

Augmented Cognition: New Design Principles for Human-Computer Symbiosis

LCDR Dylan Schmorow, MSC, USN
Naval Research Laboratory
schmord@onr.navy.mil

Laura Worcester
Potomac Institute for Policy Studies
lworcester@potomacinstitute.org

LT James Patrey, MSC, USN
United States Air Force Academy
jim.patrey@usafa.af.mil

Key Words

Neural Science, Cognition, Simulation, Psychology, Cybernetics

ABSTRACT

The goal of Augmented Cognition is to extend, by an order of magnitude or more, the information management capacity of the human-computer integral by developing and demonstrating quantifiable enhancements to human cognitive ability in diverse, stressful, operational environments. Specifically, this would empower one human's ability to successfully accomplish the functions currently carried out by three or more individuals. A key objective is to foster development of novel- and improvement of identifiable- prototypes and enabling technologies, in order to experiment with and understand the means by which they may be integrated into existing operational systems, as well as those in development. Augmented Cognition will deliver new design principles for human-computer symbiosis.

Augmented Cognition explores the interaction of cognitive, perceptual, neurological, and digital domains to develop improved performance application concepts. The advanced applications will be tailored to military problems in order to demonstrate potential pay-off for operational users. Success will improve the way humans interact with computer-based systems, advance systems design methodologies, and fundamentally revolutionize decision making. Perhaps most important among the enabling breakthroughs are (1) the abundance of laboratory results which are accruing from the cognitive revolution and, (2) the results of research on brain mechanisms based on functional Magnetic Resonance Imaging (fMRI) technology. This revolution in human information capacity is further enabled by continued gains in speed and memory growth in digital technologies that blend virtual representations across perceptual modalities.

1.0 Background

Military operators are often put into complex human-machine interactive environments that have been shown to fail when a stressful situation is encountered. To help improve readiness, the Augmented Cognition develops technology to enhance human performance using intrinsic capabilities (brain function) through well-understood scientific principles that have heretofore been inadequately exploited in human-computer system designs.

The impact of this technology to the military services is both direct and formidable. These technologies have the potential to enhance operational capability currently beyond reach (e.g., the control of multiple entities by one operator), support the reduction in the numbers of persons required to perform current functions, and improve human performance in stressful operational environments.

2.0 Augmented Cognition Objectives

The objective of Augmented Cognition is to extend, by an order of magnitude or more, the information management capacity of the human-computer integral by developing and demonstrating quantifiable enhancements to human cognitive ability in diverse, stressful, operational environments. Specifically, Augmented Cognition will empower one human's ability to successfully accomplish the functions currently carried out by three or more individuals.

A key objective is to foster development of novel- and improvement of identifiable-prototypes and enabling technologies, in order to experiment with and understand the means by which they may be integrated into existing operational systems, as well as those in development. Augmented Cognition will accomplish this by delivering new design principles for human-computer symbiosis.

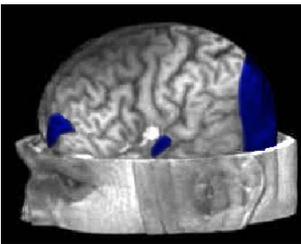


Figure 1: A Brain on Today's HCI

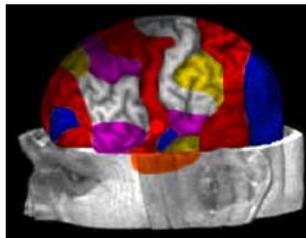


Figure 2: A Brain on Augmented Cognition

Augmented Cognition explores the interaction of cognitive, perceptual, neurological, and digital domains to develop improved performance application concepts. The advanced applications will be tailored to military problems in order to demonstrate potential pay-off for operational users. Success will improve the way humans interact with computer-based systems, advance systems design methodologies, and fundamentally re-engineer military decision making.

3.0 Technical Challenges

1. Rapid Context Switching: Limited transfer of information to the human when transmitting in parallel via different sensory channels; not enough is known about the parameters of each sensory channel, and very importantly how they interact.

2. Designing Interfaces Based on Cognition: Graphical User Interfaces are organized by application, not by content; and largely a single modality – vision.

3. Developing Decision Forecasting Tools that Exploit Human Inquisitiveness: “What-if, fast-forwarding” results are typically calculated and displayed based on default visualization techniques (such as monotonic trend lines) which do not exploit human inquisitiveness, and in no way portray what is NOT likely to happen.

4. Dynamic Modeling of Context: Models do not work in real time or provide the appropriate level of analysis to determine how concepts within a knowledge space relate.

5. Monitoring Decision Maker(s) Paths Through Context Rich Knowledge Space: Primitive pattern-based models are virtually “contextless” – no external awareness; reactive with no understanding of intent or individual differences or strategies.

6. Continuous, Autonomous Reconciliation of Computer Behaviors to Human Mental Models and Decision-Making Needs: Cannot determine associative structures (patterns) in any number of factors that might affect human perception, behavior, and decision-making.

7. Designing System Interfaces That Help People Remember: Interfaces are designed to promote ease of use with little or no regard for the impact that they have on users' subsequent cognitive representations.

8. Incorporating Uncertainty, Sensitivity, and Value Representations into Reasoning: Erroneous conclusions are frequently made by experienced individuals in situations where available data is not properly interpreted.

9. Generating Context and Organizing Symbols into Manipulatable Semantic Structures: We are capable of sensing the environment, but not able to convert raw data stream into symbols for processing by a computer. Even if we had environmental information in symbols, we are not capable of generating a meaningful context from it.

4.0 Summary

Augmented Cognition develops and demonstrates technologies to enhance the performance of operational users in perceptual, cognitive, memory, and decision tasks. The focus of the technology development is on the individual human user. Transition of this technology will be guided by early involvement of other relevant projects.

Technology transition to the military has been accelerated by the interest shown by the military services. The challenge for Augmented Cognition is to find near term, factors of improvement applications. For example, the basic single monitor computer – human interface paradigm, through simple techniques of multiple monitors, spatially arranged, has shown to increase performance of simple tasks by a factor nearly 2X. There are other multi-modalities of cognitive enhancement that have been anecdotally reported – it is time to subject these concepts to the rigor of scientific experiment and early prototype evaluation in operational environments.

About the Authors

LCDR DYLAN SCHMORROW, MSC, USN is serving at the Naval Research Laboratory as the Military Scientist for Modeling and Simulation Science and Technology and at the Office of Naval Research and the Defense Advanced Research Projects Agency as a Program Manager in Information Technology and Human Systems. He currently directs science and technology research programs in the areas of augmented cognition, virtual environments, advanced distributed learning, modeling and simulation, and biomedicine. These interdisciplinary programs integrate advances in cognitive, neural, behavioral and computer science to provide technologies vital to ensuring DoD military superiority. He has a Ph.D. in Experimental Psychology from Western Michigan University and Masters degrees in Operations Research, Modeling, Virtual Environments, and Simulation, and Psychology from Western Michigan and the Naval Post Graduate School.

Laura Worcester is a senior research associate at the Potomac Institute of Policy Studies, a Arlington, VA public policy and research institute. She is the deputy director of Human Systems and Information Technology programs. She has a Bachelor of Science degree from Virginia Technology Institute and a Masters degree in Public Administration from American University.

LT James Patrey, MSC, USN is as an Assistant Professor in the Department of Behavioral Sciences and Leadership at the United States Air Force Academy where he focuses primarily on teaching and mentoring cadets. In addition to teaching and advising, he also interacts with cadets through additional tutoring, as the assistant academic officer for one of the cadet squadrons, and contributes to the summer science program. He has a Ph.D. in Cognitive Psychology from the University Illinois.