ENHANCING ARMY TRAINING AND EDUCATION WITH THE BRIGHT FOX SYSTEM

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***Abstract*—The Australian Army has identified a need to develop a cognitive edge over adversaries to maintain a competitive advantage. As part of Army's current modernisation efforts, it is seeking to enhance current training and education methods using new and innovative technologies. In particular there is a focus on enhancing individual decision making by teaching officers 'how' to think, not 'what' to think using digitised training systems. DST has partnered with Rheinmetall to develop a computer-based program called Bright Fox (BFOX) that attempts to analyse how individual commanders solve tactical problems. Using advanced qualitative data analytic methods, BFOX automatically generates a time-series trace (or cognitive profile) of an individual's thinking to allow a detailed and objective assessment of how they generated a tactical solution. In this paper we outline the BFOX concept, describe its current functionality and initial results from user testing with Army personnel. Recommendations are outlined for future research and development to help realise BFOX's potential as a training tool and assist Army to maintain a cognitive edge.**

Keywords—data analytics, decision-making, tactical training

I. INTRODUCTION

The Australian Army has identified a strategic requirement to develop a cognitive edge due to a "decline in technological advantage" over adversaries [1]. As a result, Army is seeking new and innovative ways to cognitively prepare (train and educate) personnel for future operations as part of current modernisation efforts [2]. More specifically, Army has articulated a requirement to enhance individual decision-making [2], develop digitised training systems to support cognitive development [3], and enhance critical thinking skills of junior leaders [4]. In 2014, the Army's Head of Modernisation and Strategic Planning articulated a need to identify the cognitive attributes of higher performing personnel and to use this information to develop computer-based training packages. These capability needs are likely to require Army to evolve current training and education practices to prepare personnel for future environments.

To help address Army's requirements, Defence Science and Technology (DST) has partnered with Rheinmetall to develop a new technology called Bright Fox (BFOX) that combines cognitive science methods and data analytics to capture and analyse commander decision-making when solving tactical problems. This paper describes the concept and current functionality of BFOX, as well as initial findings from user testing with Army personnel. The paper concludes with directions for future work to help realise BFOX's potential as a training and education tool for Army.

II. THE BRIGHT FOX CONCEPT

BFOX is a software program developed by DST and Rheinmetall to support research into tactical decision-making by combat team commanders. The need for BFOX grew out of efforts to better capture and analyse commanders' thinking during deliberate planning activities such as tactical exercises without troops (TEWT). This is a non-trivial endeavour due to the complexities of capturing human thinking. In the cognitive sciences, typical methods for capturing thinking include post-exercise interviews (which have a time impost and are subject to memory recall errors) and interrupting personnel mid-exercise to ask questions (which disrupts thinking). In the Australian Army, the Military Appreciation Process (MAP) is the doctrinal planning and decision-making tool. MAP workbooks are routinely used on training courses to support the process. These workbooks provide useful insights into a commander's appreciation but mostly capture outputs of individual thinking, not how an individual conducted their appreciation. Also, current methods for teaching tactics rely on (a) paper-based artefacts (e.g., maps, overlays, workbooks) which are less amenable to knowledge sharing than digital artefacts, and (b) qualified instructors assessing trainees' plans based on mostly subjective criteria.

BFOX was developed to address these issues by logging what individual decision-makers think about as they step through tactical problems – from the moment they receive their mission orders to the generation of their final plan. In addition, by using advanced data analytic methods, BFOX can provide a more objective assessment of how users solve a problem and then compare this with other trainees or data from past exercises to support learning. By capturing user inputs in digital format, BFOX can build a repository of how different users approached tactical problems, understood the situation, and surfaced a COA. This captures how users were thinking, over and above merely what their final output was. With sufficient appreciation data, this input can be used to support 'big data' analytics, attempting to find patterns that might have been otherwise unnoticed by an instructor.

Conceptually, the aim of BFOX is to identify and understand: (1) How different users solve different tactical problems (in terms of where they direct their cognitive efforts and in what order and amount), (2) What different users focus on within the tactical environment, and (3) How these cognitive attributes change as a function of the attributes of the tactical situation. From these data, it is predicted that: (1) different users will display different problem-solving characteristics, (2) different clusters of problem-solving style groups will emerge, and (3) a relationship will exist between these groups and higher or lower performance. This information can then be used to support tailored cognitive development of individuals. The goal being to accelerate expertise by accessing prior solutions from peer recognised ‘experts’ as a reference base; using experts to support cognitive training has been found to be effective [5]. From our assessment of the current literature, BFOX is a unique way of capturing thoughts and is well advanced on other approaches such as the US Army Think Like a Commander program [6].

III. Enhancing Tactical Training and Education

BFOX has the potential to enhance Army’s tactical training and education in several ways. Firstly, by capturing and analysing individual appreciations of tactical problems (e.g. TEWTs) and providing users with feedback on their problem-solving style, BFOX can support more tailored learning for individuals over their career. As previously mentioned, Army currently relies on experienced instructors and doctrinal tools to support training and education; such methods are highly subjective, applied differently by different individuals, and may overlook information that supports better learning outcomes. Secondly, by allowing individuals to access others’ thinking styles, BFOX can support peer learning. Currently, individual opportunities for peer learning occur in barracks on training courses via group exercises, observation and discussions. BFOX would provide individuals with a wider network of peers (and learning opportunities) over their career. Thirdly, by creating a repository of tactical scenarios and prior solutions that can be accessed anytime, BFOX can support Army organisational learning. Currently, TEWTs are conducted in classrooms using paper and pen methods (e.g., IMAP workbooks, printed maps with overlays) and the products are usually discarded after use thereby limiting knowledge sharing within Army. By advancing on these current approaches, BFOX can support improved training and education delivery.

IV. Current Functionality of BFOX

The current version of BFOX is a mature prototype consisting of a user interface and an analytical engine. These features, along with the data capture process used in BFOX, are briefly described in the following paragraphs.

User Interface. The user interface provides a digital environment for conducting tactical exercises such as TEWTs. Once users enter their details into the login screen (Figure 1) they can start using the program. Upon login, users are presented with the main user interface screen (Figure 2). From this screen users can access pre-loaded tactical scenarios with associated 2D maps, overlays, prior solutions, and terrain imagery from drop-down menus. The tactical scenarios are pre-loaded with mission orders, briefing materials, and orders of battle (ORBAT) for the friendly and enemy forces. Users can also import other imagery (e.g., satellite imagery) and maps to suit their needs, or draw their own tactical overlays using standard NATO 2525 symbology. BFOX is designed to be used on low-end machines with a keyboard and mouse. It is capable of being emailed as a small zip file so users can create and share their own scenarios and solutions with others. This also allows BFOX to be deployed to remote sites without IT support and promote ongoing data collection with many users.

Figure 1: BFOX Login Screen

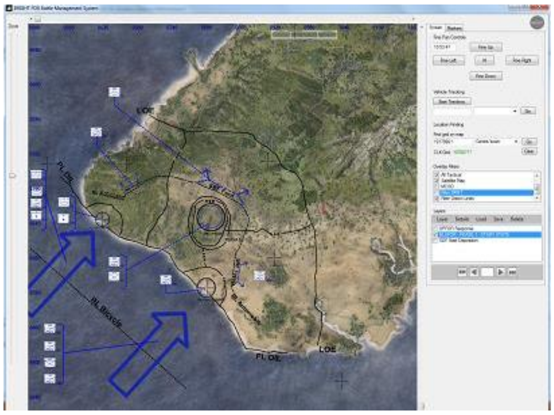

Figure 2: BFOX Main User Interface Screen

Data Capture and Appreciation Dialogue. Once the relevant scenarios have been loaded, and the user has read the mission orders, they can commence their appreciation of the problem and develop their COAs. This process is completed in the appreciation dialogue table (Figure 3). The BFOX interface for the appreciation dialogue has been designed and developed in conjunction with Army subject matter experts over several months to ensure ease-of-use and relevance for military users. The current interface has 9 pages that cover the scope of tactical problem-solving in the military context, namely:

(1) Analysing Objectives
(2) Analysing Resources/Boundaries of Action
(3) Opposition (or Opposing Factors)
(4) Projecting Future Events
(5) Developing COAs
(6) Making Decisions
(7) Identifying Situational Observations
(8) Noting Familiar Patterns, and
(9) Generating a final solution/Scheme of Manoeuvre.

Each page is presented as a tabular workbook with prompts for the user to consider as they complete their appreciation and generate a final solution.

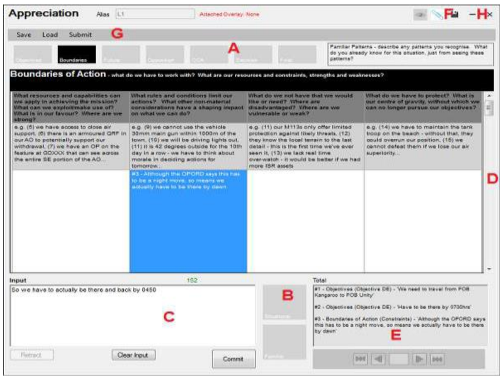

Figure 3: BFOX Appreciation Dialogue Screen

Data Analytics. BFOX also contains a prototype analytical engine to automatically analyse data inputs. BFOX analyses inputs based on which boxes they are entered into in the Appreciation Dialogue, and what they refer to with respect to the tactical problem (content analysis). The boxes in the Appreciation Dialogue are used as proxies for different cognitive problem-solving behaviours. Collectively, this gives insight into how users allocate and shift their cognitive effort over time as they work through the problem. Equally, the content analysis shows where users direct their attention within the 'environment' and what associations and conclusions they make over time. This total input is then mapped against a set of known/discovered patterns to generate a 'fingerprint' of how the user approached the problem, covering both 'cognitive space' (cognitive behaviours the user engaged in) and 'topic space' (elements in the environment the user focused on). These data are then partitioned by performance group, or other variables of interest, and statistically analysed to search for predictors and commonalities. Conceptually, the process is similar to biomedical analysis of genes. Data is collected, mapped to a genetic fingerprint, and then analysed based on expressed health or physical outcomes (for example, genes associated with longevity or certain types of diseases). This knowledge can then be used to develop treatments for improving outcomes or, in our case, tailored tactics training.

Cognitive Profile. The current profile automatically generated by BFOX provides a high level text summary of the user's problem-solving style, and a time-series trace of the cognitive behaviours (Figure 4). These cognitive behaviours, described in Table 1, were identified from an extensive review of the cognitive sciences literature. The profile can then be compared with others to see how they distributed their efforts and attention at given times. The outputs can then be discussed with instructors or peers to support learning.

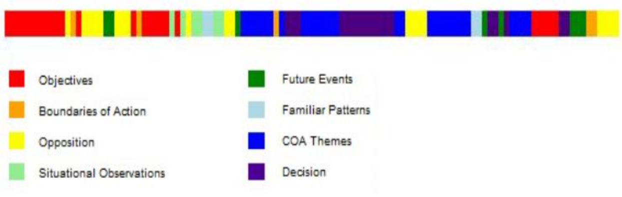

Figure 4: Example time-series trace of cognitive behaviours

TABLE 1: KEY COGNITIVE BEHAVIOURS ASSESSED IN BFOX

Cognitive Behaviour	**Description**
Analyse Objectives	User specifies an end-state or preferred set of conditions to be achieved at some point in the future
Detail Situation Past	User recalls a set of conditions that existed or might have existed in the past
Detail Situation Now	User makes a statement about conditions as they exist at time now
Detail Situation Future	User projects forward in time to discuss what might occur in the future
Analyse Resources & Constraints	User discusses what they have to work with or what they cannot do. This includes noting any boundaries of actions, limitations or requirements that will shape their future options
COA Generation	User is considering or describing a future action they will or might take including any relevant pre-requisites
COA Future	User is projecting forward in time to consider the outcomes of a course of action (COA) including possible enemy responses
COA Evaluation	User is evaluating the pros and cons of a possible COA
Decision	User is deciding between two or more options
Flag Unknown	User is identifying some unknown in the situation, a gap in knowledge, or an information requirement to resolve this gap
Meta-cognition	User is reviewing own problem-solving or asking a question
Switching	User is switching between different lines of enquiry during their appreciation process


Figure 5: Participant using BFOX on Surface Pro

V. PRELIMINARY OUTCOMES AND WAY FORWARD

To date, we have conducted BFOX user testing with a range of Army personnel of different ranks and experience levels. Preliminary feedback regarding BFOX usability and functionality from these personnel has been positive. The software has been stable and reliable and users report the interface to be easy and intuitive to use. Furthermore, initial analyses of a limited set of user solutions (to the same TEWT) also show promise, with differences between individual thinking styles and cognitive behaviours identified. We have recently collected BFOX data from a large sample of Army personnel and will provide detailed findings at the conference. Based on initial exposure, there has been enthusiastic support and buy-in from Army stakeholders for the BFOX concept. This has provided a strong foundation for future research and development efforts and realising BFOX's potential as a training and education tool. Possible areas for future research and development include:

- Exploring the concept of employment of BFOX in Army's training and education system, including how it will integrate with existing training methods.
- Building a library of TEWTs of varying difficulty that can be loaded into BFOX while preserving the integrity of TEWTs used on Army training and education courses.
- Collecting TEWT data from peer-recognised high performers to benchmark other users' against and inform data-driven personalised training.
- Exploring information technology solutions that support flexible use of BFOX by Army personnel including access to other user solutions on defence networks.
- Exploring and testing other implicit and non-invasive methods for capturing 'thinking' during problem-solving including interactive, game-based versions of BFOX with embedded metrics of cognitive behaviour.
- Integrating BFOX data analytics capability with other future training systems such as BMS-TEWT.
- Development of automated summary outputs that are instructor-suitable, learner-centric, and align with Army's current pedagogical methods.

VI. Conclusion

BFOX represents an innovative approach to modernising training and education and assisting Army to maintain a cognitive edge. By converging technology and cognitive science to gain more objective insights into individual thinking processes, BFOX has the potential to be a game-changer for Army. Initial results from user testing are promising and provide a foundation for further research and development activities. To help realise BFOX's potential DST and Rheinmetall are working with Army to explore how it can be integrated into training and education practices, and ensure it is underpinned by rigorous science.

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