3
How long did you spend on the game or simulation? (the time before)	17.6	11.8	29.47	17.6

4.2 Janus Performance Scores

To assess participant performance, loss exchange ratio (enemy kills were divided by friendly losses) was used. This generated a performance score relative to that of the enemy. This also allowed enemy performance over time to be monitored.

4.2.1 Communication architecture

Table 5 shows the effect of communication architecture on loss exchange ratio. In line with the hypothesis that open communication architecture would facilitate situation awareness, open communication has produced higher performance scores.

Table 5. Communication architecture and the influence on Janus Kill/Loss ratios

	Mean	Standard Deviation	Max
Open	2.04	1.26	5.60
Restricted	1.44	0.79	2.67

4.2.2 Previous Experience

Table 6 shows a substantial difference between the military personnel and the civilian participants. This supports the hypothesis that military personnel would outperform civilian subjects.

Table 6. The effect of previous experience on Janus scores

	Mean	Standard Deviation	Max
Military	2.82	1.93	5.60
Civilian	1.56	0.80	3.19
Overall	1.72	1	5.60

4.2.3 Performance Measures Across Groups

Table 7 shows that although military personnel achieved higher performance scores on the current Janus simulations, there was variation between the civilian groups' performance scores.

Table 7. Janus performance across groups

	Group 2	Group 3	Group 4	Group 5
Mean	1.87	1.4	1.42	2.82
Standard Deviation	0.53	1.13	0.66	1.93
Maximum Score	2.67	3.19	2	5.60

4.2.4 Development of Expertise Across Trials

Figures 4 and 5 show mean performance scores across trials. Neither graph seems to indicate a straightforward development of expertise. Performance seems to increase over time. However, there is no meaningful linear or quadratic function to illustrate this. Dips in performance are found at trials 2, 4, and 7. During Days 1 and 3, participants performed better in their initial trials each day. In addition, the second day of participation produced higher performance scores than the first.

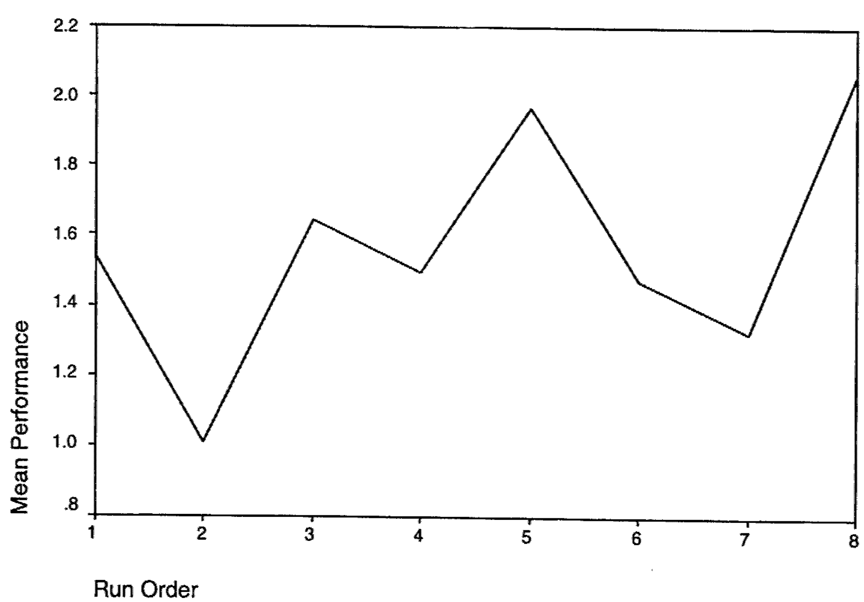

Figure 4. The average performance of civilians across trials

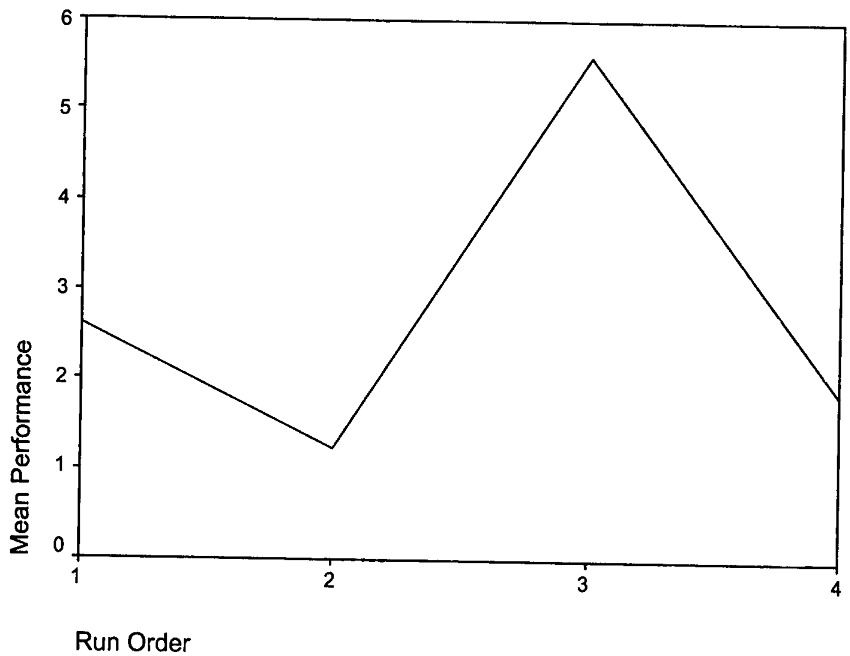

Figure 5. *The development of expertise over trials for military participants*

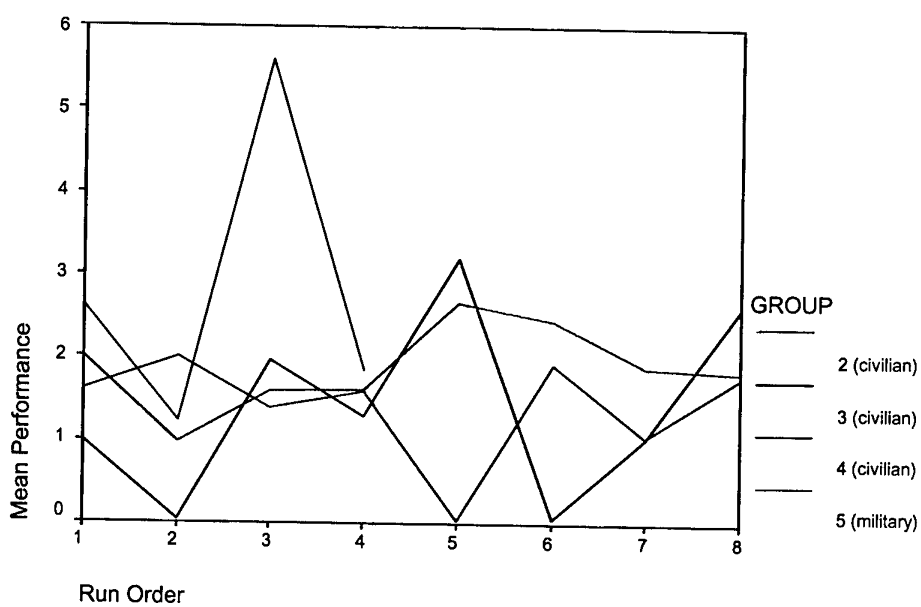

Figure 6. *The performance for each group across the eight trials*

4.2.5 Enemy Performance Over Time

Enemy performance seemed to stay relatively constant across trials. Three peaks on Figure 7 indicate scenarios where the enemy had few losses.

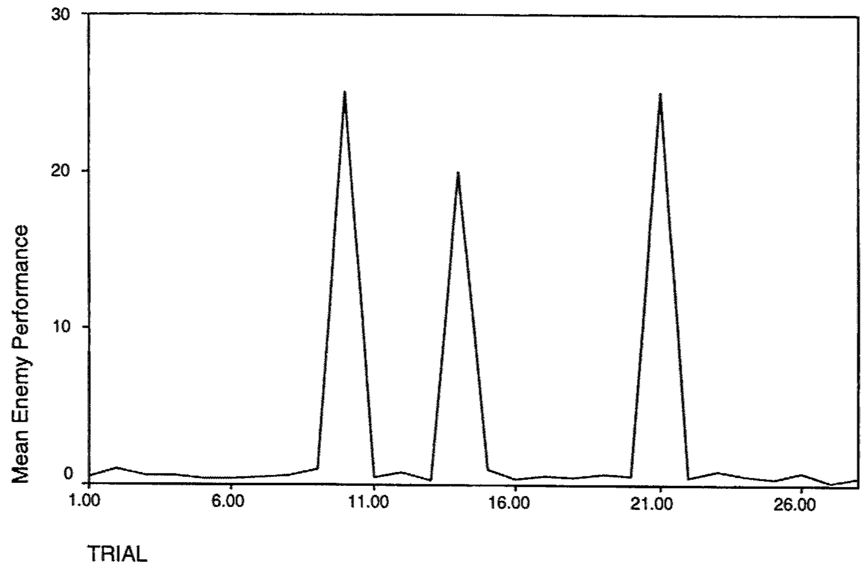

Figure 7. The enemy's performance over time

4.3 Communication

There was only minor variation in communication across groups. Table 8 shows that the most noticeable differences were a larger number of acknowledgments and updates made by military personnel, while they made less requests for information. Another noteworthy result was that the provision of information was less than the requests for each group. The military group seems to have the closest relationship between information request and information feedback.

Table 8. Communication

Communication Action	Mean Number			
	Group 2(C)	Group 3(C)	Group 4 (C)	Group 5(M)
Acknowledge	N/A	25	22	40.75
Provide updates	30.25	31	19.2	49
Identify Actions that Need Correcting	7.75	7	9.2	7
Request information	37.5	38.4	16	19
Provide Requested Information	31.7	32.6	11.2	18.5
Identify actions that need correcting	7.75	7	9.2	7
Identify problems to task completion	7	11.4	6	5.25

4.4 Self-Perception

4.4.1 Situation Awareness

Figures 8 and 9 show participants' perception of their changing situation awareness. All participants except one felt that their situation awareness increased after the first day. This was true for both military and civilian participants. However, no significant correlations were found between participants' performance score and beliefs about their development of situation awareness.

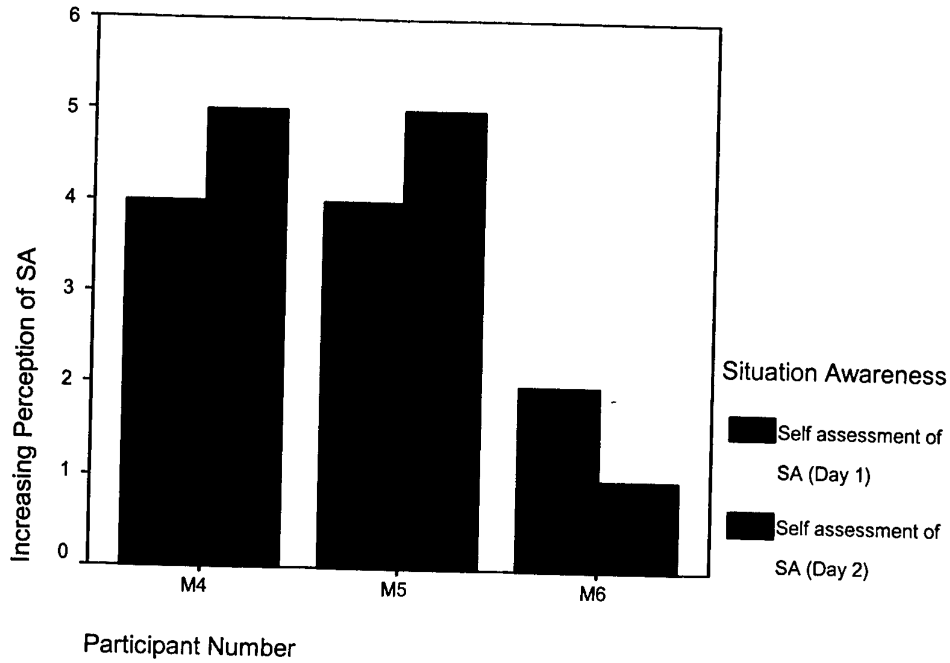

Figure 8. *Perception of situation awareness for military personnel*

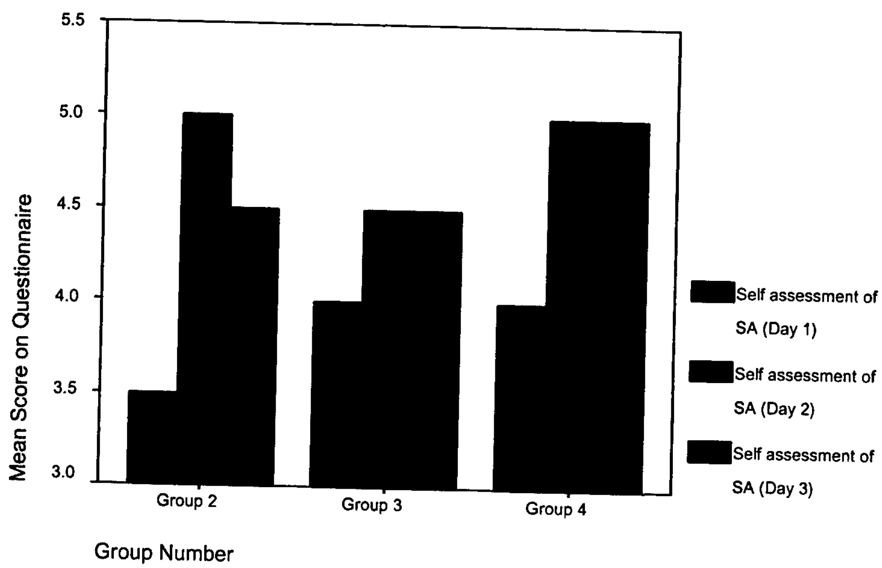

Figure 9. *Perception of situation awareness for civilians*

4.4.2 The Development of Expertise

Four questions in the post–trial questionnaire assessed whether participants thought they were developing expertise in the task. The responses to these questions ranged from disagree to strongly agree on the five-point scale. The majority of participants tended to agree or strongly agree with these statements. For example, at the end of the trials, 100% of military participants strongly agreed that they had become more skilled commander/sub-unit leaders under these wargame conditions. Of the civilian participants, 66.6% strongly believed this. There also seemed to be a general trend for participants to agree to a higher extent with these statements across trials. However, no significant correlations were found between participants' performance score and beliefs about their development of expertise.

4.4.3 Communication Architecture and Situation Awareness

The majority of participants believed that open communication improved their situation awareness and performance. After the first two trials, 70.6% of participants preferred open communication, 5.9% preferred restricted, and 5.9% could not decide. At the end of the three days (8 trials), 77% preferred open communication and 22% of people could not decide. No participants preferred restricted communication. This preference for open communication is consistent with the finding that open communication produces significantly higher performance scores.

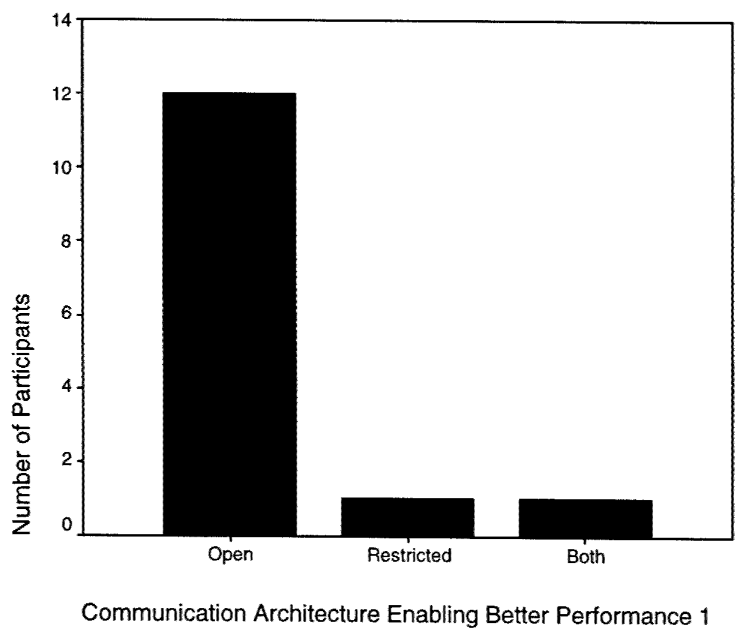

Figure 10. Preferred communication architecture after Day One

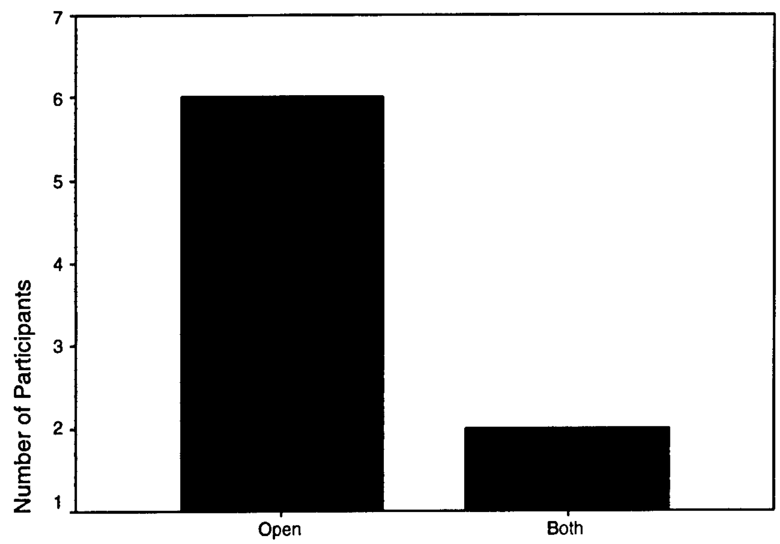

Figure 11. *Preferred communication architecture after Day Three*

4.4.4 Effectiveness of Training Regime

The training regime seems to have been relatively effective. From the post-trial questionnaire, 53.4% of participants agreed or strongly agreed that they understood Janus capabilities from the training. 86.7% of participants responded that they understood the experimental expectations from the supplied information (See Appendix B).

4.4.5 The Interactor/Participant Interaction

Participants indicated that interactors played an important part in the outcome of the trials. According to check-sheets, 85% of what interactors did was in compliance with the participant's command. This included explaining capabilities, acting on command, and clarifying commands. This would suggest that interactors would not have negatively influenced the scores. In addition, out of a mean number of moves of 382.5, the level made by each interactor was relatively similar, ranging from 10.45%- 9.21%. This represents an even number of commands issued across trials.

3.22% of good relationship indicators were witnessed (eg. encouragement and friendly comments). The remaining 11.88% of actions that may have influenced results include such things as delayed response (1.2%), incorrect response (1.9%), tactical suggestions (1.89%), ignoring commands (0.2%), and acting on their own initiative (6.5%). One interactor was responsible for 37.11% of the incidences of using one's own initiative to play the wargame. The same interactor was also responsible for 71.42% of the tactical suggestions made. A comment made by the participant regarding the interactor was:

> *My interactor took over when he got bored. I found this very frustrating and felt that I could have gotten more out of the exercise if he let me make my own mistakes at the start. ...It took a while to learn what was what. I still don't understand it all. I need to be able to make more mistakes.*

Two interactors stood out with the amount of explanations offered. These percentages were 37.67% and 24.43% compared to the other interactors who ranged from 3.3% to 16.17%. Only 5 interactors responded incorrectly to commands. Out of this group, one was responsible for 69.62% of the incorrect responses made.

5. Discussion

This study used the computer simulation wargame Janus to investigate the effect of communication architecture, and previous experience on NDM. The development of expertise was also monitored across trials. The current study has proven successful in identifying issues that need consideration when designing experiments on naturalistic decision-making. It also revealed trends that can be pursued in future research.

5.1 The Effect of Communication Architecture on Janus Performance

The data revealed a difference between the two communication architectures, with open communication producing higher performance scores. This supports the hypothesis that open communication facilitates situation awareness. This result is also consistent with Chapman (2000), where *Networked Fire Chief* was the experimental tool. This provides some validation of the use of *Networked Fire Chief* experiments to develop the NDM theory in relation to the military. For future research, it is recommended that this comparison be investigated with larger participant numbers. Forming larger teams could also be beneficial, as it may be the case that with larger hierarchies, open communication may not be as effective, as members would have to filter more information.

5.2 The Effect of Previous Military Experience on Janus Performance

A difference was found between subject groups, with military participants outperforming civilians. Because the difference was substantial, this would be an important comparison for future research. However, it is important to treat this data with some caution. The unbalanced design, with one military group compared to three civilian groups, as well as the unbalanced number of trials between civilian and military groups, could have produced this result. These issues need to be addressed in future studies.

It is also necessary for future research to more clearly define what constitutes expertise. According to Randel, Pugh, and Reed (1996) an expert is defined in terms of the following qualities:

- Factual knowledge;
- Efficient retrieval of stored knowledge;
- Ability to monitor motor and perceptual processes; and
- Ability to efficiently allocate cognitive resources.

The experts used in this study were all military officers. However, they indicated that they were only involved in combat training once per year. In addition, their roles in the military were not directly related to weapon unit control. Taking the above definition of expert into account, it should prove valuable to use military participants who are actively involved in the areas in the wargame scenario. It would be expected that because of the clear difference found between groups in this study, recruiting participants who fit the definition of expert more closely should increase the difference in performance between groups.

5.3 The Development of Expertise Across Trials

5.3.1 Experimental Participants

No simple trend was revealed in terms of the development of expertise across trials. The civilian sample showed a broad range of variability in performance across their trials. However, isolating the first and last trials reveals an increase in performance. The variability of performance in the other trials results could be partially accounted for by fatigue. The participants commented that three trials in one day left them exhausted. One commented that "by the third scenario on each day I think there tended to be a big loss of interest and it was much more difficult to keep focused."

Observations during trials also showed that participants' enthusiasm for the task was reduced after a number of trials. While this varied from group to group, the second or third scenarios being run each day was generally affected.

For future research, it would be beneficial to try to reduce participant fatigue and maintain their interest in the task. This proves difficult when running experiments where large numbers of trials are needed to generate meaningful outcomes. The balance between ideal experimental design and participant willingness and availability has to be taken into consideration.

5.3.2 Enemy Performance

Enemy performance over time did not seem to improve, with performance remaining relatively constant. Three peaks of performance stand out that could be accounted for by anomalies in the Janus recording log and/or chance occurrences.

It is important for an experimental design such as this to have an intelligent enemy, who can react to moves made by the participants. At the same time enemy performance must be held as constant as possible, so as not to confound participants' results across time. Overall, the current study achieved this result.

5.4 Communication

Military participants used substantially more acknowledgments and update reports than civilians. This type of communication helps to facilitate teamwork and situation awareness. This could partially explain the overall difference in performance scores between military and civilian participants. Unlike the civilians, military personnel also requested information and provided requested information at close to the same frequency. This is what you would expect if each request were given a response. A related issue was the high level of information requests from some of the civilian participants. This further demonstrates their lack of expertise in the area. In particular, it is likely that they did not know which information to filter out, so were requesting more than was necessary for optimal performance.

5.5 Self-Perception

The validity of the self-reports in the current study can be questioned due to the fact that the majority (excluding the participants' perceptions about communication architecture and its effectiveness) did not significantly correlate with performance scores. However, it is anticipated that by refining techniques of extraction, more reliable self-perception data can be obtained. In addition, larger participant numbers would help to consolidate this issue.

5.5.1 Self-Perception of Situation Awareness

In the civilian sample, there was a perception of increasing situation awareness from day 1 to day 3. However, Group 2 reported higher situation awareness on day 2, compared with day 3. This may be due to different interactors giving varying quality in support. The remaining two groups reported approximately the same levels of situation awareness across day two and three.

Two members of the military sample agreed that their situation awareness increased over trials, while the third military participant believed that his situation awareness decreased across days. To clarify this issue, it needs to be tested with larger participant numbers. Also, to obtain a more accurate measure, a different method could be used to measure participants' self-perception of situation awareness. The current study used a 5-point scale, ranging from strongly disagree to strongly agree. Most participants tended to agree or strongly agree. It may be more useful to measure the degree to which they felt their situation awareness had improved via a short interview after each trial.

5.5.2 Self-Perception of Expertise Development

100% of military personal and 66.6% of civilians strongly agreed they were becoming more skilled commander/sub-unit leaders under these wargame conditions. However, the data on expertise development showed both increases and decreases in performance. It is possible that participants were trying to please the experimenter by answering in a manner expected. Future studies should refine statistical performance measures of expertise development to consolidate conclusions.

5.5.3 Self-Perception of Communication Architecture

The majority of participants preferred open communication to restricted communication. One of the civilian participants commented; "being aware of what the commander and other commander (sub-unit leader) were communicating about helped my situational awareness". Another participant stated that, "restricted communication introduced a significant delay in requesting artillery support. This made estimating where to order strikes on moving targets much more difficult." Thus, participants recognised that their performance was improving with open communication architecture.

5.6 Training

The training protocol used in the current study seems to have been effective in giving participants a suitable level of information about the Janus system. The majority of participants agreed or strongly agreed that they understood Janus capabilities. However, during the trials, interactors provided a large amount of capability explanations. This could have slowed down the decision-making process and resulted in possible loss of weapon units in the Janus simulation.

For future investigations it is recommended that the training regime be reviewed, and tested on mock subjects. Clarity of expression, amount of information, necessity of information, and time allocated for training should be considered. The method of presentation should also be reviewed. In the current study, participants were asked to read through the training protocol. Following this, a Janus expert took them through a practical demonstration. During this time, questions were answered. This occurred directly before the first trial. If the training occurred on a separate day, and a short practice session was included, participants may feel more comfortable with the system capabilities. This may improve their performance in initial trials, and remove Janus system learning effects. A consideration, however, is the required time commitment for participants. This would effectively add another morning or afternoon to the testing period.

5.7 Interactors

In this kind of investigation where humans are used as experimental aids, a certain level of control must be kept. The results indicate that the majority of interactor time was spent performing actions to facilitate experimental outcomes. However, a number of issues arose that need to be addressed. Firstly, the relationship between the interactor and the participant clearly varied from day to day as different interactors were scheduled on. Some interactors merely acted on commands. Others would laugh at participant's jokes, share smiles, gossip between game play or make suggestions. This may have influenced performance across trials.

In addition, some interactors would indirectly make suggestions. For example, they would ask "Would you like me to...?" or "What do you want to do with X ?". This implies that an action should be taken, but not which action. This may have prompted participants and given them an advantage compared with those where the interactor did not indirectly suggest actions.

A more in-depth training scheme should also be established to familiarise interactors with Janus. Several interactors stated that they did not feel confident with the system at the beginning of trials. This could be combated with more intense training. Also, a requirement for interactor screening should be put in place before the trials begin. As mentioned in the results, there were interactor differences in terms of using their own initiative instead of following orders, and making tactical suggestions. A participant affected by this became frustrated by the end of the day and commented that "it took a while to learn what was what. I still don't understand it all. I need to be able to make more mistakes". This might have influenced learning and the development of expertise over time as this interactor was scheduled on the first day of the team's trials, where it would be most important for the participants to try the program and make a few mistakes in order to learn.

5.8 Limitations

5.8.1 BCSS Usage

The current study used BCSS as a situation awareness tool for the commander. It provided updates of the friendly force positions at regular intervals. A BCSS interactor was not used in the current study because of time and resource constraints. Commanders were provided with transparencies over the BCSS screen on which to mark anything they required (enemy position, artillery zones). There were several problems with this setup. For example, when friendly units were destroyed on the Janus screen, they stopped moving on the BCSS screen but were still present. Commanders reported that they found this confusing. This problem could be combated in future research by having a trained BCSS interactor who could remove weapon units reported as lost.

A second problem was that the screen could not show a large zoom and still show all the weapons units at the same time. There was also a lack of correlation with the map found on the BCSS monitor and that in Janus. Land types seemed not to match between maps. It is important that a high correlation between maps is present; otherwise effective communication is more difficult.

5.8.2 Scenario Development

During scenario development, the friendly force was divided into a ground force and a support force. This created a cooperative situation that could have reproduced the same kinds of communication requirements experienced in *Networked Fire Chief*. To a certain extent this seemed successful. However, the simplicity of the scenario was of concern, as was the lack of wide variation in the performance scores.

The clear difference between the power of the red force compared with the blue force meant that the enemy had many problems posing an effective attack. This is an internal programming aspect of Janus. It may be that in order to create a fairer battle, the enemy needs a greater number of units. This would possibly create a greater distribution in performance scores.

The scenario could also be made more complex by having multiple sub-unit leaders, each of whom would be in charge of certain weapon units. This would allow use of larger teams.

Another aspect of the scenario relates to the duration of the trial. 1½ hours was recommended by a Janus expert as an appropriate length of time to draw meaningful results. During the trials, one of three things tended to happen:

1. The team defeated all of the enemy's ground units, and spent the remaining time searching for artillery (usually fruitlessly);
2. The team surrendered because they felt they had been defeated; or
3. Both teams had reached a town and they spent the remaining time scanning through this area of extremely low visibility.

The third response is possibly an artefact from the extremely low visibility in the urban zones of Janus. This caused difficulty locating enemy units within the urban zone. Therefore time spent searching was lengthened, whereas actual engagement with enemy units was almost impossible.

With a more complex scenario and a larger red force, the battle tactics and time-pressured decision-making may continue until the end of the trial.

It should also be noted that in this type of exercise, it is more important to generate accurate performance measures than for the participants to achieve their goal. Therefore, a scenario with a higher level of complexity amongst the blue force, as well as equal distribution of power across the blue and red forces, is recommended. It should also be pointed out to participants that the intent statement is only a guide, and that it is acceptable if they do not achieve the goal within the allocated time.

5.8.3 Respect for the commander

A problem in the current study was the limited use of the commander across groups. The scenario would often be played out without many interactions with the commander. Because of the random allocation of roles, the most experienced or most confident person for the role did not always play the commander. In the military, commanders are respected because of their experience. In the current experiment, this element was not present, and respect for the commander may have been compromised. This could explain the lack of attention paid to the commander by many sub-unit leaders. If the commander had more knowledge, it may also have been less intimidating for him to step in and take charge. Commanders may have been making no decisions because:

- They were not confident in their own ability; and/or
- They were not well informed of the situation by BCSS updates and did not have enough experience to make situation reports/updates to facilitate situation awareness.

Another observation related to the level of respect subordinates had for a commander was that often under the open communication condition, commanders would be bypassed in the communications. Instead, subordinates would communicate directly with each other. This would exclude the commander from the decision-making process, and break down the C2 structure.

In future research, a sample of military participants should be in roles consistent with rank and experience. In addition, the commander should be provided with better situation awareness via an interactor at the BCSS monitor.

5.9 Conclusion

In summary, the current research was useful as means of determining how this type of experiment could be continued. It also revealed trends, and identified issues that need further examination. In addition, it identified the following methodological details that need to be taken into account in future research:

- Large participant numbers;
- Amended interactor training;
- Interactor screening;
- Revised training regime;
- An interactor for the BCSS monitor, who is an expert BCSS user;
- A larger team structure (to see more complexity emerge in the communications.);
- Amended maps with high correlation between them; and
- More appropriate scenarios developed.

This study also provides support for the concept that Networked Fire Chief is an appropriate tool for investigating some aspects of naturalistic decision-making theory.

However, the investigation of issues related to expertise in a military context may not be an appropriate area for investigation with this microworld. As is suggested in the literature, this study indicates that expertise is largely context specific. There are significant differences between a fire fighting context and a battle context. It is recommended that future work should further examine the use of Janus in Human Factors research. Also, the validity of Networked Fire Chief should be further investigated to determine the extent to which results can be generalised between areas that require naturalistic decision-making.

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Appendix A: Participants Literature and Check-sheets

A.1. Information for Participants

Thankyou for volunteering to participate in this pilot study. Your results will be strictly confidential. However if you would like to have an indication of the study's outcomes, I can e-mail you a summary of results around the end of February. This is a schedule of what you will be tackling over the three days.

Time	Monday	Time	Tuesday	Time	Wednesday
9:30	Training	9:20	Plan/ Restricted (1)	9:20	Plan/ Open (2)
10:30	Break	11:30	Lunch	11:30	Lunch
11:00	Plan/ Open (1)	12:30	Plan/ Open (2)	12:30	Plan/ Open (1)
1:00	Lunch	2:35	Break	2:35	Break
2:00	Plan/ Restricted (2)	2:50	Plan/ Restricted (1)	2:50	Plan/ Restricted (2)
4:00	Finish/ Debrief	5:00	Finish/ Debrief	5:00	Finish/ Debrief

(This schedule rotated communication architectures for groups)

Further Information

The current study uses a computer war game simulation, JANUS, which represents two armies warring against each other. A comparison will be made between experienced participants (military) and inexperienced participants (civilian DSTO employees). Under these war game conditions, participants will be tested under the two different communication architectures, defined in Chapman's experiment (2000).

For each communication architecture the subjects will undergo 4 trials, and learning effects will be monitored. This way we can investigate the development of expertise, and contrast whether this development is different for military personnel compared to civilian subjects. This study should also help to understand whether expert's NDM decision-making performance results are context specific.

You will be acting as part of a team in this study. Each team involved in the study consists of 3 members. One team member acts as the commander, while the other two act as sub-unit leaders controllers.

The plan of each session will be:

Intent/Ops orders given to team → Phase 1: Team planning carried out → Phase 2: Wargaming / fighting the battle

Training
Each team will be asked to take part in a training session to familiarise you with the specialised set up of JANUS. This training session will follow closely a training protocol written by Chapman (2000), which outlines the capabilities of Janus, and the tactical information you will need to understand.

Intent Statement
The intent statement for the exercise will be given to the participants to read.

Planning
In the next phase, you will be given a lesson in the basics of mission planning. You will consequently have a 20 minute planning period, in which you will work with your fellow team mates to form a plan. During the planning you will be provided with a large map of Kamaria (the land in which the battle takes place), a plastic overlay, and some transparency markers. You can plan routes and tactics to accomplish your mission in this session. This planning phase will take place before each of the 8 trials begins.

Janus Trials
Following your planning you will be required to perform one and a half-hour war-gaming sessions. This length of time is needed for Janus to generate some meaningful outcome data. The ordering of these sessions is as is scheduled above.

A.2. Demographic Information

Participant number: ____________________________________

Allocated Role in Janus *(please circle)*Commander /Sub-unit leader

Rank or Field of Expertise: ________________________________

Sex *(please circle)* Male Female

Age: ________________ years

Please read the following questions carefully and circle the appropriate response.

1. Are you, or have you ever been involved in the military?
   Yes / No *(please go straight to Q. 4)*

2. If so, what was your main role? (*Please describe.)*

____

3. How long were you (or have you been) in the military?

____

3. How often are you involved in practical combat training?
(Please circle appropriate answer.)
every day / weekly / monthly / every six months / yearly

4. Are you or have you ever been involved in another organisation which requires you to make emergency decisions? (For example: CFS, hospital emergency room)
   Yes / No

5. Have you previously used JANUS?
   Yes / No

6. Have you worked with your team members before?
   Yes / No

7. Have you ever played a computer game or simulation?
   Yes / No.

8. When was the last time you played a computer game and/or simulation? *Please write number in appropriate time span.*
   _____Days ago Weeks ago_____ Months ago_____ Years ago_____

9. How long did you spend on the game or simulation? *Please tick appropriate box*
   Less than 30 minutes
   30 minutes to 1 hour
   1 to 3 hours
   more than 3 hours

10. When was the time before that that you played a computer game? (*Please write number in appropriate time span.)*
   _____Days ago Weeks ago_____ Months ago_____ Years ago_____

11. How long did you spend on the game or simulation? *Please tick appropriate box*
   Less than 30 minutes
   30 minutes to 1 hour
   1 to 3 hours
   More than 3 hours

Questionnaire is completed. Thank you for your effort

A.3. Notes to the Commander

As commander you are responsible for overseeing the actions of your subordinates, and making higher level decisions based upon your knowledge of the "overall picture". You will need to coordinate your ground forces (tanks and APC's) with your support forces (artillery and recon. helicopters) in order to effectively destroy the enemy.

During this exercise you are given aids to help you create a good situation awareness of the battle taking place.

You will have a BCSS monitor available. This is a restricted, situation awareness tool that provides you with a map of Kamaria (This correlates with the Janus screen). The system updates the positions of your weapon units controlled by both sub-unit leaders on that map periodically. Enemy sightings do not appear on your screen. Rather, you will need your sub-unit leaders to radio through the coordinates to you, and you can update them on the transparency overlay covering the BCSS screen. If your friendly units are destroyed, they will cease to move on the BCSS screen. Your sub-unit leaders should notify you of casualties and coordinates. Then you can identify which unit/s have been destroyed, and mark them on the overlay if desired.

Below the BCSS screen you will have a picture of the map on the Janus screen your subordinates are using. This may help with communication.

You also have a whiteboard if you wish to use it. You may want to write tasks here during the planning phase that you can refer to them later.

You are provided with a casualty sheet (if you wish to keep a track of how many units are left), and a sheet outlining weapon ranges/sensor ranges, and maximum speeds. These may be useful also.

It is recommended that you keep a few sheets of paper near the BCSS screen so that you can copy down coordinates when they are radioed through, and update them on the overlay later.

If you have any questions about any part of this ask me, and we will try and sort it out.

Rules of Engagement

1. You must not move the vehicles forward of the beginning positions during deployment. You are only required to design manoeuvre routes.
2. The use of mines is not allowed. (It is against Kamarian legislation)
3. You should give coordinates to your commander regarding enemy sightings and casualties etc...

A.4. Notes to the Sub-unit Leaders

Your role is to make lower level decisions, and to report all relevant information (eg. Coordinates of casualties, Coordinates of enemy sightings, and situation reports) back to your commander.

It is very important that you do communicate this information to him/her, because s/he is responsible for overseeing the "big picture", and s/he needs reports in order to do so.

Rules of Engagement

1. You must not move the vehicles forward of the beginning positions during deployment. You are only required to design manoeuvre routes.
2. The use of mines is not allowed. (It is against Kamarian legislation)
3. You should give coordinates to your commander regarding enemy sightings and casualties etc...

A.5. Weapon Unit Guide

Blue Forces

Combat system name	Combat system type	Weapon range (km)	Sensor range (km)	Max Speed (km/h)
M1A1 Abrahms	Main Battle tank	3	5	66
FCV25	Infantry fighting vehicle	2	5	100
FARH	Armed recon. Helicopter	8	12	~300
155 mm Hzr	Howitzer	42		60

**Time to plan a mission before firing is 30 seconds.
Time of flight for the round before impact can be 5 to 58 seconds (depending on range.)

Possible Red forces

Combat system name	Combat system type	Weapon range (km)	Sensor range (km)	Max Speed (km/h)
T-80	Main battle tank	4	5	80
BMP-2	Tracked Armoured personnel carrier	4	5	80
2S6	Surface to air missile vehicle	8	10	65
152 mmHzr	Howitzer	Always in range		

A.6. Casualties: Blue Force Scenario 1 & 2

You may keep a count of casualties on this sheet if desired.

Ground Force: Initial Units Description

M1A1 Abrahms	16	Main battle tank (MBT)	
FCV25	16	ASLAV25 Light combat vehicle	

Support Force: Initial Units Description

.55 mm HZR	12	155mm Howitzer	
FARHI	6	Armed Reconnaissance Helicopter	

A.7. Radio Protocol

In order to make your radio transmissions clearer, we ask that you use the following format.

1. State the person's call sign you wish to talk to.
2. State your own call sign.
3. Relay your message.
4. Finish with either "over" or "out" ("Over" indicates that you expect a response from the person you have just communicated with. "Out" suggests that you are finished and do not require a response.)

An example of a communication sequence:
Hicon:
" **Locon1, locon1, this is hicon**. Please provide me with a situation report **over**."
Locon 1:
" Receiving you hicon please standby **over**"
Locon 1:
"We are currently about 2 km west of our goal, we have sighted enemy forces to the south east, and are currently monitoring them with our FARH. We have lost 16 units in total so far, **over**."
Hicon:
"Receiving you locon 1. Continue monitoring the enemy to your south east, and report immediately once you have identified the forces. **Hicon out**."

Locon 1:
" **Locon 1 out**."

Call signs you will need to be aware of:

Locon 1:____________________________

Locon 2: ____________________________

Hicon: ____________________________

A.8. Check sheet

Subject__________Date__________Time__________Condition__________Observer__________

	Communication (problems)			Communication (SA maintenance)						Control		Morale			Situation Awareness (Pre-empting behaviours)			
	Ignore request	Ask for quiet/no chatter	Ask for repeat of what was said	Verify information	Provide clarification of information	Request information	Provide requested information	Repeat information	Provide updates	Decision made/command given	Communication Acknowledged	Banter	Sarcastic/belittling tone	Humorous tone	Detect situations that require corrective actions	Identify problems/impediments to task completion	Anticipate changes to scenario	Provide information without request
5																		
10																		
15																		
20																		
25																		
30																		
35																		
40																		
45																		
50																		
55																		
60																		
Total																		

A.9. Puckster Checksheet

Subject_________Date_________Time_________Condition_________Observer_________

	Desirable Behaviours			**Undesirable Behaviours**						
	Explaining capabilities	Acting on commands	Clarification of command	Delayed response to command	Incorrect response to a participants command	Tactical Suggestion made by puckster.	Ignoring Participant's Request	Acting on own initiative	Good relationship/morale	COMMENTS
5										
10										
15										
20										
25										
30										
35										
40										
45										
50										
55										
60										
Total										

Appendix B: Janus Information

B.1. Training Protocol

During this study, you will be participating in a two-sided war game. Janus is an interactive simulation war game portraying realistic events during multi-sided combat. It uses digitized terrain effecting line of sight and movement, depicting contour lines, roads, rivers, vegetation and urban areas. It has the capability to be networked with other systems, in order to simulate a war game with multiple sides.

You will be working with a group of three people in this study, representing a simplistic hierarchy. One team member will act as the commander, the other two as his/her subordinate unit leaders. Each of you will be looking at your view of the battle on a computer screen (all physically isolated from one another.) Commands will be issued by the commander, and feedback is required from the sub-unit leaders. As well as this, in order to move anything on the screen, carry out any action, or request computer information simply make a request to your "interactor". Your interactor links you to the action happening on the computer. This person is responsible for translating any of your commands to the entities on the Janus screen. They will act on commands given to them, as well as, suggesting the closest possible action that could be taken using Janus if requests you make are impossible. **However, they cannot guide you in your decision-making!!** Your role is that of the **battle commander** for the blue team. In this role you are responsible for overseeing the moves of your 2 subordinate sub-unit leaders. You should keep track of the "overall picture", and make high-level battlefield decisions, leaving the more intricate decisions to your subordinates. Your view of the battle will be provided by BCSS. This is a computer generated map, which updates the positions of your forces and any enemy forces that are sighted. You are also responsible for communicating information of enemy sightings to both of your subordinates as much as possible. Your communication will take place using a radio system.

OR

Your role is that of the **sub-unit leader** for the blue team. In this role you are responsible for receiving and acting on orders given to you by the commander. You should continually give feedback on your actions to the commander, so that s/he is able to keep track of the "overall picture". You should also inform your commander of any enemy sightings as much as possible. Your communication will take place using a radio system. You are asked to treat this situation as realistically as possible, as we are looking at your situation awareness and decision-making processes. Therefore we need to replicate real world cognitive processes.

Janus' capabilities are outlined below, so that you can gain an understanding of what you are able to do on the program. Also while you are playing, keep the Janus info sheet close to you so that you are able to refer to it if in doubt.

B.2. Janus Information

Game Time

The timer at the bottom right hand of your screen expresses time in simulation clock: days, hours and minutes.

Communication

You will be tested using two different communication architectures:
Open communication – where all team members hear all communications.
Restricted communication – where communication is limited between you and one of your sub-unit leaders at any one time. Nobody else can hear that transmission.

Capabilities

You will need to familiarise yourself with the capabilities of Janus in order to effectively plan and carry out your mission. The capabilities you need to be aware of are:

- Terrain –Map shows topographical features, man made obstacles and natural obstacles. Allows for different zoom levels.
- Movement – route planning, tracked, wheeled, foot, aviation
- Line of Sight – Obscuration by smoke, , terrain and vegetation are taken into account
- Direct fire engagements (automatic) / Indirect fire engagements (manual).

Terrain

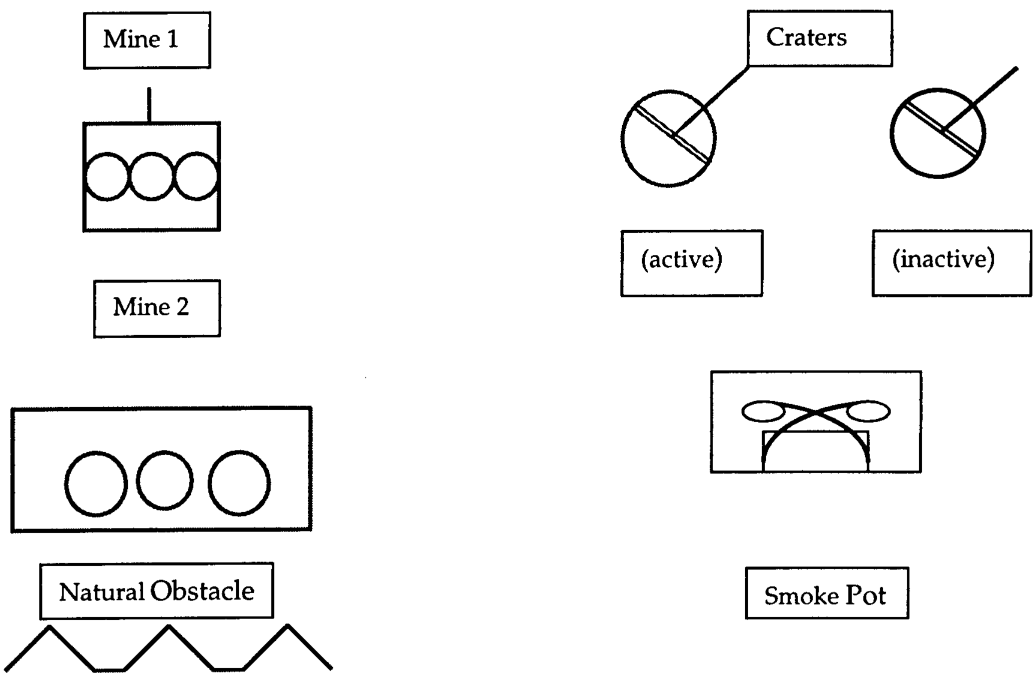
The Map

The map represents a fictional land called Kamaria. The map shows topographical features, man made obstacles and natural obstacles. You will notice rivers, roads, areas of vegetation and contour lines. You should take all of this into account when planning your movement routes. Your "friendly" forces are represented as blue. Enemy forces that have been identified are red.

Zoom

Provides you with the capability to magnify the screen in order to see more clearly what is happening on the map. Your magnification level is located above the time on the bottom right hand side of the screen.

Man Made Obstacles→ Everything shown in black appears white on the computer screen



1. Mines
The enemy may have mines laid. These cannot be seen on the screen until one of your units discovers them.

2. Clouds
The enemy may also have smoke pots/grenades laid out. These will be seen when you activate "clouds" on the Janus menu. Dust and smoke will appear on the screen (in the form of a white circle) as they occur during game time. This affects sight and movement regardless of whether you have the "clouds" menu option active.

3. Negotiating Obstacles:
Routes through man-made barriers will only be visible to the side that have deployed them.
Breaching: Some vehicles however have the ability to breach obstacles. When they reach an obstacle they will automatically breach the obstacle with a slight delay.

<u>**Movement**</u>
Planning: During planning you will need to consider the routes you intend to use to accomplish your mission. These can be set at the beginning of the war game, and may be displayed and adjusted as the game continues. Stop nodes can be included, at places where you would like the vehicle to pause until instructed to proceed.

Manoeuvre: You will continue along your planned route unless you decide to stop, or change your route plan. If you feel it is necessary to show your movement routes this is possible.

Sprint: Each system in the simulation has movement speeds and capabilities defined in the database. The speeds depend on the type of system and whether it is moving on a road or cross-country. A group speed is entered at the server to set units in a Task Force to move together at the group speedThis keeps task forces moving together in formation. It is possible to have whole task forces "sprinting, or it is also possible to sprint one of your units.

Mount/ Dismount: You are able to mount one system onto another (ie. Soldiers onto troop carriers, or vehicles onto transports.) When you are doing this however you will have to take into consideration the weight and volume of the objects mounted in relation to the capacity of the transporting unit. Once you have reached your desired destination you can order a dismount of either a single entity, or all those loaded onto that carrier.

Status: You can acquire the status for all units in a selected task force, or individual units. The information includes: unit number, system name, initial strength, remaining strength, fuel status, velocity, delay, hold fire, suppression, breach and chemical status.

Flight Capabilities: Aircraft do not land when stopped they will hover or circle the area. If you put stop nodes behind screening crests you can take advantage of the pop-up capability. The helicopter will remain popped up for 60 seconds and will observe and/ or fire at targets that he acquires. After these 60 seconds the helicopter will automatically lower. It will continue to pop up and down until it finds a target and shoots. It will then proceed to its next stop node.

<u>Line of Sight</u>

Line of Sight & Firing Range: Obscuration by smoke, terrain and vegetation are taken into account when a vehicle's line of sight is displayed. Orange lines radiate from the unit and represent what the unit can see within its vision limits. This is bound by a white arc. A break in the line is dead ground. A purple dotted arc indicates maximum effective range of the unit's primary direct fire weapon. This can be shown for all units on the screen in your force. (See Figure 1.)

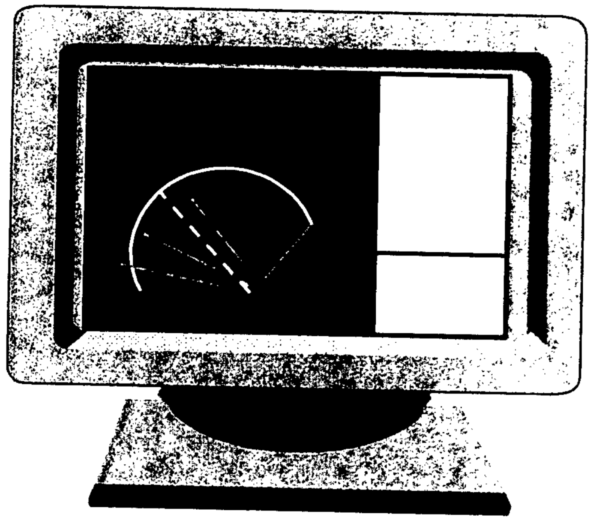


Figure 1: Screen view for line of sight

An element's view fan can vary from 360 degrees to a very narrow arc of interest. The lesser the arc of interest, the quicker a unit will be able to detect enemy units within that arc. (Because it will have less distance to scan.) However if you are looking in a direction different to where the enemy is approaching you will not be able to see them and are vulnerable.

There is also an option that predicts your line of sight at any point on the screen. The interactor can help you to do this as well as setting you're the current line of sight and view fan for each element.

Levels of Detection:

As your units move across the terrain they will detect other units (enemy or friendly) that are in their line of sight. These will appear on your screen as follows:
Yellow box – Unknown type.
Yellow icon - Appears in the form of a type of entity.
Red icon – Identified as enemy icon.
➔ Be careful to make sure not to shoot at "friendly" units. This will decrease your performance scores!!

Firing

Rules of Engagement:

Direct fire units automatically engage enemy units once they have been acquired and are within range.

If more than one enemy is spotted the unit will engage at the highest priority target. If a unit is fired at it will also automatically engage with its enemy. (see diagram below)

Hold Fire (HF) permits you to order the unit not to shoot regardless of the proximity of the enemy. This function may be necessary in order to refrain from attacking your own "friendly" forces. It is important that you communicate with your team members before firing at an unidentified unit.

Effects of an Engagement: As a result of a firing engagement the following symbols may appear on your screen at the point of that battle:

A = Killed by artillery

C = Casualty

S = Suppressed

M = Minefield casualty

B = Chemical kill

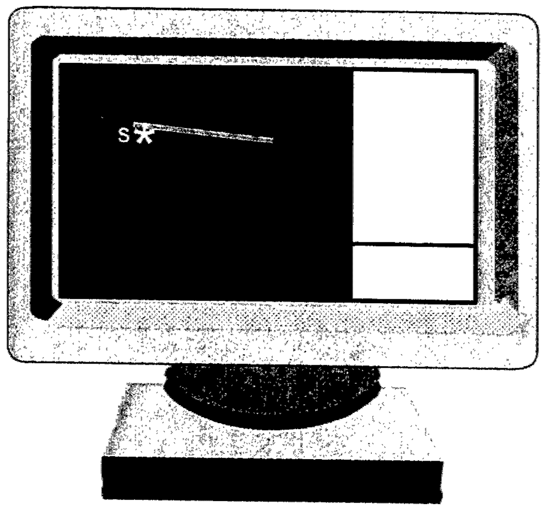


Figure 2: Screen view after engagement

Artillery Information: You can obtain information on what type of artillery is present on each of the "friendly" entities.

Kill Statistics:

A running total of your unit loses is kept. You can obtain 3 different reports on this:
1) The initial strength, strength remaining, and losses for the highlighted task force.
2) The same information but for the group.
3) The same information for the entire side.

Planning Artillery/Indirect Fire Missions:

You can plan/ alter artillery missions of the type:
- HE - High Explosive (standard artillery round),
- IC - Improved Conventional HE round (more accurate),
- RP - Rocket Propelled HE (increased range),
- CH - Chemical,
- PG - Precision Guided HE by laser designation,

Depending on the artillery unit used, the type of fire mission will determine what other functions it is used in conjunction with. You must select ammunition type. Number of volleys and aim point. When a firing unit has twelve missions assigned, its mission queue is full and it will not accept any additional missions. Great discipline must be employed to prevent excessive use of Artillery mission planning to avoid redundant fire missions from being fired. You have a limited number of rounds and as such artillery should be employed as it would be in real life.

Planning.

Prior to the actual planning stage, you'll be given the statement of intent from the superior commander. You will need to read, understand and analyse this in order to complete the planning and wargaming parts of the experiment. This will give you the aims and goals of the mission you are about to plan.

Once planning begins, you should find (based on what the military subjects were observed to do last week) that there are 4 main phases within planning. These are outlined in your handout.

First, there is the *review and confirm* stage. This essentially involves taking the intent statement (and the aims you extracted from it) and relating it to your starting positions, the troops you have, the information you have on the enemy activities and positions, and your map. You should at this stage confirm with Doug Williams or myself (Monique) where your approximate starting locations are, and where you will be heading during the game.

Next, you should be *evaluating* several things: the possibilities for movement of your troops, the terrain factors that will impact on this, the potential enemy movements and their impact on what you want to do (ie. the potential risks associated with your troops doing what you want them to), the speed at which you can potentially achieve what you want to, and the best locations for the deployment of your troops.

Third you will need to *develop and analyse your Courses Of Action.* Your should be putting forward ideas about where and how fast to move your assets, what routes they should take, potential locations/routes for good recon, and the groupings or formations you want your troops in. You should analyse each set of ideas for utility and the possible consequences and decide on your best options. Then you should assign tasks to your troop groupings.

Finally, the commander will need to *confirm* with his/her subordinates the details of the missions. That is, confirm the course of action for the mission (the rough routes and headings and objectives, etc), the taskings of each group (locon 1 and 2), the location of potential coordination points on the map (if you think these are necessary), and the type of communication you'll be using in the scenario and channels your radios should be on.

Following this planning phase, you will be given approximately 10 minutes to move to your assigned rooms (locon 1 or 2) and instruct your Janus puckster in how you want your troops deployed. After this, the game will start and you will be fighting the red force.

Appendix C: Mission Planning Information for Civilian Participants

C.1. Prior to planning:

Read and analyse the superior commander's intent statement
During planning:
1. Review and confirm
- Initial positions for each group (company/battalion/etc)
- General headings for the groups
- Own forces: ie. numbers, elements, weapons, functions of each element, etc
- What is known about the enemy
- What the objectives of the mission are

2. Evaluate
- The possibilities for movement
- Terrain factors
- Potential enemy movements
- Ability of own troops to achieve the objective
- Risks associated with carrying out certain actions
- To what locations troops should be deployed

3. Develop & Analyse COAs
- Put forward ideas on:
    - Movement routes
    - Locations/routes for recon
    - Troop/element groupings or movement formations
- Analyse possible outcomes/consequences of each
- Determine best cost/benefit outcome ratio of possible COAs
- Assign taskings to groups

4. Confirm
- Mission plan (movement routes, objectives, ROEs, etc)
- Taskings
- Location of coordination points on map (if necessary)
- Type of communication used in each scenario and the radio channel you should be on

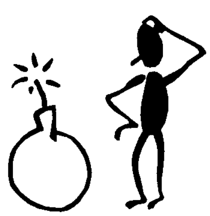
At this stage, you will go to your respective rooms with your puckster to deploy your forces, after which the wargame will begin. The higher commander will stay in the planning room (hicon).
Post planning:
The commander (hicon) should write up taskings and situation updates on the whiteboard for his/her own reference: the military tended to use the following format:

H Hour: (*start time*)

Locon 1 (TF1) <u>*name*</u>Locon 2 (TF2) <u>*name*</u>
[Ground / support force] [Ground / support force]
<u>Tasks:Tasks:</u>
101 201
202
203
204
205 ....etc
Contacts & Casualties
Locon 1Locon 2
Grid referenceElement & numberGrid referenceElement & number

Your locons will each be one of these two categories

This whiteboard list is helpful in aiding the commander to keep track of what's going on during the battle, and allows him/her to make decisions and alter plans as necessary. Your grid references and elements / numbers of elements column should allow you to track casualties, contacts with enemy, and own troop positions. It also allows you to track unidentified entity sightings for later identification.



C.2. Types of Actions to Consider While Planning COAs

Securing flanks of certain locations/terrain features (roads, towns, etc)
Prevent enemy capturing towns/features
Provide fire support to other task force
Securing township(s)
Recon certain areas of interest/areas of potential enemy concentration / features
Provide security to flanks of force
Attack any enemy encountered
Provide support to attacks planned by other task force
Provide indirect fire support
Synchronise attacks (fire missions)
Coordinated meeting locations
Frequency of reporting between locon COs and hicon CO (especially during restricted communication conditions)
* This is not an exhaustive list, but should provide an initial guidance for you to work from.

Brief Glossary of Terms:

COA: Course Of Action : what you (and your troops) will be attempting to do to achieve the intent (aims of the mission)
Intent: The aims or goals of the mission / battle you are about to undertake
Locon: Lower control (lower level company commanders)
Hicon: Higher control (higher commander's HQ)
TF: Task Force
ROEs: Rules of Engagement (eg. shoot the enemy as you identify them)
Ground force: M1A1s (main battle tank) *and* FCV25s (light combat vehicle)
Support force: FARH1s (armed reconnaissance helicopters) *and* 155mm Howitzer artillery units

C.3. General Factors to Consider While Conducting Mission Planning

Again, this is not an exhaustive list; rather, it should trigger you to consider the important issues.

Terrain:

- What type of terrain is around your start positions?
  Eg. Are there areas in which to hide /camouflage your vehicles?
- What type of terrain will you be passing through?
  Eg. Crossing rivers, driving through forested areas, or going uphill will slow your vehicles considerably: roads provide the fastest movement routes, but can be too obvious
- Are there features the *enemy* may use to hide behind?
  Eg. These features can also hide the enemy's vehicles/troops: think about conducting recon behind/around potential masking features

Initial enemy information:

- What has the enemy done up to now (ie. where are they and what have they just done to get there) and what is their apparent main objective in the near future?
- What enemy assets exist and where are they located?

Own troops information:

- How many of each element do you have at your disposal?
- What are their start positions?
- How do you want your forces grouped?
- What are your elements' capabilities?
- What are your objectives relative to the terrain, and how easily can you get to them?

Appendix D: Statement of Intent for Janus Study

D.1. First Scenario

You have deployed in the mountains East of the township of Jalingo to mount an attack to capture the town from the Musorian forces.

Intelligence sources indicate that the Musorian army has a Coy + Mechanised battle group stationed around the town.

Coordinate your ground, air and indirect fire assets to locate, engage and destroy any enemy elements on your way to capturing the town of Jalingo.

The Musorian Army is believed to have some indirect fire assets located in the town.

D.2. Second Scenario

Musorian forces have increased their activities on the Island of Kamaria and are believed to be using the township of Tandaho as a base to launch an offensive on the main city of Lagowa. Local businessmen travelling between Tandaho and Lagowa have reported seeing a number of Musorian vehicles just off the main highway between the towns.

Co-ordinate your combat teams to conduct a search and destroy mission on these Musorian forces before they can establish a strangle hold on the major route between the towns and launch an offensive.

Appendix E: Janus Post Trial Questionnaire

To be filled out after finishing experimental trial 8.

Participant Number:
Job Title:
Age:
Sex:
Date:
Please read the following statements carefully, and circle the most appropriate response.

ENVIRONMENT & ARCHITECTURE

1. The information sheet and training before the testing sessions made me aware of what my role was, and what was expected of me.
Strongly disagree / disagree / neutral / agree / strongly agree

2. The training before the testing sessions made me aware of Janus' capabilities.
Strongly disagree / disagree / neutral / agree / strongly agree

3. My "interactor" understood and followed my commands well.
Strongly disagree / disagree / neutral / agree / strongly agree

Comments:____

COMMUNICATION & SITUATION AWARENESS

1. I feel that I was aware of what was happening on the computer screen in the Janus simulation.
Strongly disagree / disagree / neutral / agree / strongly agree

2. I feel that I could communicate well with my fellow team members.
Strongly disagree / disagree / neutral / agree / strongly agree

3. I feel that my fellow team members responded well to my requests/suggestions.
Strongly disagree / disagree / neutral / agree / strongly agree

4. I feel that I provided good, clear, useful information to my fellow team members.
Strongly disagree / disagree / neutral / agree / strongly agree

5. I passed information to the appropriate person without being asked.
Strongly disagree / disagree / neutral / agree / strongly agree

6. I feel that open/ restricted communication enabled me to achieve a better situation awareness. (Please circle the appropriate response.)

8. I feel that open/ restricted communication enabled me to perform better on the Janus war game. (Please circle the appropriate response.)

Comments:____

DEVELOPMENT OF EXPERTISE

1. I feel that as I progressed through the trials my understanding of the war game situation increased.

Strongly disagree / disagree / neutral / agree / strongly agree

2. I feel that as I progressed through the trials I became a more skilled commander/sub-unit leader under these wargame conditions.

Strongly disagree / disagree / neutral / agree / strongly agree

3, I feel that as I progressed through the trials I began to feel my decision-making became more intuitive.

Strongly disagree / disagree / neutral / agree / strongly agree

4. I feel that as I progressed through the trials I began to filter the information on the screen that I attended to.

Strongly disagree / disagree / neutral / agree / strongly agree

Comments:____

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If you would like a summary of results from this study when they are compiled please write your e-mail address below:

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The Use of the Janus Wargame simulation to Investigate Naturalistic Decision-Making: A Preliminary Examination

Taryn Chapman, Vanessa Mills, Monique Kardos, Christina Stothard and Douglas Williams

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19. ABSTRACT

The Janus wargame was assessed as a means of investigating naturalistic decision-making (NDM). A further aim was to establish the generality of previous research that uses non-military simulation. Participants were divided into hierarchically structured teams of 3 (one military team, and three civilian teams). Each team was tested using open and restricted communication architectures. In line with predictions, open communication was more effective than restricted communication. In addition, military personnel out-performed civilian participants. No linear or quadratic patterns were found regarding the development of expertise. It was concluded that Janus was an effective means of examining NDM. In addition, the data indicated that non-military simulation can generate valid data in relation to communication architectures, but not in relation to the development of military expertise.

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