WHAT INFLUENCES A DECISION?

David Daniel - HVR Consulting Services Ltd
John Holt - HVR Consulting Services Ltd
Graham Mathieson - Defence science and technology laboratory

INTRODUCTION

At the last ISMOR one of us (Graham Mathieson) presented a paper describing current research work looking at the relative effect of information (and other factors) on Command decision making. The study was building on earlier experimental work, including that of David Daniel. The common approach to these studies was the use of a simple wargame with a single decision, and a single (or at most, a pair) of players as decision–makers. The approach enabled experimental control of the variables of interest, not usually possible with more realistic study environments. The level of player involvement suggested sufficient realism to provide meaningful results.

During the earlier experimental study by David Daniel, John Holt joined the team as a Psychology student and has also been associated with contemporary work. As authors of work spanning 25 years, we thought that it might be enlightening to re-examine the continuing relevance or otherwise of the experimental gaming work to the contemporary scene.

THE PIONEER GAMES OF THE '70s

In 1979 Daniel completed and reported[1] the results of a series of highly controlled command decision experiments, or games as they are generally called in Operational Research. These games were inspired by those of another colleague, Sutcliffe (1971)[2]. Sutcliffe is cited by Bowen[3], as creating the first useful examples of OR games to provide quantitative data. Because there is no readily available record of these games it is worth summarising them in this paper because of their elegant simplicity. However, simplicity should not be confused with lack of realism since the games were later used as training aids. Creating realistic decision situations does not require elaborate infrastructure.

The Submarine Commander Game

In the Sutcliffe game a submarine commander is presented with the objective of identifying and closing a Naval Task Group within a background of other shipping in a series of scenarios. Current submarine captains played the game. Pre-prepared, time sequenced, information covering several classes of data thought to be relevant to this

[1]Daniel D W(1980) What Influences a Decision? Some Results from a Highly Controlled Defence Game, Omega Vol 8 No 4 pp 409 to 419.
[2] Rose RP and Sutcliffe PM (1971) Submarine Approach, A Game Technique for Target Recognition Decisions, DOAE Memorandum 7007, Submarine Approach, A Game Technique for Target Recognition Decisions, DOAE Memorandum 7008.
[3] Bowen KC (1978) Research Games, an OR Society monograph with contributions by Harris J I . Taylor and Francis, London, UK.

tactical decision are available. The submarine commander's task is to request information, at the cost of time for each addition, until he believes he has sufficient information to decide whether to break off his initial searching task and commit to close a contact. In the context of the diesel submarines of the day, committing to close on a contact (which may turn out to be harmless or a decoy) seriously degraded the ability to continue searching for contacts, and hence could impair the commander's ability to identify and close the intended target. The contact data are presented in a format identical to that used in real submarine operations and are therefore familiar to the players. The contact plots portrayed contained merchantmen and spurious transient contacts, as well as the Naval Task Group, though in one experiment the latter did not appear. The objective was to find out what information was critical to the submarine commanders' decisions to close on the intended target irrespective of whether this really was a target or something else. Contact bearing rate was found to be a critical piece of information. This, being a function of miss distance and closeness, is in effect a measure of the urgency of the need to make a decision, but its importance was not fully appreciated before the games were played.
Also of particular relevance to this paper is the observation that newly trained captains, who had recently taken up their first command, required little information to trigger a response (training emphasised the need to react quickly). Captains with about 6 months experience of command needed a lot more. But with increasing levels of experience the amount of information needed decayed until it reached a similar level to the newly trained captains. 152 games were played in all.

The Corps Commander Game

The Daniel games were played at a more strategic level of decision making. These games were played by single players fed with controlled levels of data determined by an experimental design in the context of a land battle in Central Europe. They were asked to play the role of Corps Commander and with the consequence that sufficient players with direct experience of the decision (i.e. at 2 Star level) could not readily be found. Players were all Army officers of at least the rank major with higher command potential. They were asked to decide when and where to deploy their reserves (approx 1/3rd of the total force available) in the face of an overwhelming armoured assault against prepared defensive positions. The player made one decision and the game was then terminated. Strenuous attempts were made to eliminate any possible learning effects between games. A combat model was used to generate the scenarios and the same model was used to evaluate, quantitatively, the quality of decision made.

The player sits at a table in a room which has suitable maps pinned to the wall, which simulates an Army HQ command cell. He is told that he is to play the role of a land force commander. His task is to decide when and where, within nominated boundaries, to deploy a reserve formation in such a way as to halt the enemy advance, or delay it for as long as possible, and to inflict the maximum casualties. As the game proceeds, the player is given data on the progress of the battle in the form of map overlays and written briefs. The written briefs simulate what, in reality, would be mostly oral Intelligence or Operations reports. They are written so that the experimenter knows that each player

receives exactly the same data. It is felt that oral briefs, though more realistic, are difficult to control and more liable to transmit nuances. All battlefield data were grouped into 4 categories; initial intelligence was one category then all data during the battle was divided into: data on Blue status, data on Red status derived from long range sensors and data on Red units in contact. Each category was played at either the maximum or minimum level considered militarily credible. This corresponds very approximately to 80% and 20% of a complete picture.

The results from the initial 18 games showed that the variation between players was very large compared to the variation within a single player. (This is illustrated on one of the presentation graphic). More data does lead to better decision quality but this effect is small compared to the difference between players. Changing one data set from 20% to 80% improved quality measures by about 10-15% except for initial intelligence which, although players were observed to spend little time considering it, had about twice this effect. A further set of 9 games showed that Players can substitute one type of data for another and still extract the same amount of information to improve decision making. Players who took longer to play the games made better quality decisions than faster players.

Improving a variety of game artificialities with a new set of players made no difference except in the following, remarkable, case. In the initial game a player was on his own whereas in reality a commander has staff to talk to. It was felt that this isolation could contribute towards the observation that players tended to be conservative in the range of options they reviewed and began favouring particular options rather early in the game. It was, therefore, decided to try playing players in pairs. The behavioural science literature of the day suggested that a hierarchical structure should be imposed on each pair at the beginning of the game series rather than let them sort out a way of working in committee. There is some evidence that unstructured committees may produce polarised behaviour which is either ultra-conservative or over-reckless. In any case, a hierarchy is more realistic. The Army List provides a clearly defined order of seniority for all Army officers. It is, therefore, an easy matter to choose the undisputed senior from any pair of players and give him ultimate responsibility for taking the decision in the game. The role of the subordinate player was left to the discretion of the senior player.

Playing players in pairs had a dramatic effect. 3 pairs of players played 3 games. In the first game each pair played they produced a result much better than single players, statistically significant at the 1% level (illustrated in another presentation graphic). However their second game was worse than their first and their third worse than their second. The chance of getting such a sequence of results randomly is 1 in 216. The evidence that paired players did better in their first game than single players, but that their performance dropped off steadily with each game played is conclusive. Tape recording, followed by classification, of the conversation between members of a pair and direct observation of their behavioural patterns indicated something else. Each pair produced a different working relationship, though each was of comparable effectiveness. But whatever relationship did develop, it did not appear to alter through the sequence of

games. This suggests that observations of the interactions between players may bear little relationship to the quality of decisions made and need to be treated carefully.

One way in which it may be possible to extract more information from each game, without it becoming interactive and therefore complicated and uncontrollable was also tested. In these games players were asked to say what decision they would have taken at various decision points in the game even though these decisions, unless they coincide with pre-determined scenario events, are not implemented; in other words to get the players to act as advisers rather than decision-taker. To make players take this advisory role seriously they knew that at some stage in each game they would change from being an advisor to take full responsibility for taking the decision. Statistical tests showed that the quality of advice given was the same as the quality of decision taken. However, the aggregate quality of decisions in these experiments was below average. The difference is not sufficiently large to be significant statistically but subjectively this group of players was not of below average ability. The conclusion one might draw from this is that players may perform differently if their role is even subtly changed. A total of 69 games were played over a period of 2½ years.

COMPARISONS WITH OTHER STUDIES

Other subsequent studies, all set in a maritime environment, using the same method of a single decision point game include:

1. Pickburn, Hallam, Reinmann and Davis (1990)[4]- ASW assessment

2. Davis and Reimann (1991)[5]- Task Force Cdr

3. Perry and Moffat (1994)[6] - Task Force Cdr

4. McCarthy, Mathieson, Osborn, Rugg-Gunn and Payne-(2001)[7] - RN Principle Warfare Officer (PWO)

5. Mathieson and Malish (2002)[8] - Extend PWO results.

Pickburn, Davis and Reimann

Of these the first two are the most similar to the Sutcliffe and Daniel games in that their primary aim was to investigate the influence of levels of data on quality of decision, one

[4] Pickburn GA, Hallam J, Reinmann PL, and Davis RN (1990) Command Decision Making an Investigation by Analytical Gaming, AOW/649/90.
[5] Davis RN and Reinmann PL (1991) The Single Decision Study, CPSE TM 91002.
[6] Perry W and Moffat J.(1997). Developing models of decision making. Journal of the Operational Research Society **48** pp 457-470.
[7] McCarthy RM, Mathieson GL, Osborn R, Rugg-Gunn M and Payne P (2001) The Impact of Information on Decision-Making. DERA/DSTL/WP00623/1.0
[8] Mathieson GL and Malish P (2002) The Impact Of Information On Decision Making - Further Analysis And Future Plans. Dstl/WP04154/1.0

game at a tactical level the other at a more strategic level. Experienced players were found to perform better given the same information but variations, again between 20% and 80%, had little effect.

Perry and Moffat

Perry and Moffat's aim was to try to establish, at a strategic level and using RN staff of an appropriately high rank, what class of information influenced command decision making. The study found that the information requested was not a predictor of the decision taken, all players overwhelmingly requested information on combatant forces. Information sets most requested consisted of order of battle, plans and operations, and combat effectiveness. Decisions taken most frequently did produce "good outcomes", but regardless of information requested, players decided between two specific courses of action. However, further analysis showed that internal influences, not captured in any examination of external information sets were dominant e.g. player's strategy aims. A total of 28 games were played.

Matheison at al

The McCarthy, Mathieson et al and Mathieson and Malish games were designed to address some of the questions arising from the historically earlier work, for example to test the hypothesis that course of action selection is not affected by changes to information, given that a minimal basic level is provided.

McCarthy and Mathieson did extend the basic logic of the underlying game structure by using correlation between information levels (and other experimental variables such as personality type) and course of action taken instead of measures of decision quality. They and others made progress in cognitive data gathering using questionnaires during or after a game and Perry and Moffat were able to tape record dialogue because they played players in pairs.

Review

Reviewing the Daniel game results with the rest, one finds a high degree of consistency but also some interesting developments. Large differences between players, compared to differences in information levels, are significant in all games. Sutcliffe and Pickburn find interesting correlations between decision quality and player experience. McCarthy and Mathieson, find that personality influences the course of action chosen but information influences the geospatial aspects of decision making (where to act). Prior intelligence is significant in two other games, but Sutcliffe concludes that his players were quick to reject incorrect prior intelligence if it conflicted with the real flow of tactical data. No one else has investigated the "pairs" effect or the conclusion from the "adviser" games that players may perform differently if their role is subtly changed. In one set of games Daniel fixed the pace at a slow rate, McCarthy and Mathieson controlled time in order to impose a degree of time stress.

The observation of greatest importance to emerge from this comparison is that behaviour has been consistently shown to be at least as important as information flows in terms of influencing a command decision.

RECENT GAMES

Recent games, by Mathieson and Malish (2002) are described in more detail. They incorporated ideas from US Psychologist, Gary Klein, that have been very influential[9]. Klein's model, referred to as "Recognition-Primed Decision-making" (RPD), is derived from initial work in the field with fire chiefs. He argues that expert decision-makers do not base their action on building up a complete picture of a situation that they analyse rationally. Rather, they match the patterns of cues and indicators based on their past experience. Recognition provides access to pre-learned response cues.

The study also made use of Endsley Situation Awareness (SA) levels to assess the possible linkage between situation awareness and Command behaviour[10]. Endsley describes three levels of SA as follows:

- Level 1 - *perception* of key elements in environment, which define the situation.
- Level 2 – *comprehension* of the current situation, combining level 1 events into a comprehensive holistic pattern.
- Level 3 – *projection* of the current situation into the future in an attempt to predict the evolution of the tactical situation.

Klein and Endsley ideas were combined to produce an approach to gaming. The aim of conducting an RPD game was to test decision-makers' predisposition to select courses of action using a snapshot judgment situation. By placing subjects under time pressure, and asking for subject's first reaction response, this was designed to elicit subjects' first response, hence obtain a pattern match. Because it was found that RPD game behaviour was a partial predictor of behaviour in the main game, where time pressures were lower, further analysis was done to explore the relationship between situation awareness and courses of action.

In the RPD game, subjects were briefed, given information updates, then asked:

- What is your action
- What is the situation
- What are the key indicators
- Having thought, do you wish to amend your action?

[9] Klein, GA (1989) Recognition-Primed Models Decisions, Advances in Man-Machine Systems Research Vol 5 p50/.
[10] Endsley, MR (1977) The role of Situation Awareness in Naturalistic Decision Making, in Naturalistic Decision Making, (Eds) Zsambok CE and Klein GA. Lawrence Erlbaum Associates, Mahwah New Jersey, USA

The key indicators were categorized using the Endsley SA levels. An ideal assessment for a game should show all three levels.

It was concluded that the feasibility of experimentally measuring relationships between command behaviour and aspects of situation awareness had been established. Comprehension of patterns of behaviour rather than individual entities dominated the key indicator set, whilst their situation descriptions contained a balance between patterns and projections of future events. Statistical analysis did not find any relationships between course of action and level of situation awareness in situation descriptions or key indicators identified.

A separate extension of the analysis previously carried out in the main game results confirmed that where PWOs acted (geo-spatially) was exclusively dominated by information, whereas how the acted was driven by personality.

In the future, a game is proposed to be developed in the Land area. Repertory Grids for in depth construct elicitation will enable hidden knowledge to be accessed in a different way.

CONCLUSIONS

The presentation highlights a number of observations and unanswered questions. A main observation is that the gaming approach is now a well established research tool, though wider use would be desirable. A further observation is that behavioural aspects of Command decision-making are at least as important as the information levels provided and require equal investigation. Of the unanswered questions, a key one is whether the development of systems should focus on having information systems that are designed to reflect the information that will actually be used by Command.