Cognitive Weaponry: Optimizing the Mind

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ABSTRACT

As technology becomes increasingly interoperable and human-computer interaction affords us the ability to work seamlessly with external memory, automated filtering, automated tasking, and other support tools, we create the opportunity to optimize the capabilities of the human mind and operate at a higher level of agility. This symbiotic human-technology hybrid concept could create warfighter capabilities currently unseen but would require not only an understanding of human-computer interactivity but also associated changes to how we identify talent as well as how we focus and deliver military education and training. We would see a transition from separately developing technology and training humans to seeing warfighter systems that incorporate both and which work together to achieve optimized solutions. Given the significant research that has been conducted in the areas of resilience, mindfulness, cognitive load theory, decision making, and education for increasing readiness plus the advancements in technological interoperability allowing real-time experiences to be tracked and analyzed, we are now at a point where we need to consider combining our deep understanding of human abilities and limitations with the technologies that can monitor, measure, and compensate for or accelerate the warfighter's cognitive weaponry assets.

Accordingly, this paper investigates the enabling factors of technological interoperability and improved experience measurement as well as enabling tools such as wearables, augmented reality, learning science strategies, and emotional regulation strategies to create a future vision of seamless human-computer interaction. Benefits discussed include the concepts of mind armor (filtering out emotionally charged information to reduce PTSD onset), cognitive agility (enhanced cognitive maneuverability through automated filtering and augmented reality usage), intellectual recovery (react, recover, reload: improving recovery abilities through mindfulness training and bio-feedback from wearables), and mental endurance through stress inoculation (elongating the time to stress-induced chemical release through systematic desensitization techniques combined with bio-feedback from wearables during simulation exercises).

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BACKGROUND

The National Defense Strategy (NDS, 2017) recommends three key areas of focus: (1) increased lethality and improved readiness, (2) strengthening and expanding international partnerships, and (3) improving business practices. Each of these three pillars highlights the changing space in which warfare is happening. However, as we are entering a non-co-located cyber battlespace, changes in the conduct of war may also occur. Though the nature of war will likely remain the same, the weapons used, the assets recognized, and the human capabilities favored may change. For example, decision making has always been a cognitive activity but when adversaries are physically present, it is the physical body, agility, and reactions that matter most. It also means that physical prowess, size of military unit, and financial and technological resources have significant impact. Alternatively, in an intellectual and psychological warfare space where there is no physical component, the size or physical capabilities of the individual may not matter at all. The team organization can be optimized differently because individuals can be connected virtually allowing for increased options not hindered by deployment status. It also means that countries with fewer financial and physical resources can both contribute to multi-national operations in more meaningful ways, while adversaries with fewer resources can compete at a level not previously seen (Suciu, 2014). In other words, technology, connectivity, and cyberspace have helped level the playing field not just in business, equity of access, and social connectivity but also in defense operations. **It means that the United States defense program must expand its definitions of weapons, talent, capabilities, and resources.** A cyber defender capable of task switching with minimal loss of focus, anticipating an adversary's motives by analyzing computer code, or psychologically baiting groups of people outside the defense arena may be equally effective in the future warfare space as those whose physical agility allows them great advantages (Burke, 2018; DIB 2018).

However, while it is unlikely that the physical battlespace will diminish, it is likely that the sophistication and complexity of warfare will expand (Raybourn, Schatz, Vogel-Walcutt, & Vierling, 2017). Accordingly, it is necessary to consider: (1) how the mind, body, and technological resources can be optimized as a system, (2) how we can expand our talent identification and management metrics to ensure that cognitive assets are measured and matched to military needs, and (3) reframe the approach to intellectual assets, focusing on cognitive weaponry development and brain protection (Lynch, 2018). Independently, these are not entirely new concepts (U.S. Navy, 2019). However collectively, they have not reached a level of maturity that makes them optimized in effectiveness. Stated another way, we have, through research, education and training practices, and technological development many of the key components necessary to create this holistic system of metaphorical cognitive weaponry, or mental resilience, agility, and strength, but to date, no one has connected the dots. It's like having all the parts of a car but no blueprint to connect them. Without that blueprint, an entire capability of transportation is lost, and with it, significant secondary and tertiary impacts. Accordingly, this paper aims to start looking at the new technology warfare problem holistically. It will pull from existing literature to make some observations and recommendations for moving forward.

CURRENT RESEARCH

Recognizing the impending need to better understand and ultimately optimize human assets, significant research has been conducted in the areas of resilience, mindfulness, cognitive load theory, decision making, and education for readiness. Resilience has long been understood to be a necessary component of warfare but what has garnered more attention over the past decade of research is how to measure it, optimize it, and teach it (Reivich, Seligman, McBride, 2011; Seligman, 2011; Arnetz, et al., 2009). Mindfulness is a relatively newer consideration for warfighters but has also received significant attention, especially with marines (Johnson, et al., 2014; Jha, Stanley, Kiyonaga, Wong, & Gelfand, 2010; Stanley, Schaldach, Kiyonaga, & Jha, 2011). The goal is to improve mental health, stamina, and recovery in theater. Cognitive load theory has most typically been tested and addressed in educational settings, especially clear, problem-solving tasks (Sweller, 1988), but more recently has been considered as a basis of measurement for understanding not only the maximum amount of information a person can learn at a time but also how much stress, input, or emotional trauma can be endured (Coyne, et al., 2009; Proayska-Pomsta, et al., 2008). When we better understand the limits of cognition, we are better able to optimize those limits without exceeding them. Decision making tendencies, approaches, and strategies have also been heavily studied by researchers for decades (Snyder, 1989; Eisenhardt & Zbaracki, 1992; Zsambok & Klein, 2014; Crichton & Flin, 2017; Flin, Salas, Straub, & Martin, 2017) helping to build both frameworks but also education programs aimed at reducing bias in decision making, increasing speed of decision making, and improving quality of decision making through a variety of strategies (e.g., metacognition, heuristics, observations, teamwork). All of this work has started to infiltrate military education and training at multiple levels. In research, there have been multiple projects that focused on the cognitive elements and determining how enhanced cognitive capabilities could lead to improved small unit decision making, leadership training, perceptual skills development, and a number of technological tools to support training and performance have been developed (e.g., modeling, simulation, gaming technology, augmented reality, virtual reality, wearable devices, and more). But to date, these research outcomes have largely not been fully integrated into operations, standard training, talent identification or management strategies, and only recently begun to garner significant attention across force education and training (Raybourn, Schatz, Vogel-Walcutt, & Vierling, 2017). The demand signal is for optimized, holistic learning and development plans that are personalized, motivating, enhance readiness, and that improve cross-branch capabilities.

Simultaneous to the recognition, and study of, enhanced cognition, technology has become increasingly mature, interoperable, and interactive with humans. These advancements create a significant number of possible capabilities. Human-computer interaction, largely studied within human factors psychology (Schmorrow, 2005), has contributed significantly to the understanding of how humans-in-the-loop must be considered when developing technological tools and capabilities. For example, we can measure real-time stress metrics through wearable devices allowing us to control what information is coming to an operator and in what manner it is presented. Augmented reality, another technology used in HCI work, can allow us to use focus strategies like highlighting to help clarify for the warfighter what is important in the field but further, it can help connect seemingly unrelated data points in the field to help more quickly and more accurately identify threats (Livingston, et al., 2011; Furht, 2011). Further, technological interoperability is nearing reality and xAPI specifications are becoming standards, allowing real-time experiences to be tracked and analyzed (Presnall, & Radivojevic, 2018). Thus, when we combine these theories from cognitive science with the technological tools, we create the opportunity to filter unnecessary information that could overload the mind in theater.

What has captured less attention, however, is the use of this interoperability to create a symbiotic human-computer-team system-of-systems that when connected, could create a meta-impact. In other words, human limitations and capabilities have been studied. Technology has been created. The need to consider the two together as a complementary unit, has been researched. But systematic use of all these findings has not been implemented holistically and without a connecting blueprint, similar to the car reference, we lose the metaphorical capability of transportation. In this case, the missing capabilities are cognitive agility, resilience, and fortitude. More specifically, if the brain and technology are combined, what results is a set of cognitive weapons that can be used to defend against adversaries, stress in theater, and create enhanced warfighters. **Ultimately, it's not about improving a single skill, or even a set of skills, it's about elevating the warfighter's total functioning and as a result, creating new capabilities.**

CURRENT CAPABILITIES

To date, there are many examples of how human optimization and technology maturation have improved over recent research projects. These advancements have yielded single-problem-focused, but impactful, outcomes. They range from measuring changes in cognitive state to creating a deeper understanding of learning science to using both findings to inform changes in education and training practices, talent identification, and talent management. In each case, problems have been identified singularly and scientists have steadfastly over the past several decades researched these issues and made recommendations that improve each problem noted.

For example, wearables allow us to measure action but also internal states of military personnel during both training and in theater. Accordingly, it provides a second dimension of measurement not previously available. It creates the potential for combining internal state data with externally measured performance data to drive improved decision making (Bedek et al., 2012; Cowley & Ravaja, 2014; St. John, Kobus, Morrison, & Schmorrow, 2004; Berka, 2007; Bolton, A., Campbell, G., & Schmorrow, 2007). It even allows training activities to alter in real time in response to the combined data. Research shows that the combined data, compared to the performance only data, typically used to assess training outcomes, is significantly impactful to learning trajectories (Vogel-Walcutt & Abich, 2011). In other words, we can better optimize training systems by more accurately assessing the performer's skills using multiple measurement techniques. Augmented reality also works on cognitive load – reducing it by offloading micro-decisions and allowing the technology to manage the logistics of deciding what to look at and how to connect it to other data points whether they are behavioral actions or observable data (e.g., IED triggers). **Combined, it means not just that a human mind can offload both information and take on recommended patterns; it also means that the human can be enhanced holistically to be able to better think, function, access and change course, and overall act more efficiently and more effectively.** Emotional regulation strategies can also be honed through a variety of psychological techniques such as systematic desensitization (Fillol, et al., 2018) where individuals learn to reduce their emotional reactivity to stressful stimuli in a systematic fashion that can start with basic imagined exposure and ending with full physical presence. This technique is often used to eradicate phobias but repurposed, can be additive to a warfighter's toolkit. Other psychological techniques such as meditation can be used to improve mind resiliency, speed of recovery from stress, and even prolonged survival (Russo, 2019; Shapiro, 2019; Nidich, et al., 2018). Considerations regarding the use of intentionally overloading the brain so that stressful stimuli or events cannot reach long term memory, and therefore not be fully experienced or remembered, may even result in an ability to reduce stressful experience reactivity or memory of the events. These findings yield rich insights into measuring human cognitive changes and capabilities, but they do not, independently, create an improved warfighter hybrid system.

However, if these techniques were infused with learning science strategies it would allow education and training practices to not only be enhanced but the entire system could be holistically transformed. To reframe the military's approach to learning as a method for training human-computer interaction skills, a new hybrid capability could be achieved that would not only improve the functionality of both but would optimize the capabilities of the hybrid warfighter system. Yet a holistic approach to how these changes will result in the building of an additional full operational capability has not been developed and therefore also not deployed. Rather, piecemeal changes are occurring in response to specific recognized deficits or challenges in military capability. A comprehensive talent management strategy that recognizes and supports the proactive recruitment of intellectual and psychological warriors is now arguably necessary. However, it is not as easy as widening recruitment eligibility requirements. Instead, it requires a deeper understanding of what skills are needed, how we can enhance them through advanced educational methods and delivery options, and a psychologically safe environment that promotes creative, diverse, and challenging ideas. Without these system changes, we will predictably attract cognitively agile out-of-the-box thinkers who will not be retained due to a lack of intellectual freedom to test, hone, and extend their cognitive weaponry assets (Gruss, 2018; Pomerleau, 2019). More importantly, we will lose the extended capability of an intellectual force that can fully deploy as enhanced warriors in non-co-located operations.

Changes needed include: (1) a capability goal set that looks beyond singular human or technology assets and instead measures capabilities reached through combined assets, (2) an education and training system that personalizes training trajectories and focus so that human limitations at any level can be augmented by technological complements, and (3) expand the weaponry arsenal to include mind armor, optimized cognitive agility, and whole-person functioning and resilience. **Combined, we will create enhanced warfighters who will be not only singularly more effective but force-wide, will create an enhanced military that optimizes human assets and prepares our defense program for the battles of the near future.** Creating human-computer synthesis and training our personnel to approach capability building with this goal in mind, has the potential to evolve our readiness capabilities beyond what is imaginable today.

HUMAN-COMPUTER SYNTHESIS

Independent, siloed enhancements created by improved human-computer interaction could enable humans to work seamlessly with external memory (computers acting as an off-loaded memory sight), automated filtering (using heuristics, data analysis, and artificial intelligence to manage cognitive load), automated tasking (using analytics to develop a task list for humans, again reducing the load on the mind), and other support tools. Combined, we have the opportunity to optimize the capabilities of the human mind and operate at a higher level of agility. Cognitive agility fundamentally changes the way a human works within the battle space. It also changes the approach to education and training. **By approaching the mind as a weapon to be honed, skilled, enhanced, improved, and optimized, the development of competency goals and in response, learning goals, will naturally adjust.** Essentially, we are talking about changing the mission goal of education and training in some spaces and that change leads to significant methodological changes but also research recommendations.

Enhanced Warfighter System

Thus, the idea of a symbiotic human-computer system is not new. However, an organized and planned approach to developing the individual and as a system of units has not been organized. Innovation programs across the branches has been extensive yet coordination and cooperation across them, limited (Walcutt, 2019). Human and technological interoperability are hot topics within strategic level military planning (Raybourn, Schatz, Vogel-Walcutt, & Vierling, 2017) but system interoperability focus has not yet been attained. Accordingly, the idea of creating and developing enhanced warfighters is a missing, but plausible, capability. So how do we aid in the evolution of this system and what is the process to get there? First, we need to define what mission success looks like. We need to define the art of the possible. If we combine elements from innovation and research programs across the services, we see elements of a possible system that when combined, could be a game-changer in how we approach defense maneuvers and responses. By way of analogy, when it rains, we want to be shielded. At one point, finding shelter was the best option. Eventually, someone proposed a portable shelter called an umbrella. But to make an umbrella, we needed the metal for the handle, a mechanical mechanism to raise and lower the shield, the spokes to open the shield, and the tarp to act as the shielding agent. Though each of these pieces was independently created, when put together, it created a much more useful asset. To date, research has been investigating and testing how to create each of these metaphorical pieces of the greater umbrella concept. Now it is time to combine them to create an organized, mutually beneficial, system.

This future system will need to contain several complementary pieces. Building cognitive weaponry capabilities will rely on a synthesized view of human-computer interaction and a holistic approach to education and training that measures ultimate capability over separately training humans and developing technology and then training them to work together. The pathway would look more like this:

Human development support → military talent identification → human computer simultaneous training → synthesized asset support and deployment

Human development support refers to the improvement and evolution of the U.S. educational system writ large. In other words, it is no longer viable to make individual changes and augmentations to the opportunities and methods we use to educate Americans across the lifetime. Rather, the system itself needs to be re-imagined focusing on several key changes including: (1) focusing on developing the whole human from birth, not just focusing on cognitive development, (2) emphasizing 21st century skills of diverse and creative thinking, (3) personalizing learning trajectories with the goal of optimizing each person's individual natural interests and capabilities, (4) focusing on real-world application of learning material, (5) inspiring life-long learning skills such as meta-cognition and self-regulation, (6) using assessment methods that emphasize an asset model of development focusing on what needs to be learned next rather than a deficit model that emphasizes what needs remediation to meet a standard, (7) infusing technological interoperability standards and metrics to augment and enhance learning pathways rather than using technology as an a separate component in classrooms, (8) recognizing and crediting learning occurring outside formal classrooms, and (9) creating policy that empowers teachers to approach learning holistically crossing time boundaries and expectations, reducing linear and siloed learning structures, and focusing on instilling a love of learning and problem solving that can extend beyond the classroom. It is beyond scope of this paper to delve deeply into these goals but a fully developed blueprint of this evolved system can be reviewed in the book, Modernizing Learning: Developing the Future Learning Ecosystem (Walcutt & Schatz, 2019).

Military talent identification refers to expanding the aperture of what constitutes a warfighter. Physical capability and endurance under stress has historically been a benchmark requirement of active duty military personnel. Yet with the advancements in science, there are now aided humans, who may have lost a limb or other internal function that with surgery or prosthetics are fully capable of many of the physical demands at the same level of capability and in some cases better than others (Moreton, 2012). Perhaps the warrior mindset is the asset or personality trait than must be present but does age matter as much as previously? Would the military not benefit from the wisdom that comes from life experience outside the military realm when looking to protect critical infrastructure? Would the military not benefit from external problem-solving approaches that with them bring new methods for recognizing, accessing, and addressing adversaries? To date there have been complementary military-civilian-humanitarian-intelligence communities but what is lost in these separate systems are the spaces in between. By way of example, when an international cyber threat is detected in the U.S., it falls outside the FBI's jurisdiction because it is considered an act of war, but it falls outside the military's jurisdiction because it occurs within the states. The running time now for involvement and coordination is 72 hours, far longer than adversaries need to infiltrate and affect damage. More to the point, it is civilian cyber professionals that are detecting these issues and addressing them but without the full intelligence or capabilities of all our assets at their disposal (911.gov). Meta-talents and coordinated programs will be facilitated by not only acknowledging the need for a wider scope of skills but by creating policy and structures for how to improve talent recruitment, management, and empowerment strategies across the lifetime of military service. Some key factors for consideration include: (1) adding military occupation specialties (MOSs) that support capability needs of the near future (innovation.defense.gov/recommendations), (2) recognizing the benefits of non-financial compensation (Walcutt, 2019), (3) creating flexible military entrance times and involvement structures (USMC, 2019). It is beyond scope to completely organize this evolution but a full review and blueprint can be seen in Innovating Government: Redesigning the executive branch (Walcutt, 2019).

Synthesized education and training refers not to ensuring learning occurs as holistic education compared to part-task training but rather, in this case, it refers to synthesizing human-computer training as a holistic concept. Rather than measuring or developing singular skills, working toward a symbiotic joint capability that expands the skills and capabilities of humans and human teams beyond natural capability. What does this look like in practice? First, it involves ensuring that technological interoperability is at a maturity level that allows for sharing of all types of data from formal educational outcomes to performance-based measures to experientially gained wisdom. xAPI provides the technological standard that will allow for these data to be shared in a meaningful way (Smith & Ram, 2019). The Total Learning Architecture is being developed and implemented military-wide to create everything from universal records (Tan, 2015) to creating personalized pathways for learning (U.S. Navy, 2019) to ensuring that military service experiences are captured, measured, and shared in understandable formats to businesses following service (Force Education and Training, 2018). These pathways of data sharing make possible a connected, optimized system. More importantly though, they create the opportunity to provide an entirely new level of readiness development and training not previously viable.

The goal of the human-synthetic enhanced warrior is to maximize the capabilities of human focus, agility, endurance, and recovery. In doing so, we optimize the human asset but also make possible the ability to optimize a system of assets, elevating the entire defense program and approach. This is especially important in non-co-located warfare battle spaces. Education and training would therefore change from focusing on the human alone to focusing on human optimization with a set of tools that would create a dashboard of data. These data could be combined to inform both the human but also the technological assets to create a symbiotic interplay and system optimization. The first goal is to insulate the brain from trauma that could affect one's ability to navigate in theater or react in cyberspace. It is often inaccurately assumed that warriors not co-located with their adversaries experience less trauma from military events. This is not true (Chappelle, Goodman, Reardon, & Thompson, 2014). Further, the effects of this trauma extend well past the moment of effect and can lead to depression, anxiety, social difficulties, and at its worst, Post Traumatic Stress Disorder. These issues are the result of continuous stress and trauma to the mind that resurface in ways that can be significantly or totally debilitating. Therefore, it is necessary not only for the operational readiness of military personnel but also for subsequent functioning abilities to find new ways to develop insular properties using natural hindrances in the brain's capability to take in significant data. **Mind armor**, or the use of technological and intentional overloading of the mind during high stress to reduce the impact of stressful stimuli combined with the use of technologies to help filter out emotionally charged information from working memory before reaching long term memory, can help insulate the mind from the effects of traumatic experiences. Ultimately, the goal is to allow the human to maintain longer focus and attention in high stress scenarios but also to reduce the likelihood of PTSD onset or severity of symptoms.

The second goal is to ensure that warfighters are able to cognitively maneuver through intellectual battlefields. Thus, **cognitive agility**, or enhanced cognitive maneuverability through automated filtering and augmented reality usage, is an important cognitive capability. It can be honed through the use of a variety of devices that would augment the operators' capabilities. In this manner, extended cognition enables the operator to better manage their load and be agile in a high stress environment.

Extended cognition is the human's use of the environment around them, as a dependence on the cognitive processes in the brain, and body (Aizawa, 2014). Extended cognition may also be viewed as the continuous interplay of actions in the environment and cognition (Clark & Chalmers, 1998). This approach to cognition is most easily understood by extending the receptors of the mind-body-environment to what Clark and Chalmers referred to as environmental supports. Meaning the items that are found in the surrounding environment, or tools that are issued to operators are useful in cognitive management. This can be explained as a calculator to assist with doing math problems; a pen and paper or even a whiteboard to extend the space in which the cognitive process occurs. Clark and Chalmers go on to point out that these environmental supports serve as functions to extend the cognitive processes that typically occur inside the brain, and as such, these external supports should get part of the epistemic credit for the assist.

Consider the utilization of a glass (or digital) cockpit, which presents displays to the pilot or aviator, like a dashboard. These displays are often complex, working and calculating routing, targeting solutions, or providing situational awareness of where other aircraft are relative to one's own. These tools found in the cockpit environment work to provide more information, while offering the off-loading of cognitive processes, which again, allow the pilot to focus on key information to plan. Much like a pilot uses the dashboard provided to determine how each part of the plane is functioning, so too can the military operator manage himself or herself. Cognitive agility requires a) optimized cognitive load to be maintained and b) task switching time and flow loss to be minimized. To achieve both, augmented reality can help focus the mind on the most salient datapoints in the field and minimize distractions. This can be accomplished through highlighting key visual cues, blurring less important cues, and aiding the human in connecting, as well as interpreting, the patterns of cues in the environment (Vogel-Walcutt, Fiorella, & Malone, 2013).

Third, the ability to regain focus after trauma is necessary. **Intellectual recovery** involves the improvement of resilience. In short terms, we refer to it as react, recover, reload, or improving recovery abilities through mindfulness training and biofeedback using wearable devices. Initially, researchers developed electroencephalogram (EEG) with 256 electrodes that provided insights about human engagement and arousal (Berka, 2004; 2007) but these data were very noisy and the apparatus difficult to work with. The focus on augmented cognition did not wane, however, and instead, more ideas and more accurate as well as moveable products were created (Stanney, et al., 2009). Today, these devices are commercially available at a relatively low cost and can track everything from heart rate variability to sleep quality and time. What these devices have not yet focused on is how to combine the data in real time to improve mind resilience to stress stimuli. In other words, the apparatus are now at a level of maturity and our scientific understanding of flow, interruptions, and re-engagement allow for a marriage of these concepts to provide not only warfighters better insight into their optimal task and though switching capabilities but more importantly, these data can inform technological complements that can enhance the symbiotic capabilities of human-machine hybrids.

Finally, **mental endurance** is the ability to maintain a high level of intellectual engagement during stress. Through stress inoculation, elongating the time to stress-induced chemical release through systematic desensitization techniques, combined with bio-feedback from wearables during simulation exercises, we can now teach humans to maintain focus for longer periods than naturally attained, train the mind to delay the release of stress chemicals, and accordingly create a superhuman capability to maintain focus for improved decision making. Systematic desensitization is a psychological technique often used to reduce or eradicate phobias. The process involves first using mental exposure to stressful stimuli while teaching the person to remain calm and focused during the experience. Once the person masters one level of stress, the next level is approached. Levels may move from purely thinking about a stimulus to being physically exposed to being personally involved. At each layer, calming techniques are used until the individual can remain calm without effort. Essentially, the brain is being re-trained to remain calm during a situation in which previously a release of chemicals led to a fight or flight reaction. Applying these techniques in combination allow for an optimized system that maximizes focus.

OPTIMIZED HUMAN-COMPUTER HYBRID SYSTEM

This is not about creating yet another framework; it is about reframing our approach and structure and ensuring we have a pathway to develop it. Significant research has already been conducted in a variety of key areas yet the combination of these findings into a holistic plan for augmenting not only the warfighter's capabilities but more specifically, changing the way we train and educate our military personnel, has not yet occurred. The goal of this paper is to lay the foundation for a new approach to readiness that involves not only training of the human and improving our technological assets but moving to a system that approaches readiness development as a holistic focus, training humans with technology in tandem. Certainly, some of this already occurs in specialized populations whose access to technological assets in theater is high. However, many issues have arisen. For example, a lack of trust of non-human teammates has resulted in robotic firing machines and other similar products being left behind during in-theater operations, even when it means operating a man-down. Additionally, the capability to capture, aggregate, and visualize the data needed for a system architecture that would enable full hybrid human-computer warfighters is only just now coming to fruition (Smith, Gallagher, Schatz, & Vogel-Walcutt, 2018; DoD Instruction 1322.26). With the versatility, mobility, and agility of wearable devices, combined with the data tagging abilities of xAPI to measure experience, combined with the Total Learning Architecture's data streaming capabilities, combined with USA's Learning policy support to build these connections, and now the Federal Data Strategy set for full operational capability as of 2020, the situation, technology, and training and education communities are ready for a transition to recognition of and development of a hybrid education of cognitive weaponry. Recommendations for next steps necessarily include first reframing how we approach the development of programs of instruction – refocusing on total capability as opposed to time in training or personal passing score. This mindset shift will lead to the incorporation of different cognitive and emotional support skills. The addition of technology day 1 will be needed as well to ensure that warfighters are working synonymously with their devices. Finally, use of a data-backbone will be needed in order to track all the information being pulled from the human the apparatus, aggregate it, and push recommendations to the instructor and student. This real-time data loop will ultimately be what creates the opportunity for personal feedback and system-enhancement.

References

Aizawa, K. (2014). Extended cognition in Shapiro, L. (Ed.), The Routledge handbook of embodied cognition. pp. 59-67. Routledge.

Arnetz, B. B., Nevedal, D. C., Lumley, M. A., Backman, L., & Lublin, A. (2009). Trauma resilience training for police: Psychophysiological and performance effects. *Journal of Police and Criminal Psychology*, *24*(1), 1-9.

Bedek, M., Seitlinger, P., Kopeinik, S., & Albert, D. (2012). Inferring a Learner's Cognitive, Motivational and Emotional State in a Digital Educational Game. Electronic journal of e-Learning, 10(2), 172-184.

Berka, C., et al. (2004). EEG correlates of task engagement and mental workload in vigilance, learning, and memory tasks. Aviat Space Environ Med, 78(5), 231-244.

Berka, C., et al. (2007) . Real-time analysis of EEG indexes of alertness, cognition, and memory acquired with a wireless EEG headset. *IJHCI, 17(2*), 151-170.

Bolton, A., Campbell, G., & Schmorrow, D. (2007). Towards a closed-loop training system: Using a physiological-based diagnosis of trainee's state to drive feedback delivery choices. D.D. Schmorrow, L.M. Reeves (Eds.): Augmented Cognition, HCII 2007, LNAI 4565, pp. 409–414. Springer-Verlag Berlin Heidelberg.

Burke, C. (2018). The Pentagon should adjust standards for cyber soldier – as it has always done. Retrieved from: https://warontherocks.com/2018/01/pentagon-adjust-standards-cyber-soldiers-always-done/.

Chappelle, W., Goodman, T., Reardon, L., & Thompson, W. (2014). An analysis of post-traumatic stress symptoms in United States Air Force drone operators. *Journal of anxiety disorders*, *28*(5), 480-487.

Clark, A., & Chalmers, D. (1998). The extended mind. A*nalysis*, *58*(1), 7-19.

Cowley, B., & Ravaja, N. (2014). Learning in balance: Using oscillatory EEG biomarkers of attention, motivation and vigilance to interpret game-based learning. Cogent Education, 1(1), 962236.

Coyne, J. T., Baldwin, C., Cole, A., Sibley, C., & Roberts, D. M. (2009, July). Applying real time physiological measures of cognitive load to improve training. In International Conference on Foundations of Augmented Cognition (pp. 469-478). Springer, Berlin, Heidelberg.

Crichton, M., & Flin, R. (2017). Command decision making. In *Incident command: Tales from the hot seat* (pp. 201-238). Routledge.

Defense Innovation Board (DIB; 2019). www.innovation.defense.gov.

Defense Innovation Board Recommendations. (2018). https://innovation.defense.gov/Recommendations/

DoD Instruction 1322.26 (2017). Distributed Learning (DL). Retrieved from: https://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodi/132226_dodi_2017.pdf?ver=2017-10-05-073235-400/home_new

Eisenhardt, K. M., & Zbaracki, M. J. (1992). Strategic decision making. *Strategic management journal*, *13*(S2), 17-37.

Fernández Fillol, C., Serrano-Ibáñez, E. R., Ruiz-Párraga, G. T., Ramírez Maestre, C., Esteve Zarazaga, R., & López Martínez, A. E. (2018). Effective therapies for the treatment of complex posttraumatic stress disorder: A qualitative systematic review. *Salud Mental*, *41*(2), 81-90.

Flin, R., Salas, E., Straub, M., & Martin, L. (2017). *Decision-making under stress: Emerging themes and applications*. Routledge.

Furht, B. (Ed.). (2011). *Handbook of augmented reality*. Springer Science & Business Media.

Gruss, M. (2018). Silicon Valley will never love DoD. Retrieved from: https://www.c4isrnet.com/opinion/2018/05/15/silicon-valley-will-never-love-dod/

Jha, A. P., Stanley, E. A., Kiyonaga, A., Wong, L., & Gelfand, L. (2010). Examining the protective effects of mindfulness training on working memory capacity and affective experience. *Emotion*, *10*(1), 54.

Johnson, D. C., Thom, N. J., Stanley, E. A., Haase, L., Simmons, A. N., Shih, P. A. B., ... & Paulus, M. P. (2014). Modifying resilience mechanisms in at-risk individuals: a controlled study of mindfulness training in Marines preparing for deployment. *American Journal of Psychiatry*, *171*(8), 844-853.

Livingston, M. A., Rosenblum, L. J., Brown, D. G., Schmidt, G. S., Julier, S. J., Baillot, Y., ... & Maassel, P. (2011). Military applications of augmented reality. In *Handbook of augmented reality* (pp. 671-706). Springer, New York, NY.

Lynch, J. (2018). Inside the Pentagon's struggle to build a cyber force. https://www.fifthdomain.com/dod/2018/10/29/inside-the-pentagons-struggle-to-build-a-cyber-force/

Moreton, C. (2012). London 2012 Olympics: Oscar Pistorius finally runs in games after five year battle. Retrieved from: https://www.telegraph.co.uk/sport/olympics/athletics/9452280/London-2012-Olympics-Oscar-Pistorius-finally-runs-in-Games-after-five-year-battle.html

National 911. (2019). https://www.911.gov/about_national_911program.html

Nidich, S., Mills, P. J., Rainforth, M., Heppner, P., Schneider, R. H., Rosenthal, N. E., ... & Rutledge, T. (2018). Non-trauma-focused meditation versus exposure therapy in veterans with post-traumatic stress disorder: a randomised controlled trial. *The Lancet Psychiatry*, *5*(12), 975-986.

Pomerleau, M. (2019). For tech all-stars, working at the Pentagon can be a career killer. Retrieved from: https://www.defensenews.com/smr/cultural-clash/2019/01/28/is-better-talent-management-the-key-to-government-attracting-silicon-valley/.

Porayska-Pomsta, Kaska, Mavrikis, Manolis, and Pain, Helen. (2008). Diagnosing and acting on student affect: the tutor's perspective. *User Model User-Adap Inter*, *18*, 125-173.

Presnall, A., & Radivojevic, V. (2018). Learning analytics with xAPI in a multinational military exercise. In *Proceedings of the I/ITSEC*.

Raybourn, E., Schatz, S., Vogel-Walcutt, J.J., & Vierling, K. (2017). The Tipping Point. Paper to be presented at I/ITSEC, November 28-December 2, Orlando, FL.

Reivich, K. J., Seligman, M. E., & McBride, S. (2011). Master resilience training in the US Army. *American Psychologist*, *66*(1), 25.

Russo, C. (2019). The Group Benefits of Mindfulness Meditation in Education and Mental Health Care. *Human Arenas*, 1-7.

Schmorrow, D. D. (2005). *Foundations of augmented cognition*. CRC Press.

Seligman, M. E. (2011). Building resilience. *Harvard business review*, *89*(4), 100-6.

Shapiro, D. (2019). Transcendental Meditation (TM) shown to significantly reduce ptsd and depression. *Mental Health Matters*, *6*(2), 28-29.

Smith, B. & Ram, P. (2019). Interoperability. In Walcutt & Schatz (Eds.): Modernizing Learning: Building the Future Learning Ecosystem. Government Publishing Office. Washington, D.C.

Smith, B., Gallagher, P. S., Schatz, S., & Vogel-Walcutt, J. (2018). Total Learning Architecture: Moving into the Future. In *Proceedings of the Interservice/Industry Trainging, Simulation, and Education Conference (I/ITSEC)*.

Snyder, J. (1989). *The ideology of the offensive: Military decision making and the disasters of 1914* (Vol. 2). Cornell University Press.

St. John, Mark, Kobus, David A., Morrison, Jeffrey G., Schmorrow, Dylan. (2004). Overview of the DARPA Augmented Cognition Technical Integration Experiment. *International Journal of Human-Computer Interaction*, *17(2)*, 131-149.

Stanley, E. A., Schaldach, J. M., Kiyonaga, A., & Jha, A. P. (2011). Mindfulness-based mind fitness training: A case study of a high-stress predeployment military cohort. *Cognitive and Behavioral Practice*, *18*(4), 566-576.

Stanney, K. M., Schmorrow, D. D., Johnston, M., Fuchs, S., Jones, D., Hale, K. S., ... & Young, P. (2009). Augmented cognition: An overview. *Reviews of human factors and ergonomics*, *5*(1), 195-224.

Suciu, P. (2014). Why cyber warfare is so attractive to small nations. Fortune. Retrieved from: https://fortune.com/2014/12/21/why-cyber-warfare-is-so-attractive-to-small-nations/

Summary of the 2018 National Defense Strategy of the United States of America (2018). Sharpening the American Military's Competitive Edge. Retrieved from: https://dod.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf

Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive science*, 12, 257-285.

Tan, M. (2015). Army's new 'universal transcripts' draw interest of other services. Retrieved from: https://www.armytimes.com/news/your-army/2015/11/04/army-s-new-universal-transcripts-draw-interest-of-other-services/.

U.S. Marine Corps (2019). Marine Corps establishes volunteer cyber auxiliary to increase cyberspace readiness. Retrieved from: https://www.marines.mil/News/Press-Releases/Press-Release-Display/Article/1845538/marine-corps-establishes-volunteer-cyber-auxiliary-to-increase-cyberspace-readi/

U.S. Navy. (2019). Ready Relevant Learning. Retrieved from: https://www.public.navy.mil/usff/rrl/Pages/default.aspx

Vogel-Walcutt, J.J. & Abich, J. (2011). Using neurophysiological data to inform feedback timing: A pilot study. Paper to be presented at the Augmented Cognition International Conference, Orlando, FL, July 9-14.

Walcutt, J. J. (2019). *Innovating Government: Re-designing the Executive Branch*. OPM Washington United States.

Walcutt, J.J. & Schatz, S. (2019). Modernizing Learning: Developing the Future Learning Ecosystem. Government Publishing Office. Washington, D.C.

Zsambok, C. E., & Klein, G. (Eds.). (2014). *Naturalistic decision making*. Psychology Press.