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Cognitive Readiness: Preparing for the Unexpected

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September 2004

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IDA Document D-3061

Log: H 06-000702

This work was conducted under contracts DASW01 04 C 0003/ W74V8H 05 0042, Task AK-2-2349, for the ODUSD(S&T). The publication of this IDA document does not indicate endorsement by the Department of Defense, nor should the contents be construed as reflecting the official position of that Agency.

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Preface

This work was performed under the "Science and Technology Support for Training Transformation and the Human Systems Technology Area" task. Technical cognizance for this task is assigned to Dr. Robert Foster, Director, Biosystems, Office of the Deputy Under Secretary of Defense for Science and Technology (ODUSD(S&T)).

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Executive Summary

Since the most predictable characteristic of military operations is their unpredictability, how do we prepare military personnel for the unexpected, which, by definition, is something we cannot anticipate or decompose into specific tasks, conditions, and standards for training?

Unpredictability is the most predictable characteristic of military operations. Unanticipated tactics, new technological capabilities, novel applications of existing technologies, and surprise are characteristics of combat engagements. However, noncombat operations, such as peace-making, peace-keeping, humanitarian relief, and crisis management, are also known for their potential to effect unanticipated chaos.

Despite the unpredictability of military operations, military units and personnel are expected to assume at least some pre-specified roles and responsibilities, and much can be done to prepare them for their missions (e.g., Fletcher and Chatelier, 2000). Anticipated operational requirements can be decomposed into specific task lists, essential task lists, mission essential task lists (METLs), and even joint METLs. The tasks can be described in detail, including the conditions under which the tasks are to be performed and the performance standards that have to be met. The reductionist nature of this approach has been a matter of concern because of the eventual need to deal with the full gestalt of unit performance once these tasks are reaggregated into mission functions, but the basic task lists lead to education and training objectives that we can achieve reliably. Nonetheless, the potential for chaos and the unexpected remains.

In our effort to prepare military personnel for the unexpected, we have begun to treat this matter as an issue of cognitive readiness (Etter, Foster, and Steele, 2000). This document discusses 10 components—situation awareness, memory, transfer, meta-cognition, automaticity, problem solving, decision-making, mental flexibility and creativity, leadership, and emotion—that may form a basis for cognitive readiness and then attempts to answer three questions:

1. Is the concept of cognitive readiness necessary?
2. For whom is the concept of cognitive readiness intended?
3. What remains to be done?

Cognitive Readiness: Preparing for the Unexpected

A. Overview

The most predictable characteristic of military operations is their unpredictability. Unanticipated tactics, new technological capabilities, novel applications of existing technologies, and surprise are notorious characteristics of combat engagements. However, noncombat operations, such as peace-making, peace-keeping, humanitarian relief, and crisis management, are also known for their potential to effect unanticipated chaos.

Still, military units and personnel are expected to assume at least some pre-specified roles and responsibilities, and much can be done to prepare them for the missions they may be expected to perform (e.g., Fletcher and Chatelier, 2000). Anticipated missions can be decomposed into specific task lists, essential task lists, mission essential task lists (METLs), and even joint METLs. The tasks can be described in detail, along with the conditions under which the tasks are to be performed and the performance standards that are to be met. The reductionist nature of this approach has been a matter of concern because of the eventual need to deal with the full gestalt of unit performance once these tasks are reaggregated into mission functions, but the basic task lists lead to education and training objectives that we can achieve reliably. Nonetheless, the potential for chaos and the unexpected lies in wait.

How, then, do we prepare military personnel for the unexpected, which, by definition, is something we cannot anticipate nor decompose into specific tasks, conditions, and standards for training? We have begun to treat this matter as an issue of cognitive readiness (Etter, Foster, and Steele, 2000), for which we have suggested the following general definition:

> Cognitive readiness is the mental preparation (including skills, knowledge, abilities, motivations, and personal dispositions) an individual needs to establish and sustain competent performance in the complex and unpredictable environment of modern military operations.

This definition transcends issues of the unexpected and applies to all operations. However, it is particularly relevant to situations that arise suddenly and require immediate attention—situations that are increasingly characteristic of the post-Cold War operating environment.

After reviewing many research studies, Morrison and Fletcher (2001) identified 10 components that might form a basis for cognitive readiness. They determined the extent to which each component can be measured and improved by instruction. These components, along with research findings concerning their trainability and ways they can be measured. are briefly summarized below.

1. **Situation awareness.** Situation awareness is generally defined as the ability to perceive and comprehend oneself in relationship to all relevant elements of the present environment and then accurately project different courses of action into the future (Endsley, 1988). It can be measured by simulated operations that permit interruptions to compare participants' perceptions with the "ground truth" held by the simulation. Practice and feedback in complex, simulated environments have been shown to improve situation awareness.

2. **Memory.** Memory is described as an active, reconstructive ability to recall and/or recognize in the current operational situation patterns that will lead to likely solutions. It can be supported by two underlying theoretical mechanisms: (1) encoding specificity (Tulving and Thompson, 1973), which stresses the importance of attending to relevant external and internal perceptual cues, and (2) transfer of appropriate processing (Morris, Bransford, and Franks, 1977), which stresses the actions performed during encoding and retrieval. Memory can be directly measured by testing for knowledge and skill retention. Tradeoffs exist between the efficiency of initial instruction and the less efficient conditions of learning (e.g., overlearning) designed to improve long-term retention and reduce the need for sustainment training (Wisher, Sabol, and Ellis 1999).

3. **Transfer.** Transfer is described as the ability to apply what is learned in one context to a different performance context. It can be measured by the ability to select and apply procedural knowledge gained in one context to another ("low-road" transfer) or by the application of principles abstracted from a set of contexts ("high-road" transfer) to another (Salomon and Perkins, 1989). Massive amounts of practice with feedback will improve "low-road" transfer, and training in forming mindful, conscious abstraction will enhance "high-road" transfer.

4. **Meta-cognition.** Meta-cognition refers to the executive functions of thought, more specifically those needed to monitor, assess, and regulate one's own cognitive processes (Flavell, 1976). It can be measured by determining the

accuracy with which individuals predict their own performance. Metacognitive skills can be improved by exercises designed to increase awareness of self-regulatory processes (Hacker, 2001).

5. **Automaticity.** Automaticity refers to processes that require only limited conscious attention (Shiffrin and Schneider, 1977). It can be measured in dual-processing situations requiring simultaneous attention and correct reactions to two or more different cues. Automaticity can be trained by large amounts of practice with feedback and overlearning.

6. **Problem solving.** Problem solving can be cast as the ability to analyze the current situation; identify tasks and subtasks leading to targeted goals; develop a plan to achieve these goals using processes such as trial and error, proximity, fractionation, and knowledge-based retrieval; and apply the resources needed to carry out the plan (Hayes, 1981). Practice with feedback and overlearning can improve problem-solving ability in many tasks. It can be measured by determining the probable success of courses of action identified for achieving the targeted goals. Techniques for problem solving matched to goal and situation categories and the knowledge base needed to implement them can be taught successfully.

7. **Decision-making.** Decision-making is a component of problem solving. However, the emphasis in decision-making is on (1) recognizing learned patterns, (2) reviewing courses of action, assessing their impact, and selecting one, and (3) allocating resources to the problem (Slovic, Lichtenstein, and Fischoff, 1988). Decision-making can be measured by assessing individuals' successes in recognizing learned patterns and matching them to courses of action that achieve targeted goals. Instruction in assessing courses of action has been shown to improve decision-making, but some aspects of successful decision-making are more likely to be inborn than trained.

8. **Mental flexibility and creativity.** Mental flexibility and creativity can be cast as the ability to generate, adapt, and modify courses of action rapidly, as required, in response to variable situations (Klahr and Simon, 2001). In military operations, it can be measured by the ability to devise plans and actions that differ from and improve upon "school solutions" by improving the probabilities for success. Capabilities that widen the range of options considered in military operations can be taught, but higher levels of creativity are more likely to be inborn than trained.

9. **Leadership.** Leadership can be described in terms of motivational patterns and as a combination of technical, conceptual, ethical, and interpersonal competencies that encourage and support others in carrying out a designated course of action (Yukl, 1989). Leadership can be measured by role-playing exercises that require individuals to match different leadership styles

successfully to different groups and different goals. The technical and interpersonal skills needed by leaders at all levels can, to an appreciable extent, be taught. The patterns of motivating others—patterns that are required for highly successful leadership—appear to be inborn rather than taught.

10. **Emotion.** Emotion in cognitive readiness must be channeled and controlled if military personnel are to perform complex tasks under the stress and confusion that accompanies modern military operations (Hunt and Ellis, 1999). Measuring one's ability to channel and control emotions can be accomplished by assessing performance in deeply engaging, sensory immersing simulations. Engaging in such simulations and building confidence through education and training and developing automaticity can improve the ability of military personnel to react appropriately under highly stressful conditions.

These components reveal several recurring themes, which suggest that cognitive readiness can be generally conceived as a set of three basic abilities to

1. Recognize patterns in chaotic situations (situational awareness, memory, transfer)
2. Modify problem solutions associated with these patterns as required by the current situation (metacognition, flexibility and creativity)
3. Implement plans of action based on these solutions (decision making, leadership, automaticity, and channeling emotions).

These considerations indicate that, to a significant extent, components of cognitive readiness are both measurable and trainable. Techniques to do so should be developed and employed. However, as the research suggests, some aspects of cognitive readiness are not amenable to training, and efforts to teach them might be better expended on improving techniques to select and acquire talented people who can achieve the highest levels of cognitive readiness.

B. Is the Concept of Cognitive Readiness Necessary?

In addition to the need to prepare units and individuals to deal with the unexpected, the necessity of cognitive readiness keys on two questions, as posed by Toiskallio (2002). Do we want individuals to act as cyborgs and simply apply learned procedures—reacting rapidly and automatically to emerging situations? Or, do we want ethical, fully rounded human beings to respond in a holistic manner to the severe and frequent challenges presented by modern military operations?

These are fair questions. To the exigencies that inevitably arise in operational environments, our cyborgs will respond rapidly and automatically while our humans are still mulling over alternatives. On the other hand, our humans will be applying ethical and reasoned “human” judgment to complex, ambiguous, and, most importantly, unexpected situations that cyborgs will rush in to solve. As Toiskallio points out, both sides have their strengths, but another important question is this: How will cyborgs deal with the unexpected?

In cognitive psychology, a substantial body of empirical findings from research into human learning, memory, perception, and cognition has led to the view that cognitive processes are constructive and regenerative. The research suggests that these processes involve an “analysis by synthesis” activity in which the information received by our sensory receptors (e.g., eyes and ears) is filtered and reassembled as cues that are used to construct an executable simulation of “reality”—the world as we perceive it. Instruction, then, does not involve the whole-cloth transmission of information from teachers to students, but rather the transmission of cues that students use to construct, verify, and modify their models of the world (Fletcher, 1982). Systematic, empirical research in experimental psychology has taken general psychological theories of perception and learning from the logical positivism of behavioral psychology, which emphasized the study of directly observable and directly measurable actions, to greater consideration of the internal, less observable processes that are assumed to mediate and enable human perception, memory, and learning. It has led us through data gleaned from hundreds of empirical studies and findings to cognition.

The keynote of these conceptions of cognition—and much contemporary cognitive psychology—was articulated by Ulric Neisser, who stated, “The central assertion is that seeing, hearing, and remembering are all acts of *construction*, which may make more or less use of stimulus information depending on circumstances” (1967, p. 10). These ideas, although they have had moments in and out of fashion, have been part of the fabric of scientific psychology since its inception. For instance, William James gave the following as the general law of perception: “While part of what we perceive comes through our senses from the object before us, another part (and it may be the larger part) always comes out of our mind” (p. 747, 1890/1950).

In one sense, every human being creates the world for himself or herself. We may seek to produce cyborgs, but we are unlikely to succeed because each individual is reacting to a reality created by himself or herself. Moreover, if we need the creative, innovative side of human nature to meet unexpected exigencies, we will have to dig deeper than observed human behavior and performance. We need to involve the whole person—ethics, culture, and emotional reactions. We must deal with a "web of beliefs" as Toiskallio (2002) and others (e.g., Rorty, 1991) have put it. At some level, our training must produce individuals who will rapidly construct views of reality in the situations presented by modern military operations—views that allow them to recognize and respond creatively to unexpected challenges.

We cannot, therefore, get the successful performance we need by limiting training to observed performance. We must reach to its foundations in the inner world of cognition. If we seek success in military operations, we should ensure that the human beings, who are an essential and inevitable component of every operation and every military system, are performing at the highest level of cognitive competence of which they are capable. If we seek to ensure the action competence discussed by Toiskallio (2002), we must deal in cognitive and in physical readiness.

C. For Whom Is the Concept of Cognitive Readiness Intended?

Many factors appear to have increased the complexity of the current military operating environment. In 1989, great optimism arose at the end of the Cold War. Many people assumed that peace had finally arrived and began to count the blessings—monetary and otherwise—of the "peace dividend." The optimism now seems based on illusion. Rather than ending, the Cold War appears to have metastasized. Instead of a great war involving peer nations in opposition across the plains of Europe, we now have small operations all around the world involving interventions of major powers into the affairs of lesser powers. Our armed forces are frequently called on not to defeat and destroy hostile armed forces, but to deal with complex affairs involving the social, economic, and political development of a population. The complexity is increased by rapid advances in and proliferation of technology, the dispersal and independent operation of military units, the intermingling and interdependence of military and civilian activities and personnel, the presence of asymmetric threats, and irregular participants who disregard international laws and conventions—all combined with continual shifts in responsibilities, tasks, and missions.

Who must deal with this complexity? Earlier, and especially in land operations, it was assumed that day-to-day tactical issues would be guided by officers who understood the strategic implications of their decisions and actions. Their cognitive readiness would have been at a premium. Matters are different now and have given rise to the notion of the “strategic corporal” (e.g., Krulak, 1999). In today’s diffuse and metastasized threat environment, junior noncommissioned leaders everywhere will be at the strategic point of action. They will man the checkpoints, provide security to relief organizations, respond first to crises, control crowds, and decide instantly who are friends and foes. They will have enough weaponry to knock aircraft out of the sky, demolish buildings, bring down infrastructure, and start major wars. In many situations, they will have neither time nor opportunity to consult with senior officers, yet their actions will have strategic consequences that until recently were beyond their concern. We must, of course, attend carefully to the cognitive readiness of our officers, but we must with equal care attend to the cognitive readiness of our junior leaders—our strategic corporals.

D. What Remains To Be Done?

Research is still needed to verify the conclusions suggested by this brief survey of cognitive readiness and to determine if the list of components now assumed to comprise cognitive readiness is correct. Changes are to be expected. Such research might involve the following categories and issues:

- Cognitive theory
  - Representation of “higher order” cognitive capabilities (e.g., decision-making, problem solving, meta-cognition, pattern recognition, critical thinking, situational awareness, teamwork)
  - New concepts and theories of cognition and cognitive workload based on new measurement capabilities using emerging capabilities for display, timing, data recording, data analysis emerging from computer and communications technology
  - Valid and verified representation of expertise and its development in complex, ill-structured environments
  - Knowledge representations and ontologies that allow interoperability and logical operations within and across disciplines.
- Cognitive readiness assessment
  - Automated development, verification, and validation of cognitive models
  - Automated processes for performing cognitive analysis and cognitive readiness assessment

  - New forms of computer-administered assessment items using the full display, timing, and natural language capabilities of technology
  - Generation of valid, unobtrusive, near-real-time assessment from interactions of individuals, teams, crews, and units with the learning or performance-aiding environment
  - Automated capture of expertise—self-generating, self-modifying databases built from cases and examples of successful problem solving and decision-making
  - Representation of subject matter misunderstandings and their sources
  - Assessment of cognitive workload.
- Training for readiness
  - Ability to match cognitive goals with the current state of the user and optimal tutorial strategies
  - Principles of training design and presentation that ensure reliable achievement of targeted cognitive state(s) by individuals, crews, teams, and units
  - Technology-based tools that will allow distributed users to manage their own progress
  - Predictions of learning rate and success from user profile information
  - Management of user dialogue based on model of user cognitive abilities, style, and progress toward objective(s).
- Military value
  - Relationship between measures of cognitive readiness and subsequent operational effectiveness.

The final element concerning military value in this research agenda is the most difficult and most important. It will provide an empirical basis for determining the value, criticality, and priority of cognitive readiness. It will also establish the ability of efforts to increase cognitive readiness to deal with the unexpected.

The research agenda aside, some practical steps should be taken immediately. These steps are suggested by the previous discussion, which proposed components of cognitive readiness. Many of the capabilities for training aspects of cognitive readiness are already in use. These capabilities need to be prioritized and focused on issues of cognitive readiness, but they do not require technological discoveries or breakthroughs.

Many aspects of cognitive readiness can be measured and assessed but need systematic development. Among other things, the reliability (do they measure things right?), the validity (do they measure the right things?), and the precision (how closely do they distinguish one unit or individual from another?) of cognitive readiness assessments need to be more fully developed.

Much can be done without requiring technological discoveries or breakthroughs and by capitalizing more fully on the rapidly emerging capabilities of computer and communications technology. The manner and degree to which cognitive readiness remains to be included in routine assessments of readiness must be determined and included in policy. As with most administrative decisions, it is not so much a matter of desirability, or even of necessity; rather, it is one of reconciliation among competing priorities. The suggestion here is that among all these priorities, cognitive readiness deserves weight and consideration.

References

Endsley, M.R. (1988). Design and evaluation for situation awareness enhancement. *Proceedings of Human Factors Society 32nd Annual Meeting,* Santa Monica, CA: Human Factors Society, 97–101.

Etter, D.M., Foster, R.E., and Steele, T.P. (2000). Cognitive readiness and advanced distributed learning. *Crosstalk: The Journal of Defense Software Engineering, 13,* 5–6.

Flavell, J.H. (1976). Metacognitive aspects of problem solving. In L. Resnick (Ed.), *The nature of intelligence* (pp. 231–235). New Jersey: Lawrence Erlbaum Associates.

Fletcher, J.D. (1982). Training technology: An ecological point of view. In R.A. Kasschau, R. Lachman, and K.R. Laughery (Eds.), *Psychology and Society: Information Technology in the 1980s* (pp. 166–191). New York, NY: Holt, Reinhart, and Winston.

Fletcher, J.D., and Chatelier, P.R. (2000). In S. Tobias and J.D. Fletcher (Eds.), *Training and retraining: A handbook for business industry, government, and the military*. New York, NY: Macmillan.

Hacker, D.J. (2001). Metacognition: Definitions and empirical foundations [On-line Report]. Memphis. TN: The University of Memphis. Retrieved May 30, 2001, from the World Wide Web: http://www.psyc.memphis.edu/trg/meta.htm.

Hayes, J.R. (1981). *The complete problem solver.* Philadelphia, PA: The Franklin Institute.

Hunt, R.R., and Ellis, H.C. (1999). *Fundamentals of cognitive psychology* (6th Ed.). Boston: McGraw-Hill College.

James, W. (1890/1950). *Principles of Psychology: Volume I,* New York: Dover Press.

Klahr, D., and Simon, H. A. (2001). What have psychologists (and others) discovered about the process of scientific discovery? *Current Directions in Psychological Science, 10,* 75–78.

Krulak, C.C. (1999). The strategic corporal: Leadership in the three block war. *Marines Magazine.*

Morris, C.D., Bransford, J.D., and Franks, J.J. (1977). Level of processing versus transfer-appropriate processing, *Journal of Verbal Learning and Verbal Behavior, 16,* 519–533.

Morrison, J.E., and Fletcher, J. D. (2001). Cognitive readiness (IDA Paper P-3735). Alexandria, VA: Institute for Defense Analyses.

Neisser, U. (1967). *Cognitive psychology*. New York, NY: Appleton, Century, Crofts.

Rorty, R. (1991). *Objectivity, relativism, and truth.* Cambridge, United Kingdom: Cambridge University Press.

Salomon, G., and Perkins, D.N. (1989). Rocky roads to transfer: Rethinking mechanisms of a neglected phenomenon. *Educational Psychologist*, *24*, 113–142.

Shiffrin, R.M., and Schneider, W. (1977). Controlled and automatic human information processing: II. Perceptual learning. *Psychological Review, 86*, 127–190.

Slovic, P., Lichtenstein, S., and Fischoff, B. (1988). Decision-making. In R.C. Atkinson, R.J. Herrnstein, G. Lindzey, and R.D. Luce (Eds.), *Steven's handbook of experimental psychology (2nd Ed.) Volume 2: Learning and cognition* (pp. 673–738). New York: John Wiley and Sons.

Toiskallio, J. (2002). Cyborgs and humans. In H. Florian (Ed.), *Military pedagogy* (pp. 83–100). Frankfurt am Main, Germany: Peter Lang.

Tulving, E., and Thomson, D.M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review, 80,* 352–373.

Wisher, R.A., Sabol,, M.A., and Ellis, J.A. (1999). *Staying sharp: Retention of military knowledge and skills* (ARI Special Report 39). Alexandria, VA: U.S. Army Research Institute for the Behavioral and Social Sciences (http://www.ari.army.mil).

Yukl, G.A. (1989). *Leadership in organizations* (2nd Ed.). Englewood Cliffs, NJ: Prentice-Hall.

Glossary

ARI	U.S. Army Research Institute for the Behavioral and Social Sciences
METL	mission essential task lists
ODUSD(S&T)	Office of the Deputy Under Secretary of Defense for Science and Technology

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE: September 2004

2. REPORT TYPE: Final

3. DATES COVERED *(From–To)*: July 2004–September 2004

4. TITLE AND SUBTITLE: Cognitive Readiness: Preparing for the Unexpected

5a. CONTRACT NUMBER: DASW01 04 C 0003/W74V8H 05 C 0042

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S): J.D. Fletcher

5d. PROJECT NUMBER

5e. TASK NUMBER: AK-2-2349

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

Institute for Defense Analyses
4850 Mark Center Drive
Alexandria, VA 22311-1882

8. PERFORMING ORGANIZATION REPORT NUMBER

IDA Document D-3061

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)

OUSD (S&T) Biosystems
Director, Biosystems
1777 N. Kent Street, Suite 9030
Rosslyn, VA 22209

10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited. (27 June 2006)

13. SUPPLEMENTARY NOTES

14. ABSTRACT

The most predictable characteristic of military operations is their unpredictability. Anticipated operational requirements can be decomposed into specific tasks, conditions, and standards, but how should individuals, teams, and units prepare for the unexpected, which, by definition, cannot be anticipated? This matter is viewed as an aspect of cognitive readiness. Situation awareness, memory, transfer, meta-cognition, automaticity, problem solving, decision-making, mental flexibility and creativity, leadership, and emotion are considered as bases for ways in which we can prepare operational personnel to deal with the unexpected. Science and technology (S&T) developments in cognitive theory, cognitive readiness assessment, training for cognitive readiness, and assessing the military value of training are needed to devise reliable techniques for ensuring cognitive readiness in this area.

15. SUBJECT TERMS

adaptability, cognitive readiness, education training

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
					Dr. Robert Foster
a. REPORT Uncl.	b. ABSTRACT Uncl.	c. THIS PAGE Uncl.	SAR	16	19b. TELEPHONE NUMBER *(include area code)* 703-588-7437

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std. Z39.18