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Keywords
Teamwork, Shared Situational Awareness, Simulation and Gaming, Network-Centric Organisation

Disciplines
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Lessons from Go*Team Simulations on Shared Situation Awareness

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Abstract. The ancient game of Go is traditionally played by two opposing players (black and white) who take turns laying stones on a board of up to 19x19 squares. The stones can be laid so they eventually encircle stones of the opposing colour, thereby capturing territory and stones. Go has been the inspiration for Go*Team which has been developed as a web-based application for two or more teams; each team with a number of players. Go*Team emulates some of the issues that a Network Centric (NC) environment might bring and consequently allows investigation of issues such as situation awareness. It is designed to ensure that there are cooperation and competitive pressures on players. Individual players in a team have their own local view of the game consisting of a Go*Team board showing the positions of their own stones plus any stones of the opposing team that are closer to their stones than those of any other player on their team. To play successfully, players need information from their team-mates. The form of communication between team members therefore affects performance, particularly in distributed teams but communication from others may or may not be accurate, and may not be interpreted correctly. This paper discusses the use of Go*Team for exploring Individual and Shared Situational Awareness (SSA). A number of definitions and measures for SSA are discussed in the paper, including subjective measures and objective measures. The conduct and outcomes of Go*Team live sessions, data collection and analysis are viewed in terms of shedding light on SSA and investigating the potential of Go*Team.

1 INTRODUCTION

Go is an ancient game invented by the Chinese some three thousand years ago. In its original form there are two opposing players (black and white) who take turns laying stones (of their colour) on a board on which the number of squares varies from 9x9 (beginners) to 19x19 (advanced). The stones can be laid so they eventually encircle an area, surrounding and capturing stones of the opponent. The main object of the game is to capture as much territory (that is, area) and as many stones as possible.

This paper focuses on the use of Go*Team for exploring what factors affect situation awareness (SA) and SSA and how performance depends on SA and SSA which can thus be treated as both dependent and independent variables in the research analysis. Following an analysis of relevant literature a number of definitions and measures for SA and SSA are presented, including subjective and objective measures. The conduct and outcomes of a series of five Go*Team sessions and analysis, to date, are presented. The results are discussed in terms of findings on SSA, both perceived and actual, as well as its relationship to individual roles and team performance. Conclusions are drawn on issues of SSA within the NC paradigm and the suitability of Go*Team for studies of SA and SSA is also discussed.

2 THE GAME: GO*TEAM

The original Go game has been changed to emulate some of the issues that a NC environment might exhibit and consequently allow investigation of those issues. From the original game with two opposing players, Go has evolved into Go*Team which has two or more teams playing, each team with a number of players. There is no concept of taking turns, rather there is a relaxation time for each side, in which a side can place stones and then the other side has an equal time. In Go*Team, the traditional patterns of moves from the original Go game may not always apply, however patterns of stones and the territory they cover can still be scored in the same way and so Go experience is still useful. The tempo of the Go*Team game can be adjusted, communication from others may or may not be accurate, and the team mode of playing, all ensure that there are cooperation and competitive pressures [6].

Another important part of Go*Team is that individual players in a team have only a local view of the overall Go*Team "world" in which they are embedded. Only the stones of the player (not those of others on his/her team) and the opposing team's stones closest to that of the player (as opposed to anyone else on his team) are visible to that player. Explicit communication (communication being via VoIP, chat rooms etc) is required so that players on each team can share information on their partial view of the Go*Team world. So that working memory is not overwhelmed

however, a player can place markers based on information they receive from team members, as a result of this communication. This, however, can introduce errors of various sorts that affect the performance of individual players and the team as a whole. Notions of individual Situational Awareness (SA) and Shared Situational Awareness (SSA) are central to this problem and critical to working effectively in a NC environment.

3 INDIVIDUAL SITUATION AWARENESS

In order to understand the role of SA in the Go*Team environment, the concept of individuals' situation awareness is first introduced. SA is generally described as knowing and understanding what is going on around you and predicting how things will change (Wikipedia). A more formal definition of 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 [5]. 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 [11]. Endsley [2] further describes SA as dynamic and affected by attention and workload stress.

4 SHARED SITUATION AWARENESS

In the 1980's, little attention was directed to questions about SA in team dynamics. However, with the increasing use of teams and virtual teams, the focus has shifted from the individual to the team. According to Endsley [5] SSA is defined as the degree to which team members have the same SA on shared SA requirements. She goes on to say that rarely would a team require entirely the same SA in all members. According to [10] the military prefers the definition of SSA as the shared awareness of a situation.

The article on shared SA (SSA) by [10], is particularly concerned with SSA for distributed teams. Like many others, Nofi attempts to delineate the difference between individual and shared situational awareness. He believes that there is considerable agreement [10] on what SSA includes. He states there are three processes involved in cultivating SSA; building individual SA, finding common ground amongst the members of a team to enable the sharing of individual mental models and the integration of individual SA to produce SSA. However SSA does not imply identical mental models, although there has to be sufficient "overlap" to perform the mission [10]. This overlap should occur on the factors affecting the performance of a mission and consequently information on those factors should be shared. The difficulty in developing SSA is largely due to the difficulty of building common ground in a distributed team. Finding common ground can obscure the SSA of a group as

> "Dysfunctional SA is faster and more mysterious in a virtual group because there are no overt cues and because leadership is measured, frequently, by articulacy" [Susan Schwartz, in 10, p35]."

5 ELEMENTS OF SA AND SSA

The question of how to measure SA directly is still in search of a definitive answer. Self-rating by participants has a number of issues associated with it. Firstly it is widely acknowledged that such ratings are subjective and often biased by the trial outcome as it is likely that the experimenter is collecting confidence levels rather than measures of SA [2]. Another subjective rating is questionnaire answers. Unfortunately questionnaire answers often overgeneralise and overrationalise [9]. In an effort to gain answers based on immediate experience, some have turned to on-line questionnaires. But they are a secondary task and may interfere with the performance of the primary task [2]. Other subjective ratings, such as observer ratings, suffer from incomplete knowledge of the participant's SA by the observer. However such observer ratings offer useful information and should be used in conjunction with other measures.

An objective measure is suggested by Endsley [2]. She suggests use of the random freeze technique, which implies the task can be paused. The Situation Awareness Global Assessment Tool (SAGAT) is a tool to assess all levels of SA, system status and pertinent features of the external environment [2]. SAGAT is objective and very suited to computing environments. SAGAT blanks the screen for several periods during which operators are asked various questions. The operator's perceptions are compared to expert answers for assessment. SAGAT also has reasonable measurement reliability according to [4] enabling both easier and more accurate scoring of SA.

It is said that performance data is not directly a reflection of SA. Performance is a result of information, integration, workload, decision making and action and these are some of the areas which may influence performance. Performance, decision making and actions are good candidates for dependent variables in relation to SA. Degraders of individual SA include ambiguity, fatigue, biases, stress, overload (task or information), mission complexity, fixation and lack of experience [10] and may be viewed as independent variables in relation to SA, as can training and rules.

In regard to SSA, [1] defined team knowledge as the sum of the team mental model (general knowledge) and team SA (specific knowledge of a situation). They ask how can one distinguish between knowledge that is unique to a team member and required by other team members, as opposed to distinctive knowledge which is only required by an individual in that role [1]. One would think that in warfare, knowledge similarity is not necessary, however, accuracy similarity is necessary [1]. Similarly role knowledge and interpositional accuracy and knowledge distribution metrics would give a window on assessing team SA.

Cook et al [1] believes interviews and questionnaires are good for general understanding, realising that such

methods are mainly used to measure mental models. Process tracing/ protocol analysis, (i.e. think aloud) is a task performance measure and better for assessing SA. However these methods mainly measure mental models at the level of the individual and consequently should be used with caution in assessing teams.

Integrating notions of SA and SSA to determine what specifically can be assessed or measured, Endsley [2] defined SA as having three levels:

- Level 1: perception of elements
- Level 2: comprehension of current situation
- Level 3: projection of future status

According to [10] subjective measures of SSA are questions such as:

1. Do members understand the team mission?
2. Do members understand their individual roles on the team?
3. Is information flowing into the team?
4. Is information flowing amongst members of the team?
5. Are decisions being made by the team in a timely fashion?
6. Are appropriate actions being taken by members of the team?

Objective measures [10] are then responses to the questions:

7. Does the team understanding of the situation, at any particular moment, conform to reality?
8. Is the mission being executed successfully?

6 GO*TEAM, SA AND SSA

In this section of the paper the concepts and measures of SSA enumerated in Nofi's list above will be related to Go*Team and protocols of Go*team sessions. Table 1 summarises this, noting that Go*team functions and protocols will be explained later.

In Go*Team, Endsley's level one SA is the position of the stones and markers on the board. Jones [7] suggests that prior experience will have a large influence on what is perceived. Similarly level two and three SA would also vary with the player's Go/Go*Team expertise.

The issue of Go expertise is an interesting one as Endsley makes an argument against using an unfamiliar type of game to study SA. She relies on the finding of Holland et al in [2] that default information is better in experts and refers to recognition-primed decision-making, which reduces the load on working memory.

When considering Go*Team, it is highly unlikely that there is a well developed team mental model and so the focus is on the measurement of team understanding and knowledge. However we are aware that Go expertise may influence the outcome. As can be seen in the previous work mentioned, the focus is very much on highly dynamic environments and the relevant measurement of SA.

7 GO*TEAM SESSION PROTOCOLS

*7.1 Go*Team network set up*

The Go*Team sessions reported in this paper were conducted in a Usability Laboratory set up in a 6-room cottage on a University campus. The configuration for the Go*Team session uses the computer (server) in one central room, set up with recording equipment normally used for usability testing. This provides several options for recording data during game sessions, principally screen video capture by the Camtasia © program. Camtasia also captures the audio of any team communicating verbally via microphone. Eight other computers are set up as isolated clients in other rooms in ways such that teams can communicate either via Web Chat or verbally.

Table 1: Subjective and Objective elements of SA and SSA

Team or individual SA issues	**Go*Team function or protocol**
Do members understand the team mission?	Pre-session briefings and experience
Do members understand their individual roles on the team?	Determined from post-session debriefs based on experience
Is information flowing into the team?	n/a
Is information flowing amongst members of the team?	The communication between team members is tracked and recorded
Are decisions being made by the team in a timely fashion?	Position and time of stones played by each team member are recorded
Are appropriate actions being taken by members of the team?	Scores of territory and stones captured
Does the team understanding of the situation, at any particular moment, conform to reality?	Comparison of confusion levels and marked positions
Is the mission being executed successfully?	Territory and stones captured.
Individual perception of elements	Marked position
Individual comprehension of current situation	Communication record
Individual projection of future status	Communication record
Individual stress	Relaxation Time
Individual overload, complexity	Number of players, richness of communication media

The screen on the server shows both the Server view of the Go*Team board in play and all team Chat windows. At the end of the game the Chat of each team for the session is saved into a text file and the view of the board on each of the client (player) screens is saved as a screen dump. This enables us to determine which stone is played by which player as well as providing a record of their set of markers. The researchers replay the Camtasia video and enter into a spreadsheet all stone plays, communication messages and marker placements, for each player, against the

elapsed time of the game. As will be described later in the paper this data is plotted against time to show the rhythm and tempo of each game session, giving a framework on which to interpret the qualitative data elements.

7.2 General Game Session Protocols

To date all sessions have taken place on one board between two teams of three or four each. Selected groups of players are invited to participate and assigned to teams in accord with the objective of the session or of a series of sessions. Demographic details of players are collected and players are give tests for personality traits and team role tendencies. With Go*Team, the basic rules are easily understood so that players quickly become quite competent at playing although becoming a master is extremely difficult. This means that after one game, novice players have very similar Go skills over a number of subsequent sessions.

Data is collected, as the game unfolds, on player moves, player markers, player communication, stone captures, using software. Player communication is also recorded for qualitative analysis. Levels of confusion are measured by players nominating a value between 1 and 10, every 5 minutes, during the game. Before and after each session players are asked questions pertaining to the constructs of interest. Before sessions, teams are given ten minutes to discuss team tactics. After sessions, all players are debriefed and this debrief is recorded and analysed. Where the same players participate in a series of sessions, as is the case in the study presented here, their learning is observed both as to their performance as well as to their ability to cooperate.

8 GO*TEAM SESSIONS OF THIS STUDY

The results reported here come from a set of 5 Go*Team game sessions played with essentially the same two teams of university staff and students. 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. 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. The settings for each game are listed in Table 2. The players' characteristics are summarised in Table 3. No player had any particular Go expertise.

Table 2 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 3 Relevant Players' Characteristics

B-1	Black Player 1 all games	M - student
B-2	Black Player 2 all games	M - staff
B-3	Black Player 3 all games	M - student
W-1	White Player 1 all games	M - student
W-2	White Player 2 all games	F- student
W-3	White Player 3 game 1 White Player 4 game 5	M- student
W-4	White Player 3 games 2-5	M- student

9 DATA ANALYSIS

The data collected from the series of 5 Go*Team games is summarised in Table 4.

Table 4 Session Data Summary

Game		1	2	3	4	5
White chat (number of messages)	All	223	143	176	162	345
	1	80	88	85	44	80
	2	52	53	47	66	49
	3		2	45	52	91
	4	92				125
Black chat (number of messages)	All	362	333	332	291	251
	1	88	100	100	76	64
	2	70	95	49	88	57
	3	205	139	184	127	130
White markers (average) (1=marker correct) (2= marker incorrect)	All	1.92	1.72	1.34	1.803	1.42
	1	1.97	2.16	1.7	2.18	1.49
	2	1.72	1.48	1.17	1.46	1.38
	3	2.06	1.52	1.15	1.77	1.44
	4					1.38
Black markers (average) (1=marker correct) (2= marker incorrect)	All	1.33	1.4	1.41	1.377	1.41
	1	1.29	1.33	1.44	1.41	1.39
	2	1.37	1.44	1.61	1.56	1.5
	3	1.33	1.42	1.18	1.16	1.33
White confusion (average) (1 = not confused) (10 = very confused)	All	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	5.23	5.92	6.23	6.31	5.69
	4					3.85
Black confusion (average) (1 = not confused) (10 = very confused)	All	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
White stones captured		9	19	23	17	26
Black stones captured		10	9	5	21	10
Winning Team Points		W 73	B 161	B 119	W120	B 110

The analysis begins with the game performance as shown in the last three rows of Table 4. In games 1 and 4 team performances were substantially even, while games 2, 3 and 5 were clear wins to the Black Team, both on territory and relative stones captured. The trend across the series of 5 games was as follows:

Game 1: 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.

Game 2 had the same players, board size 15x15 and settings as Game 1, except that W4 replaced W3 on the White Team. The White Team communication broke down technically at one stage. The Black Team won comfortably.

Game 3 had the same players as Game 2 but had a reduced (40 second) relaxation time and a larger 19x19 board. All 6 participants, playing for the second or third time, were now competent Go*Team players. The White team again lost communication with W3 for a while and this greatly hampered their efforts, being the main point in their de-brief. The unhindered Black Team became more strategic and performed well.

Game 4 had the same players as Game 3 but they were 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.

In 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.

In game 1 and to a certain extent game 2 players were on a learning curve with much chat and de-brief discussion about mechanics and aim of the game. In regard to Question 1 from Table 1 this meant that by game 3 the mission (purpose and objectives of Go*team) had become well understood by all players. In game 2 the chat became more task-oriented with the emergence of a leader in the Black Team. In regard to Question 2 from Table 1, the Black Team had developed defined team roles while the White Team did not appear to have distinct roles for each member.

The focus of the data analysis will now be on games 3-5 by which time all players had sufficient familiarity of the game so that lack of individual expertise would not cloud other aspects of SA. Teams had experience at working together and could plan moves and tactics at pre-game briefs. The whole game data (Table 4) plus during game analysis from our data is analysed against the following items from Table 1:

In regard to Information Flows, players received information from the game software board, timing and other feedback displays on screen. Information also flowed between team members in these sessions via the chat which can be evaluated objectively by number of messages or subjectively by analysing the chat content. Performance (and presumably SSA) degraded when there was a break-down of this communication (eg White Team in games 2 and 3) or when the time for communication (the relaxation time) was short, as in game 4 or in a larger team (White in game 5). It was noticeable that the communication of the more successful and more structured team (Black) became more tactical and strategic in games 3 and 5 while message from the White team became more factual (eg B at C3). It can be seen from Table 4, that the emergent leader of the Black Team (B3) consistently sent more messages and made more plays than others on his team. In the White Team there was no consistent pattern in this data.

An inspection of the Table 4 data with regard to Team Decision and Actions shows that in games 3 and 5 the Black Team captured most stones and rated best on team score while game 4 was even on stones captured with a winning, but low, score to the White Team. Team and player actions during the game can be seen in our data showing how the tempo of games unfold. For example, the White Team chart for game 4 shows alternative periods of poor marking (beginning, middle and end) with periods of more correct marking (flattened lines from all 3 players) just before they capture Black stones (the darker triangles). Such team performance patterns are discussed in relation to SSA in the remainder of this section of the paper.

Data in regard to SA Perception is measured by the confusion levels and can be judged against the correct positioning of markers. In games 3 and 5 the overall marker data for both teams are not significantly different even though the Black Team had decisive wins, while in game 4 the Black Team had a much lower (ie better) average marker score, 1.377 than White 1.803 when the White Team performed better. Supporting Venturino et al [3] the subjective measure, as overall average team confusion levels, did not show any significant difference between teams or games. However the changes in confusion levels during games do appear to have some significance as these tend to follow trends in decision and actions, decreasing as teams capture opponent stones and increasing when their own stones are captured.

Endeley's three levels of individual SA are best observed by following the various data during the game (marker placement, confusion levels, stone placements) for level 1 (perception of elements) and then comparing these with the content of the corresponding communication for levels 2 (comprehension of current situation) and 3 (projection of future status). While detailed results of this analysis are beyond the scope of this paper, we can say that the wealth of data collected to date indicates that this does provide a good indication of individual SA as it changes during the Go*Team games.

Influences on SA, particularly stress, were evident in this series of games. The increase in stress level induced by shortening the relaxation time in game 4 appeared to have a significant affect on communication and performance. This was not so evident at SA level 1 (perception of elements as seen in marker placements) but rather at SA levels 2 and 3 where the Black Team underperformed. Game 5 provided evidence of an increase in the level of complexity as the White Team had an extra player thereby increasing their communication load.

10 FINAL OBSERVATIONS AND CONCLUSION

A number of lessons have been learned from Go*Team simulations. Firstly, it was found that Go*Team offers, at relatively low cost, a realistic task-oriented team environment representing many of the features of a network-centric configuration. Work to date has shed light on factors such as information flows, communication support, stress and complexity that contribute to SSA and then in turn, on team dynamics, development and performance of task.

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 we had experienced Go players as participants. To date this has not been the case. 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.
As far as SSA is concerned the mode of communication is critical and these issues can be studied using the relatively poor medium of chat 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 SA levels, although the higher levels tend to degrade under stress as shown in game 4.

A major advantage of the Go*Team set up is that the unobtrusive collection of objective data during Go*Team sessions can be plotted and then compared with subjective impressions of the record team chat contents, possibly contributing to the understanding of SSA. This would be difficult to do elsewhere and has the potential to contribute significantly to the area, particularly in contrasting individual with team SA. As Go*Team sessions can be co-located or virtual it would be ideal to answer the following questions by [10]:

1. What differences exist in the process by which collocated and virtual teams develop SSA?
2. Is there a difference in the SSA developed by collocated and virtual teams?
3. Are there differences in the factors that foster or impede the development of SSA in collocated and virtual teams?
4. What techniques facilitate or impede the development of SSA in virtual teams?

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