West Point cadets use virtual reality goggles to conduct reconnaissance of their objective 12 June 2017 during urban-raid lane training at West Point, New York. (Photo by John Pellino, West Point DPTMS VI)

Putting Concepts of Future Warfare to the Test

Maj. John Spencer, U.S. Army

Lionel Beehner, PhD

Capt. Brandon Thomas, U.S. Army

The Army's vision of a future multi-domain battlefield makes many assumptions about the cognitive demands and capabilities of current and future soldiers. These assumptions, among others, include that soldiers of the current millennial generation are inherently more tech-savvy than their predecessors because of extensive, lifelong exposure to technological devices such as personal computers, virtual gaming, and cell phones. Thus, they should be able to better leverage new technologies to increase their

Imagery of an objective is displayed on virtual reality goggles for West Point cadets 12 June 2017 during urban-raid lane training at West Point, New York. (Photo by John Pellino, West Point DPTMS VI)

performance in executing military missions. There is also an assumption that sequentially adding technologies into military skills training only after soldiers are trained in fundamentals will be adequate.

Our research suggests otherwise. The purpose of this study was to test a set of hypotheses and assumptions that younger cadets and soldiers possess a higher aptitude and familiarity with digital technologies that could be used to increase combat performance. Our research was conducted over the summer of 2017; it entailed a randomized control trial of West Point cadets participating in urban-raid lane training utilizing new technologies such as virtual reality (VR) goggles. The results of our research showed a sample of millennial soldiers with limited experience and proficiency in military tasks were too cognitively overloaded to accept new and unfamiliar technologies while under the stress of military requirements—despite the clear advantage these technologies held for completing their mission. Our results provide preliminary evidence that cadets generally default to analog technologies—namely, a notepad, pen, or paper—under duress or in the heat of battle, even one simulated. Moreover, our findings demonstrate that the need to train and develop spatial-projection skills are even more important than implementing new technology earlier in the training cycle.

Digital Natives and Military Technologies

The popularity of today's video games, such as *Call of Duty*, *Halo*, and *Grand Theft Auto*, with millennials has not gone unnoticed by the U.S. military. The transfer of lessons and skills from these games, especially massively multiplayer online role-playing games, to improve soldier aptitude and agility has become a desire of military training. The gaming environment is of particular interest to the Army, based on the Army Capabilities Integration Center's Early Synthetic Prototyping efforts—such as Operation Overmatch—to better understand how technologies are used.[1] These "lightweight simulations" are meant to mimic the characteristics of the current operational environment with a great deal of fidelity, including "stress training," which seeks to simulate time, noise, and performance pressures.

Moreover, the role of new technology, from robotics to information technology, will be increasingly important in future wars.[2] In anticipation of such, the Army is developing a new multi-domain battle concept in preparation for fighting and winning its next war. Planners believe future battles will be fought in an operational environment where the Army will be challenged to maintain freedom of maneuver and superiority across not only the air, land, and maritime domains but also across space and cyberspace domains, as well as in the electromagnetic spectrum.[3]

To maintain freedom of maneuver and superiority in future wars, future soldiers will have to arrive on high-tech battlefields cognitively ready to maximize U.S. military strengths while exploiting enemy weaknesses and taking advantage of split-second opportunities. As a result, they will have to be trained and equipped to use a wide range of enablers and technologies. Yet, the doctrine and techniques the Army will need to fight across all domains—especially for integrating tools and assets in space, cyberspace, and the electromagnetic spectrum—are still to be developed.

As efforts are underway to develop new concepts and capabilities, there is a prevailing assumption among military planners that trust in automation is greater among younger generations, given their "digital nativism" as everyday users of new technologies, from gaming to social media. As a result, the military's plan to integrate technology into a digital-native force structure is based largely on a previously untested assumption that digital natives will readily adopt technology and subsequently increase proficiency. For example, a 2013 study suggests that younger learners should seek greater speed, constant connectivity, and the ability to multitask more than their counterparts from previous generations.[4] Similarly, another study found that video gaming provides long-lasting positive effects on users' cognitive skills, including mental processes such as perception, attention, memory, and decision making.[5] Other researchers assert that older generations tend toward greater caution when presented with unfamiliar or new technologies and put greater stock in trust cues.[6]

Additionally, such studies are seemingly supported by the findings of some psychologists who assert that novices in new situations or faced with new tasks require more instruction than expert learners. Even after novices are given cues or essential information, they often interpret new information or technologies as redundant, leading to what is called "cognitive overload."[7] Put simply, this refers to the inability of learners to take in new information or demands without making the task overly complex.

The Modern War Institute at the United States Military Academy recently tested these assumptions during a tactical training exercise that included replicating many attributes described in the multi-domain battlefield discussions. The research results suggest that the integration of technology

Maj. John Spencer, U.S. Army, is the deputy director of the Modern War Institute at West Point, New York. He serves as the course director of the Cadet Capstone Research Course and an instructor of the Introduction to Strategic Studies course in the Defense and Strategic Studies Program. He holds an MPM from Georgetown University. During his career, he served as a military Fellow with the chief of staff of the Army's Strategic Studies Group, the joint staff, the Army staff, 4th Infantry Division, 173rd Airborne Brigade, and the 4th Ranger Training Brigade.

Lionel Beehner, PhD, is research director at the Modern War Institute at West Point, New York, and assistant professor in the Defense and Strategic Studies Program. He is course director of Research Methods and previously was course director of Military Innovation.

Capt. Brandon Thomas, U.S. Army, is an instructor with the Department of Behavioral Sciences and Leadership at West Point, New York. He holds a BS from the United States Military Academy and an MS from Georgia Institute of Technology. During his career, he served with the 1st Cavalry Division and the 2nd Cavalry Regiment. His current duties include serving as course director for the Engineering Psychology Program's Experimental Psychology and Anthropometrics/Biomechanics courses.

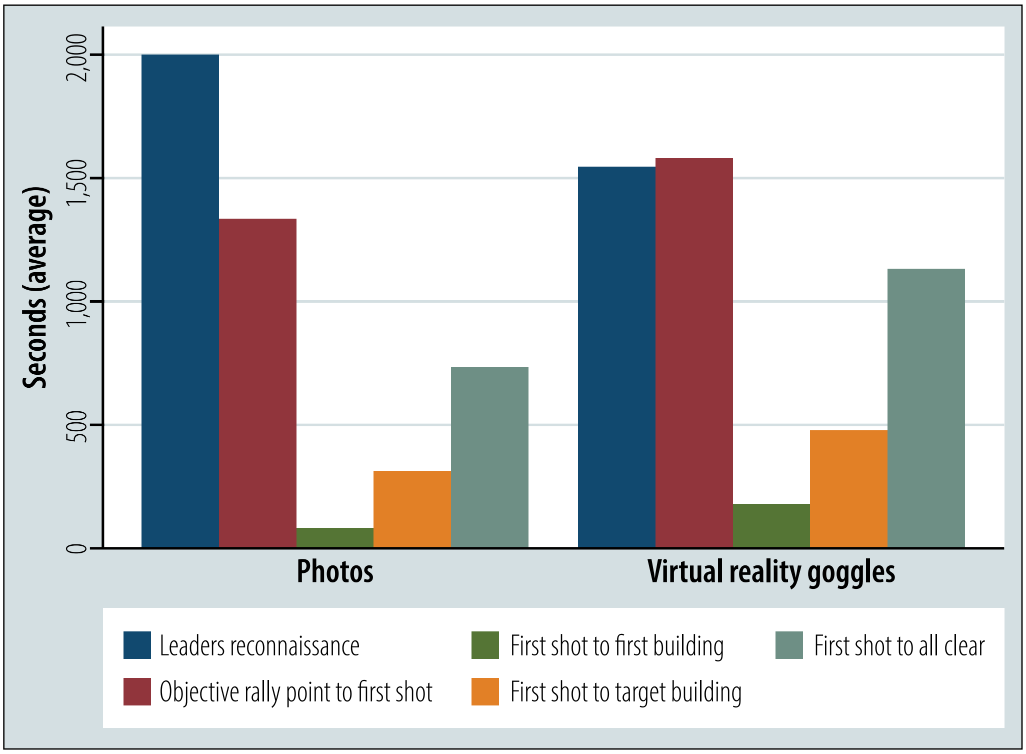
in training and on the battlefield should take place *only* after soldiers achieve a certain level of tactical proficiency without the benefit of supporting technology.

In addition to concerns about the impact of experience on the ability to receive new information, the study results showed the cognitive ability to mentally visualize and rotate images is essential for high levels of performance, but that such skills are notably lacking in many millennial trainees. This visualization and projection skill should be considered a prerequisite fundamental in individual soldier skills training. In simple terms, we must teach soldiers to mentally project and rotate objects from imagery to a greater degree than how we currently train soldiers to envision their land navigation routes. The overreliance on digital mapping navigation (e.g., Google Maps or Waze) has greatly reduced the skill set necessary for the previously mentioned mental processes. That is, we should not assume that younger soldiers, by virtue of growing up immersed in a culture of video games and other platforms, are naturally comfortable, competent, or confident in the use of digital technologies that draw

Table. Effect of Virtual Reality Goggles on Cadet Performance

	Mean time (seconds)	Average treatment effect (standard error)	P-value
Leaders reconnaissance	1764.1	-462.75 (96.8)***	0.00
Objective rally point to first shot	1446.4	247.5 (0.19)*	0.051
First shot to first building	104.3	91.9 (17.2)***	0.00
First shot to target building	385.12	172.92 (47.5)***	0.00
First shot to all clear	916.3	397.3 (65.7)***	0.00
Total N=120			

(Graphic by authors. Note: First column lists average times [in seconds] for all five performance measures. Second column shows the virtual reality treatment effect [a negative sign equates to fewer seconds] and thus a higher performance measure [Robust standard errors in parentheses]. Third column lists p-values for a one-tailed t test: *p<0.1 ** p<0.05 ***p<0.01.)



(Graphic by authors)

Figure. Mean Treatment Effect; Photos versus Virtual Reality Goggles

upon unlearned or underutilized skills in combat situations. Our findings are bolstered by parallel research of cadets' trust in and use of technology.[8]

Creating a Realistic Operating Environment

During their final summer at West Point, all cadets are required to execute a four-week field training exercise called Cadet Leader Development Training. The training is modeled after a phase of Ranger School and carried out in the dense forest a few miles from the academy. Cadets conduct a number of missions, or "lanes," and are evaluated in leadership positions while executing platoon-level infantry missions to include ambush, raid, and movement to contact. The Modern War Institute (MWI) partnered with the Army Cyber Institute and the Department of Behavioral Sciences and Leadership to create a training exercise with many of the characteristics of warfare forecasted to be a part of the multi-domain battlefield.

The MWI designed a mission that required cadets to plan a platoon raid on an urban site. The objective was a seven-building village where the enemy had established a command node. The main building was equipped with a closed-circuit video system. The enemy consisted of seven personnel equipped with personal weapons, a heavy machine gun, and an unmanned aerial vehicle for observation and early warning.

Cadets planned their mission in a patrol base. During planning, cadets were provided with a cyber specialist from a cyber electromagnetic activities (CEMA) team with the ability to hack into cameras located on the objective and to "shoot down" (send an electronic message telling the device to shut off) any enemy drones they encountered. The cadets conducted a vehicle movement to a checkpoint where they would begin their walk into their area of operations. At the checkpoint, cadets were met by a two-man Special Forces team that gave the platoon leadership an intelligence update and guided them into their objective rally point (ORP). The movement from the checkpoint to their ORP was approximately eight hundred meters.

In their ORP, the Special Forces team provided the cadet leadership the ability to walk their objective by using sets of VR goggles that projected 360-degree panoramic photos of the objective. These photos and the virtual experience replicated photos taken by a human intelligence source (local informant) or footage captured by a drone. During the leader's recon, cadets were able to hack into the closed-circuit video cameras located on the target building. Finally, the CEMA team soldier was able to shoot down the enemy drone upon the cadet platoon leader's command while executing actions on the objective.

The development of the virtual reconnaissance capability was significant. Officers from the Army Cyber Institute captured more than one hundred pictures in and around the objective using a 360-degree camera, linked the photos to waypoints with a three-dimensional VR programming language called Unity, and ultimately used a common virtual tour exploration application to allow a user to move between hotspots. Using an Android smartphone and a set of gaming goggles as the delivery tool, cadets were able to move from one end of the objective to the other, hopping from hotspot to hotspot to virtually walk their objective. They could stand in front of all the buildings, observing the number of entryways, the direction of door openings, and the lines of sight from anywhere outside the buildings. Cadets could also go to any planned support-by-fire, assault, or security sites to determine what they could see from those positions. Cadets received hands-on training on all three systems (counterdrone rifle, video-hacking capabilities, and VR reconnaissance goggles) prior to beginning their field exercise to reduce any issues with not knowing how to use the equipment when it was introduced during the field exercise.

Method

The creation of a realistic and advanced operating environment also served as a closed lab to test hypotheses applicable to modern and future warfare. In partnership with the engineering psychology program within the Department of Behavioral Sciences and Leadership, the MWI formulated a research plan to answer the following research question: Does a VR capability increase performance in military operations?

An experiment was conducted to determine if providing cadets with the VR reconnaissance goggles that allowed them to virtually walk their objective prior to the raid mission would increase their performance. During the study, twelve platoons consisting of forty cadets each were provided VR goggles while they were in their objective rally point and before conducting their leader's recon of the objective. Another twelve platoons, the control group, were provided a target packet consisting of twenty-five high-definition photos of the objective. The treatment and control groups were randomly selected. To prevent a violation of the trial's exclusion restriction, cadets in the control and treatment groups had zero interaction or contact with their counterparts before or during the study.

There were two strongly held assumptions that contributed to the development of the research question. The first was that the millennial-age cadets were "digital natives" who grew up on and were highly proficient at video gaming and the use of ever-advancing mobile technologies, and consequently should have been better able to leverage technology and translate that to battlefield effectiveness at the tactical level. This assumption was so prevalent that it was heavily debated whether to evaluate cadets on their execution of the mission. It was believed that the cadets' technological abilities and the chance to virtually walk their objective would give them a marked advantage compared to cadets conducting the mission without technological assistance. The final decision was to grade the cadets just like the other missions.

A second assumption was that based on the cadets' ubiquitous use of technologies in their everyday lives, they would welcome and willingly use the VR reconnaissance goggles offered to them. There was a thirty-minute maximum set on the use of the goggles to prevent the cadets from spending too much time using them.

Dependent Variables

The study examined five time-performance measures:

- the amount of time the cadet leadership took to conduct their leader's reconnaissance,
- the amount of time between leaving their ORP and their first shot (this included positioning all elements into their security, support by fire, and assault positions),
- the amount of time from first shot to the assaulting element reaching the first building on the objective,
- the amount of time from first shot to the assaulting element reaching the target building, and
- the amount of time from first shot to all buildings searched and cleared of enemy personnel.

Time as a performance measure was chosen based on its association with multiple aspects of the characteristics of the offense. As described in Army Doctrine Publication 3-90, *Offense and Defense*, the main feature of offensive missions is taking and maintaining the initiative.[9] The four doctrinal characteristics of the offense—audacity, concentration, surprise, and rapid tempo—all indicate the vital importance of time. The least amount of time used to gain and maintain the initiative served as an effective metric to measure sound tactical execution.

The goal of the research was to understand whether VR reconnaissance can increase performance in military operations. We varied elements of the application of VR (the treatment effect) to assess and passively measure the key performance indicators and thereby determine if VR reconnaissance had a noticeable effect, either positive or negative.

Results

First, we examined the results using a difference in means OLS (ordinary least squares) regression as shown in the table (on page 84). We found that in all but one of the five performance measures, the treatment effect of using the VR goggles led to a significant increase in time—in other words, using the goggles had a negative effect on the cadets' performance. The use of the goggles led to sufficiently slower times in the second, third, fourth, and fifth performance measures. All the measures, except for the second, were statistically significant to the .05 level. In the figure (on page 84), we see that the use of VR goggles had a significant effect in speeding up the leader's reconnaissance performance measure, but it had a very negative effect on the performance measure "first shot to all clear."

Discussion

The surprising response from the cadets was a hesitation or refusal to use the technology. When given the opportunity to use the VR reconnaissance capability, cadets *overwhelmingly chose not to use it* or only used it for a short amount of time before leaving for their physical reconnaissance. The average length of use of the goggles was five minutes, the minimum was thirty seconds, and the maximum was eight minutes.

One of our initial assumptions was that the cadets did not feel comfortable with the particular technology tool or the simulated virtual environment. This was unsupported by the evidence when compared to the amount of time the control group cadets spent looking at the photos of the objective. There was no significant difference in

A cadet's hand-drawn sketch of the objective is displayed 5 June 2017 during urban-raid lane training at West Point, New York. (Photo by Maj. John Spencer, U.S. Army)

the average, maximum, or minimum time of cadet use between the goggles and the photos.

The quantitative results show that the use of the goggles increased the speed of the cadets' leader's reconnaissance but found they were slower in the actual performance of all the other critical tasks or steps measured. This can be attributed to the cadets gaining a false sense of knowledge from only a few minutes of using the goggles and maps, thus rushing through their physical leader's reconnaissance while failing to use the goggles to obtain the information that an experienced soldier might. The cadets did not use the goggles to obtain the critical information (e.g., lines of sight, building approach, building access points, covered and concealed positions) that would have allowed soldiers with experience in urban raids to considerably increase their performance on the mission.

The qualitative observations of the cadets suggested that they were overwhelmed by their lack of expertise in the leader and collective tasks they were being asked to execute. The cadets' cognitive load was so full that they were not open or could not accept any additional information, technology or not. When presented with the goggles or high-definition photos, cadets could not spare the cognitive load to process the new information. They looked at the goggles or photos for a few moments—most likely only because they were being watched by evaluators—but preferred either to use simple tools such as a hand-written sketch or to see it for themselves by moving as close to the objective as they could get. Cadets would use these sketches standing directly above the high-definition photos or VR goggles they were provided.

Furthermore, cadets demonstrated a lack of an ability to spatially project themselves onto their objective. They could not picture themselves on a street or in front of a building and then use that mental imagery to discuss or alter their plan of action. This is consistent with lessons learned in land navigation at the United States Military Academy, where cadets demonstrated the same lack of visualization abilities when planning routes for land navigation. The ability to develop a visuospatial sketchpad (i.e., create a mental image) is critical for encoding information into our brains for learning and subsequently, decision making.[10] Furthermore, the ability to rotate images and utilize projection of situational awareness on future events is a fundamental skill of modern warfare, where satellite or aerial imagery is often all soldiers are provided before conducting missions.

Implications

The results of this study provide insight into two widely held assumptions: first, that the current generation of soldiers (ages eighteen to twenty-five) want more technology based on their use of it during their civilian lives and therefore will be able to easily incorporate technology into military tasks and increase performance in accomplishing missions; and second, that military training with technology requires a progressive and sequential methodology that includes learning fundamentals in a technology-free environment and then incorporating technology once a level of competence has been demonstrated.

With respect to the first assumption, this study shows that despite being digital natives, cadets did not immediately welcome the use of a new piece of technology. They chose to use both the VR goggles and photos for only a few moments. Based on the experiment and survey results, this in part seems to be caused by the cadets lacking the requisite cognitive space; they were too fully loaded with the stresses of inexperience and time to permit any new technology or information. This is consistent with research on the cognitive free space of experts versus beginners.

The lack of participants' use of aids was practically significant. The effect of experience—in terms of temporal workload and spatial situational-awareness projection—has significant practical implications for future training techniques and stands in stark opposition to current technological adoption assumptions. This should inform basic theories of soldier confidence and openness levels to technical advances and military plans to integrate more technology into soldier equipment sets.

A senior special operations leader visited the research lane. He commented on the integration of technologies with experts compared to overtaxed beginners. He felt that soldiers in a special operations unit can assess a new technology or piece of equipment and quickly know if that piece of equipment would help in the execution of military tasks. Beginners, on the other hand, lack the training and experience to know whether a new piece of equipment will benefit their performance.

The second assumption addresses the appropriate training methodologies and the timing of using more technologies to build fundamental military skills; the results of this study support the longstanding military progressive-and-sequential training model that emphasizes learning technology-free basic fundamentals first and then incorporating technology later. The cognitive resources and mental stress of executing new tasks can be reduced with experience and therefore has been shown to allow space for new information or tools.

But the realities of the modern battlefield cause a need for the ability to use technologies and information inputs such as satellite imagery or drone footage before executing a mission, because U.S. forces are often not able to infiltrate enemy-held terrain to physically see their objective beforehand, which is the method emphasized in training that has been passed down from previous wars. The ability to use technology-enhanced information feeds directly into the ability to spatially project future actions onto the location of the mission, a phenomenon that has previously never been explored.

We found that spatial projection was one of the core capabilities the cadets lacked. We determined that spatial projection is a learned mental ability or process that combines the use of the visuospatial sketchpad in relation to information encoding to the working memory, mental rotation, and situational awareness as applicable to anticipation of future events. Spatial projection allows a person to "see" the objective from multiple perspectives in order to make mission-critical decisions. In its simplest form, in a military context, it allows a soldier to plot the most advantageous route from point A to point B. In the case of executing a tactical task on any given objective, it allows for the soldier to use knowledge of terrain, images, etc., to paint a picture that influences decision making and actions on the objective.

While learning basic military skills before adding technologies still remains relevant, this research highlights the need to train and develop individual spatial projection skills. The lack of ability to spatially project was also observed while trying to teach cadets land navigation skills at West Point. After continued decrease in cadet land navigation scores, a visualization class was added to the normal map reading and land navigation classes. After their visualization training, cadets were required to sketch a pictorial of their planned route between two points and verbally brief it to an instructor. The brief included verbalizing what the cadets would see on their route, the elevation changes, key types of terrain they planned to see, and major terrain features. This change significantly increased cadet performance on the land navigation course.

Spatial projection is a fundamental skill requirement to use information from technology like the VR goggles and photos, along with intelligence, surveillance, and reconnaissance tools for mission planning. This skill set may be more important than what technology is provided to soldiers. If we are able to train these fundamental cognitive abilities and skills through concerted training at the individual soldier skill level before we introduce the technology, we believe the future soldier will indeed be able to pick up new technology and effectively glean all that there is to be learned or used from it in the most efficient manner possible.

Way Ahead

The impact of technology on battlefield performance is a relatively new area of study in the fields of military science and innovation, so there is not much rigorous or empirically tested literature about the impact of VR technology on combat effectiveness. Moreover, extant academic studies suffer from internal/external validity problems. The research attempted here was extremely pioneering and can contribute to establishing a foundation for future researchers to build from. To assess the validity of the study's findings, it should be replicated with more formations containing a variety of expertise such as operational units going through the Joint Readiness Training Center.

However, this research strongly suggests that the Army should not assume millennial generation soldiers are more tech-savvy than their predecessors are, nor that they are more capable of using new technologies to increase their performance in executing military missions without development of certain cognitive skills as a prerequisite. This suggests that the addition of visualization and spatial projection training at the earliest point in training will benefit new soldiers as they become more proficient at military tasks and open to the use of more information inputs and technology.

Finally, the research conducted here was also a demonstration of how low-cost training can incorporate multiple aspects of both modern and near-future operating environments. The complexity of the individual and collective tasks was not increased; rather, the complexity of the environment was. The cadets who performed the best were the ones that utilized the doctrinal fundamentals they had been taught in their military science course. ■

Notes

1. Adin Dobkin, "New Army Gaming Prototype Preps Soldier for Future War," Defense Systems (website), 12 September 2017), accessed 26 December 2017, https://defensesystems.com/articles/2017/09/12/army-gaming-operation-overmatch.aspx.

2. Michelle Tan, "Top Army General Outlines Plans for New Brigades, New Technologies," *Army Times* (website), 21 January 2016, accessed 26 December 2017, https://www.armytimes.com/news/your-army/2016/01/21/top-army-general-outlines-plans-for-new-brigades-new-technologies/.

3. David G. Perkins, "Multi-Domain Battle: Driving Change to Win in the Future," *Military Review* 97, no. 4 (July–August 2017): 6–12.

4. Penny Thompson, "The Digital Natives as Learners: Technology Use Patterns and Approaches to Learning," *Computers & Education* 65 (2013): 12–33.

5. Adam Eichenbaum, Daphne Bavelier, and C. Shawn Green, "Video Games: Play That Can Do Serious Good," *American Journal of Play* 7, no. 1 (2014): 50.

6. Christian Pieter Hoffmann, Christoph Lutz, and Miriam Meckel, "Digital Natives or Digital Immigrants? The Impact of User Characteristics on Online Trust," *Journal of Management Information Systems* 31, no. 3 (2014): 138–71.

7. John Sweller, Paul Ayres, and Slava Kalyuga, *Cognitive Load Theory*, vol. 1 (New York: Springer Science & Business Media, 2011).

8. Richard Pak et al., "Evaluating Attitudes and Experience with Emerging Technology in Cadets and Civilian Undergraduates," *Military Psychology* 29, no. 5 (December 2017): 448–55.

9. Army Doctrine Publication 3-90, *Offense and Defense* (Washington, DC: U.S. Government Publishing Office, August 2012).

10. Alan Baddeley, "The Episodic Buffer: A New Component of Working Memory?," *Trends in Cognitive Sciences* 4, no. 11 (November 2000): 417–23; Alan Baddeley, "Working Memory: Looking Back and Looking Forward," *Nature Reviews Neuroscience* 4 (October 2003): 829.