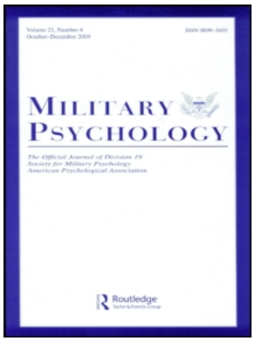

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Soldier Performance in High Operations Tempo Conditions: West Point Contributions

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Faculty and cadets at the U.S. Military Academy (West Point) are vitally involved in the Sustaining Performance Under Stress project. A cadet research team completed an experiment that found that a cognitive prime presented during a cortically aroused state was more effective than startle-based prime in maintaining vigilance in a simulated command and control monitoring task. In addition, over 20 male and female West Point cadet athletes served as research participants in experiments conducted at the University of Texas, thus increasing the generalization of the results to the target military population. Finally, West Point military faculty served as subject matter experts to the project to help maintain a valid operational focus.

Faculty and cadets at the U.S. Military Academy (West Point) have been involved in a variety of ways in supporting the Sustaining Performance Under Stress project. The faculty at West Point are uniquely situated to bridge the gap between traditional academic research and the very real challenges posed to soldiers and their leaders in operational settings. The majority of West Point instructors are Army officers in the rank of captain or major, almost all of whom have been deployed in combat in either Afghanistan or Iraq. These officers provide a rich source of information that may guide more formal scientific protocols aimed to improve soldier performance in high operations tempo (optempo) deployments. Moreover, the senior military and civilian faculty maintain close connections with commanders in operational units that may facilitate exchange of information and ideas relevant to the project.

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Of equal importance, West Point educates and trains approximately 25% of the new lieutenants that enter the Army each year. The cadets complete a challenging 47-month-long regime of Ivy League–level education (only Harvard, Yale, and Princeton have produced more Rhodes Scholars than West Point) in the context of strict military training and physical fitness development. While all cadets are held to high standards of physical fitness, most far exceed Army Physical Fitness Test (APFT) standards, and all are either intercollegiate or intramural athletes. Combined with their growing knowledge and experience of Army doctrine and training, this provides a rich participant pool to include in the current project.

West Point's contributions to the project focus in three primary areas. First, faculty-led cadet research teams conduct research projects dealing with the human factors involved in the design of future command and control technologies. Second, West Point is providing 30–40 cadet research participants each year to be tested in the exercise physiology and fMRI efforts at the University of Texas. Third, faculty serve as Army domain-specific subject matter experts, providing insight and guidance into posing research questions, and helping civilian professors—most with no military experience—better understand the challenges that soldiers face in operational settings. The remainder of this article will summarize ongoing efforts in these areas.

BASIC RESEARCH PROJECTS

An important question for designers of digital command, control, communications, computers, intelligence, surveillance, and reconnaissance (C^4ISR) technologies is ensuring that the human operator is able to function at the highest possible level. Command and control displays can now convey tremendous amounts of information on friendly and enemy forces, provide detailed maps of terrain in different scales, and coordinate voice and digital communication up, down, and across echelons. These technologies are often situated in the context of a tactical operations center (TOC) that is staffed by a large number of personnel, many different systems, and operating continuously around the clock. Highly salient activities may direct attention away from more mundane monitoring tasks. Or, perhaps more commonly, hours of routine operations may challenge operators to maintain vigilance while monitoring one or more complex displays.

One important research question, therefore, is what might be an optimal means for maintaining vigilance in such situations? An obvious answer is to design cues or warning signals that indicate when particularly important information is being transmitted. However, the literature on warning signals is mixed. Though one could design a unique signal for almost any type or class of information change, the result might be a cacophony of noises, and past studies suggest that operators simply turn off the warning signals in such situations. An alternative approach is to devise ways of maintaining vigilance through restoring or maintaining cortical activity. Said more simply, how can we keep operators alert during long work periods under conditions of distraction and restricted sleep?

A solution being investigated by the Engineering Psychology Program at West Point is to analyze how different alerting stimuli may maintain or restore cortical arousal. Past research and pilot data (see Ness, 2007) from our laboratory suggest that a cognitively meaningful stimulus, presented while the operator is still cortically aroused, may be more effective than such a stimulus presented when the operator drifts into a less aroused state. And such a stimulus may also be more effective than a more traditional "startle" type of stimulus presented when the operator drifts out of cortical arousal. Accordingly, a cadet research team has designed and is currently in the process of executing a study that compares the relative efficacy of two types of alerting stimuli (cognitive versus startle) presented in two different states of cortical arousal (alert versus entering sleep). These four approaches are being studied in the context of a 90-minute-long monitoring task, where participants (40 West Point cadets) are tasked with detecting changes in icons on an analogue Force XXI Battle Command Brigade and Below (FBCB2) task. Preliminary results are consistent with the hypothesis that a cognitive prime (in this case, a short aural presentation from a set of the research participant's favorite music) results in more correct detections (approximately a 32% advantage versus control subjects), more accurate detections (a 44% advantage over controls), and substantially fewer false alarms (a 250% advantage compared to controls). Moreover, the cognitive prime outperformed each of the other four conditions in almost all comparisons made over the entire 90-minute duration of the experimental sessions.

Another approach to enhancing the ability of operators to detect changes in icons in digital displays involves understanding how stress, sleep restriction, and cognitive workload might affect the ability of the human eye to detect changes in the working field of view (WFOV). The WFOV is the area of the eye, including the fovea and surrounding areas, that detects granular changes in visual stimuli. When you are reading fine print, for example, you automatically orient the eye toward the words in such a way as to direct the visual stimuli to this region of the retina. This is also the same region of the eye that is used to view and detect changes in icons. Interestingly, there is evidence (e.g., Ball, Beard, Roenker, Miller, & Griggs, 1988) that the WFOV shrinks under conditions of stress, sleep restriction, and high cognitive workload. However, no research has been reported to date that explores the degree of WFOV change that occurs in the context of detecting change while viewing icons in C^4ISR settings. We are beginning a series of studies to address this gap in the literature. The first experiment will examine the effect of cognitive workload on the degree of WFOV change while viewing stimuli on a flat screen monitor. Employing a mixed between-subjects/within-subjects design, cadet participants will engage in no added cognitive task, a low-effort cognitive task, or a high-effort cognitive task while viewing a series of stimuli presented at different distances and angles from the central fixation point. Eye trackers will be used to supplement hit or miss reports. Follow-on studies can then begin to suggest optimal sizes for icon displays that are designed to adjust for operator workload (or fatigue and stress) or are of sufficient size to be detected under the least optimal conditions.

The effects of cognitive workload on change detection are also being examined by a cadet research team. The change blindness literature (e.g., Durlach, 2004) clearly shows that detecting changes in icons is difficult, even under optimal conditions. Results from a pilot study showed that cadet participants engaged in a distracting secondary task took over twice as long compared to those who were not distracted to detect changes in a simulated command and control task. Follow-on research from this cadet project should lead to subsequent studies on how to best signal the presence of key changes, especially in contexts likely to be encountered in operational settings (tedium, noise, restricted sleep, stress, high workload, etc.).

A unique role that West Point faculty and cadets may play in the high optempo project is the ability to link other members of the research team to opportunities for field tests of concepts and technologies being developed. For instance, West Point was able to arrange for Dr. Eagleman to field-test his flicker-fusion fitness for duty device during an 8-day combat survival course conducted at the Royal Norwegian Military Academy. Because this course exposes the Norwegian cadets to 8 days of continuous military operations without sleep, the impact of extreme sleep deprivation on flicker-fusion performance can be charted in a sample and setting that approximates extended high optempo missions. There are several different venues that West Point military and civilian faculty have access to that can easily be cleared in which to test this technology.

PROVIDING DOMAIN-RELEVANT RESEARCH PARTICIPANTS

To maintain good external validity, it is important to include in testing protocols research participants with some familiarity with the Army and its mission, tactics, and doctrine. Moreover, given the goals of this particular project, it is also important that potential research participants be in top physical condition. West Point has, to date, provided over two dozen male and female cadets to serve as participants in Dr. Coyle's testing regime and Dr. Schnyer's fMRI work.

The cadet participants are unlike those often recruited from traditional student populations. They are, of course, quite gifted academically (the mean SAT for entering cadets is around 1280, V + Q). Since all cadets must engage in either intercollegiate or intramural athletics, all are also in superb physical condition. Perhaps most importantly, they are true volunteers. Federal law prohibits paying military personnel for participating in research projects. Thus, cadets who volunteer do so for other reasons. After completing their participation, most report that they

FIGURE 1 Cadet Kim DeFiori, USMA Class of 2008, participating in an experiment on physical exhaustion and cognition. Cadet DeFiori organized the participation of over two dozen other West Point cadets as participants in the project and was the principal investigator on a research project on maintaining vigilance in command and control centers.

learned a lot about their own capabilities by virtue of the experience. For example, in Figure 1 the second author rides an exercise bike to exhaustion while completing a short series of cognitive tests.

Because West Point has both male and female cadets, we are able to provide participants of both sexes in sufficient numbers to allow researchers to explore for any possible interactions among sleep deprivation, physical and cognitive workload, and sex. Some preliminary findings (as summarized in other articles in this volume) suggest that men and women, while equally effective, may respond physiologically and neurologically in different ways to the testing protocols employed in the current slate of experiments. This could have important implications for the design of strategies to maintain performance in high optempo conditions.

In summary, by including West Point cadets in the mix of research participants in the project, researchers achieve higher external validity of their results. Especially when imaging the brain during command and control tasks, there can be little doubt that experienced brains will give more valid results than naïve ones.

PROVIDING DOMAIN-SPECIFIC SUBJECT MATTER EXPERTS

A frequently encountered challenge in military research is how to harness the academic expertise and ingenuity of civilian scientists and engage them in research with hugely important implications in a domain they are most often unfamiliar with. West Point faculty, and through them their contacts, are acting as go-betweens in the high optempo project to help bridge this science-operational gap.

A good example of this occurred in August 2007 when West Point hosted the first meeting of all members of the research team. To improve the understanding of the unique challenges our soldiers face in combat, I brought together a panel of five senior captains and newly promoted majors, all of whom had commanded an Army company in combat in either Iraq or Afghanistan. Each of these officers was a true soldier/scholar, having completed a master's degree from an Ivy League university about 3 months prior to the panel. They were all currently assigned as cadet company tactical officers at West Point. In addition, a lieutenant colonel, currently a doctoral candidate in human factors engineering and a former deputy brigade commander in Iraq, participated in the panel. The ensuing discussion between scientists and the domain subject matter experts was invaluable in developing a big-picture understanding of the challenges that soldiers and their leaders experience every day during combat deployments. Although somewhat intangible, this session may have been the most valuable component of the 2-day meeting.

Another manifestation of this role is the connections that West Point faculty have with key scientists and Army personnel not formally involved in the project. In planning the first conference (held in December 2007), it was this author's connections that enabled us to include Major General (Retired) Robert Scales on the program. General Scales' address framed the unique challenges facing the U.S. armed forces in 21st-century warfare. His talk prompted much discussion. Indeed, every subsequent speaker—all basic research scientists—made explicit reference in their own talks to General Scales' points.

The cadets also contributed to the broader mission of defining issues for the project. Cadet Kim DeFiori led a panel at the December symposium that closed out the meeting. Cadet DeFiori, along with Major Jared Sloan of the West Point Engineering Psychology Program and Dr. Laurel Allender of the Army Research Laboratory, focused the ensuing discussion on how to take the basic science emerging from the project and apply it within operational Army contexts.

It is vitally important that the high optempo research project not be just another hodgepodge of good science that is divorced from the operational realities of to-day's world. West Point will continue to strive to maintain this larger situational awareness among members of the research team to maximize the payoff to the Army from these efforts. This collaboration between traditional academia, operational Army units, and West Point soldier/scholars provides a good model for applied experimental research in military psychology.

CONCLUDING COMMENTS

There is a revolution of sorts occurring in how to understand the adaptation and performance of leaders and their soldiers in combat. Colonel Thomas Kolditz, head of the Department of Behavioral Sciences and Leadership at West Point, is leading the way in this work through his construct of *In Extremis* leadership (e.g., see Kolditz, 2007). In short, Kolditz's view is that domain experts in situations where risk of death or injury is high do not respond in ways that nonexperts do. These experts respond with confidence and competence to situations that would paralyze the uninitiated. Thus, studying how college sophomores (the "white rat" of modern cognitive psychology) respond to highly artificial command and control games will tell us almost nothing of value about how real soldiers and real Army leaders respond in real operational contexts.

Another important component of the *In Extremis* approach is that expert leaders have a positive impact on their subordinates that allows even relatively novice soldiers to adapt and perform at high levels of proficiency in difficult circumstances. This may lead to future research questions for the current project. What is it about these leaders that enables better performance among their subordinates? Are there psychophysiological correlates of these effects? How might we capture the parameters of expert-leader influence to further improve soldier adaptation and performance in high optempo settings?

The role of West Point in the current project, in closing, involves a variety of contributions. Perhaps most important, however, is that of maintaining perspective on the ultimate customer of the results of the project—the soldiers who volunteer to serve in our Armed Forces knowing they will be exposed to the challenges and risks of long deployments in combat zones.

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