

Military Medical Research on Cognitive Performance: The Warfighter's Competitive Edge



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DESPITE THE MILITARY'S captivation with high technology systems, human performance remains the keystone of successful military operations. Computerized, digitized, networked, and even robotic or biochemical performance-enhancement tools can be force multipliers of great value; but they are only as useful as the human designers engineer them, and are only as productive as clever human operators learn to employ them. To link system designers more closely with human operators, multidisciplinary research and development teams consisting of engineers, psychologists, physicians, physiologists, and actual users of the product integrate towards achieving a well-defined and realistic goal. These teams work on answering both basic and applied research questions to produce performance enhancement tools that are providing our forces with the competitive edge required to win on the battlefield.

The military medical cognitive research community, often led by behavioral scientists, is increasingly joining with National Aeronautics and Space Administration (NASA), Department of Transportation (DoT), Academia, and partnering with small businesses and the Defense Advanced Research Projects Agency (DARPA) to leverage unique, cutting-edge, expert capabilities. These scientific teams often collaborate with colleagues in allied national laboratories and universities. Together, their collective products help enable U.S. soldiers, sailors, airmen, and marines, as well as forces of allied nations to fight better, longer, stronger, smarter, and safer. These multidisciplinary teams of scientists adhere to mission mottos such as "Conducting Research for the Soldier," "Conserve the Fighting Strength," "Protect and Sustain a Healthy and Medi-

cally Protected Force," and "Research to Sustain and Enhance Human Performance." Their stated goals include ensuring that military forces are deployed in a state of superb health and are equipped to protect themselves from disease, injury, and the many health hazards that accompany operation of complex military equipment in high-tempo deployments in harsh environments. Most of all, these multidisciplinary researchers focus on extending human capabilities to permit combatants and support personnel to engage in optimal performance in the face of arduous battlefield operations (1).

Government-employed behavioral scientists are few in number, and increasingly are managing research programs rather than performing research themselves. In the future, they will likely be leading multi-service, multi-agency research efforts focused upon specific missions common to all participants. With today's budget constraints, maintaining redundant intramural research infrastructure and capabilities, and supporting multiple parallel intramural programs is a luxury no longer affordable.

For an example of a successful multi-service, inter-agency cognitive research project, augmented cognition may be considered, as just discussed in the previous segment by my colleague, Admiral (Ret) Kollmorgen. Over 40 yr ago, it was envisioned that one day human

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brains and interactive computers could be coupled together in a man-computer symbiosis, or a partnership that would permit advanced, augmented human intelligence and extend human thinking and cognitive abilities well beyond what the human brain can do by itself (2). Recently, the DARPA IWIIUS Program has made "augmented cognition" a household phrase within the cognitive performance community. The original augmented cognition concept, which has now emerged as a burgeoning scientific discipline, assumed that humans were not an anachronism, and hypothesized that computers could adapt to and improve human performance. Augmented cognition scientists and developers seek to revolutionize the way humans interact with computers by coupling traditional electromechanical interaction devices (e.g., mouse, joystick) with psychophysiological interaction (e.g., eye blinks, respiration, heart rate, electroencephalogram) such that subtle human physiological indicators can be used to improve human-machine interactions. The augmented cognition field is aimed at maximizing human cognitive abilities through the unification of humans and computational systems (8,9).

Elements of computer augmented cognitive performance are already in the field-testing stages thanks to the success of collaborations of the type discussed above. The Army/Honeywell Labs Augmented Cognition (AugCog) Team conducted a platoon level field evaluation of their AugCog system at the Aberdeen Test Center, Mulberry Point Military Operations in Urban Terrain facility at Ft. Detrick, MD. The purpose was to evaluate the cognitive state of Army soldiers operating in an urban environment by assessing moment by moment their brain and physiological signals using wearable sensor systems. The 24-h exercise was scripted so the AugCog team could gather data on the subjects under various stress levels, though a degree of "free play" occurred. During this exercise, the subjects were put into short-duration high-engagement periods, and long-duration waiting and searching periods to test vigilance. Most of the subjects were also sleep deprived during the end of the 24-h exercise. The soldiers with enabled AugCog technologies were better informed for controlling actions and responses during the experimental sessions than the control group (Giralomo H. Personal communication; 19-29 June 2006). Overall the first-ever full field evaluation of an augmented cognition technology in a simulated battlefield environment was considered a success. This field evaluation also represented a successful collaboration between military, academia, and industry towards improving cognitive performance for today's warfighting efforts.

Within U.S. Army Medical Research and Materiel Command, three laboratories perform medical research towards improving cognitive performance. For example, Walter Reed Army Institute of Research, Silver Spring, MD, is assessing human alertness, attention, and cognition through Fourier transformations of electroencephalographic signals of up to 500 Hz in sleep deprived individuals (10,11). U.S. Army Institute of Environmental Research, Natick, MA, is assessing cognitive functions, physiology, and performance of U.S.

Army Rangers undergoing rigorous training (3,4). U.S. Army Aeromedical Research Laboratory, Ft. Rucker, AL, is monitoring aspects of judgment and decision-making performance in aviation environments and mobile platforms (5,6) under simulated operational conditions. Successful collaboration across these Medical Research and Materiel Command laboratories with colleagues from Army Research Laboratory, Air Force Research Laboratory, Naval Health Research Laboratory, NASA, and academia resulted in the 2005 publication of *Aviation, Space, Environmental Medicine*, "Cognitive Performance in Operational Environments," and resulted in a highly successful triservice, multi-agency Cognitive Performance; Judgment, Decision-making Research program. This program sponsored two successful workshops: "Cognitive Performance: The Future Force Warrior in a Network-centric Environment" and "Cognitive Performance: Force Multiplication through Human-in-the-loop Augmentation," and through peer-reviewed medical journals published this valuable research. "Operational Applications of Cognitive Performance Enhancement Technologies" carries on this effort to publish operationally useful experimental results, and also enters into the new territory of neuroethics.

In "Operational Applications of Cognitive Performance Enhancement Technologies" a discussion is begun of the ethics of applying pharmacologic performance enhancement agents in military scenarios (7). Ethical arguments both supporting and limiting the use of enhancements are critically needed as we progress toward operational applications. Commentaries from representatives of allied nations accompany the main paper, and highlight that international discussions are critical towards the development of multi-national doctrine.

The supplement "Operational Applications of Cognitive Performance Enhancement Technologies" itself is also an example of a near-term product from an increasingly collaborative research program. The Guest Co-Editors from U.S. Army, U.S. Navy, and Academia teamed with journal section authors from U.S. Air Force, U.S. Army, NASA, DARPA, and industry to collectively identify, prepare, review, and publish manuscripts focused around themes relevant to both civil and government operational communities. This scientific product subserves current and future cognitive performance technologies. Creating this supplement required a team of 100 contributing authors, over 60 reviewers, 6 section editors, 3 guest co-editors, and support by the *Aviation, Space, Environmental Medicine* journal over an almost 2-yr period. The communication and interactions among the team members created new scientific awareness and understanding, and matured both the science and the collaborative relationships. The supplement will be available to the over 3500 journal subscribers internationally and many more through web-based access.

Future military medical research seeking to improve cognitive performance under stress will increasingly be a product of collective and collaborative efforts, dispersed across geographical boundaries, incorporating

ethical considerations, and not constrained by mortar and brick structures. Just as the brain is dynamic and evolving, so must be our approach to the challenging cognitive performance research topics presented in this supplement.

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