Using immersive simulation to understand and develop warfighters' cognitive edge

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Abstract. The Australian Army recognises personnel need a "cognitive edge" over any adversary. To better understand cognitive performance of military personnel in current and future land operating environments and inform training requirements, we have created an immersive tactical team simulator representing possible elements of the future operating environment, including novel use of technologies by adversaries. The most recent study analysed behaviours of two military teams, each consisting of a three vehicle platoon. Examination of individual and team strategies identified the decision making approaches adopted by the individual teams in response to novel and unexpected threats in a high tempo situation.

Keywords. Cognitive edge**,** immersive simulation, autonomous systems

1. Introduction

The future land operating environment is expected to be crowded, connected, lethal, constrained and collective (Australian Army, 2014). Advances in information and communication technologies will mean our forces, adversaries and other actors will be highly interconnected. Military effectiveness is likely to be enhanced through increased uptake of autonomous systems. At the same time, the ability of adversaries to develop improvised weapons via dual use technologies may also increase. Unlike the Army, who will be hesitant to adopt systems they perceive as untrustworthy due to the risks involved (e.g., collateral damage), adversaries may not feel the same constraints.

Army personnel need to have a "cognitive edge" enabling them to outsmart a shrewd, intelligent, lethal, agile, adaptable and well-connected adversary that may have access to similar technologies as the Army, but may also not face the same constraints to their use. Several questions need answered to enable development of a cognitive edge program. For example: How can personnel be trained to counter novel use of extant and future technologies by an adversary? What skills are necessary to best exploit technologies? How will such technologies impact on current operating procedures? The Cognition and Behaviour capability within Defence Science Technology Group (DST Group) have begun to address such questions in conjunction with Army clients and industry and academic partners (see e.g., Carter, Thiele, & Wong, 2015; Fidock, 2015; Pomeroy, 2013; Temby, Fidock, Oostergo & Shillabeer, 2015).

To answer the question of how to generate a cognitive edge, some may be tempted to use brain training approaches to accelerate skill acquisition and/or enhance cognition, despite limited empirical support to date (Hambrick, 2014). Empirical support for game-based training approach is also limited in part due to the simulation environment lacking both cognitive and real-world fidelity, having a focus on basic skills, and use of research paradigms that do not adequately allow examination of agile and adaptive responding (Whitney, Temby & Stephens, 2013).

Although there are programs such as the United States "Think Like a Commander", skills taught in such programs are basic competencies expected of Army commanders[1]. What is needed is a means to train personnel so they have an advantage over competent and skilled adversaries. Associated with this is a necessity to identify the impact of new capabilities (e.g., digitised battlespace, computerised vehicles) on current operating procedures. The ability to maximise the effectiveness of new capabilities and to adapt and respond agilely to novel threats is likely to provide a cognitive edge through enabling personnel to better achieve their allocated mission objective(s) in highly contested environments.

Much existing training assessment within the Australian context is hampered through use of "correct" responses to pre-identified critical events, with "correctness" being assessed by subject matter experts[2]. However, the complex, lethal, adaptive, and uncertain nature of the military operational environment means problems are unlikely to have a singular optimal solution (Zweibelson, 2012). Decisions resulting in mission effectiveness are more likely to be based on naturalistic decision making (NDM) and sense making (Klein, 2008; Ntuem & Leedom, 2007), with the tacit knowledge used to refine behaviours coming from the opportunity to gain insights and expertise through making errors in a range of situations (Klein, 2015). In the military context decisions are often made in accordance with the Observe, Orient, Decide, Act (OODA) loop. Applied correctly, the OODA loop is an iterative process operating in time and space. Through use of sensemaking and feedback loops it "describes emergence, learning, and growth", accounts for simultaneous and sequential actions, and encompasses intuitive decision making (Tremblay, 2015).

Our focus on emergent behaviours, naturalistic decision making, and sense making, in conjunction with focused interviews based on cognitive task analysis, allows us to better understand how military personnel might adapt to novelty in the operational environment. To overcome some of the limitations of extant approaches and to build on prior empirical research, we have developed an immersive simulation capability that allows exploration of rapid decision making in the context of operationally indicative scenarios nested within a broader campaign. This capability also allows us to emulate some of the key characteristics of a digitised battlespace, emerging technologies, and novel use of technologies by a highly capable and agile adversary (Fidock, 2015), where "correct" responses are unlikely to be sufficient. The ability to dynamically monitor and review behaviour and performance allows provision of enhanced feedback to operators on their cognitive responses to challenging future scenarios, as well as more timely and targeted feedback to enhance cognitive capacities. To the best of our knowledge, although similar capabilities exist for Army training, comparable simulation environments are not being used for examination of Army adaptation to novelty and uncertainty in high tempo situations.

Although contributing key insights that can inform future training systems and approaches, the overall aim of our tactical team research program is not to train Army personnel. It is to (a) better understand factors impacting on team performance (human-human; human-system; and human-autonomous systems); and (b) to identify interventions that the Army trainers could use to enhance performance, especially decision making, of personnel when:

- in complex, lethal, high tempo, novel, and uncertain environments;
- using new or emerging technologies, including autonomous systems;

[1]MAJGEN Sengleman's comments during a briefing at Defence Science Technology Group Edinburgh supports this view
[2]MAJGEN Orme, SimTect Conference 2012

- faced with an adversary using technologies in novel and/or unconstrained ways.

Four main tenets underpin this research:

- the full potential of new capabilities can only be realised if the human operator(s) has the skills to use them to their full extent;
- military success when faced with unfamiliar situations depends on the ability of personnel to rapidly apply appropriate actions, whether through adaptation of existing responses or formulation of new ones;
- a better understanding is needed of the role trust in technology plays in effective uptake of new capabilities and/or factors impacting on effective human/autonomous systems teams;
- their repetitive procedural training means Army personnel are expert fighters in contexts consistent with prior training and experience and as such, use naturalistic decision making in similar highly time-constrained tactical situations.

2. Method

The research approach adopted for the tactical team research program is quasi-naturalistic. Trustworthiness (reliability) is being achieved through a multi-year program of studies that retain a core focus on examining tactical responses to time pressure, uncertainty and novelty and using a diverse range of tactical sub-units. Appropriateness (validity) is being achieved through use of realistic and operationally relevant immersive scenarios, as well as triangulation of observational, perceptual and behavioural data and employing an analytic approach that seeks to identify confirming and disconfirming evidence[3].

Our most recent study investigated how a course of action (COA) is synthesised within a team acting in a novel, uncertain and high tempo environment. Personnel from 7th Battalion, The Royal Australian Regiment (7RAR) (1 Lieutenant; 2 Lance-Corporals; 11 Privates) were allocated to two military teams, each consisting of a three vehicle mechanized infantry platoon. Due to personnel and simulator constraints, no dismounted infantry were represented in this study. The Lieutenant took the role of Platoon Commander for one team and a Lance Corporal with relevant recent deployment experience commanded the other team. Each vehicle represented a driving node in which personnel sat in motion-enabled chairs, and drivers had a steering wheel and pedal controls. In some scenarios the Platoon Commanders also had access to a simulated touch screen Battle Management System (BMS) and a paper map.

Scenarios were generated using the military version of Virtual Battlespace 2 (VBS2) and were set in the context of Australian M113-AS4 armoured personnel carrier platoons operating as part of a joint US-Australian intervention in the Asia-Pacific region. These scenarios were deliberately designed to maximise novelty, uncertainty, and time-pressures. Participants were engaged in six, two hour missions that were part of a larger unfolding operation in the fictitious island of Sahrani. The overall study lasted for 10 days.

Prior to commencing a mission, experienced Army Majors embedded within DST Group provided briefs similar to what would occur during deployment (e.g., Commanding Officer, intelligence, logistics). These Majors also conducted After

[3] see Golafshani, 2003; and Leung, 2015 for discussions on reliability and validity in qualitative research

Action Reviews (AARs) at the end of each scenario. Across the missions personnel were exposed to an intelligent and agile adversary using a range of techniques, including novel fully autonomous platforms armed with improvised explosive devices (IEDs) to examine how military participants adapted their behaviours to allow them to potentially counter these devices and continue with their mission.

For example, during a mission requiring a hospital resupply, participants encountered Sahrani Army fighters, insurgents, and were attacked by capabilities that were not identified during mission briefs as likely to be present (e.g., a conventional armoured tank and fully autonomous platforms). One of these platforms was an unmanned rotor-coptor (Fly-ED) that autonomously patrolled the road network on search and destroy missions, and attempted to attack the vehicles with an explosively formed penetrator. The other was an unmanned autonomous ground system (gun-bot). These autonomous platforms were also resistant to conventional electronic countermeasures and electromagnetic pulse directed energy weapons.

Behaviour (e.g., changes from standard operating procedures to new COAs) and verbal responses (e.g. communication content) of the teams were captured by audio and video feeds, with video footage also capturing the driver's view of the screen (emulating the view that would be seen from the driver's window of the armoured personnel carrier). VBS2 also recorded behavioural responses. The military led AARs were complemented by targeted focus groups based on cognitive task analysis (CTA) and led by the researchers.

A COA analysis was undertaken involving detailed examination of the sequence of actions manifested with events of particular relevance by drawing on the behavioural and audiovisual data. Thematic analysis was also undertaken on triangulated data from the AARs and interviews to assist in understanding the influences on the courses of action.

3. Results

This study identified several key themes.

i. How the military personnel adapted: Although aware the Army valued adaptation and many had operational experience, participants' initial response to novelty suggested this necessary behaviour had not been internalised during their Army training or operational experience. However, during the course of the study personnel came to realise that adversaries might also innovate. This realisation changed their perspective with respect to the way they responded to novel events within the scenarios. One Commander also reported he was using his new knowledge to interpret news events in different ways. Consistent with NDM and the OODA loop, these findings highlight the importance of repeated direct experience with novel situations for developing an adaptive response. Participants also identified this during the AARs: "Current regimental drills are not adapted/flexible enough to adjust to the current battlespace".

ii. How personnel approached novelty and uncertainty: Participants abstracted novel technologies and events to their own previous experiences (e.g., "we're being attacked by an unknown entity, but the rounds are not penetrating the hull, so we should push through, given that the entity is apparently not a threat to either the vehicle or the mission"). This behaviour often resulted in complex behaviour patterns due to the dynamic and complex nature of the environment. In some instances participants were able to identify the impact of their actions, resulting in changed behaviours in similar situations.

iii. Potential means of improving adaptation on the fly: Despite incorrect schema sometimes being used, their previous experience did allow personnel to find a means of dealing with novelty.

The key challenge is to ensure military personnel have a sufficiently large repertoire of representative schema that they can draw upon when faced with uncertainty and novelty.

iv. Issues in identifying and describing novel threats: Participants described novel threats and objects in extant terms (e.g., the gun-bots were called “technicals[4]” and the Fly-Ed an “IED”). Although this reflected the similarity of the novel threats to current ones, it led to confusion about the enemy weapons systems present in the area of operations as personnel receiving communications about “technicals” and “IEDs” were looking for conventional forms of these and unprepared for the novel technologies they encountered.

v. The importance of cultural training: The disbelief displayed by the participants on encountering a savvy adversary underscores the need for sound cultural awareness training in the military. It is important that cultural training identifies that the adversary can be clever and innovative as well as behave in unexpected ways due to different legal, political and social constraints.

vi. Low cost simulations have benefits for exploring behaviour in a complex, uncertain, and dynamic tactical battlespace: This simulation used medium fidelity three-degrees of freedom motion seats and a basic VBS2 simulation environment. Nonetheless, the military personnel were clearly immersed in the scenarios, especially when the relevance and purpose of the study was made clear to them. The realistic nature of the briefs and fictitious operating environment also played a key role in this level of immersion.

4. Conclusion

The aim of this study was to identify how a team’s course of action unfolded when faced with novelty, uncertainty and time pressure. Although critical thinking was demonstrated via communication between vehicle crew, this largely reflected an incomplete understanding of the situation due to (a) an insufficiently large repertoire of relevant schema; (b) failure to correctly describe novel threats; and (c) disbelief at facing a savvy and technologically capable adversary. Participants initially tried to treat novel threats as conventional IEDs. Consistent with principles of NDM and the OODA loop, participants gradually adapted their procedures resulting in new courses of action. This study demonstrated: the value of immersive, operationally relevant scenarios for examining the way in which decision making and courses of action in response to novel threats unfold over time; and the potential value of such an approach for enhancing cognition and hence providing the cognitive edge. Another key finding of this study is the importance of cultural training being extended to include the concept that asymmetrical adversaries are just as likely to be shrewd and competent warfighters with the capabilities to exploit technologies in novel ways to achieve tactical surprise and potential overmatch.

A follow up study is planned involving tactical teams with analysis of individual, team and organisational influences on performance. Future studies will also include

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[4] The military participants used the word “technical” to describe a utility truck with a weapon rigged onto the back.

scenarios designed to generate failure so we can observe how teams learn and adapt (human-human, human-system, and/or human-autonomous system). The realism of the simulation environment will be further improved through increasing the civilian complexity of scenarios to more faithfully reflect an urban operating environment (e.g., crowds, traffic densities, moving civilians, housing density). Increased realism will also be obtained through red teaming with unconventional weapon systems and behaviours. The value of a fully immersive virtual and augmented reality environment that represents the tactical battlespace (e.g., opponents, technology) is also being explored.

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