Go*Team Experimentation Results: Research, Train and Sustain. Human Dimensions of NCW Sub-task Report

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ABSTRACT

This report discusses the use and usability of Go*Team, an online gaming environment based on the ancient strategy game Go, that embeds participants in situations where they must cooperate as a team to make strategic decisions based on shared information. Go*Team is designed to simulate situations in which people and groups coordinate, cooperate and share information to achieve organisational goals in the anticipated future network-centric environment. Over forty Go*Team game sessions were conducted with diverse groups of participants, most at the Activity Theory Usability Laboratory at the University of Wollongong, and the development of appropriate protocols for these sessions is discussed. Findings from the sessions are discussed in terms of shared situation awareness, team cooperation, team composition, work-place team building and the effect of increased tempo. It is proposed that Go*Team be used for further research into network-centric environments, training and sustaining teams.

RELEASE LIMITATION

Approved for public release

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Go*Team Experimentation Results: Research, Train and Sustain. Human Dimensions of NCW Sub-task Report

Executive Summary

This document reports on experimentation on Go*Team, an on-line microworld simulation, which takes an innovative gaming approach to the understanding and development of network-centric capability. The experimentation was conducted in the Activity Theory Usability Laboratory at the University of Wollongong, under a number of Research Agreements with DSTO. Go*Team, an online gaming environment, developed by DSTO, embeds participants in situations where they must cooperate as a team to make strategic decisions based on shared information.

The Go*Team sub-task is part of an overarching task designed to increase understanding of the human aspects of network centric environments, to develop a means of increasing network-centric capability in the Australian Defence Force, and to input into the development of the Human Dimension of NCW Model (see separate report). Concurrent task work and previous research had identified team attributes that were essential elements of the network-centric environment: self-directed teams; situational awareness; distributed leadership; conflict, cooperation and competition; shared understanding in communication; trust, collaboration and information sharing; performing under stress; an uncertain and unpredictable environment; local strategic decision-making; high tempo decision-making; and the role and consequence of ICT. Go*Team was developed to explore these constructs. The identified constructs were investigated through experimentation with the Go*Team game in 40 game sessions with diverse groups of participants

The findings are multifaceted and rich. For instance, it was observed that shared situational awareness partially contributes to performance but there is a complex mix of other factors that contribute to effective shared situational awareness, such as team size, composition, communication, experience and the absorptive capacity of information receivers. It is also apparent that teams benefit from developing a strategy both to share information and to coordinate making sensible moves as soon as time allows. It is evident from experimentation to date that, in addition to its use for research, Go*Team can be used for raising awareness of team dynamics and effective collaboration, training and profiling. The system is designed to provide experiences in which people confront the notion that each member of the team has a different awareness of any situation. Players must explore the strategic benefits of collaborating to use all the insight and information available. The game provides an opportunity for players, while embedded in an entertaining environment, to explore new strategies associated with working in teams. The game can also be used to identify people with certain attributes and to train people to further develop those attributes that will enable effective performance in a network-centric environment.

It is recommended that research with Go*Team is continued in partnership with the University of Wollongong, and DSTO begins discussions with the Commercialisation Unit of the University of Wollongong to facilitate this partnership.

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Contents

1. Introduction

This document reports on experimentation on Go*Team, an on-line microworld simulation, which has taken an innovative gaming approach to the understanding and development of network-centric capability. The experimentation was conducted in the Activity Theory Usability Laboratory at the University of Wollongong, under a number of Research Agreements with DSTO[1]. Go*Team, a gaming environment developed by DSTO, embeds participants in situations where they must cooperate as a team to make strategic decisions based on shared information. This work has been undertaken by the Human Dimension Concepts Team (HDCT) of the Joint Operations Division of DSTO as part of the CDE 07/031 Future Force Integration and Analysis Task[2] (and, before that, Task STR 06/117 Future Force Enablers: The Human Dimension). The other outcomes of these tasks have been reported on separately (See HDoFW, 2007; Ali et al, 2008; and Pascoe et al, 2008).

The aim of the overriding task was to increase understanding of the human aspects of network centric environments, to develop a means of increasing network-centric capability in the Australia Defence Force (ADF), and to input into the development of the Model of ADF Warfighters' Perceptions of the Human Dimension of NCW (see Pascoe et al, 2008). Concurrent task work and previous research had identified team attributes that were essential elements of the network-centric environment: self-directed teams; situational awareness; distributed leadership and power; conflict, cooperation and competition; shared understanding in communication; trust, collaboration and information sharing; performing under stress; an uncertain and unpredictable environment; local strategic decision-making; tempo in decision-making; and the role and consequence of ICT (see Annex A, HDoFW, 2007 and Pascoe et al, 2008, for more information). Go*Team was developed to explore these constructs.

The identified constructs were investigated through experimentation with the Go*Team game in sessions of team activity and team training for people working in a network-centric environment. This included the conduct of theoretical and applied research as well as the development of Go*Team protocols of use. The process used also demonstrates how Go*Team can potentially be used for research, for training, and for sustaining teams. The experimentation is the focus of this report; the technical implementation of the software has been reported on elsewhere.

This report:

- provides an overview of the background research and underpinning concepts for Go*Team in Section 2,
- provides information on the creation of Go*Team and details of its development and protocols of use in Section 3,
- describes the research conducted to date with Go*Team in Section 4,

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[1] DSTO has had rolling, annual research agreements with the University of Wollongong since January 1, 2006.
[2] Sub-Requirement CDE 07/0051 Human Dimensions of NCW

- presents outcomes of the research in Section 5,
- gives guidance as to the potential future of Go*Team in Section 6,
- gives a timeline for the research to date, in Appendix A.

2. Background

The Go*Team research builds on a body of knowledge on network-centric environments, teamwork, complexity and gaming from other tasks and research carried out by the extended HDCT team involved in the Go*Team project. Consistent with the overriding aim to understand the human and social aspects of a network-centric organisation, are the complex activities of team-based knowledge work in a rapidly changing world shaped by information and communications technologies (ICT).

Since 2003, the HDCT has examined the broad psycho-social issues that need to be considered so that the ADF can develop a Force able to fully exploit future technologies and future operating concepts. One component of this research involved conducting semi-structured interviews with personnel who had returned from deployment to the Middle East. Over 130 interviews, totalling about 200 hours, were conducted with interviewees drawn from all three Services, both genders, and ranks ranging from Private (and equivalents) to Brigadier (and equivalents). During the interviews, questions were asked about a range of issues including decision-making processes, interdependence between Services, nations (or other agencies), information gathering and sharing, communication flows and channels, important skills and competencies and lessons learnt.

This research, to date, strongly suggests that the way in which humans organise themselves, share information, work together and cooperate in a network-centric environment has much more than might be expected in common with the way they manage in less technologically sophisticated situations. The technology tends not, of itself, to lead to the creation of new relationships or links but rather is more important in supporting those that have been established through other means (HDoFW, 2007; Pascoe et al, 2008). It is the knowledge and understanding gained of the other party, and the trust created as a result of this type of interaction and relationship building, which forms the basis of successful working links between the different parties concerned. The Go*Team project aim is to develop protocols for developing this capability in Defence personnel working in cooperative team-based environments, particularly those that cross traditional service boundaries.

For more information on the lead-in work and other related tasks see Warne et al, 2004; Warne, 2006; HDoFW, 2007, Pascoe et al, 2008 and Ali et al, 2008. The link between the outcomes of this Interview Program and the Go*Team project is taken up in Section 3.1 of this report. In this section the relevant theoretical foundations from the literature are presented to lay the groundwork for the work presented in subsequent sections of the report.

2.1 Team Metrics

In order to describe current approaches to measuring team behaviour and performance, it is necessary to first identify the key underlying variables. There is a large amount of literature on measuring team performance, all with a slightly different emphasis. However, there are some useful compendiums available. One such resource is Shanahan et al (2007) which focuses on the subset of teamwork variables related to the behavioural, cognitive, and motivational dimensions underlying team performance that are supported by a substantial, systematic body of empirical research.

The research reviewed in the Shanahan et al (2007) report suggests that emergent states such as collective efficacy, cohesion, and trust are associated with team performance. The clear implication is that by including these variables in measurement approaches for teamwork research or team training, there is the potential for improving team outcomes. The measures provide a means of gauging the existing level of these variables in a particular team, and evaluating the efficacy of interventions geared at improving them. What is also clear is that the nature of the relationship between these emergent states and team performance is complex. They are most likely to act as moderators or mediators of team processes and inputs, but further research is required to clarify the exact mechanisms by which they have an effect.

Outcomes of the Go*Team project reported in Section 5, demonstrate that Go*Team sessions are suitable for this research. It may be noted that, while many quantitative measures are identified, qualitative approaches should also be included in a comprehensive study of the complexity of the human factors and team dynamics in network-centric configurations.

2.2 Network Centrism Implicit in Go*Team

The benefits of a networked organisational configuration in the commercial world were recognised in research reported in the early 2000s (see Huang et al, 2000, Sambamurthy, et al., 2003). The military picked up this technical focus in their adoption of the term Network-Centric Warfare (NCW). More generally, the network-centric paradigm allows organisations to change their culture from one determined solely by a command and control, rule-based hierarchy to one which supports more dispersed decision-making through the sharing of information and knowledge (Friel, 2002; Crawford et al, 2008).

In some of the early literature, the term 'network-centric' only referred to the connectivity achieved through technological networks, in particular the Internet and Web enabled applications. Mitchell et al (2004), reflect the early emphasis of NCW on control and automation as the solution to the increasing complexity of their sphere of operations. However, the connotations of network-centric environments continue to expand as ICT networks and applications are transforming the ways in which people gather, share, and process information and knowledge and, consequently, on the ways they make decisions to act. It is now accepted that effective network-centricity is essentially about knowledge, people and communities rather than the technology alone. While the technical component enables, the organisational and behavioural components generate added value (Pascoe & Ali, 2006; Warne, 2006).

A hybrid of a formal hierarchy and a more organic network, often supported by new social technologies, allows organisations to blend the advantages of networks in agility and adaptability with the clear chains of authority and accountability found in traditional hierarchies (Friel, 2002, Peltokorpi & Tsuyuki, 2006). The nodes of these networks are often semi-autonomous, self-directed teams with the agility and flexibility that is needed for an organisation to carry on operations as usual and also have the capability to respond appropriately to unanticipated, disruptive events. This arrangement can be designated as a more human focussed network-centric paradigm (Warne et al, 2004).

In such complex settings diversity and dissent are strengths (Billings & Watts, 2007) and this ensures that the scope of the decision making process is sufficient for the complexity of the context and that all participants actively evaluate the quality of the information and interaction available as they make shared decisions about operational outcomes. In contrast, formal decision making processes, conducted in a hierarchical organisation, are often badly informed by out of date or incomplete information in systems and cannot be made at a tempo that is fast enough for effective adaptation to rapid change. In rapidly changing situations requiring creative and speedy adaptation, informal leadership roles emerge according to the evolving demands of the situation. Leadership in networks is defined more holistically by the need to grasp the complexity and changing demands of dynamic situations, and to catalyse speedy, effective responses.

The Go*Team research takes a holistic approach to network-centric environments, recognising its essentially complex nature and attempting to retain the complexity, rather than reducing it. This is because concepts of network-centric team activity are situated in a context characterised by attributes of Complexity Theory such as change, self-organisation, non-linearity and emergence (Snowden, 2002). As will be explained in Section 2.4 this justifies the adoption of gaming as a research tool where the dynamics of multiple interrelated variables are retained in realistic game sessions following principles of complexity theory and experiential learning. Analysis and interpretation of the data from successive series of game sessions leads to a better understanding of contemporary socio-technical practices that are beginning to infiltrate network-centric environments.

2.3 Attributes of Self-directed Teamwork

The research discussed in previous sections determined that aspects of teamwork that are significant to the network-centric paradigm are many, varied and interconnected so that constructs are difficult to isolate, identify and evaluate. Valuable team-member elements include cooperation, trust, imagination, creativity, agility, flexibility and adaptability. Team elements include self-direction, collaborative behaviour, multi-mode communication, redundancy of resources, emergent roles, shared situation awareness, and variation in team composition. Among these constructs, many can be instantiated in the variables used in Go*Team sessions and these are discussed below.

2.3.1 Cooperative Behaviour in a Competitive Culture

In a network-centric arrangement it is necessary to foster a culture of cooperative behaviour in a competitive environment (i.e. 'co-opetition', as defined by Angehrn and Loebbecke (2004)).

In understanding how self-directed teams are enabled, supported and their value to the enterprise appreciated, the cooperation and sharing of information must be based on common goals, common identity and mutual trust; together with leadership that reflects these values. This is often counter to the existing organisational culture and some social learning (Warne et al 2003) is required before 'co-opetive' behaviour becomes accepted and adopted. In the gaming environment, elements of fun and community come naturally. For many people, particularly the young, this is an integral part of their non-work life. As in their social lives, there is a growing need for individuals to learn to cooperate in self-directed, distributed teams at work where communication and shared understanding leads to innovative decisions and actions (Daft & Lewin, 1993).

2.3.2 Shared Situational Awareness

Situational Awareness (SA) is "the perception of the elements in the environment within a volume of time and space, the comprehension of their meaning and the projection of the status in the near future" (Endsley et al, 2003 p 13). It has also been defined as the "continuous extraction of environmental information, integration of this information with previous knowledge to form a coherent mental picture in directing further perception and anticipating future events" (Vidulich et al, 1994 p 11). Endsley (1995) further describes SA as dynamic and affected by attention and workload stress.

In order for a team to engage successfully in collective activity there must be transfers of information and knowledge among members. The resultant understanding underpins ongoing collective sense-making, leading to appropriate and creative actions for organisational outcomes. With the increasing use of teams and virtual teams, the focus has shifted from the individual to the team. According to Endsley (Endsley et al, 2003 p. 197) shared situational awareness (SSA) is defined as the degree to which team members have the same SA on shared SA requirements, although rarely would a team require exactly the same SA in all members.

Endsley (1995) defined SA, and implicitly shared situational awareness (SSA), as having three levels: Level 1, perception of elements, which requires information sharing among team members supported by a physical tool. Level 2, comprehension of the current situation, which requires knowledge sharing through co-created mental models of the state of play so that knowledge is understood as 'information made actionable'. Level 3, projection of future status, which takes knowledge into the realm of the 'big-picture' with understanding, insight and wisdom needed. Baber et al (2006) define SSA as a systems level perspective of a situation that can be determined through the input of relevant information and the words and behaviour of team members. Both interpretations of SSA are translated into the design of the Go*Team game. Team members share information during the game to support collective knowledge for each decision and action leading to the evolution of cooperative purpose and strategic understanding.

2.3.3 Diversity in Team Composition

According to the principle of *requisite variety* proposed by Ashby (1957) the internal diversity of any self-regulating system, such as a self-organising team, must match the variety and

complexity of its environment if it is to deal with the challenges posed by that environment. Diversity of knowledge and skill can provide a resource for innovation and learning (Jehn, 1998). If the systems which regulate don't have enough (or requisite) variety to match the complexity of the regulated, then regulation will fail and the system will be out of control. If a team is heterogeneous, or complex, it is likely to have plenty of variety; if it is simple (homogeneous) the variety is usually low and it will struggle to perform a complex task in a complex environment (Hasan, 2006).

Individual characteristics of team members that contribute to its diversity include age, gender, ethnicity and job or profession. In several Go*Team sessions standard tests[3] of personality and team skills were used to diversify teams, as well as generational categories (X, Y etc).

2.3.4 Multi-mode Communication

There has been much written on the effects of media richness on communication in virtual communities (e.g. Billings & Watts, 2007) that is now becoming dated as digital devices become a ubiquitous part of our lives. Kansawattanachai and Yoo (2005) confirm that teams in today's organisations are increasingly virtual with regular communication via computer-mediated tools. Their paper provides a summary of a decade of literature on virtual team attributes of trust, leadership, group composition, appropriation of communications technologies. One of the interesting dimensions in their study of teams of MBA students shows how task-knowledge coordination is initially vital but gives way to cognition-based trust in time. The study of Douglas et al (2006) demonstrated how multiple forms of team communication had a significant effect on team participation and acceptance of the transformation from a bureaucratic management system to a network-centric model of self-directed work teams. They showed the value of what they termed 'soft influence tactics' against command and control approaches.

2.4   Games as Experiential Learning Tools

There is no universally accepted way to best prepare people to operate in loosely coupled networks of self-directed teams. Most staff training programs are structured in a way that reinforces the existing hierarchic command-and-control paradigm. In contrast, the gaming, context is a natural environment for allowing staff to explore the less structured and less formal network-centric world.

Although academics have for some time proposed the idea of using gaming for workplace training, managers have tended to shy away from gaming on the basis that it is a waste of time to play games at work (Lewis, 2007). Speaking from experience, Lewis avoids the G-word and uses the word 'simulation' instead. Recently the term 'serious games' has emerged which seems more acceptable to serious organisations.

There is, however, general acceptance that gaming, whatever it is called, is cost effective and leads to successful learning outcomes. Turoff et al (2006) have done extensive research with a serious game employing competing human teams as a way to develop high confidence

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[3] IPIP-NEO (International Personality Item Pool Representation of the NEO PI-R™) was the standard test used.

emergency plans within an organisation. Corti (2006) described how game-based learning leverages the power of computer games to captivate and engage users to develop new knowledge and skills. Participants are enticed into training with an appealing simulated environment and a challenging but fun activity that would otherwise be costly, risky or impossible.

The Go*Team gaming environment and activity has both an engaging and challenging quality while simulating the serious, distributed decision making of the network-centric paradigm. As noted by Ryu et al, (2005) such activity provides learning by doing and can be extremely effective when done well. The outcomes of this project are confirming the value of a product such as Go*Team, whether serious game or simulation, for research into network-centrism and for training in network-centric capability.

3. Go*Team Creation, Development and Protocols of Use

3.1 Research Origins and Motivation

In order to further investigate the observations and findings from the Middle East Area of Operations Interview Program in more depth, a parallel activity of the research mentioned above was the development of the simulation game. The team agreed that such a gaming environment could create a micro-environment that simulates aspects of network-centric environments that appear to have particular relevance to human and group functioning in this kind of environment.

The basic idea was to build an online team version of the ancient Chinese board game, Go, which has been popular as a strategy game for centuries and so has stood the test of time as to its popularity and enduring challenge to players. Its suitability for research lies in this appeal, while at the same time, the basic rules are quite simple to learn. This led to the creation of Go*Team, a computerised client-server team version of Go: as a team version of Go. Go*Team could encapsulate not only strategic decision-making but also simulate various human aspects of network-centric phenomena such as information sharing, communication, shared situation awareness, and cooperative behaviour.

Go*Team is implemented as a multiplayer networked computer game (see Jagiello et al, 2006). This task was facilitated by use of a Simulation Framework designed for setting up distributed simulations of real-time robotic applications (Jagiello & Eronen, 2007a). The simulation framework provides a component architecture for implementing game rules, game entities and their sensors. It also provides time step scheduling and networking. Distributed simulators are tools that are often used to examine the conditions of complex systems. For an effective simulation, models must be found that accurately represent the states and transitions of the complex system. Simulation models of complex systems can be implemented as custom applications dedicated to a particular domain with dedicated GUIs and support tools. Alternatively, the same effect can be achieved by building a generic simulation framework

and then implementing the simulation model as a specific instance of that framework. The purpose of a simulation framework is to provide a basic infrastructure for development of simulation experiments (Gottlieb et al, 2001).

The exceptional quality of Go*Team is that it succeeds in placing its players in an environment exhibiting features of the network-centric paradigm in order to explore how the players function in that environment (Hart et al, 2006). The game embeds its players in an environment that involves conflict, cooperation and coordination, but also competition. Other components include uncertainty, complexity and the need for effective information sharing for timely and appropriate decision making. It thus provides an ideal tool for the research team to meet the aims and objectives of the research.

The original motivation for developing Go*Team to study characteristics of the network-centric paradigm has been published by Hart et al, (2006) while further analysis of the alignment of Go*Team attributes with network-centric concepts, as identified by the research team (summarised in Table 1, in Section 3.3), has been described by Hasan et al (2006) and Warne et al (2006). The technical makeup of the Go*Team application is described by Jagiello et al (2006), Jagiello & Eronen (2007a,b).

3.2 Elements of the Game

3.2.1 Go

In its standard form, Go is played by two opposing individual players with black and white stones on a board with, at least, a 9x9, but up to a 19x19, grid where the players take turns to place their stones (see AGA, 2005). The two players each have a collection of 'stones' (181 for black and 180 for white for a 19x19 sized board), each of which may be placed on an intersection of two of the lines on the board. Stones once played cannot be moved or removed unless they are surrounded by the opponent's stones in which case they are captured and removed. The fundamental aim of the game is to encompass as much territory on the board as possible, which essentially involves not only capturing 'virgin' territory but also trying to surround opposition stones in order to capture them and thereby gain the territory they previously held. While the rules of Go are simple, to play the game well requires a degree of sophistication and subtlety. The basic rules are:

- each player takes it in turns to place a stone on the board;
- a stone may only be placed on an unoccupied intersection;
- a stone, once placed, cannot be moved or withdrawn from the board, unless captured;
- a stone may not be placed in such a way as to 'commit suicide' – that is, so that it and any of its companions become surrounded and therefore captured;
- the winner of the game is decided by which player at the end has the larger total of surrounded unoccupied intersections on the board plus captured opposition stones; and
- the end of the game is decided by mutual agreement of the players or, less commonly, when all the stones have been placed.

3.2.2 Go*Team

Go*Team is a computerised client-server team version of the original game of Go. Unlike standard Go, opponents in Go*Team are teams which can be homogeneous or heterogeneous based on skills, personality types or any other criteria. They can be chosen to have complementary or conflicting skills. They may have already worked together as a team, could have just been introduced or could be assigned to a client machine not knowing who their team-mates are. The composition of teams can thus be varied considerably as can the pre-game training of individuals and teams. There is also no preset command structure built into the Go*Team game. As far as the game software is concerned all team members are peers with no predetermined roles and there is no 'team leader' with more power or capabilities than other team members.

Unlike standard Go, teams playing Go*Team no longer have to take turns; a team's next turn can be taken after a "relaxation time", specified via the server, regardless of whether or not the opposing team has done anything in the interim. During the relaxation time no play is possible for either team, so that members are forced to take time to communicate, sending information on stone locations and discussing future plays. The relaxation time can be set to any value, can differ between teams and can be varied at any time during the game. This may, for example, increase boredom if lengthened or increase stress levels if shortened to a point where a sudden large reduction would constitute an extreme event.

A critical feature of Go*Team is that individual players in a team have only a local view on their computer screen of the overall Go*Team "world" in which they are embedded. The client screens for each player (i.e. team member) show only a partial view of the board (see the different stones on the two screens of Figure 1). Each player sees only the stones he or she plays and those of the opposition team closest to them. This modification is to introduce the problem of information sharing and integration into the game.

Players on the same team make use of communication tools such as email, voice over IP, Chat rooms and the like, to effect the cooperation and coordination they need to successfully play the game, to discuss moves and strategies as well as to communicate their view of the board to others for shared situation awareness. Not only is it necessary for information to be shared but players must also have the capacity to absorb it.

To augment the absorptive capacity of players in developing an integrated overall picture of the state of the board, each player has the ability to place various types of 'markers' on their local view of the Go*Team board. They can select from a number of shapes, colours or letters to mark information on their board. They can use these markers to record information received from team members on where stones belonging to the other members of their own team as well as those of the opposition are (see Figure 1). Even if teams can accurately achieve completely accurate shared situation awareness in the time available, they then have to decide not only what the next best move is, but also who makes it.

Figure 1.   The boards of two players on the Black team (the same game as the server screen seen in Figure 2) showing different sets of stones visible to each player and positions of non-visible stones marked (the small letters are the markers) from information sent by other team members.

There are a considerable number of variables and factors that can be determined, set, changed and/or measured when playing Go*Team for the purpose of research. Some of these can be set before or during the course of the game (e.g. the size of the board, team composition, relaxation time). Factors can be introduced during the game to simulate hostile external events such as a breakdown in communications or distraction of some players. Some variables (e.g. stones played and captured, situation awareness, messages sent etc) are recorded and the results analysed and interpreted. Unlike traditional Go, there may be many opposing teams and multiple boards, although games to date have been with two teams on one board. Team members can be allocated different numbers of stones each making up the standard issue to each team. The mode of communication between team members can also be varied from verbal, to online Chat, to video, or a combination of these.
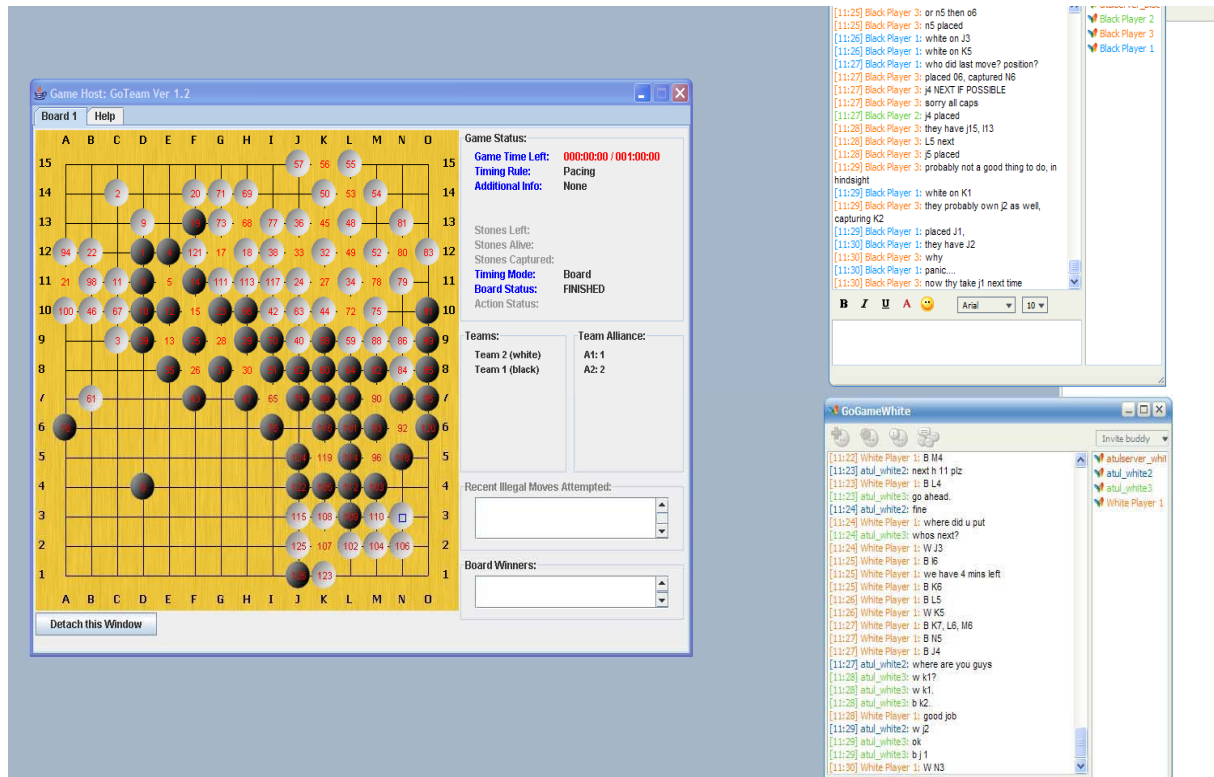
Figure 2   A still of the server screen video captured showing the whole board and the Chat of the two teams during a trial game.

3.3 Network-Centric Elements and Go*Team Parameters

Once a working version of the Go*Team game was developed, the research team held a series of meetings to determine what research could be undertaken with this tool and how to proceed with the conduct of this research. From the brainstorming sessions of the group, a specific set of network-centric elements were identified to be investigated with Go*Team. These elements transpired from earlier research on NCW (Warne et al, 2004; HDoFW, 2007). Some of the broad candidate constructs are listed in Table 1.

*Table 1   Broad Network-Centric Constructs to be researched using Go*Team*

Self-directed teams
Situational Awareness
Distributed leadership and power
Conflict, Cooperation and Competition
Shared Understanding in communication
Trust, Collaboration and Information Sharing
Performing under stress
An uncertain and unpredictable environment
Local strategic decision-making
Tempo in Decision-Making
The role and consequence of ICT

Table 2 summarises the alignment of network-centric constructs with Go*Team elements that have evolved through the experience of conducting research session with Go*Team. Such mapping is difficult where the variables are not inherently quantitative or where a combination of variables may be involved in a given construct or where the alignment needs further investigation. On the other hand, there are obvious alignments such as training behaviour and team composition or alignments that can be implied. For example, tempo and stress can be implied from Go*Team timing while stones captured can be an indication of effective decision-making. Such quantitative measures are convenient but need to be calibrated through a number of Go*Team sessions. Other constructs are inherently qualitative and need to be determined through reported perceptions and interpretation of the play, messages and discussion.

*Table 2   Suggested alignments of network-centric constructs with Go*Team elements*

Network-centric constructs	Go*Team Session Setting	Variables/Measures
Shared Situation Awareness	Built into the game as individual players only see some of the stones played	Correctness of markers of non-visible stones (see Figure 1), Subjective confusion levels
Information sharing	Built into the game as individual players only see some of the stones played	Number and content of messages between team members
Effective decision-making	Progress on the game as stones are played	Stones played, territory covered and opposition stones captured
Learning	Over single session, between a series of sessions	Pre-briefs and de-brief interviews
Player characteristics	Age, gender, personality, etc	Demographic data, other tests
Team composition	Allocation of players to teams	Homogeneous / heterogeneous, previous experience together, size of teams
Group dynamics, Cooperative /competitive behaviour	Messages between players, de-brief	Text content of messages and de-brief
Team roles, leadership	Pre-determined or emergent	Number of plays and messages per player
Communication Quality	Messages record during game	Number and Text Content of messages
Communication Mode	Verbal (face to face, phone), text (email, chat)	Richness of media, player familiarity of mode
Stress	Game motivation, play timing, unexpected events during play	Reward for players, vary relaxation time, size of board, game time
Training	Go Tactics, computer skills in playing Go*Team, skills in communication	Pre-game instruction, experience

When running Go*Team simulation sessions it is possible to set the values, both quantitative and qualitative, of the following independent variables: time of game, size of the board, relaxation time, size of team, composition of team, characteristics of individual players on

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teams, motivation: (for individuals and teams), means of communication, previous experience with Go*Team (or Go itself) and training. Dependent variables include: number of stones played, number of stones captured by teams and individuals, number and content of messages sent, if correct markers were placed, learning, changes in individual behaviour, changes in group behaviour.

Correctness of non-visible, stone position marking gave an objective measure of situation awareness of each individual player and the 'confusion levels' estimated every five minutes were a subjective indication of situation awareness, viewed as an intermediate variable.

In respect of independent variables, Go*Team timings, board and team sizes can be used to alter the complexity and stress of the game environment. Team composition could be varied along many dimensions of the individual players: age, gender, experience and so. Standard personality and team skills tests were conducted on players in some games to see if these attributes had a role to play. Values of these variables can be assessed from three perspectives:

- changes during the ebb and flow of the game,
- overall comparisons for each game, and
- changes between games of a series which represent learning.

It was found that a substantial number of constructs would be active in any one session, so it proved to be a daunting task to find and verify meaningful measures for the constructs and establish a way for the collected data to be analysed. The research group was also aware that network-centric characteristics can not be understood or developed in isolation but that an integrated, balanced approach would be more appropriate. Feedback from players participating in Go*Team sessions suggests that the complexity of the Go*Team world reflects that of a real network-centric environment so that a research approach that allowed findings to emerge through experience would sit comfortably in the same complex space.

It was decided that an evolutionary regime of sessions using Go*Team would be conducted through which to gain a better understanding of how it simulates the network-centric environment for research purposes. These sessions would allow the gradual evolution of suitable protocols of play with sets of meaningful variables that could be recorded in the sessions and later analysed. The following section describes appropriate session protocols (pre-brief, game directions, de-brief etc) for the evolving research process.

3.4 Game Session Protocols

Suitable protocols for running Go*Team sessions have emerged through the experience and the analysis of data collected from a number of initial trials held in 2006. The planning for each session or related series of sessions begins with a determination of its research purpose. Detailed objectives are then set in accord with this purpose and these objectives guide session planning, team formation, as well as appropriate settings of systems parameters, team composition and communications media. Each session begins with a brief (referred to as a pre-brief) of players, game instructions for new participants and often a short face-to-face meeting of teams. This is followed by the playing of the game and then a de-briefing activity. All parts of the sessions are recorded using a facility to capture, on video, the server screen

(see screen dump in Figure 2), all oral and Chat communication as well as discussion at the de-briefing.

In several cases, a series of three or four sessions were conducted a few days apart with the same teams. In each session, or series of sessions, selected groups of players were invited to participate and assigned to teams in accordance with the session objectives. Board sizes were varied, going to the maximum 19x19 as players became competent. Relaxation times were varied between and during games as a means of imposing stress on team participants. Demographic details of players were collected and players were given tests for personality traits and team role tendencies. All settings, player and team characteristics were viewed as independent variables for the sake of analysis. Performance was taken as the dependent variables and so players were made aware that their goals were both to perform well at the game (i.e. capture territory and stones) and to perform well as a team. The natural competitive spirit of gaming was enough to motivate players towards these goals so that no extrinsic rewards were needed.

Most sessions involved two teams of three or four each using online Chat for communication and game times around one hour. All players were trained to a level of proficient play where they were familiar with the rules and objectives of the game but were not experts. They did, however, vary in their computer skills and their level of comfort in using Chat to communicate.

The configuration for the Go*Team session uses one computer set up as the server. This provides several options for recording data during game sessions, principally screen video and audio capture by the Camtasia©[4] program. Six to ten other computers are set up as clients in ways such that players can not see each other's screens and teams can communicate via Chat rooms or, on some occasions, members can talk to each other.

As with all gaming systems the collection of qualitative data is relatively easy although its analysis and interpretation can be much more difficult due to the quantity and variety of data types. All possible quantitative elements during games were recorded against game time, for example: who played which stone where, messages sent by each play, correct and incorrect marking of stone positions by each player, and a subjective assessment of 'confusion level' rated out of ten by each player every five minutes during the game. The discussions during the pre-brief and de-brief, and the team Chat during the games were collected as text and the analysis was qualitative.

Whenever a series of games was played with the same teams, elements of between–game learning could be studied by the research team. Of particular interest were changes in performance related to learnt cooperative team behaviour. To assist in the learning process, teams view the recording on the server after each game where they see the overall picture and reflect on how the game was played. Before subsequent games, short face-to-face team meetings were allowed to develop tactics and strategies for play and communication. De-briefing after each session included discussion on players perceptions on their learning both on playing the Go*Team game and on their role in directing the team.

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[4] Camtasia is a screen video capture program for Microsoft Windows, published by TechSmith

4. Go*Team Sessions

This section of the report presents an account of over 40 completed Go*Team sessions. These fall into three phases as follows:

- Phase 1: A set of single-session studies to explore Go*Team, through experience; to prioritise protocols and constructs listed above in respect of Go*Team capability; and to determine how Go*Team could be used most effectively in subsequent trials.

- Phase 2: Based on the findings of Phase 1, several series of Go*Team each of 3-5 sessions were planned to simulate and investigate high priority constructs concerned with the social aspects of the network-centric paradigm. Two of these series will be described in some detail as examples of empirical research with Go*Team.

- Phase 3: An ongoing set of sessions to expand the range of viable Go*Team session configurations and applications. Phase 3 is continuing.

4.1 Phase 1: Early Exploratory Games

As stated above, a series of initial trials were held in 2006 to explore appropriate ranges for game settings and the alignments between network-centric concepts and Go*Team session variables. Research with Go*Team from this Phase, aimed at developing and refining these constructs, as well as firming up the design of Go*Team sessions. A summary of the findings of these game sessions is as follows.

With respect to game settings, the initial games showed large divergence in the efficiency of face-to face verbal communication compared with online media such as Chat rooms. This accords with the established literature on media richness. It was decided to use online Chat for all team communication in Phase 2 as it was likely that nothing new would be learnt through investigating differences in communication mode and varying it would mask variations in some of the other team constructs that were of more interest.

In addition, there was a considerable change in performance between 'teams' with sizes of one and two, where communication was not needed (one player) or was one-to-one (two players), and thus relatively straightforward, compared with teams of more than two. So, as team size difference could mask more subtle differences in other variables, all subsequent games used teams of three or more. Suitable game parameters were :

- game time 30 minutes to 1 hour;

- board-sizes 15x15 to 19x19;

- training for proficiency with some instruction in game modes, rules, and tactics, followed by one 10-minute trial game;

- relaxation/pacing time around 40 sec. This gave time for basic information to be communicated using online Chat, although this varied with the familiarity of the player

with online Chat and the seriousness of the game when a longer time was preferred. Shorter times were used to increase stress in the game.

```
Black :

    [10:25] B 1: black K12
    [10:26] B 3: white at I11
    [10:26] B 2: placed r16
    [10:26] B 3: and J12 and H12
    [10:26] B 1: go P17
    [10:26] B 3: placed P17
    [10:26] B 3: we also need Q17
    [10:27] B 1: go for it
    [10:27] B 2: placed r17
```

```
White:
    [10:43] W 1: hi
    [10:43] W 2: w q12
    [10:43] W 3: hi, were have you been?
    [10:43] W 2: we get 2
    [10:43] W 3: good
    [10:43] W 1: WE die 4
    [10:44] W 1: Man, we lack of communication
    [10:44] W 2: b m9
    [10:45] W 3: you were not here! we didn't get any
    message from you! come on, play
    [10:45] W 1: we lost f14, g14, e13,f13,e12
```

Figure 3   Examples of the Chat from two teams during play show a very factual efficient style in the black team and a more verbose, social Chat of the white team.

Results from these early games confirmed alignments between some network-centric constructs and Go*Team session variables. In these games two dependent variables were adopted: (a) game performance, as a quality measure of decision-making, and (b) the calibre of each group as a team. A mix of number of stones played, territory covered and stones captured was used as the indicator of successful team game performance. A subjective assessment was made of the calibre of the team from during-game messages and discussion in the post game de-brief. Patterns of messages during play give a picture of team communication. Figure 3 shows an example of Chat message during play. Figure 4 shows an example of the de-brief recorded with Zing©[5] groupware technology: an engaging tool for group discussion that uses wireless keyboards, laptop and a data projector to collect and store the views of all participants.

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[5] See Zing Technologies Pty Ltd at http://www.anyzing.com/

How competitive did you feel once you got playing?	
W 1:	much more competitive then before
B 2:	similar to last time
B 1:	opponent become more fierce than last time
W 3:	less then last time, but i had more control over myself this time
B 3:	Probably a little more competitive as I was getting frustrated at the lack of communication regarding stones placed.
W 2:	really it was the most competitive that i hd felt in all games
How well did your team cooperate and coordinate?	
B 2:	not as well as last week - less advic was given
W 1:	not very good, not as good as last time
W 3:	it was really hard to talk in this short time
W 2:	it is harder to communicate well with the short time
B 1:	I feel the effeciency of communication is bad, and a lot of misunderstanding
B 3:	Not as well as last time. It felt like the last move wasn't communicated quicly enough and that led to stoned being placed without the info required.

Figure 4   An example of comments in a de-brief using the groupware system.

During the games of Phase 1 quantitative variables were processed manually by research assistants. This was a slow laborious process which was also error prone. Data collected this way included:

- viewing the video recording of the server screen to see which stones were played and captured over time.

- stills of the screens of each player showing which stones each player played, where they placed markers for stones not visible on their screen and if these were correct.

- records of the Chat messages of each team to see who sent messages at what time.

In order to visualise the ebb and flow of the game this data was plotted against time as shown in Figure 5. This graph depicts at each time during the game which players are active in playing, correctly marking stone positions, and sending messages as well as their subjective estimate of how confused they are. This gives a context for the qualitative analysis of the content of the communication between team members at each stage of the game.

A request was made of the software development team to include a mechanism within the game to log data automatically. This was finished towards the end of Phase 2 of the game and has speeded up the data analysis of the more recent sessions of Phase 3.
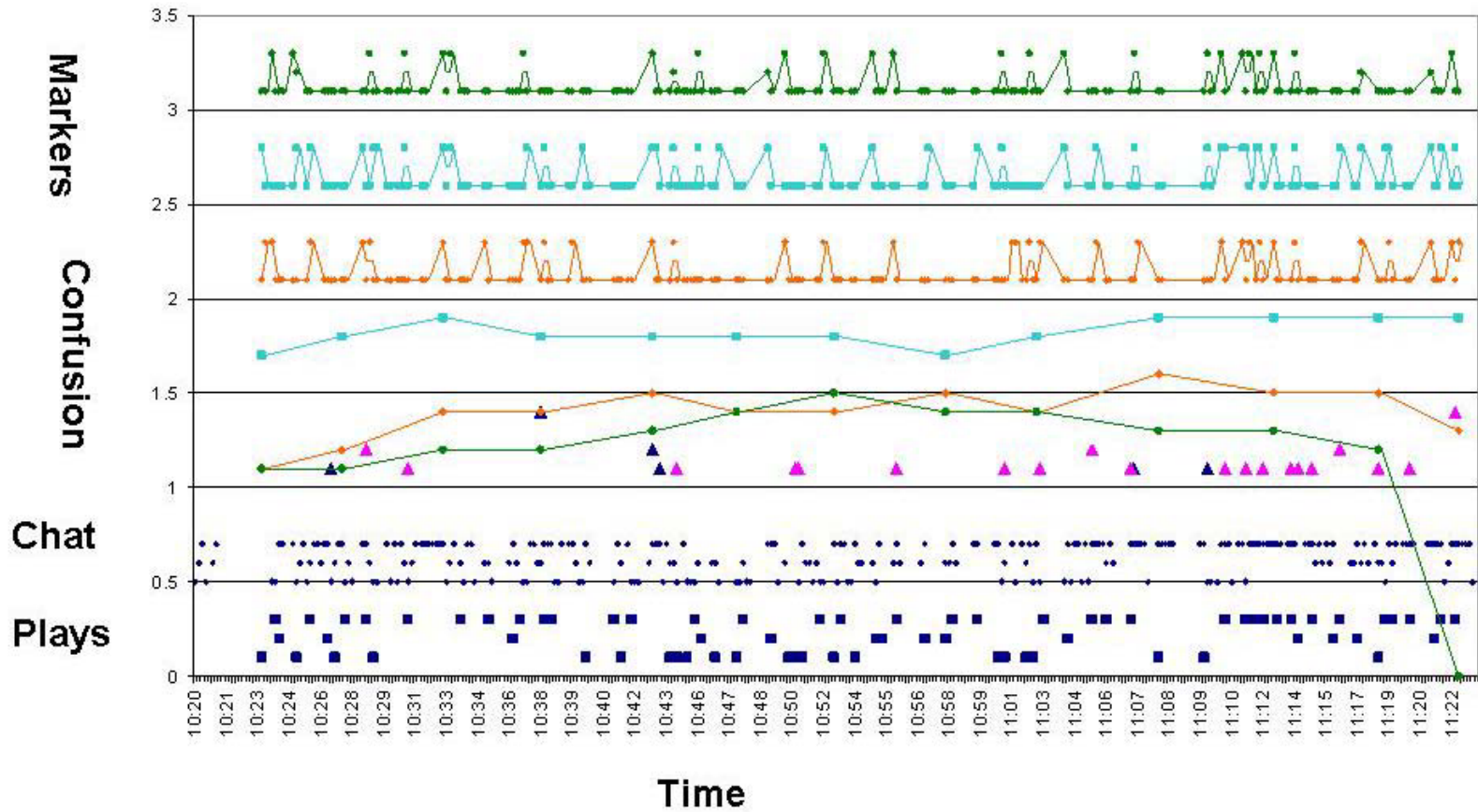
Figure 5   This shows an example of the graph of data against play-time from one black team of three players. For the Markers and Confusion levels brown is player 1, aqua is player 2 and dark green is player 3. For markers, the higher values for each player are incorrect annotations, the baseline shows stones correctly marked. Blue triangles are black stones captured; pink triangles the opposition, white, stones captured. For Plays and Chat messages, player 1 is the lowest then 2 and highest is player 3. From visual inspection, player 3, the emergent leader, as later acknowledged by his team members, sends more messages and places stones more regularly than team-mates.

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4.2 Phase 2: A Planned Series of Games to Study Specific Team Constructs

Using the findings on suitable game settings and constructs from Phase 1, several series of sessions were played, each set between the same teams. Each series aimed to study particular team attributes. The series of games also allowed for the investigation of team learning from one session to the next. Two of these series are described in this section, one aimed at studying the connection between cooperative behaviour and shared situation awareness, and the other at studying the effect of team diversity on performance and learning.

The screen on the Server, showing both the Server view of the Go*Team board in play and all team Chat windows, was recorded for each game as a video. At the end of the game, the Chat of each team for that session was saved into a text file and the final board set up on each of the client screens was recorded as a screen dump. This determined which stone was *played by which player as well as providing a record of their set of markers.* The researchers replayed the video and entered, into a spreadsheet, all stone plays, communication messages and marker placements for each player. The plays, messages and marker values were summed and averaged for the whole game for each player and for each team.

4.2.1 Games for Shared Situation Awareness and Team Cooperation

Given the complexity and multiple constructs that were involved, the research team decided that the objective of the first set of Go*Team sessions to be conducted for the military would focus on issues of situational awareness and cooperative behaviour. The results reported here come from a set of five Go*Team game sessions played with essentially the same two teams of university staff and students. The settings for each game are listed in Table 3. As these sessions were aimed at exploring the potential of Go*Team, players were chosen on availability and reliability rather than representing any particular cohort. No player had any particular Go expertise. Other details of the players are shown in Table 4 with a selection of personality attributes in Table 6.

*Table 3   Dates and Settings of 5 Go*Team Sessions*

Game	Aug-24	Aug-31	Sep-07	Sep-14	Sep-21
Board Size	15x15	15x15	19x19	19x19	19x19
Relax Time	50	50	40	30	40

Table 4   The Players

B-1	Black Player 1 all games	Male – PG student
B-2	Black Player 2 all games	Male – staff - oldest
B-3	Black Player 3 all games	Male– PG student
W-1	White Player 1 all games	Male – PG student
W-2	White Player 2 all games	Female- PG student
W-3	White Player 3 games 1& 5	Male- PG student
W-4	White Player 3 games 2-5	Male- PG student

These Go*Team sessions were conducted in a Usability Laboratory. Players were isolated from one another in different rooms. Sessions were conducted a week apart to give the

researchers time to collect all data from each session and analyse it to determine the settings for each subsequent session.

Table 5 Summary of results from 5 games

Game		1	2	3	4	5
White chat (number of messages)	All	223	143	176	162	345
	W1	80	88	85	44	80
	W2	52	53	47	66	49
	W3		2	45	52	91
	W 4	92				125
Black chat (number of messages)	All	362	333	332	291	251
	B1	88	100	100	76	64
	B2	70	95	49	88	57
	B3	205	139	184	127	130
White plays	All	58	62	78	106	58
(stones played)	1	20	3	22	17	18
	2	23	33	17	51	10
	3		7	7	18	11
	4	7				18
Black plays	All	54	60	75	105	74
(stones played)	1	16	11	23	18	24
	2	8	20	11	20	14
	3	20	20	32	38	36
White confusion (average) (10 = very confused)		4.77	4.54	4.59	4.743	4.54
	1	5.69	5.39	4.54	3.38	3.31
	2	3.38	2.31	3	4.54	5.31
	3		5.92	6.23	6.31	5.69
	4	5.23				3.85
Black confusion (average) (10 = very confused)		5.15	5.23	3.87	4.95	4.95
	1	5.23	5	2.23	4.23	4
	2	7.38	6.69	7.62	8.15	8.23
	3	2.85	4	1.77	2.46	2.62
Winning Team Points		W 73	B 161	B 119	W 120	B 110
White captured		9	19	23	17	26
Black captured		10	9	5	21	10

The recorded quantitative data from the series of five games using the same set of players is summarised in Table 5, which shows the total number of Chat messages sent and total number of stones played by each team and player. Confusion levels, rated by each player, every five minutes during the game, on a scale of 1 to 10, are averaged over each game and are also shown. The game performance measures are in the last three rows at the bottom of the table. This is shown as both a winning team's points score (rated by the software as territory captured) and the number of stones captured by each team. This summary was used as

background for the analysis of the qualitative data. A de-brief session was held to collect subjective data on the games.

This set of five games provides some indication of how the teams under different levels of pressure responded to unexpected events such as a breakdown in communication. The evolution of the Black team also illustrates the strategic importance of emergent leadership within teams. Key events and aspects over the five games are summarised below:

- Game 1 both teams had 3 players, all were Go novices. There was a lengthy 50 second relaxation time on a 15x15 board. Players were on a learning curve, Chat of both teams was about the mechanics and aim of the game, giving neither team a distinct advantage, although player B3 was starting to give direction to his team.

- Game 2 had the same players and settings as Game 1, except that W4 replaced W3 on the White team. The Black team had more efficient Chat and were more task-oriented during play. An examination of the team Chat indicated the emergence of B3 as leader.

- Game 3 had the same players as Game 2 but had a reduced (40 second) relaxation time and a larger board. The White team lost communication with W3 for a while and this hampered their efforts becoming the main point in their de-briefing. The Black team became more strategic in their Chat led, by B3, and performed well.

- Game 4 had the same players as Game 3 but play was reduced to a 30 second relaxation time on a 19x19 board. Several players reported an increase in stress and reduced quality of communication. This produced a more level playing field but more aggression and frustration of players, as seen in the Chat.

- Game 5 the White team had all 4 players and the relaxation time went back to 40 seconds on a 19x19 board, which players liked. The Black team communicated well and co-ordinated with confidence, while White players commented that the extra team-members reduced the effectiveness of communication.

It was observed that over this series of 5 games, the more stable Black team exhibited the most learning and development, while the White team did not develop to the same extent and did not perform as well. The White team suffered from a technical breakdown in communication in Games 2 and 3, of which they were not always aware and did not correct. They also had a change of player between games 1 and 2 and all 4 players in game 4. Despite this, they did function cooperatively, doing best in comparison with the other team when under time pressure in game 4.

The IPIP Short Form for the IPIP-NEO (International Personality Item Pool Representation of the NEO PI-R™) was used to test personality traits of participants (see http://www.personal.psu.edu/j5j/IPIP/ipipneo120.htm) and some of these scores relevant to the discussion on emergent leadership, are listed in Table 6.

Table 6 Scores on some personality attributes (IPIP-NEO)

	B-1	B-2	B-3	W-1	W-2	W-3	W-4
EXTRAVERSION	12	52	36	47	60	31	61
Assertiveness	44	40	33	55	37	73	25
Excitement-Seeking	10	51	77	54	22	26	46
AGREEABLENESS	38	75	58	20	6	60	73
Trust	70	83	47	47	76	70	92
Cooperation	54	53	66	10	9	63	44
CONSCIENTIOUSNESS	61	57	6	43	48	20	38
Achievement-Striving	4	78	5	59	48	35	48
NEUROTICISM	37	34	48	63	43	71	35
OPENNESS TO EXPERIENCE	37	75	60	45	40	29	80
INTELLECT	48	56	71	34	67	18	59

Some observations on emergent behaviour from these games were as follows:

- Emergent leadership in the Black Team: B3 the youngest player, had personality attributes shown in Table 6 that were highly adventurous and cooperative and the highest intellect. Both B1 and B2 had personalities with high levels of trust which may have supported B3's emergence as leader, even though B2 was considerably older.

- Emergent cooperative behaviour: Although the de-brief showed that the teams became more competitive as they became more experienced players, cooperative behaviour was observed in both teams but both suffered under stress in Game 4.

- Effective decision-making: As indicated by game performance, this was evident under stable conditions although this deteriorated under adverse conditions – in the stable Black team under time pressure in game 4 and in the White team in games 2, 3 and 5.

Some of the observed merits of Go*Team are that it makes the need to cooperate apparent and provides support to do so while retaining elements of competition normally found in a gaming environment. It also quickly raises participants to a level of competence so that lack of expertise is not a major issue. This could be different if experienced Go players had participated. Furthermore, it incorporates a need for tactics and strategy and, in simulating a valid team experience, allows team roles to emerge rather than be mandated. This supports the use of Go*Team as a tool for research into complex team behaviour as emergence is a key feature of Complexity Theory.

As far as shared situation awareness is concerned, the mode of communication is critical and these issues can be studied using the relatively poor medium of the Chat room where even a change of team size from 3 to 4 places an extra burden of complexity on team coordination. In addition, the imposition of the relaxation time allows teams to exchange information at all three of Endsley's (Endsley 1995) situational awareness levels, although the higher levels (comprehension and projection) tend to degrade under stress as shown in game 4.

4.2.2 Game Sessions to Study Team Composition

One series of three Go*Team sessions had the purpose of comparing the performance and development of a homogeneous team with one that was heterogeneous in order to add to the understanding of the challenging issue of how diversity within teams can be leveraged to advantage. Three Go*Team sessions were held in three successive weeks with the same two teams, each of three players. Sessions were arranged and recorded as described above with online Chat used for within-team communication. The maximum board size 19x19 was used for all games and each began with a relaxation time of 40 seconds which was reduced to 30 seconds later in each game. Sessions one and two each had 40 minutes playing time and session three was one hour. Players rated their confusion level between 1 (low) and 9 (high) every five minutes during the play.

Sessions were conducted using a network of seven laptops (one server and six clients) in a meeting room large enough so that team members could not talk to each other or see each other's screens but the researchers could address the whole group of six players at once in the de-brief. In the pre-brief of each session players were instructed that their performance aim was to capture as much territory and opposition stones as they could during the game time. They were also advised that they could best do this by cooperating as a team. In each session de-brief, players were encouraged to discuss how they played and behaved as a team. After play in each session, players could watch a replay of the server video where they could see the placement of all stones, unlike the restricted view on their own screens during the game. They could thus get a complete view of the way the game unfolded, particularly where they missed opportunities to capture opposition stones or block capture of their own stones. In the pre-brief of the first session extra time was spent reminding players of the way Go*Team is played. Before play in sessions two and three, teams met face-to-face for ten minutes to discuss tactics based on what they had learnt from previous sessions.

For this series of sessions the most important aspect of session planning was the composition of the teams. Black was setup as the homogeneous team, demographically, with three female players of about the same age all being graduate research students from the same Business Faculty who had worked together in the past. White was set up as the heterogeneous team with two male and one female, a large age difference and two, who were students, came from different Faculties. Each team had two players that had played Go*Team a number of times before and one player each (White 1 and Black 2) who had only observed play before. By far the most significant independent variable for this series of Go*Team sessions was team composition. As described above, other variables were kept constant with appropriate values based on lessons learnt from previous Go*Team studies.

Team performance as determined by stones captured in the three sessions of the series is shown in Table 7. The heterogeneous team (White) performed poorly in the first game, better in game 2 and was quite competitive in game 3 performing as well as the opposition. Black was dominant in games one and two but showed no improvement in game three.

Table 7   The number of opposition stones captured by each team during each session.

	Game 1	Game 2	Game 3
White	0	5	18
Black	9	22	20

Table 8   Data for each player in each game of the series. Stones Played, Levels of Confusion and Correct Markers are simple aggregates while Situation Awareness is Correct Markers as a percentage of total stones played for the game. Note that the game in session three was longer than the others

	Stones Played			Confusion Level			Correct Markers			Situation Awareness			Messages Sent		
Session:	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Player:															
W1	37	31	36	31	42	51	14	33	44	13.6	39.3	25.1	31	42	55
W2	2	13	18	39	42	57	23	54	93	22.3	64.3	53.1	39	41	46
W3	5	8	33	40	36	78	25	46	96	24.3	54.8	54.9	40	34	78
B1	18	20	34	45	79	105	65	75	142	63.1	89.3	81.1	45	78	105
B2	5	12	21	36	61	116	66	70	124	64.1	83.3	70.9	56	59	116
B3	36	23	33	43	51	54	46	46	70	44.7	54.8	40.0	43	50	51

A summary of the basic data on each player is shown in Table 8. In the homogeneous (Black) team the inexperienced player (B2) played fewer stones and, although he improved with each session, his level of confusion increased. In the heterogeneous (White) team the inexperienced player (W1) played many more stones in the first two games but this evened out in the third game when this team performed much better. Overall the homogeneous team had a much better level of situation awareness (percentage of correct markers), admitted to higher levels of confusion and sent more messages although whereas B1 and B2 increased their messaging in sessions two and three, B3 did not and indeed expressed some animosity to her team-mates in game three. Messages of the Black team were not only more numerous but also tended to be longer and more verbose. In general, there was no dominant message sender in either team indicating that no team leader had emerged, as had occurred in the series of game sessions reported in Section 3.2.1.

Screen shots of the server towards the end of each game are shown in Figures 6-8. These give a picture of how the two teams developed over the series of games. In the first game the homogeneous team (black) captured more territory and stones than the white team which struggled to play effectively (see the pattern of stones in Figure 6 towards the end of the game). However, the patterns in subsequent games show much improved performance from the more heterogeneous white team.

Overall the content of the team Chats during games and the de-briefing sessions were typical of the co-operative behaviour in network-centric arrangements of self-directed teams as described in Section 2.4. Players were obviously motivated to cooperate with each other and saw this as the best way to achieve team success. The de-briefing discussion revealed the complex nature of the activity. Even when the Black team was winning comfortably, players

indicated that they were still in confusion as to where all the stones were and what the best next play may be.

Figure 6.   Game 1 – here Black is superior having more contiguous territory within which white stones have been captured (e.g. 5, 12, 20, 18, 24, 29). White stones are scattered around. With the game so one-sided, the most experienced player from each team had their own game for a bit more of a challenge (white stones 14 and 22, bottom left).
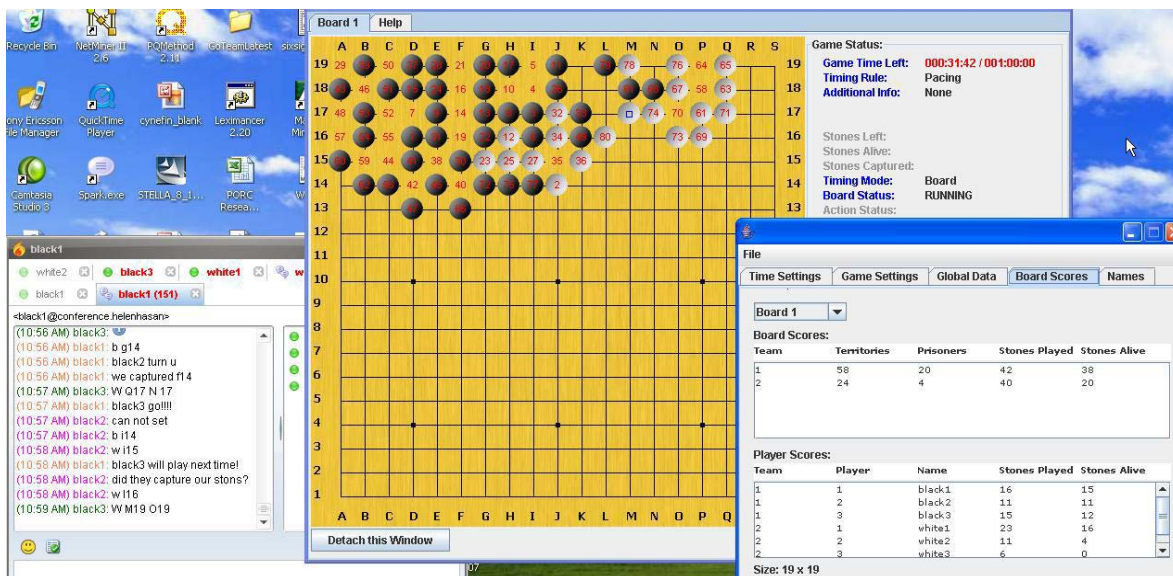

Figure 7   Game 2 shows White making progress but Black still capturing more white stones. Each team has captured contiguous territory although Black's is greater that White's.

Figure 8   Game 3 sees both teams asserting dominance over territory and capturing opposition stones with a couple of break away plays. Black, in fact, has become somewhat trapped in the bottom left whereas White has more potential to grow their territory.

As may be expected, initially the heterogeneous team had difficulty working together and the homogeneous team performed better. Also as expected, learning occurred through the reflection during, and after, each session, so that the heterogeneous team improved their cooperative skills and their performance as a team taking advantage of their different complementary capabilities. An unanticipated result of the study was that this improvement did not come with more communication or situation awareness as these were still much lower in the White heterogeneous team than their homogeneous opponents as measured on a quantitative basis.

In regard to the three levels of SA described above, this played out in the following way. In game one, both teams were struggling at level one (perception) perceiving the elements (i.e. positions of stones) of the activity. In game two the homogeneous team (Black) was getting to SA level two (comprehension) with some of their Chat messages and comments in the de-briefing revealing some understanding of the overall situation. Going by some of the Chat messages, by session three, it was estimated that both teams were at least at SA level 2 with some indication of SA level 3 (projection). Indeed the heterogeneous team (White) was in the better position to move forward and capture more territory.

The two main indications are, firstly, that heterogeneous teams are potentially able to perform complex activities better than homogeneous ones once they have learnt cooperative team skills, and, secondly, a team gaming environment, such as Go*Team, may have the capacity to enable such learning.

4.3 Phase 3: Games to Explore Further Applications of Go*Team Sessions

In this most recent phase of the Go*Team research, sessions have been conducted to test a variety of options that can be incorporated into the planning and conduct of future Go*Team

sessions. These sessions have involved a wider range of players in different settings as a portable network of laptops was used for all sessions. In addition, the software now produces a log of stones and markers played so that data collection is not only quicker but more accurate than the manual process used in Section 4.1. The most significant findings of these sessions are as follows.

4.3.1 Online Team Behaviour of Generation Y.

Generation Y is generally considered to include those born after 1982, who have grown up with social technologies and the Internet. Go*Team affords the opportunity to study this generation. Playing Go*Team games with high-school students has demonstrated how comfortable they are communicating with 'clunky' digital media such as online Chat. Indeed, it seems that they move from one media to another with no discernable loss in effectiveness, unlike previous generations (Fuangvut & Hasan, 2005). Although it is difficult to determine whether other behaviour is due to age or generational factors, it was also observed that these players were very comfortable playing in a team where there was no appointed, elected or emergent leader and generally saw no need for one. Among this cohort it was also clear that the males were almost all extremely competitive, particularly within the teams, whereas no such characteristic was seen in the females. In contrast to Generation X (born 1965 to 1982), members of Generation Y are socially active having seen the distress of downsizing and being bombarded with real-time catastrophes by the global media (Smola & Sutton 2002). Allen (2004) observes that they are thirsting for skills and intellectual challenges, and want: a) work that makes a difference to the world; b) to work with committed co-workers who share their values; and c) flexible work packages that meet their personal goals. This causes concern in traditional work-places that are finding Generation Y difficult to manage. There is, in turn, speculation about how the environment of the work place will change as this generation rises into higher levels of organisations such as the ADO.

4.3.2 Games for Work-place Team Building.

The potential of Go*Team as a work-place, team-building mechanism, for business government and military, was recognised by the research team when it first assembled. The research team has given some effort to designing Go*Team sessions for this purpose and have run two trials in this regard, one with administrative staff at the University of Wollongong, and one with Navy personnel in Nowra. The team-leader of university administration staff was concerned to improve inter-department collaboration and was particularly enthusiastic to trial Go*Team. She thus acted as a real client and the Go*Team session was planned with her to choose teams that included participants from different departments. At her request, a report was produced that included profiles of the performance and de-briefing comments for each player. These have been produced and will be shown to her at an upcoming meeting. Her response should give a valuable indication of Go*Team as a mechanism for both training and profiling participants.

Participants in these training sessions were told that Go*Team would allow them to explore how they function in the team environment and, afterward, reflect on the techniques that are more successful and the barriers that inhibit them from operating effectively as a team. The general procedure for these sessions has been:

- Introduction and brainstorming of ideas on the network-centric paradigm and the viability of networked teams

- Pre-brief: collect experiences of participants as members of teams and attitudes to working in teams

- Video on the Go*Team software application and an Introduction to Go*Team techniques

- Selection of teams and a short trial game on a network of laptop computers

- A five to ten minute face-to-face team meeting where players can talk strategies and tactics

- Play Go*Team for up to 1 hour

- De-brief: a reflection on challenges faced on sharing information, team cooperation and lessons learnt.

Lessons learnt from observation, data analysis and the de-briefs of these trials are:

- People see a need to improve cooperative behaviour in their workplace and are enthusiastic about the potential of Go*Team for this purpose.

- Preparing for this application of Go*Team requires a clear statement of the benefits that sessions could offer any particular client organisation and a mechanism by which the client can identify session outcomes specific to their needs. Go*Team sessions can then be designed with these needs in mind, relevant data collected and an appropriate report produced to feed back to the client.

- Participants in the two trial sessions have all approached them as part of their job and taken them much more seriously than participants on other sessions, undertaken for research. They needed to have a work-related purpose for the sessions explained to them at the outset and they were uncomfortable treating the game as 'play' where they could explore options and take risks. They wanted to know how they would be assessed and to perform well at a specific task.

- The military personnel in particular wanted to know the rules, objectives and tactics of the game and wanted more time (or a richer medium) between plays so that they could communicate more effectively during the game. They were very uncomfortable when the pacing time was reduced during the game so that they did not have time to get all the information they needed and they had to make decisions with incomplete knowledge. When the teams met before the main game, they appointed a team leader and roles for each team member.

These two sessions have demonstrated the gap that exists between the typical 'ordered' workplace culture and that of the network-centric paradigm as outlined in Section 2 of the report. After the games some players made comments such as "we needed to discuss the team strategy prior to playing and assign team roles" and "it was as frustrating as normal teamwork" reflecting a traditional work culture. The way members of an organisation behave in Go*Team sessions may provide a means of classifying how prepared they are to operate in an uncertain network-centric environment where decision-making is decentralised in self-directed teams and critical actions must be undertaken with partial information under time pressures. Some comments in the De-brief indicated that the Go*Team session at the

University had positive learning outcomes, e.g. "winning is fun, but winning as a team is MORE FUN", "we didn't really have a leader but a couple of members were definitely more dominant and we won anyway", "it was nice to be able to have a laugh with people away from the normal work environment".

Cultural change is rarely achieved easily and it is possible Go*Team may have a role to play if it is recognised that an organisation needs to change to one that is more network-centric.

4.3.3 Networks of Teams.

In 2008, games have been played with 8 classes of university management students studying new organisational forms and modes of communication. With class numbers of 20-30 there was an opportunity to arrange sessions with two or three co-located players as mini-teams on each client computer and up to five dispersed clients on each of the two larger teams who must still communicate via online Chat. Photographs of one such game are shown in Figure 9. Each class was one hour long, so that the students received instructions and played a short trial game one week, then a longer game in the following week's class consisting of play for 30 minutes and then a de-brief. The larger teams met face to face briefly after the trial game to talk tactics.

Figure 9   Photos of a game played with small sub-teams on each computer linked together by the network into two larger teams, Black and White, as usual. The server is in the foreground of the picture on the left.

This configuration introduced a completely new dynamic into the environment and represents the reality of many network-centric organisations with dispersed teams. In many cases, the sub-teams operated independently in the first week's game as shown on Figure 10 but in the second week, with experience and after the team meeting, the sub-teams co-ordination was much improved and the whole team worked together as shown in Figure 11.
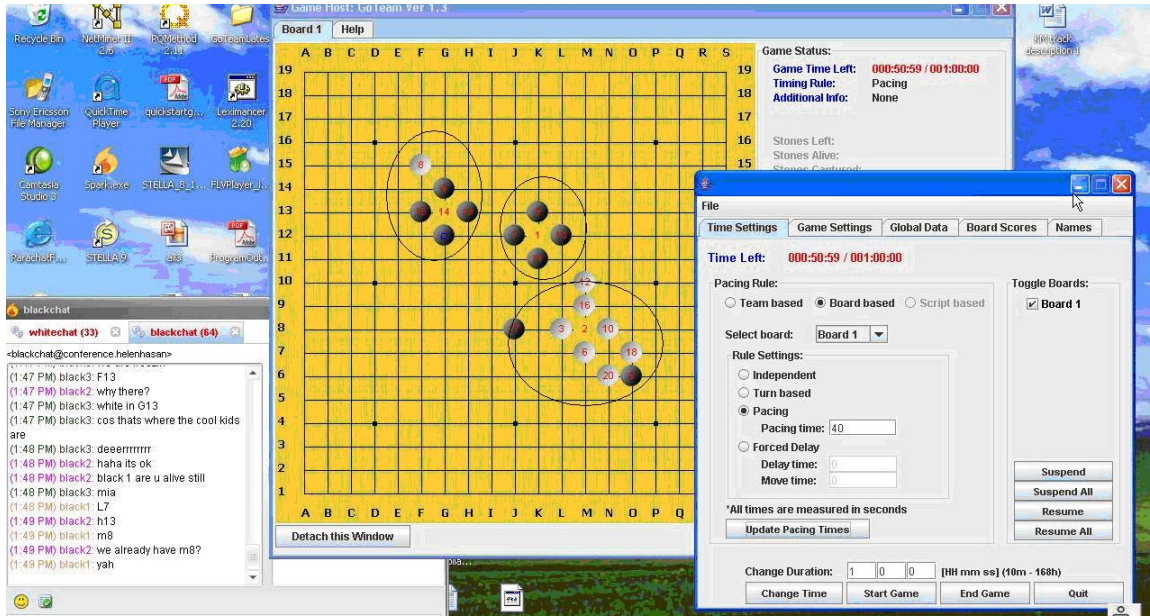
Figure 10 In this game, the first week of the networked teams, three separate games, circled, are apparent where the sub-teams, sitting together at a computer, play independent of the larger team.

Figure 11   The same class as Figure 10, playing a week later is much more co-ordinated.

4.4   Unexplored Go*Team Functions

Many functions of Go*Team have not yet been used in the research. These include having more that two teams to a board and having more than one board in play during a game.

Playing with just two teams on one board has been sufficient to demonstrate the complexity of the team activity in the game.

5. Outcomes from Go*Team Sessions

There are two major perspectives of the research in which to classify outcomes to date, namely: applied research into attributes of team behaviours; and practical techniques for training in network-centric capability. Taking a socio-technical, systemic view of the Go*Team research reveals the complexity both of the system itself and the context of its use. There are many technical and human components involved, with multiple relationships between them. Table 9 below, summarises the experimental results to date, against the constructs identified in Table 2.

Table 9   Findings to date and suggestions for further analysis

Network-centric constructs	Go*Team Session Setting	Variables/ Measures	Findings/Future Experiments
Shared Situation Awareness	Built into the game as individual players only see some of the stones played	Correctness of markers, Subjective confusion levels	SSA partially contributes to performance but there is a complex mix of other factors. SSA in turn depends on team size, composition, on communication and experience
Information sharing	Built into the game as individual players only see some of the stones played	Number and content of messages between team members	Contributes to SSA but must be matched by absorptive capacity of information receivers. Is reduced by increased stress
Effective decision-making	Progress on the game as stones are played	Stones played, territory covered and opposition stones captured	Used as an indicator for performance - thus a dependent variable Depends on SSA, Team skills, Stress and other factors
Learning	Over single session, between a series of sessions	Pre-briefs and de-brief interviews	Learning areas are: 1- Playing Capability levels out after 1 or 2 games 2- Teamwork/cooperative behaviour can continue to improve with playing
Player characteristics	Age, gender, personality, etc	Demographic data, other tests	Independent variable whose effects could be studied with more analysis of existing data
Team composition	Allocation of players to teams	Homogeneous / heterogeneous, previous experience together, size of teams	Independent variable – is a major contributor to performance and learning particularly with heterogeneous teams (friction/boredom emerged in one homogeneous team after 3 games)
Group dynamics Cooperative /competitive	Messages between players, de-brief	Text content of messages and de-brief	Dependent variable - evidence from game session is that playing Go*Team in planned sessions leads to improvement

			behaviour
Team roles, leadership	Pre-determined or emergent	Number of plays and messages per player	Pre-assigning roles was not successful, some teams self organised, sometimes roles emerged, sometimes not without detracting from performance
Communication Quality	Messages record during game	Number and Text Content of messages	Contributes to SSA and cooperative behaviour. Depends on players and communication mode.
Communication Mode	Verbal (face to face, phone), text (email, chat)	Richness of media, player familiarity of mode	Affects communication quality but this depends on players e.g. for many Gen Y equally capable with non-rich media
Stress	Game motivation, play timing, unexpected events during play	Reward for players, vary relaxation time, size of board, game time	Affects team cooperative behaviour and hence SSA and performance
Training	Go Tactics, computer skills in playing Go*Team, skills in communication	Pre-game instruction, experience	Playing experience and reflection with some pre and during game instruction has been the most successful training method.

5.1 Applied Research

As indicated by the list of possible dependent variables discussed earlier in this report, there are many applied research issues that could be studied with Go*Team. As described in Section 2, the research team determined to begin with a focus on the following concepts as they were of particular interest to the research's military sponsors and the ADF, namely:

- Team dynamics, conflict (with the other team or teams involved in the game), cooperation and coordination, but also competition (with and between the players in one's own team);

- Situational Awareness and information sharing (through the need to continually share information in order to synthesise and integrate, in a dynamic situation, multiple fragmentary and local perspectives into an overall situational picture);

- Communication and Trust (face to face and online, within and between groups)

- Timely and appropriate decision making (through the need to balance the time taken for adequate situational analysis and the pressure to avoid being overtaken by events).

To date, research with Go*Team has focused on the complex interaction of a variety of network-centric constructs to understand team behaviour. The complexity of these relationships and interactions is well illustrated by the concept of Shared Situational Awareness. Sharing information between people, each with a partial view of the board, is a necessary strategic activity for teams playing Go*Team. Such configurations enable the game sessions to explore in detail the processes and behaviours in the development of SSA (Nofi, 2000). The capacity to achieve, use and share SA is critical to the ability of a team to respond positively to a sudden extreme external event. Research in this area has traditionally been difficult to conduct and Go*Team is proving ideally suited for this.

5.2 Training and Profiling for Network-Centric Capability

Shared situation awareness at all levels becomes a challenge in the Go*Team game where effective collective action necessitates a holistic view of the game activity. It requires not only information flows between team-members, but also the synthesis of that information by players into knowledge that results in actions towards an agreed common purpose of the activity. Adaptability and flexibility are needed both by people and the technologies that support them.

Go*Team provides a generalised representation of a range of situations where people and groups coordinate, cooperate and share information for local decision-making and action in response to anticipated and unanticipated events. Go*Team software and session protocols are tools for team training in complex activities that are unpredictable. In a complex context, it is both more efficient and more effective to assume that desired outcomes can be encouraged but not mandated. Actions must often be made without complete situation awareness or knowledge of the consequences. This is the case in Go*Team games as decisions to place a stone are only occasionally made to explicitly capture or block the imminent threat of the opponent but are frequently made in the hope of improving the team's position. However, the team that learns to do this well performs better overall.

Playing the game in sessions that are planned to meet a client's specific requirement could be a fruitful team-building exercise. Go*Team has particular properties that make it suitable for strategic team activities and decision making, balancing competition with cooperation, and, through competition, introducing stress which can be increased through changes to the timing. It is clear from the qualitative analysis of team Chats and De-briefs that teams benefit from developing a strategy both to share information and to coordinate making sensible moves as soon as time allows. Due to the involvement of the team leader at the planning stage, the trial session with the university administrators has demonstrated how playing Go*Team, followed by a facilitated de-briefing session, can be effective general training for a network-centric environment and working in self-directed teams under stress.

The university administrators' experiences also demonstrate how, through observation and measurement of individual performance in Go*Team sessions, there is the potential for profiling an individual's capacity to work as a team-player in a network-centric configuration. Structuring the de-briefing sessions following a game of Go*Team could be further developed to enable assessment of the creativity, adaptability and cooperative nature of participants to determine their alignment with the culture of a network-centric environment. This could be a useful process for individual profiling for skills as members of self-directed team.

6. Future Research and Practice for Go*Team.

Go*Team's potential for both applied and theoretical research, has been demonstrated through the broad spectrum of application areas for which the system is now being used. Go*Team sessions address issues of how people and groups coordinate, cooperate and share information for local decision-making and action in response to anticipated and unanticipated

events. Of particular interest are human, social or group related factors that may impede or even prevent the successful achievement of such processes despite the availability or presence of the technological capability to support it. Adaptability and flexibility are needed both by people and the technologies that support them.

From the research perspective the ongoing challenge is to develop an alignment of network-centric constructs with the independent and dependent variable in Go*Team. This agenda will provide the empirical basis for the emerging theory of network-centric environments. However, this research program is complex, particularly where the variables are not inherently quantitative, where a combination of Go*Team variables may be involved in a given network-centric construct or where the alignment needs further investigation.

Immediate tasks that can be undertaken with Go*Team are:

- Extensive analysis of the large amount of data that has been collected in the 12 sessions conducted as networks of team as described in Section 3.3.3 above. This will provide empirical evidence to develop network-centric theory. This could be done under current and future, research agreements with the University of Wollongong.

- Use findings from the DSTO research on the Human Dimension of Network Centric Warfare (NCW) and the Model of ADF Warfighters' Perceptions of the Human Dimension of NCW (see HDoFW, 2007; Pascoe et al, 2008), to plan Go*Team sessions for further applied research into the relationships between dynamic attributes of team behaviour. This could be done under current, and future, research agreements with the University of Wollongong.

- The refinement of Go*Team sessions into a robust training regime that can be deployed throughout the ADO, but can also be presented as a commercial product for network-centric team-building in business and government organisations. The Commercialisation Unit of the University of Wollongong is willing to facilitate this in partnership with DSTO[6].

Go*Team is unique in that it brings together the strategic thinking of the game of Go that has been used for skills development by the military over the centuries (Klinger 2001) , a built in situation where team-members must share information in order to act cooperatively and the engaging environment of online gaming. Go has the added benefit of being easy to learn yet difficult to play well, as indicated by the difficulties programmers have faced in creating a computerised Go player similar to chess (Müller 2000). Playing the Go*Team game in sessions with suitable protocols produces an innovative and effective system for both research and training.

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[6] The University of Wollongong would like a licence to use the executable version of Go*Team for training activities beyond DSTO needs.

7. Conclusion

This report has documented the use of Go*Team over 40 game sessions conducted with diverse groups of participants. It is evident from exercises to date that, in addition to its use for research, Go*Team can be used for raising awareness of team dynamics and effective collaboration, training and, possibly, profiling. The system is designed to provide experiences in which people confront the notion that each member of the team has a different awareness of any situation. Players must explore the strategic benefits of collaborating to use all the insight and information available and to avoid the risks of non-collaboration and 'going it alone'. The game environment makes a shift to this fundamental network-centric orientation clearly beneficial and provides an opportunity for players, while embedded in an entertaining environment, to explore new strategies associated with working in teams. The game can also be used to identify people with certain attributes and to train people to further develop those attributes that will enable effective performance in a network-centric environment. Go*Team appears to have the capability to be used for training in strategic, team-based decision making under various forms of stress, including time pressures, and conditions where information is distributed among disparate team members. It can, therefore, potentially be used for research to train and to sustain.

The Go*Team system, comprising the simulation framework, online gaming software and the protocol of use, is showing potential for its applications in practice, training and profiling in the area of network-centric environments. Go*Team has broad application for building capability for networked, self-directed teams in organisations, like the ADF, and, to a lesser extent, the rest of the ADO, that are increasingly faced with the prospect of having to respond to sudden events and extreme threat. In this regard, Go*Team is cost-effective and has general application to team problem-solving activities.

It is recommended that research with Go*Team is continued in partnership with the University of Wollongong, and DSTO begins discussions with the Commercialisation Unit of the University of Wollongong to facilitate this partnership.

8. Acknowledgements

9. References

9.1 Go*Team References

Hart D., Eronen M., Jagiello J., and Warne L. (2006) "Go*Team: A Team Version of Go for Investigating Network-Centric Warfare Environments", *Proceedings of SimTect2006*, Melbourne.

Hasan H. (2006) "Vive la difference: leveraging diversity for effective decision-making", SOSFA Workshop, Department of Defence, Canberra.

Hasan H., Crawford K., and Hart D. (2006) "The Application of Go*Team to Network-Centric Characteristics", *Proceedings of SimTect 2006,* Melbourne

Hasan H., Warne L., and Mitchard H. (2007a) "Lessons from Go*Team Simulations on Shared Situation Awareness", Best paper, *Proceedings of SIMTECT 2007,* Brisbane

Hasan H., Warne L., and Crawford K. (2007b) "Emergent cooperative activity in distributed team performance in Go*Team", *Proceedings of SIMTECT 2007* Brisbane

Jagiello J., Eronen M., Tay N., Hart D. and Warne L., Hasan H. (2006) "Simulation Framework as a Multi-User Environment for a Go*Team game", *Proceedings of ISAGA 2006*, St Petersburg.

Jagiello, J. and Eronen M. (2007a), "A Simulation Framework", *MODSIM 2007 International Congress on Modelling and Simulation.* Modelling and Simulation Society of Australia and New Zealand, December 2007, pp. 74-80. ISBN : 978-0-9758400-4-7. [Online] URL: http://www.mssanz.org.au/MODSIM07/papers/14_s51/ASimulationFramework_s51_Jagiello_.pdf

Jagiello, J. and Eronen M. (2007b), "Go*Team, an Instance of the Simulation Framework", *MODSIM 2007 International Congress on Modelling and Simulation.* Modelling and Simulation Society of Australia and New Zealand, December 2007, pp. 74-80. ISBN : 978-0-9758400-4-7. [Online]   URL: http://www.mssanz.org.au/MODSIM07/papers/14_s51/GoTeam_s51_Jagiello_.pdf

Warne L., Hasan H., and Hart D, (2006) "Go*Team a new approach to developing a knowledge sharing culture", *Proceedings of the Australasian Conference of Information Systems*, Adelaide, Dec 2006.

9.2 Other References

AGA – American Go Association (2005) "Official AGA Rules of Go", http://www.usgo.org/resources/downloads/completerules.pdf accessed 17 Feb, 2006.

Ali, I., Warne, L., Pascoe, C., and Lewis, M. (2008*) Does team training make a difference? A comparison of early MEAO and AMTG voices on pre-deployment training and team issues - sub-task report on the Human Dimensions of NCW.* DSTO Report DSTO-TN-0842 AR 014-271, Joint Operations Division, Defence Science and Technology Organisation, Department of Defence, Edinburgh, S.A.

Allen, P (2004) "Welcoming Y", *Benefits Canada*, 28/9 pp51-54.

Angehrn, A.A. and C. Loebbecke (2003) "Open Source Communities Reflecting Co-opetitive Learning and Knowledge Exchange Networks", *Proceedings of DSS 2004*, Prato, Italy

Ashby W. R. (1957) *An Introduction to Cybernetics*, Chapman & Hall Ltd, London, now available electronically:
 http://pcp.vub.ac.be/books/IntroCyb.pdf

Baber, C., Houghton,R. J., McMaster, R. and Stanton, N. A. (2006) "Shared situational awareness as a systems-level phenomenon: applying propositional networks to shared awareness in teams" <u>in</u> *Human Factors Issues in Complex System Performance,* Dick de Waard, Bob Hockey, Peter Nickel, and Karel Brookhuis (Eds.) Maastricht, the Netherlands: Shaker Publishing. ISBN 978-90-423-0325-6

Billings M. Watts L. (2007) "A safe space to vent: Conciliation and conflict in distributed teams", *Proceedings of ECSCW'07*, Limerick.

Burmeister, J. M. (2000) "Studies in Human and Computer Go: Assessing the Game of Go as a Research Domain for Cognitive Science". PhD thesis, University of Queensland.

Cares, J. (2005) *Distributed Networked Operations: the Foundations of Network Centric Warfare,* iUniverse, Lincoln NE, RI.

Corti K. (2006) "Games-based learning: a serious business applications", White Paper from PIXELearning, Coventry, CV1 2TL, UK.

Crawford, K. Hasan, H. Warne, L. & Linger, H. (2008) From Traditional Knowledge Management in Hierarchical Organizations to a Network Centric Paradigm for a Changing World, *Emergence: Complexity and Organization* (in press).

Daft, R. L. and A. Y. Lewin. (1993). "Where are the theories for the "new" organizational forms? An editorial essay." *Organization Science* 4(i-vi).

Douglas C. Martin J. Krapels R. (2006) "Communication in the Transition to Self-Directed Work Teams", *Journal of Business Communication* 43, 295-321.

Endsley, M. R. Bolté, B. Jones, D. G (2003) "Designing for Situation Awareness: An Approach to User-centered", Design Taylor & Francis, New York.

Endsley, M. (1995) "Towards a theory of situation awareness in dynamic systems", *Human Factors*, 37(1), 32-64.

Klinger T (2001) Adversarial Reasoning: A Logical Approach for Computer Go, PhD Thesis, New York University.

Friel B, (2002) "Hierarchies and Networks", *(US) Government Executive*, URL http://www.govexec.com/story_page_pf.cfm?articleid=22497 accessed 1/8/2007

Gottlieb, E., Harrigan, R., McDonald, M., Oppel, F., Xavier, P. "The Umbra Simulation Framework", Sandia Report SAND2001-1533 June 2001.

Hasan H. (2006) "Vive la difference: leveraging diversity for effective decision-making", SOSFA Workshop, Department of Defence, Canberra.

HDoFW Research Team (2007) *The Transition from Network-Centric Warfare to Networker-Centric Warfare: Outcomes of the Human Dimension of Future Warfighting Task* (Restricted Access) .DSTO Report CR-2007-0311, Defence Systems Analysis Division, Defence Science and Technology Organisation, Department of Defence, Edinburgh, S.A.

Huang C, Ceroni J. Nof S. (2000) "Agility of Networked Enterprises: parallelism error recovery and conflict resolution", *Computers in Industry* 275-287.

Jehn K. A. (1998) "Workplace Diversity. Conflict and Productivity: Managing in the 21st Century", *Journal of Employment and Labor Law*.

Kansawattanachai P. Yoo Y (2005) "The Impact of Knowledge Coordination on Virtual Team Performance over Time", *MIS Quarterly*, 31/4 783-808.

Lewis J. (2007) "All Play, All Work", *Canadian Business*, 80/16-17, 73-74.

Müller, M. (2000) "Review: Computer Go 1984-2000", University of Alberta.

Nofi, A.A. (2000). "Defining and measuring situation awareness". Center for Naval Analyses, Alexandria, Va.

Pascoe, C. and Ali, I., (2006) "Network-centric Warfare and the New Command and Control: An Australian Perspective", in the Proceedings of the *11th International Command and Control Research and Technology Symposium*, 26-28 September 2006 Cambridge, UK, http://www.dodccrp.org/events/11th_ICCRTS/iccrts_main.html

Pascoe, C., Warne, L. and Ali, I. (2008) *A Model of ADF Warfighters' Perceptions of the Human Dimension of NCW: synthesis of Empirical Findings. Human Dimensions of NCW sub-task report.* DSTO Report DSTO-RR-xxxx, Joint Operations Division, Defence Science and Technology Organisation, Department of Defence, Edinburgh, S.A. (in processing)

Peltokorpi V.Tsuyuki E. (2006) "Knowledge governance in a Japanese project-based organization", *Journal of Knowledge Management Research and Practice* 4/1: 36-45.

Ryu C. Kim Y. Chaudhury A. Rao H. (2005) "Knowledge Acquisition via three learning Processes in enterprise Information Portals: Learning -by-Investment, Learning-by-Doing and Learning-from-Others", *MIS Quarterly*, 29/2 245-278.

Sambamurthy, V, Bharawaj A Grover V. (2003) "Shaping Agility through Digital Options: Reconceptualising the Role of Information technology in Contemporary Firms", *MIS Quarterly*, 27/2 237-263.

Shananhan, C., Best, C., Finch, M., and Sutton, C. (2007) *Measurement of the behavioural, cognitive and motivational factors underlying team performance (U).* Report number: DSTO Report DSTO-RR-0328 Air Operations Division, Department of Defence, Fishermans Bend, VIC, (Approved for Public Release).

Smola K. W. Sutton C. D. (2002) "Generational differences: Revisiting generational work values for the new millennium", *Journal of Organisational Behaviour*, 23/4 p363

Snowden D. (2002) "Complex acts of knowing: paradox and descriptive self-awareness", *Journal of Knowledge Management,* 6/2 100-111.

Fuangvut T., and Hasan H. (2005) "Accommodating Inter-generational Stakeholders in a Campus Portal", CD *Proceedings of EMCIS*, Cairo.

Turoff M. Chumer M. Hiltz R. (2006) "Emergency Planning as a Continuous Game", *Proceedings of ISCRAM* Newark, 477-486.

Vidulich M. Dominguez C. Vogel E. McMillan G (1994) "Situation Awareness". Air Force Material Command. Wright-Patterson Airforce Base. OH: Armstrong Laboratory.

Warne, L. (2006) "NetworkER-centric Warfare: Outcomes of the Human Dimension of Future Warfighting Task" *TTCP Symposium – Human Factors Issues in NCW*. 1-3 May 2006 Sydney, Australia. Online: http://www.dsto.defence.gov.au/events/4659/

Warne L. Ali I. and Hasan H. (2005) "The Network-centric Environment viewed through the Lens of Activity Theory", in G. Whymark and H. Hasan (eds) *Activity as the Focus of Information Systems Research*, Knowledge Creation Press, UCQ, 117-140.

Warne, L., Ali, I., Bopping, D., Hart, D. and C. Pascoe. (2004) *The Network-centric Warrior: The Human Dimension of Network-centric Warfare (U)* DSTO Report CR-0373, Defence Systems

Analysis Division, ISL, Defence Science and Technology Organisation, Department of Defence, Edinburgh, S.A. (Approved for Public Release).

Warne, L., Ali, I., and C. Pascoe (2003) *Social Learning and Knowledge Management – A Journey through the Australian Defence Organisation: the Final Report of the Enterprise Social Learning Architectures Task*, DSTO Report, DSTO-RR-0257, Defence Systems Analysis Division, Information Sciences Laboratory, Department of Defence.

Appendix A: Background to Go*Team Research

A.1.   The Timeline

The ancient Chinese board game of Go has been recognised for centuries as an ideal tool for developing the strategic capability of players. Early in 2004, based on a concept developed by Dr Dennis Hart of the Australian National University, who was then on study leave with DSTO, the HDCT (Human Dimension Concepts Team) at DSTO envisaged that an online team version of Go could be built as a client server application to run over a computer network. Such a team gaming environment could encapsulate not only strategic decision-making but also simulate various human factors of network-centric phenomena such as information sharing, communication, shared situation awareness, and cooperative behaviour.

Throughout 2004, Dr Jerzy Jagiello and his team at DSTO Fern Hill then developed the Go*Team client-server software, as an application of Dr Jagiello's Simulation Framework (see Jagiello & Eronen, 2007). By the end of the year, it was clear to all members of the research team that Go*Team was realising the initial vision and had great potential as a tool both for research into human aspects of network-centric environments and for training of appropriate team behaviour in this environment.

Early in 2005, the research team held a series of meetings at DSTO Fern Hill to plan the way forward. The DSTO Human Dimension Concept Team, led by Dr Leoni Warne, provided expertise for identifying a large range of cognitive and behavioural constructs that could be studied with Go*Team. A/Prof Helen Hasan from the University of Wollongong offered a usability-testing laboratory where experiments using Go*Team as group activity could be planned and monitored.

It was clear that simulating the network-centric environment in the Go*Team game was as complex as its real world equivalent and so was eminently suitable for research. This was seen as both an important opportunity with tremendous potential and as a challenge, as there was no obvious precedent that the multi-disciplinary research team could follow. Although many attempts had been made to automate Go previously, these had almost invariably been two-person Go games or person-against machine games, or other variations. For instance, in Network Centric Go™ (Cares, 2005) researchers converted the standard Go Board grid of 361 nodes and 684 links into a complex wired networked environment. However, a computerised, team version of Go had not been attempted before.

The research has since followed an exploratory and evolutionary path where over 40 Go*Team game sessions have been conducted with diverse groups of participants. Regular review of practice is fed back into the design of each subsequent session. This has led to improvements in the software and data recording; understanding of the effect of various game settings and team composition; appropriate measures of network-centric constructs; and suitable session protocols, including training, pre-briefs, game play, de-brief and participant motivation. Since 2006 there have been numerous publications from the Go*Team research team (see reference list).

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

2. TITLE Go*Team Experimentation Results: Research, Train and Sustain. Human Dimensions of NCW Sub-task Report (U)	3. SECURITY CLASSIFICATION (FOR UNCLASSIFIED REPORTS THAT ARE LIMITED RELEASE USE (L) NEXT TO DOCUMENT CLASSIFICATION) Document (U) Title (U) Abstract (U)

4. AUTHOR(S) Helen Hasan and Leoni Warne	5. CORPORATE AUTHOR DSTO Defence Science and Technology Organisation Fairbairn Business Park Department of Defence Canberra ACT 2600 Australia

6a. DSTO NUMBER DSTO-RR-0337	6b. AR NUMBER AR-014-234	6c. TYPE OF REPORT Research Report	7. DOCUMENT DATE October 2008

8. FILE NUMBER 2008/1064471/1	9. TASK NUMBER CDE 07/031	10. TASK SPONSOR BRIG Gerard Fogarty BRIG John Cox BRIG David Welch	11. NO. OF PAGES 41	12. NO. OF REFERENCES 48

13. URL on the World Wide Web http://www.dsto.defence.gov.au/corporate/reports/DSTO-RR-0337.pdf	14. RELEASE AUTHORITY Chief, Joint Operations Division

15. SECONDARY RELEASE STATEMENT OF THIS DOCUMENT *Approved for public release* OVERSEAS ENQUIRIES OUTSIDE STATED LIMITATIONS SHOULD BE REFERRED THROUGH DOCUMENT EXCHANGE, PO BOX 1500, EDINBURGH, SA 5111

16. DELIBERATE ANNOUNCEMENT No Limitations

17. CITATION IN OTHER DOCUMENTS   Yes

18. DSTO RESEARCH LIBRARY THESAURUS http://web-vic.dsto.defence.gov.au/workareas/library/resources/dsto_thesaurus.shtml Simulation, War games, Network centric warfare, Human characteristics, Team performance

19. ABSTRACT This report discusses the use and usability of Go*Team, an online gaming environment based on the ancient strategy game Go, that embeds participants in situations where they must cooperate as a team to make strategic decisions based on shared information. Go*Team is designed to simulate situations in which people and groups coordinate, cooperate and share information to achieve organisational goals in the anticipated future network-centric environment. Over forty Go*Team game sessions were conducted with diverse groups of participants, most at the Activity Theory Usability Laboratory at the University of Wollongong, and the development of appropriate protocols for these sessions is discussed. Findings from the sessions are discussed in terms of shared situation awareness, team cooperation, team composition, work-place team building and the effect of increased tempo. It is proposed that Go*Team be used for further research into network-centric environments, training and sustaining teams.