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INFORMATION OVERLOAD: A WARFIGHTER'S CHALLENGE

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INTRODUCTION

According to Statista, there are currently 3.5 billion smartphone users in the world, which equates to 45.04 percent of the world's population. In 2016, that number was only 2.5 billion users, 33.58 percent of the world's population then.[1] Humans are increasingly more connected to the internet, whether it is at home, school or the office, it is an integral part of human lives. In turn, this accessibility has ultimately changed the way humans are communicating and collaborating. To interact with family members, friends and colleagues, there is a multitude of social media applications that can be used. These applications allow for texting, sending photos and video calls directly from a smartphone. In the workplace, many companies provide mobile devices to their employees, allowing them to collaborate and be connected twenty-four hours a day, seven days a week. However, the benefit of being connected comes to the detriment of distraction and cognitive load to everyday lives. The reality of this very much applies to today's warfighter.

The current contemporary operating environment (COE) is complex. Conflicts are now fought in five different domains, air, land, sea, cyber, and space. The addition of cyber and space as domains has made the concept of war more complicated, and these new domains are not as well understood. Today's warfighters need situational awareness (SA) of all five domains to make the right decision and achieve their missions. Warfighters have mobile battle management systems (BMS) to provide, at the lowest levels, the required SA and improve decision-making. These BMS have various functions such as sending and receiving digital orders, target

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[1]Statista, *Smartphone Users Worldwide 2020*, Last accessed 6 May 2020, https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide/; Bankmycell.com, *How Many Smartphones Are In The World?* Last accessed 6 May 2020, https://www.bankmycell.com/blog/how-many-phones-are-in-the-world.

information and tracking friendly positions with limited voice interactions. While these functions enable warfighters, are these systems too much for the warfighter? How do the ever-increasing and ever-changing information affect one's ability and effectiveness on the battlefield?

This paper will demonstrate that warfighters, although cognitively limited, can operate effectively in the current and the future COE with the appropriate systems and adapted training.

This paper has five sections. First, this paper will discuss how the current COE has changed with the advancement of technology and the requirement to push more information across the battlefield. The second section will focus on the effects of multitasking on the warfighter. The third section will then focus on the impact of sleep loss by demonstrating the warfighter's requirement to be psychologically ready to face the challenge of the current COE. The fourth section concentrates on training to increase success on the battlefield, and it will finish by discussing if artificial intelligence can assist the warfighter in alleviating cognitive load.

INFORMATION TO THE WARFIGHTER NEED TO SUPPORT DECISIONS

More information doesn't always improve decision-making; in fact, it can undermine it.

— Judith H. Hibbard and Ellen Peters[2]

Armed forces have utilized "technological advances and new equipment to provide more data and more information to the [warfighters]."[3] This advancement of technology has enabled systems such as the Android Tactical Assault Kit (ATAK)[4] to provide warfighters with a digitized battlefield in the palm of their hands. Whether it be on land, sea or air, warfighters currently have high-resolution map data and can acquire, exchange and employ timely

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[2]Judith H. Hibbard and Ellen Peters, "Supporting Informed Consumer Health Care Decisions: Data Presentation Approaches that Facilitate the use of Information in Choice," *Annual Review of Public Health* 24, (2003): 416.

[3]NeuroTracker, *Why Cognitive Enhancement Training Is Set to Transform Military Performance,* Last accessed 6 May 2020, https://neurotracker.net/2019/08/19/why-cognitive-enhancement-training-is-set-to-transform-military-performance/.

[4]ATAKMap.com, *Android Tactical Assault Kit*, Last accessed 6 May 2020, https://atakmap.com/p_about.aspx.

information to plan and execute their missions. Conflicts today are against adversaries who have

adapted guerrilla tactics, which forced armed forces to adopt a more decentralized execution

approach to deter such adversary.[5] For a decentralized execution approach to be successful,

information needs to be distributed across the battlefield to enable decision-making at the lowest

level. This approach relies heavily on the ability of "sensors and warfighters to push … [and]

pull information from centralized sources."[6] Now more than ever, warfighters are expected "to

perform at new levels of performance"[7] because they have access to much more information than

their predecessors. The significant risk facing the warfighters is the overwhelming amount of

data pushed to them. It will ultimately impact their cognitive load, therefore potentially affecting

their ability to make quick, informed decisions when required.

It is crucial to understand the impacts of overloading our warfighters with information.

When surged with data, warfighters could be unable to make decisions, make errors and even

miss out on critical elements that could have impacts on the success of military operations. The

New York Times has reported an example of the fatal consequences of information overload in

the conduct of a military operation on January 16, 2011. In February 2010, a drone airstrike

incident left 23 Afghan civilians dead. To properly advise the ground troops, the drone team had

to monitor video feeds coming from the drones, exchange and participate in dozens of instant-

message groups as well as listening to radio communications. In their state of information

overload, the team overlooked reports identifying civilians in the crowd and identified the

convoy as a threat leading to the airstrike.[8] This example illustrates a real-life scenario where

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[5]From the concept of pushing power to the edge. Michael Rouleau (Lieutenant-General), Commander Canadian Joint Operations Command, '*How We Fight': Commander CJOC's Thoughts*, Memorandum, 10 February 2019.

[6]Linda R. Elliott and Elizabeth S. Redden, "Reducing Workload: A Multisensory Approach," in *Designing Soldier Systems: Current Issues in Human Factors*, 1st ed, Burlington, VT: Ashgate Pub. Co., (2012): 69.

[7]*Ibid*.

[8]The New York Times, *In New Military, Data Overload Can Be Deadly*, Last accessed 6 May 2020, https://www.nytimes.com/2011/01/17/technology/17brain.html

warfighters were impacted not only by an overload of information but cognitively as well. The situation will only worsen with time, the amount of data will only increase as new sensors become available to the warfighters, so what can be done, now, to mitigate the cognitive burden on our warfighters?

While many system designers are fielding systems to help warfighters, many may not understand their system is creating an information overload problem. Woods *et al*. characterized information overload into three categories. The first being a clutter problem – there is too much information; the second is referred to as a workload bottleneck – too much information to process in the time available; and, the third is finding the significance of data – what information is essential.[9] As system designers look at potential solutions, they need to understand these three categories as solutions might differ in each. In the first category, the clutter problem, solutions may include filtering the information being sent to the warfighter. However, only transmitting the critical data may affect overall situational awareness, which also raises the point of who decides what data gets sent? In the second category, solutions could be to improve the display of information to enable a quicker decision. Lastly, for the third category, a possible solution could be alerts and alarms to "direct attention away from a highly demanding task to one that is more important, or to help … recall forgotten information,"[10] but this can bring forth its own set of problems as well.

Many, if not all, applications use a variety of alerts, notifications and alarms to engage with users. It is a marketing tool to guide users towards the application.[11] Microsoft Outlook uses

[9]David D. Woods *et al*, "Can we Ever Escape from Data Overload? A Cognitive Systems Diagnosis," *Proceedings of the Human Factors and Ergonomics Society 43rd Annual Meeting*, (1999): 174.

[10]Lobna Chérif *et al*, "Multitasking in the Military: Cognitive Consequences and Potential Solutions," *Applied Cognitive Psychology* 32, no. 4 (July 2018): 433.

[11]Balboni, Katryna. "The dos and don'ts of in-app notifications." *Appcues.com*. Last accessed 6 May 2020. https://www.appcues.com/blog/in-app-notifications.

sound and visual representations when receiving a new email, while smartphone applications use a red bubble with a number to represent new notifications. While the term 'guiding' users' attention is used in the marketing world, it can be argued it is a more respectful way to say, 'distracting' users' attention. In some cases, the addition of alerts, notifications and alarms can ironically add to cognitive load.[12] If too much information is displayed, it then becomes a clutter problem.

While many solutions are focused on audio and visual displays, some research found practical applications for tactile displays. Tactile displays are displays that use the skin as an information channel. From the vibrating function on smartphones to a vibrating tactical torso display vest for pilots,[13] tactile and multisensory systems, in general, may bring solutions to offload the cognitive load from the warfighters. "Still, while many tactile displays have been found effective, it is not difficult to imagine a tactile display that is counterintuitive," producing more distractions to the warfighter.

System designers need to be aware of the potential impact and cognitive load their systems can have on the warfighter. Currently, warfighters get bombarded with a massive amount of information, which will only increase in the future. As outlined in the U.S. Joint Vision 2020, information superiority is advantageous only if it ultimately translates into decision superiority."[14] Finally, technological systems must not only influence but enable warfighters' decision-making. For this to happen, the system designers, with the help and guidance from the warfighters themselves, need to conduct extensive trials and experiments with their systems.

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[12]Lobna Chérif *et al*, "Multitasking in the Military: Cognitive Consequences and Potential Solutions," *Applied Cognitive Psychology* 32, no. 4 (July 2018): 433.
[13]TNO, *Tactical Torso Display*, Last accessed 6 May 2020, https://www.tno.nl/media/9513/tactile_torso_display.pdf.
[14]United States, Joint Chiefs of Staff, *Joint Vision 2020*, Washington, DC: Joint Chiefs of Staff, 2000, 8.

These trials will allow the warfighters to choose which solution to implement and for the system designers to see if their systems are genuinely helping the warfighters.

MULTITASKING EFFECTIVELY

It was mentioned in the introduction that a little over 45 percent of the world's population has a smartphone today. This increased presence of technology is significantly changing and affecting many aspects of human lives, including the management of daily tasks.[15] These days, tasks come in a multitude of ways. It can be from text messages, emails and private messages via many different social media platforms to the 'old school' form of a simple voice message. To add to this demanding environment, many people also have another smartphone for their workplace to include access to their work emails. For these people, the number of ways they can receive tasks has now multiplied.

Some say "one benefit of accessible technologies … is our ability to … multitask."[16] The Oxford dictionary defines multitasking as the "ability to deal with more than one task at the same time."[17] Multitasking in everyday life can be viewed as the parent who is dealing with three kids while cooking dinner, or the employee who is editing a document while attending a teleconference. Ultimately, it is doing multiple things simultaneously. Multitasking behaviour is often seen as a great ability to have, and many individuals are proud to proclaim they can multitask, effectively juggling numerous activities at the same time.[18] The analogy of comparing multitasking to a juggler describes what the brain is precisely doing when humans multitask. As described by Earl Miller, a cognitive neuroscientist at Massachusetts Institute of Technology

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[15]Lobna Chérif *et al*, "Multitasking in the Military: Cognitive Consequences and Potential Solutions," *Applied Cognitive Psychology* 32, no. 4 (July 2018): 429.
[16]*Ibid.*
[17]Lexico, *Multitasking*, Last accessed 6 May 2020, https://www.lexico.com/definition/multitasking
[18]Jack Krupansky, *Complexity and Cognitive Overload Are Not Your Friends*, Medium, Last accessed 6 May 2020, https://medium.com/@jackkrupansky/complexity-and-cognitive-overload-are-not-your-friends-3cf6e72f667f.

(MIT) and one of the world's experts on divided attention, "when people think they are multitasking, they are actually just switching from one task to another very rapidly,"[19] hence the juggling act referred to earlier. Earl even adds the "brains are not wired to multitasks, … and every time [individuals multitask], there [is] a cognitive cost in doing so."[20] That statement begs the question, are individuals efficient when they are managing many tasks at once? And to add to this, what is the cognitive effect on their overall performance?

Individuals who multitask think they are getting a lot of things done, although "ironically, multitasking makes [them] demonstrably less efficient."[21] Many researchers conclude that "because the involved tasks compete for our attention, multitasking typically results in a decline in each task's performance."[22] The brain quickly pings "from one task to another … [and the pinging is what] drains your brain of energy and quickly leads to temporary declines in cognitive function."[23] The decline in performance while trying to manage several tasks at once is not foreign to pilots. In fact, "[b]etween 1987 and 2001, there [was] … 27 major [United States] airline accidents in which crew error was found to be a causal factor, with most of them linked to experiences of cognitive overload."[24] It is also documented in airline accident reports, "many mistakes are more likely to happen when pilots try to manage or monitor several tasks at the same time."[25] This airline example can also be used to show similarity on how a warfighter, in

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[19]Daniel J. Levitin, *Why the Modern World Is Bad for Your Brain,* The Guardian, Last accessed 6 May 2020, https://www.theguardian.com/science/2015/jan/18/modern-world-bad-for-brain-daniel-j-levitin-organized-mind-information-overload.

[20]*Ibid*.

[21]*Ibid*.

[22]Lobna Chérif *et al*, "Multitasking in the Military: Cognitive Consequences and Potential Solutions," *Applied Cognitive Psychology* 32, no. 4 (July 2018): 429.

[23]Wanda Thibodeaux, *Too Much on Your Plate? Here's How to Avoid Cognitive Overload*, Inc.com, Last accessed 6 May 2020, https://www.inc.com/wanda-thibodeaux/why-youre-probably-suffering-from-cognitive-overload-but-dont-have-to.html.

[24]Lobna Chérif *et al*, "Multitasking in the Military: Cognitive Consequences and Potential Solutions," *Applied Cognitive Psychology* 32, no. 4 (July 2018): 431.

[25]*Ibid*.

combat operations, can find themselves under persistent threats of attack while managing complex and dynamic information all at once. "When a threat is detected, … warfighters must orient their attention to the new situation and may forget previous … information."[26] The frequent interruptions' effect on the warfighters' cognitive load is as significant as the distracted pilot because it can lead to the warfighters given wrong information to team members, missing visible information about the environment or engaging in inappropriate actions incurring unnecessary risks.[27] All warfighters will inevitably face situations where they need to multitask, which will affect their cognitive load. Warfighters need to be prepared to multitask to achieve mission success. What are the mitigating factors to enable the warfighter to perform and handle the cognitive load of dealing with several tasks then?

Overcoming cognitive overload can be done by increasing the use of checklists. The use of lists enables the warfighter's cognitive function not to be taxed with remembering all components of every task.[28] A great example to convey this point is the close air support (CAS) function in ATAK. Joint Terminal Attack Controller (JTAC) can, with only a few manual actions on the ATAK digital map, demand CAS with minimal voice communications with the aircraft. The ATAK digital CAS function is efficient, saving communications time to send the details over the radio. The process which took minutes to complete is now taking seconds.[29] Although many reports and returns (R&R) in the military could be standardized and digitized, it is not entirely possible because many R&R are not standardized across multiple nations, causing interoperability problems when they operate in a multinational operation. Nevertheless, there are

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[26]Lobna Chérif *et al*, "Multitasking in the Military: Cognitive Consequences and Potential Solutions," *Applied Cognitive Psychology* 32, no. 4 (July 2018): 432.

[27]*Ibid*.

[28]*Ibid*.

[29]Breaking Defense, *Close Air Support Timeline Cut; Wait For Tech Was Too Long*, Last accessed 6 May 2020, https://breakingdefense.com/2019/05/close-air-support-slashed-to-seconds-wait-for-tech-was-too-long/.

many examples of digitized processes currently being used by the military to effectively increase

its use where appropriate and therefore reduce the cognitive load from the warfighter.

Another solution to overcome cognitive overload is the use of alerts and alarms.[30]

Automated alerts can remind warfighters of forgotten tasks, and the use of alarms can be for a

significant event requiring swift actions, helping warfighters to manage their workload better.

But, as described earlier, even if such a solution "can reduce workload, … [alerts and alarms]

can sometimes compromise performance when the level of automaticity is too high, … the

intrusiveness is too high, or they are simply not appropriate for multitasking context."[31] The

management of alert and alarm interruptions becomes a challenge in itself. Warfighters can

easily suffer from memory failure, ineffective prioritization and overall reduced effectiveness.

"At some point, even experienced and expert operators will become overwhelmed."[32] Arguably,

alerts and alarms are still required, such in the case of critical malfunctioning of an aircraft; the

point is to have an excellent balance to avoid overwhelming the warfighters.

Although warfighter's performance decreases under a multitasking situation, it does not

mean warfighters cannot perform at all. "Every individual has some capacity for cognitive

[load], including thinking, planning, reacting, and responding to input from the real world."[33]

Under stressful combat operations, the performance of the warfighters differs significantly.

While many perform remarkably under stressful combat operations, others do not. A study from

Morris *et al.* found cognitive skills can be assessed during personnel selection, and these tests are

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[30]Lobna Chérif *et al*, "Multitasking in the Military: Cognitive Consequences and Potential Solutions," *Applied Cognitive Psychology* 32, no. 4 (July 2018): 433.

[31]*Ibid.*, 436.

[32]Linda R. Elliott and Elizabeth S. Redden, "Reducing Workload: A Multisensory Approach," In *Designing Soldier Systems: Current Issues in Human Factors*, 1st ed, Burlington, VT: Ashgate Pub. Co. (2012): 73.

[33]Jack Krupansky, *Complexity and Cognitive Overload Are Not Your Friends*, Medium, Last accessed 6 May 2020, https://medium.com/@jackkrupansky/complexity-and-cognitive-overload-are-not-your-friends-3cf6e72f667f.

valid predictors of job performance.[34] These types of assessments are "already being used to select air traffic controllers and pilots … [to] evaluate [their] multitasking abilities."[35]

Considering the environment in which warfighters conduct operations today and how they potentially will in the future, there is significant value in seeking out specific types of individuals. These individuals would need to possess a more exceptional ability to perform under stressful situations as well as have a higher cognitive capacity. Recruiting individuals that have a better ability to multitask would ensure their performance would be less affected in environments involving complex tasks.

WARFIGHTER READINESS AND IMPACTS OF SLEEP LOSS

Physical fitness has always been a significant aspect of the military environment. From initial recruitment and recruit training to specialty qualifications such as basic parachuting and combat diver, physical fitness tests are critical steps in successfully passing the training. In the Canadian Armed Forces, physical fitness tests are required for deployment eligibility as well as substantive promotion.[36] It is undeniably a significant aspect of a warfighter's ability to cope with military operation's harsh conditions. "Physical exercise improves musculoskeletal, … cardiovascular fitness … [as well as] psychological resilience, including mood, cognition, and pain thresholds."[37] Some research suggests warfighters' "physiology underpins all [warfighters] performance … [e]ven psychological performance."[38] To support this argument, Hilde K. Teien

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[34]S.B. Morris *et al*, "A meta-analysis of the relationship between individual assessments and job performance," *Journal of Applied Psychology* 100, no. 1 (2015), 6.

[35]Lobna Chérif *et al*, "Multitasking in the Military: Cognitive Consequences and Potential Solutions," *Applied Cognitive Psychology* 32, no. 4 (July 2018): 433.

[36]Government of Canada. National Defence. *Defence Administration Order and Directive 5023-2, Physical Fitness Program*. Last accessed 6 May 2020. https://www.canada.ca/en/department-national-defence/corporate/policies-standards/defence-administrative-orders-directives/5000-series/5023/5023-2-physical-fitness-program.html

[37]Bradley C. Nindl *et al*, "Perspectives on Resilience for Military Readiness and Preparedness: Report of an International Military Physiology Roundtable," *Journal of Science and Medicine in Sport* 21, no. 11 (2018): 1117.

[38]*Ibid*.

from the Norwegian Defense Research Establishment explains the extreme conditions under

which personnel attending Norwegian Ranger School have to perform. Candidates have to

perform nonstop for one week with no organized sleep and limited or no food.[39] Under these

conditions, Teien states physiological resilience is the main factor for success.

Some argue that psychological resilience is essential for modern military operations.

Warfighters who are psychologically resilient, not only cope better with the psychological

stressors of combat operations, but with the physiological stressors as well. Psychologically

resiliency will help warfighters at performing physically as well as cognitively during stressful

combat operations.[40] Warfighters are experiencing demands never before seen by their

predecessors. The expectations regarding the use of soldier system technologies, the processing

of information being sent to them, while so being accountable for their decisions are at an

unprecedented level.[41] As explained by Lindsay and Dyche, "[t]hese changing expectations

regarding information processing have virtually transformed the … [warfighter] into a cognitive

platform."[42] They later add, "[w]hile this platform is certainly the most capable the world has

ever seen, there are factors which limit this platform's warfighting capability."[43] Affecting the

warfighters' psychological resilience are factors such as nutritional and caloric deficiencies,

dehydration, psychological stressors, carrying excessive loads, hypothermia, and lastly, sleep

disturbance.[44] While many of these factors have been researched thoroughly,[45] Lindsay and

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[39]Bradley C. Nindl *et al*, "Perspectives on Resilience for Military Readiness and Preparedness: Report of an International Military Physiology Roundtable," *Journal of Science and Medicine in Sport* 21, no. 11 (2018): 1117.

[40]*Ibid*., 1118.

[41]Douglas R. Lindsay and Jeff Dyche, "Sleep Disturbance Implications for Modern Military Operations," *Journal of Human Performance in Extreme Environments*: Vol 10, Issue 1, Article 2, (October 11, 2012), 1.

[42]*Ibid.*

[43]*Ibid*.

[44]*Ibid*.

[45]*Ibid*.

Dyche shed some light on the significant effect of sleep loss and sleep disturbance on the warfighter, ultimately impacting their psychological resilience.

Insufficient sleep is associated with a range of health problems such as obesity, cardiovascular disease, injuries and others.[46] While these health problems are known, statistics released in 2017 demonstrated that Canadians aged from 18 to 64 averaged 7.12 hours of sleep per night with one third having less than the recommended 7 to 9 hours of sleep.[47] Sleep often receive relative attention as a component of a healthy lifestyle, and it is often justified as getting more done. In a military environment, the daily routine and the adversary often dictates the amount of sleep military members get. Whether trying to get ready for the next day's inspection on military training or being attacked by an adversary at night on operations, military members often sleep less than the recommended hours. The effect of total sleep deprivation on a person is widely known, but little is known about the impact of sleep loss over a prolonged amount of time.[48]

Researchers conducted a two-week study, looking at the changes in performance for individuals with various amounts of sleep. Individuals were separated into four different groups. Three of the groups received four, six, and eight hours of sleep, respectively. The fourth group received no sleep for three days.[49] Researchers discovered "neurobehavioral function decreased as the amount of sleep lost per night increased so that those with only four hours of sleep … performed worse on tasks than those with six or eight hours of sleep."[50] More interesting, though, is the "performance of the group with six hours of sleep, after two weeks, was not

[46]Statistics Canada, *Duration and Quality of Sleep Among Canadians Aged 18 to 79*, Last accessed 6 May 2020, https://www150.statcan.gc.ca/n1/pub/82-003-x/2017009/article/54857-eng.htm.
[47]*Ibid*.
[48]Douglas R. Lindsay and Jeff Dyche, "Sleep Disturbance Implications for Modern Military Operations," *Journal of Human Performance in Extreme Environments*: Vol 10, Issue 1, Article 2, (October 11, 2012), 4.
[49]*Ibid*.
[50]*Ibid*.

different from the total sleep-deprived group after two days."[51] This study demonstrated, even a short amount of sleep loss over time will have a significant effect on cognitive function. Also supporting this study is "[f]unctional brain imaging studies [which] show[ed] that sleep loss selectively deactivate[d] the prefrontal cortex, the brain region where anticipation, planning, and situational awareness culminate."[52]

Understanding the impact of sleep loss on the warfighters' cognitive performance and psychological resilience is essential, and it demonstrates that psychological resilience is just as crucial as physiological resilience. Given that physiological resilience is monitored through physical fitness tests and customized programs by fitness specialists, what can be done to monitor warfighters' psychological resilience? Some factors are easily monitorable, such as hydration and nutrition, whereas sleep loss is more difficult to the naked eye. With the help of technology, many smartwatches have a sleep history integrated into them. Collecting the sleep history data of warfighters could provide insight into an individual and a teams' psychological readiness. This data could prove beneficial for armed forces today and in the future.

TRAINING IS STILL REQUIRED

> *You fight like you train.*
>
> *– General George S. Patton*

Earlier stated, this paper demonstrated warfighters today have access to an overwhelming amount of information and need to manage several tasks simultaneously, which ultimately affects their decision making. While some warfighters have an innate ability to perform under stressful conditions, hence have a higher cognitive capacity, others have more difficulty. Armed

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[51]Douglas R. Lindsay and Jeff Dyche, "Sleep Disturbance Implications for Modern Military Operations," *Journal of Human Performance in Extreme Environments*: Vol 10, Issue 1, Article 2, (October 11, 2012), 4.
[52]Nancy J. Wesensten, Gregory Belenky, and Thomas J. Balkin, "Cognitive Readiness in Network-Centric Operations," *Parameters* 35, no. 1 (2005): 100.

forces could assess cognitive skills and recruit personnel who have higher cognitive abilities for greater success in the current and future operating environment. While recruitment is one solution, this could be challenging due to the yearly recruitment quotas put in place to maintain the armed forces' strength. It can also prove challenging to streamline recruitment to only recruit personnel that achieved a high assessment of cognitive ability as this could significantly diminish potential applicants. Despite this challenge, there is also another viable solution – training.

Research shows that multitasking training can improve warfighters' ability to manage several tasks simultaneously.[53] According to Dux et al., "[multitasking training] increase[ed] the speed of information processing in the [prefrontal cortex] region of the brain, thereby allowing multiple tasks to be processed in rapid succession."[54] Given the current environment warfighters operate in, it is significantly vital to understand multitasking skills are trainable since many warfighters may experience difficulties in complex scenarios. Multitasking training can be in the form of practicing a complex range scenario, where a team needs to shoot, move and communicate with friendly and enemy threats. Repetitive training has also been proving as a critical element for warfighters to prepare mentally for the hardship of combat operations.[55] In other words, to enable increase ability to multitasks, warfighters should be training as much as possible in a realistic scenario, wearing their combat equipment to get them mentally prepared for a real-world situation.

Some argue current, and future warfighters will adopt technology systems easier. Adding "millennial generation [warfighters] are inherently more tech-savvy than their predecessors

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[53]Lobna Chérif *et al*, "Multitasking in the Military: Cognitive Consequences and Potential Solutions," *Applied Cognitive Psychology* 32, no. 4 (July 2018): 429.

[54]Paul E. Dux *et al*, "Training Improves Multitasking Performance by Increasing the Speed of Information Processing in Human Prefrontal Cortex," *Neuron* 63, no. 1 (2009), 127.

[55]SOFREP, *Conquering Fear Is The Biggest Obstacle In Special Operations Training*, Last accessed 6 May 2020, https://sofrep.com/specialoperations/conquering-fear-biggest-obstacle-special-operations-training/.

because of extensive, lifelong exposure to technological devices such as personal computers, virtual gaming, and cell phones."[56] Simply put, because they are digital natives, they will leverage new technologies more naturally and require less training to adopt these digital systems.

A study with cadets at the United States Military Academy West Point suggested otherwise. The study had cadets doing urban-raid lane training; half the group were given detailed pictures of the objective, while the other half were given virtual reality (VR) goggles with 360-degree visualization of the target objective. Despite having prior hands-on training and the clear advantage of VR technology to 'walk the ground,' cadets were cognitively overloaded and relied on notepad, pen and paper to conduct their training. Further, the groups that used the VR goggles took longer to accomplish their tasks compared to those who had pictures.[57] The study demonstrated that armed forces should not assume the millennial generation, although tech-savvy, will adopt new technologies more naturally. The study also showed that technologies should be implemented progressively in military training systems to ensure warfighters understand the fundamentals first.[58] The research at West Point confirms progressive training is required for warfighters to both adopt the technologies and become more comfortable with the amount of information they have to manage.

Whether warfighters are tech-savvy or not, training will be required. This training must be as realistic as possible for warfighters to become more comfortable working in a multitask environment. The biggest hurdle to overcome with live training is the cost. Live training is expensive as there is a cost associated with the transporting of personnel and vehicles as well as fuel and ammunition, to name a few. Fortunately, technological advancement in simulation,

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[56]John Spencer, Lionel Beehner, and Brandon Thomas, "Putting Concepts of Future Warfare to the Test," *Military Review* 98, no. 2 (2018): 81.
[57]*Ibid*., 85-86.
[58]*Ibid*., 88.

which includes high fidelity simulation and virtual reality, is very accessible and can save on overall cost. Pilot training has incorporated simulators for many years. Pilots can train and maintain their skills without flying the aircraft, avoiding high prices for fuel and maintenance of the plane. By using realistic simulations, studies show warfighters "can … become more proficient on … multitasking activity."[59] Although simulation training is not live training, it can be argued that the right balance of both live and simulated training is required to improve warfighters' ability in the current battlefield environment.

CAN ARTIFICIAL INTELLIGENCE HELP?

> *Machines don't fight wars. People do, and they use their minds.*
>
> – Col (retd) John Boyd.[60]

From Apple's Siri and Amazon's Alexa to self-driving cars, Artificial Intelligence (AI) is progressing rapidly in everyday lives now. Many armed forces are currently using and experimenting with AI technologies to gain or maintain an advantage over adversaries. The U.S. Army's Patriot Missile system[61] and the U.S. Navy's Aegis combat system[62] are examples of such systems currently being used. The missiles can automatically detect and defeat incoming missiles, a solution that is much more efficient than having humans monitoring incoming missiles. Many tasks and areas can benefit from AI in military operations. Skill-based tasks like flying an aircraft become highly automatic with time. The same goes for a rule-based task that follows an 'if-then-else' structure. An example of a rule-based task can be the procedure to follow if there is a problem with an aircraft. In other areas, such as combat operations, where

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[59]Lobna Chérif et al., "Multitasking in the Military: Cognitive Consequences and Potential Solutions," *Applied Cognitive Psychology* 32, no. 4 (July 2018): 435.

[60]The Strategy Bridge, *Uploading John Boyd*, Last accessed 6 May 2020, https://thestrategybridge.org/the-bridge/2015/11/16/uploading-john-boyd

[61]Army Technology, *Patriot Missile Long-Range Air-Defence System*, Last accessed 6 May 2020, https://www.army-technology.com/projects/patriot/.

[62]Lockheed Martin, *Aegis: The Shield of the Fleet*, Last accessed 6 May 2020, https://www.lockheedmartin.com/en-us/products/aegis-combat-system.html.

knowledge and expertise are required, AI is much more challenging to implement.[63] Warfighters face uncertain and ambiguous situations where "algorithms may not be able to understand the solution space, much less achieve a feasible solution." This area of military operations, where warfighters fight, is arguably the most important but has had limited success to implement AI systems since much of the efforts has been on autonomous systems.[64]

Advocates of autonomous systems would argue that these systems will reduce the cost of humans involved in a conflict. "[U]nlike human operators, [AI and autonomous systems] do not need to sleep or eat."[65] Undeniably, these advocates are correct, the use of AI and autonomous systems will be a significant cost saving, notwithstanding many human lives will be spared. Some go as far as to say, "future conflicts will be waged in an environment too fast [and] … too complex for humans to direct,"[66] speculating that machines will fight wars. While it is a fair argument to put forth, it is not the case today and in the near future. As Marine Corps Colonel Drew Cukor explained, "AI [or autonomous systems] will not be selecting a target [in combat] … any time soon."[67] Many studies are raising legal and ethical questions with the use of autonomous systems in combat operations, so the development of solutions has been slow and incremental at best.[68]

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[63]Mary "Missy" L. Cummings, *Artificial Intelligence and the Future of Warfare*, Chatham House: The Royal Institute of International Affairs (January 2017), 1.

[64]*Ibid*., 8.

[65]Jeffrey S. Thurnher, "Means and Method of the Future: Autonomous Systems," In *Targeting: The Challenges of Modern Warfare*, The Hague, Netherlands: Asser Press (Springer), 2016, 185.

[66]P.W. Singer, *Wired for War: The Robotics Revolution and Conflict in the Twenty-First Century*, New York: Penguin Press, 2009, 128.

[67]Colonel Drew Cukor was the Chief of the Algorithmic Warfare Cross-Function Team in the Intelligence, Surveillance and Reconnaissance Operations Directorate-Warfighter Support in the Office of the Undersecretary of Defense for Intelligence in 2017. United States Department of Defense, *Project Maven to Deploy Computer Algorithms to War Zone by Year's End*, Last accessed 6 May 2020, https://www.defense.gov/Explore/News/Article/Article/1254719/project-maven-to-deploy-computer-algorithms-to-war-zone-by-years-end/.

[68]Mary "Missy" L. Cummings, *Artificial Intelligence and the Future of Warfare*, Chatham House: The Royal Institute of International Affairs (January 2017), 2.

In a more balanced view and closer to reality, AI is seen as an enabler, complimenting the warfighter and improving decision-making.[69] This view puts the human at the center of the discussion because humans fight wars. Humans are the most precious resource and the critical element of successful military operations.[70] AI-enabled systems could be used for their capacity to gather, analyze and fuse information, which would greatly benefit in areas such as intelligence, surveillance and reconnaissance (ISR) and the targeting process. Systems like drones provide high-fidelity reconnaissance capability, and their use has dramatically improved combat operations. Although successful, many of these AI-enabled systems are "teleoperated, essentially meaning that a human is still directly controlling [the systems] … [with most] requir[ing] significant human intervention to execute missions."[71] Ultimately, this increases the task load of the warfighter and impacts their cognitive capacity.

If AI is to be useful in combat operations, AI must offload some cognitive demand from the warfighter rather than adding more systems and information to manage. Solutions must help the warfighter rather than add additional stress. Heads-up displays (HUD) for pilots is an example of a solution to alleviate the cognitive load. HUD is also being trialled by the U.S. Army to improve warfighters' SA and rapidly come up with a plan to attack adversaries. The U.S. Army's most significant problem with the HUD is the bombardment of information given to the warfighter, crowding their vision with potential useless information.[72] AI could be used to filter and display the data, but how is the algorithm going to determine which information is

[69]War on the Rocks. *With AI, We'll See Faster Fights, but Longer Wars*. Last accessed 6 May 2020. https://warontherocks.com/2019/10/with-ai-well-see-faster-fights-but-longer-wars/.

[70]Hostage, Gilmary Michael, and Larry R. Broadwell. "Resilient Command and Control: The Need for Distributed Control." *Joint Force Quarterly*, no. 74 (2014): 39.

[71]Mary "Missy" L. Cummings, *Artificial Intelligence and the Future of Warfare*, Chatham House: The Royal Institute of International Affairs (January 2017), 9.

[72] Popular Mechanics, *U.S. Troops to Test Augmented Reality By 2019*, Last accessed 6 May 2020, https://www.popularmechanics.com/military/a19635016/us-troops-to-test-augmented-reality-by-2019/.

useful or not? What data gets displayed, what does not? This problem space is a massive concern for system developers, and these questions are why solutions are not operationalized yet. It can be argued that many more trials and experimentation will be required for HUDs to support the warfighters of today and the future.

CONCLUSION

The advancement of technology has brought many advantages to the armed forces as a whole. Battle Management Systems allow warfighters to rapidly exchange information and ask for support in just a few simple steps. With the substantial increase in access to information, today's warfighters are cognitively overloaded. They struggle to process the amount of information they receive, which, in turn, adversely affects their ability to make decisions quickly. While access to information intended to reduce the decision-making cycle of warfighters, this paper demonstrated otherwise.

There are many options available to offload some of the cognitive functions such as digitizing checklists and R&R using alerts and alarms. While these options are viable, to not distract the warfighter and overly increase the cognitive load, system designers need to properly trial and experiment as the design and implementation of these options is critical. It is crucial to understand humans are limited, and many have difficulties at multitasking, which could ultimately lead to significant errors of judgment.

Warfighters today not only have to be physically fit, but they also have to be psychologically ready as well. The armed forces would greatly benefit from monitoring one's psychological readiness in addition to their physiological states, as this paper demonstrated that sleep loss over time significantly impacts the warfighter's cognitive abilities.

Further, multitasking abilities are trainable. Simulation and live training events that force warfighters to manage several tasks simultaneously have shown to increase one's ability to

multitask. Assessing cognitive skills and concentrating on recruiting those who achieve higher results is another option to ensure the increase of potential warfighters who can effectively perform in a multitasking environment.

Lastly, AI has gained much attention in the past few years. AI has demonstrated little to no success in ambiguous environments where warfighters need to rely on their expertise, knowledge and minds to achieve their mission successfully. Much effort has been put towards the use of autonomous systems to reduce the cost of humans involved in conflicts. Arguably, warfighters have not fully benefited from the advancement of AI, as it has only added to their cognitive load. Although promising, the fact remains that humans are still required to teleoperate these systems, which is counter to the purpose of their use and implementation.

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