The Nation's Center of Excellence
for Medical Chemical Defense

USAMRICD-SP-13-01

Graduate Education and Simulation Training for CBRNE Disasters Using a Multimodal Approach to Learning

Part 1: Education and Training from a Human-Performance Perspective

Timothy J. Byrne, CAsP, Lt Col, USAF; **Charles G. Hurst**, MD, COL(ret), MC, USA; **James M. Madsen**, MD, MPH, FCAP, FACOEM, COL, MC-FS, USA; **John C. Stich**, RN, MSN, MSA, CCNS, CCRN, LTC, AN, USA; **Shannon A. Stutler**, DVM, MPH, DACVPM, DACLAM, CPIA, LTC(ret), VC, USA; **Robyn B. Lee**, MS; **Daniel E. Boehm**, EMT; **Cindy A. Kronman**, BA; **Peter J. Schultheiss**, DVM, DACLAM, COL, VC, USA

August 2013

Approved for public release; distribution unlimited

US Army Medical Research Institute of Chemical Defense
3100 Ricketts Point Road
Aberdeen Proving Ground, MD 21010-5400

an element of the

US Army Medical Research and Materiel Command

DISPOSITION INSTRUCTIONS:

Destroy this report when no longer needed. Do not return to the originator.

DISCLAIMERS:

The views expressed in this technical report are those of the author(s) and do not reflect the official policy of the Department of Army, Department of Defense, or the U.S. Government.

The use of trade names does not constitute an official endorsement or approval of the use of such commercial hardware or software. This document may not be cited for purposes of advertisement.

REPORT DOCUMENTATION PAGE	*Form Approved* *OMB No. 0704-0188*

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Department of Defense, Washington Headquarters Services, Directorate for Information Operations and Reports (0704-0188), 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to any penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number. **PLEASE DO NOT RETURN YOUR FORM TO THE ABOVE ADDRESS.**

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
August 2013	Education and Training	October 2009 to 3 September 2013

4. TITLE AND SUBTITLE
Graduate Education and Simulation Training for CBRNE Disasters Using a Multimodal Approach to Learning. Part 1: Education and Training from a Human-Performance Perspective

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Byrne, TJ, Hurst, CG, Madsen, JM, Stitch, JC, Stutler, SA, Lee, RB, Boehm, DE, Kronman, CA, Schultheiss, PJ

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

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

US Army Medical Research Institute of Chemical Defense
ATTN: MCMR-CDM
3100 Ricketts Point Road
Aberdeen Proving Ground, MD 21010-5400

8. PERFORMING ORGANIZATION REPORT NUMBER

USAMRICD-SP-13-01

9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)
US Army Medical Research Institute of Chemical Defense
ATTN: MCMR-CDM
3100 Ricketts Point Road
Aberdeen Proving Ground, MD 21010-5400

10. SPONSOR/MONITOR'S ACRONYM(S)

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

12. DISTRIBUTION / AVAILABILITY STATEMENT

Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
The Chemical Casualty Care Division (CCCD) of the U.S. Army Medical Research Institute of Chemical Defense (USAMRICD) approaches education and training from a human-performance perspective and uses an integrated multimodal approach that includes lectures, human actors, manikins, tabletop exercises, and computerized modeling and simulation. Part 1 of this two-part series provides a general overview of teaching at CCCD and explores the science underlying the human-performance model of learning. Topics to be examined include encoding of information by the brain, emotional-learning theory, the spectrum of stress, the "sweet spot" of the stress-performance curve, situational awareness, human error, anomalies of attention, and negative training. Teaching will also be examined from a "boots on the ground" perspective. Part 2 will discuss CCCD teaching from the perspectives of educators and students. A brief historical review of past practices representing a cholinergic crisis exercise using a nonhuman primate (NHP) will be presented as a benchmark for future manikin and computer training. The NHP exercise ended in November 2012 and was replaced with manikins.

15. SUBJECT TERMS
Multimodal; Education; Training; Emotional-learning Theory; Stress; Situational Awareness; Human Error; Anomalies of Attention; Negative Training; Stress-performance Curve; Sweet Spot

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			Timothy J. Byrne
UNCLASSIFIED	UNCLASSIFIED	UNCLASSIFIED	UNLIMITED	15	**19b. TELEPHONE NUMBER** *(include area code)* 410-436-2230

"There is nothing so likely to produce peace as to be well prepared to meet an enemy."
—GEN George Washington[1]

ABSTRACT The Chemical Casualty Care Division (CCCD) of the U.S. Army Medical Research Institute of Chemical Defense (USAMRICD) approaches education and training from a human-performance perspective and uses an integrated multimodal approach that includes lectures, human actors, manikins, tabletop exercises, and computerized modeling and simulation. Part 1 of this two-part series provides a general overview of teaching at CCCD and explores the science underlying the human-performance model of learning. Topics to be examined include encoding of information by the brain, emotional-learning theory, the spectrum of stress, the "sweet spot" of the stress-performance curve, situational awareness, human error, anomalies of attention, and negative training. Teaching will also be examined from a "boots on the ground" perspective. Part 2 will discuss CCCD teaching from the perspectives of educators and students. A brief historical review of past practices representing a cholinergic crisis exercise using a nonhuman primate (NHP) will be presented. As of November 2011, the courses no longer used nonhuman primates and were replaced with manikins which had been in development for years. Therefore the course is in compliance with DoD policy Department of Defense Instruction (DoDI) 3216.01, Use of Animals in DoD Programs, September 13, 2010.

Introduction: The mission of the research arm of the U.S. Army Medical Research Institute of Chemical Defense (USAMRICD) is to discover and develop medical countermeasures to chemical warfare agents for U.S. military forces and U.S. citizens. The Chemical Casualty Care Division (CCCD) at the institute exists to educate and train personnel in the medical management of chemical casualties and to provide subject-matter expertise for clinical collaboration with ongoing research, for developing defense and national policy regarding proper crisis management, and for clinical consultation in cases of possible exposure to chemical agents and toxins.

CCCD develops and maintains postgraduate medical education and training under the sponsorship of the U.S. Army Medical Department Center and School (AMEDDC&S), the U.S. Army Medical Department (AMEDD), the U.S. Army Office of The Surgeon General (OTSG), the Office of Health Affairs, and the Department of Homeland Security (DHS). (In this article *education* means the imparting of *knowledge*; *training* refers to the imparting of *skills*.) It offers three main courses: the Medical Management of Chemical and Biological Casualties (MCBC) course, the Field Management of Chemical and Biological Casualties (FCBC) course, and the Hospital Management of Chemical, Biological, Radiological/Nuclear, and Explosives Incidents (HM-CBRNE) course. Each FCBC and HM-CBRNE course is five days long and is conducted entirely on the campus of USAMRICD, located at the Edgewood Area of Aberdeen Proving Ground, Maryland, in collaboration with the U.S. Army Medical Research Institute of Infectious Diseases (USAMRIID) and the Armed Forces Radiobiology Research Institute (AFRRI). The MCBC course is a six-day course given for three days at USAMRICD and for three days at USAMRIID (at Fort Detrick, in Frederick, Maryland). CCCD also conducts distance learning via its website, http://ccc.apgea.army.mil, and via web-based connectivity programs such as

Adobe Connect and Defense Connect Online (DCO). In addition, all students are provided with educational products (including DVDs, CDs, and handbooks) produced in-house as reference material to assist graduates to educate and train others at their parent organizations. These offerings are accredited for continuing medical education (CME) and for continuing-education-unit (CEU) credits for physicians, nurses, and paramedical professionals.

The MCBC, FCBC, and HM-CBRNE courses have been singled out and recognized for their effective teaching approaches. After attending one of these offerings in 2010, the Attending Physician to the Congress of the United States, Rear Admiral Monahan, MD, FACP, wrote, "The course was very informative and among the most professionally and well organized military educational courses I have ever taken . . . organization and leadership of the course were exceptional . . . [and CCCD staff] took special care to . . . cover the importance of this critical area."[2] A U.S. Government Accounting Office (GAO) report cited the MCBC course as the "gold standard" of CBRNE training for military and civilian attendees while emphasizing that military medical professionals as a whole were not trained adequately to handle chemical and biological casualties.[3] The education and training courses address the practical challenges of hospital preparedness for and response to the use of chemical and biological agents and, in the case of the HM-CBRNE course, to the full spectrum of CBRNE agents.

The USAMRICD Simulation and Modeling Center at CCCD aids in teaching CBRNE, and particularly chemical-agent, topics by employing an integrated multimodal approach focusing on live human actors, human simulators (manikins), computer-based modules, and a cholinergic crisis exercise using manikins that replaced nonhuman primates (NHPs) in November 2011[4,5] to supplement didactic lectures and classroom discussions.

Part 2 of this series will examine these modalities in more detail and review of an unpublished study that provides key insight. Based on over thirty years experience, student feedback, surveys, and results from the field, CCCD believes that this multimodal approach is extremely effective in increasing the knowledge, practical skills, and confidence of students to manage a CBRNE event.

The Audiences for CCCD Training:

The first developed CCCD course was in the 1950s known as the Medical Management of Chemical Casualties; it was initially designed for the military physician. Today, however, the MCBC, FCBC, and HM-CBRNE attract a wide range of military and civilian students from around the world. Attendees include uniformed U.S. personnel (primarily but not exclusively medical personnel from both officer and enlisted ranks) representing the Army, Navy, Air Force, Marines, Coast Guard, and Public Health Service (including representatives from Special Forces units, chemical technical-support units, and National Guard Weapons of Mass Destruction Civil Support Teams) in addition to civilian clinicians (including physicians, physician assistants, nurses, emergency medical technicians, dentists, veterinarians, and psychologists) and nonclinicians (including hospital planners and public officials) from individual hospitals, the

U.S. Department of State, the Department of Homeland Security, the White House, medical personnel supporting the U.S. Congress, and students from state and local agencies, fire-fighting units, and law enforcement. Military and civilian students from a variety of other nations have also attended CCCD courses.

The diversity of student backgrounds and the changing demographics of attendees mandate continual re-evaluation of and evolutional changes to educational content and training methods. As the audience has grown, teaching methodologies have evolved to keep up with new learning philosophies and technologies. Current educational research indicates that humans learn more effectively through a multimodal training program involving a combination of approaches, and this approach has been used to train clinicians and nonclinicians for future events involving weapons of mass destruction and terrorism.[6] The multimodal approach at CCCD incorporates lectures, computer- and internet-based simulations, whole-body manikin modeling, interactive small-group simulations and discussions, videos, and students moulaged as actors; a hands-on, cholinergic crisis exercise is best to prepare students for successful management of a chemical event. Each tool in the multimodal model plays an integral role in student education (knowledge) and training (skills).

Improving Human Performance: The Roles of Learning Domains, Brain Imprinting (Encoding), and Stress Conditioning in Education and Training: In 1948, the Convention of the American Psychological Association under the chairmanship of Benjamin Bloom developed a classification system, still applicable today, to describe levels of intellectual behaviors as they relate to learning. The learning process as referenced in Bloom's classic taxonomy of education and subsequent theories progresses through three domains: the affective domain, describing how emotions are linked to memory; the psychomotor domain, relating the combination of bodily-kinesthetic adaptation to new experiences that require combining activities to develop new methods; and the cognitive domain, which encompasses the ability to remember, understand, apply, analyze, and evaluate a situation. All three domains are crucial to the management of a CBRNE event and are incorporated in the MCBC, FCBC, and HM-CBRNE courses.[7,8,9,10]

The purpose of the teaching conducted by CCCD is to prepare medical personnel for high-stress, real-life CBRNE events. This preparation focuses on knowledge acquisition and application under conditions that simulate real-life conditions so that graduates will be able to think critically and to analyze and solve problems effectively in real-world medical crises. Through this process, confidence is gained as students become desensitized to stressful situations. Both military and civilian first responders and first receivers must train as they would respond in an actual CBRNE event; they must "train as they fight," because they will "fight as they train."

To educate and train students, CCCD uses the "crawl, walk, run" model embedded in U.S. Army doctrine.[11] Students learn from lectures and discussions, perform hands-on medical care and treatment of a cholinergic crisis using a simulated nerve agent poisoning using human simulators and practice with computer-based activities, small-group exercises, and manikins before triaging and deciding upon the medical management of human actors role-playing the effects of different kinds of chemical-agent exposures. The cholinergic crisis exercise is particularly crucial for placing students into a situation in which they are faced with live patients exhibiting physiological effects from a nerve-agent simulant and evoking emotional responses and a realistic sense of immediacy regarding prompt diagnosis and effective treatment. Following this multimodal immersion, many students will train other medical professionals and co-workers. A corollary to the crawl-walk-run process is the well-known medical training adage, "See one (affective domain), do one (psychomotor domain), teach one (cognitive domain)," which leads to graded skill levels. As a student progresses through each level, he or she gains a deeper understanding of the intricacies of a given task. The first level of "seeing one" via lecture or demonstration begins the foundation of imprinting or encoding the brain but is not the final method of teaching a skill. "Doing one" helps provide the training effect and deepens the imprinting of the brain and muscles through rehearsal. "Teaching one" requires the skill or concept to be well thought-out and rehearsed (mentally, physically, and verbally) and leads to an even deeper understanding. This increases students' abilities to think critically and to solve problems, abilities that in turn better prepare the students to come up with the most practical solutions to new clinical scenarios in the real world.

Manikins and tabletop exercises provide the ability to train without risk, permit students to make errors without real-life medical consequences, and can allow for extensive student interaction. Learning with the use of algorithms has proven effective with manikins, but learning what to do when the pre-programmed algorithm seems not to apply must also be taken into account in preparing students. However, training without significant conscious thought can lead to skill-based errors due to failures of attention and/or memory. In fact, 82% of 3,200 general aviation fatal accidents that were associated with human error were caused by skill-based errors.[12] Responding to a live patient reacting in an unexpected way under controlled conditions challenges the imprinted learned response. The cholinergic crisis exercise provides just such an experience, challenging the mind and using a combination of senses to imprint the experience firmly into long-term mental and physiological memory via the senses.

Humans receive information through their senses via the eyes, nose, ears, touch, and movement (vestibular system, somatogravic system, and kinesthetic system). They then process that information and react to it by producing specific responses or outcomes of performance. The VARK (Visual, Aural/auditory, Read/write, Kinesthetic/Tactile) model[13] emphasizes that students differ on how they receive information through these senses. These differences underscore the advantages of an integrated multimodal approach over a one-approach-fits-all philosophy.

As a corollary to "see one, do one, teach one," CBRNE students in the MCBC, FCBC, and HM-CBRNE courses "see one, hear one, and do one." As a result, students have a better understanding and a more pronounced training effect because multiple senses are triggered. The more modes that are offered, the more likely that a student's preferred learning mode is addressed. Later, when they go back home, students are more prepared to share their experiences and to "teach one," albeit not exactly the same emersion capability.

Bloom's affective domain concept recognizes that emotions play a major role in learning. The emotional-learning and emotional-memory theories stress that emotional arousal often leads to stronger memories.[14,15] Under conditions of heightened emotions, brainstem neurons release norepinephrine, dopamine, serotonin, acetylcholine, and other neurotransmitters, resulting in the formation and storage of explicit memories. Mental and physical performance under extreme conditions is mediated by neurotransmitter release primed by previously imprinted mental and physical cues from training, and "artificially inducing this instinct through traumatic physical or emotional stimuli essentially creates the same physiological condition that heightens memory retention by exciting neurochemical activity affecting areas of the brain responsible for encoding and recalling memory."[16] Training under emotionally realistic conditions creates a fallback position of imprinted knowledge and muscle memory to tackle tough trials during a CBRNE incident. Physiological reactions to stressors can also compromise performance; for example, heat stress when wearing the chemical protective garment can lead to decreases in hearing, touch, vision, smell, and cognitive abilities during a CBRNE event (see Figure 1). The key is to train in a "sweet spot" of optimal stress to challenge cognitive and physical abilities without going overboard.

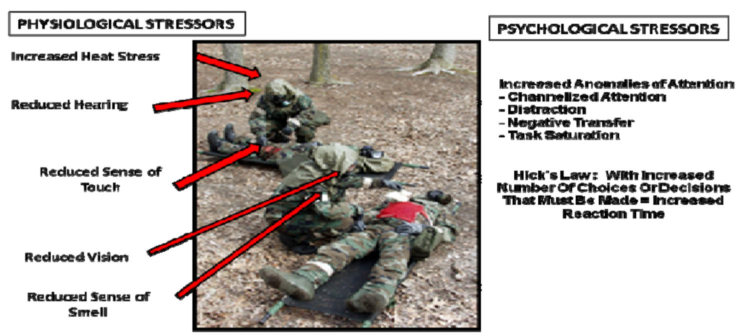

Figure 1. The Human Factor & Physiology of CBRNE Training

Imprinting (Encoding) in the Brain; Training in the "Sweet Spot": Effective training is a mainstay of human performance. Retention of skills as well as adaptation to acute and chronic stressors is important in handling evolving threats, and adding an emotional content to the presentation further crystallizes the memory.[17]

Training under ideal levels of stress can prepare the student for unexpected experiences that overwhelm the senses and fall outside the range of specific algorithms. If a horrific real-world event occurs, specific hormones increase during the well-known fight-or-flight response. Epinephrine levels increase to activate muscles to their full potential, cortisol release protects against stress, and clotting factors become activated to protect against loss of blood from wounds.[18] As previously described in Bloom's taxonomy, the emotional or affective domain influences memory. Peaks of epinephrine are associated with memory formation, as during accidents, school graduation, marriage, the birth of a child, or the saving of a life. Although the full physiological pathways involved are still not fully elucidated, the brain seems to imprint, or encode, these key emotionally charged events.

Increasing stress up to a point leads to increased learning and performance, but with too much stress, both learning and performance decrease. These hormonal and neurochemical activities relate to Hans Selye's stress-performance curve.[19, 20, 21] Both insufficient stress and too much stress impede learning, which is maximized under conditions of optimal stress. In learning theory, there must be an ideal level of stress, alertness, and energy for effective learning to occur. The optimal level of stress occurs as eustress at the "sweet spot" at the top of the curve (see Figure 2). Associated with excess stress are decrements in vision, hearing, and decreased fine motor ability, all with the potential to produce poor judgment, poor learning, and poor performance. Experiencing extreme stress on the distress side of the curve can produce acute stress disorder (ASD) and can lead in some cases to post-traumatic stress disorder (PTSD), which develops after an exposure to a terrifying event or ordeal in which the imprinted event is firmly encoded in the amygdala, known for its role in emotion, learning, and memory.[22] An adverse event may in fact be extremely difficult to forget. Dampening the learned fear of an event appears to involve areas in the prefrontal cortex where decision-making, problem-solving, and judgment reside.[23]

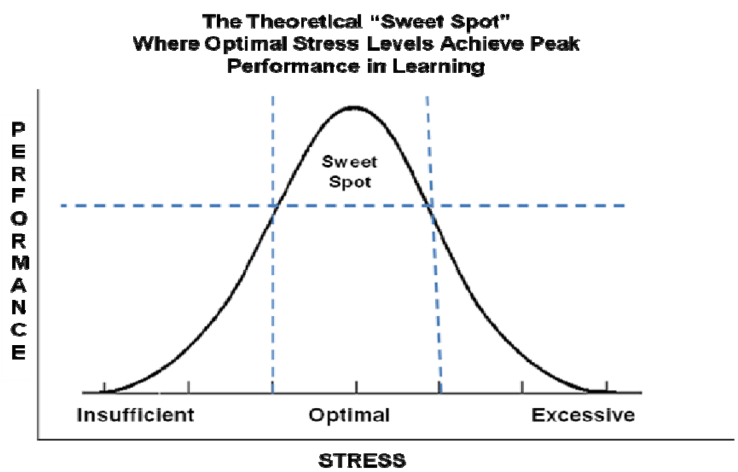

Figure 2. Stress - Performance Curve

The aim of training informed by emotional-learning theory is to educate and train in the "sweet spot" for ideal learning and performance. Subjecting students to systematically controlled stressors can essentially inoculate them against future stressful incidents through adaptation. Prior exposure to or experience with these stressors allows for better outcomes.[24] The literature on learning has long emphasized predictability and controllability, both of which may decrease perceived intensity of stressors during adverse events. Specificity of training in the sweet spot increases the cognitive constructs of controllability and predictability that enhance the training effect.

The "Boots on the Ground" Perspective:

According to David J. Litteral, Command Sergeant Major, BS, NREMT-P and Commandant of the AMEDD Noncommissioned Officer (NCO) Academy, "It is generally accepted that greater than 90% of warriors (includes Soldiers, Sailors, Airmen, and Marines) survive injuries on the battlefield. Of the 10% who do not survive their wounds, 95% die at the point of injury. An impressive 98% of the casualties who make it to a Level III facility survive. Clearly, if there are gains to be made, they are likely at the point of injury, which means first responders and Medics must have the best training available to maintain and possibly even improve upon the survival rates.

"Survivability on current battlefields can be closely linked to the advanced training for those providing care at the point of injury. Further advances in microprocessors, robotics, and virtual reality are necessary to produce the type of training tool with the emotive value needed to continue to improve upon battlefield survival rates."[25]

Training Specificity, Modeling, and Simulation: Training specificity requires individuals to train as they would perform and to perform as they would train. For example, it was observed during the treatment of stroke victims that there was minimal skill transfer unless the skills practiced were essentially identical to those desired.[26] To improve a specific skill, a person should perform that skill under conditions that mimic future performance conditions as realistically as possible. Students learning to respond to CBRNE incidents should perform in chemical protective clothing and respirators and should diagnose, triage, decontaminate, and treat simulated chemical-agent casualties successfully in field exercises. This kind of education and training not only imprints experiences into the brain but also encodes muscle memory and conditions the student to perform under adverse circumstances. Evaluated experience is the best teacher. Since in CBRNE training it is unethical and impractical to create a real-world event, especially with real human casualties, didactic training must be supplemented by modeling and simulation. This kind of training provides a "systematic modification of behavior through instruction, practice, measurement, and feedback."[27] Actual CBRNE experiences can be approximated through multimedia presentations, student acting, field-training-exercises (FTXs), and tabletop scenarios, and modeling of a nerve-agent-induced cholinergic crisis through an interactive laboratory exercise. To be effective, this simulation must closely resemble the real-world patient or situation so that the skills will transfer to the actual crisis.

Human Error in Modeling and Simulation: Using simulators or models that are inadequate or that are insufficiently developed could very well lead to human error due to latent factors and can cost lives when their limitations are not taken into account.[28] It is imperative for the simulator or model to replicate as precisely as possible what it is supposed to represent. Human error resulting in accidents may occur at different levels. The dependence of an organization on deficient simulators has been cited in the past as a causal factor in mishaps. One such catastrophic event occurred at the Three Mile Island nuclear plant in March 1979. The President's Commission on the Three Mile Island nuclear accident stated, "The simulator at B&W [Babcock and Wilcox, the manufacturer of the water reactor that failed] was a key tool in the training of operators. Simulator training did not include preparation of the operators for multiple-failure accidents . . . [and] the simulator was not, prior to March 28, programmed to reproduce the conditions that confronted the operators during the accident."[29] A simulation or model must emulate reality as closely as possible to be effective.

High-fidelity simulators and models are key to training success. They must provide realistic reflections of the human condition and of the event modeled. In the field of aviation, millions of dollars along with thousands of hours expended by highly experienced aviators and scientists have led to the current successful state of aviation simulation. Motion aviation simulators must be certified by the Federal Aviation Association for training and qualifying flight hours in aviation. However, human modeling and simulation is in the early stages of development. To date, no such accreditation or certification exists for human manikin simulators, but should be established in the future.

Situational Awareness and Anomalies of Attention: Another key aspect of simulation and modeling is the ability to take into account those aspects that cause a loss of situational awareness leading to mission or task failure in the real world. The aviation definition of situational awareness (SA) applies to the medical management of a CBRNE event as "a continuous perception of self and equipment in relation to the dynamic environment, threats, mission, and the ability to forecast then execute tasks based on that perception."[30] Human error from loss of SA accounts for approximately 80% of all fatal aircraft mishaps. Arguably, the use of simulation in aviation training to understand human error can also be applied to the medical field. Aviation simulators have long been used to train pilots to use appropriate algorithms for flying, reviewing lessons learned, actually qualifying for "training flying hours," and tasking pilots to overcome simulated spatial disorientation or loss-of-situational-awareness events that have caused fatal mishaps. Yet highly skilled pilots who are exceptionally trained in their profession still crash perfectly good airplanes because of insidious psychological traps.

The hidden traps that can cause a loss of SA are known as anomalies of attention and include channelized attention (focusing on one thing to the exclusion of others), distraction (diverting attention from a specific task), inattention (not giving enough attention to a given task), task saturation (attempting to attend to too many tasks at one time), and negative transfer (reverting to a highly learned behavior used from previous training in a system or situation and then responding inappropriately).[31] For example, students who learn that swiping a digitally enhanced card over the arm or mouth of a manikin results in a specific predetermined outcome may in a real emergency reflexively do exactly as they were trained. They may begin to swipe the card instead of reaching for an autoinjector to treat the patient with a nerve-agent antidote. Simply stated, "negative training" results in negative performance and results.

The Gulf War in 1991 was a dynamic, task-saturated, and very stressful environment that challenged all aspects of SA. The Iraqis threatened chemical-agent attacks and then attacked Israel with SCUD missiles that were not loaded with chemical munitions. There were 114 deaths due to cardiorespiratory arrest when Israelis locked themselves in sealed rooms without oxygen replenishment. Furthermore, 13 individuals suffocated after failing to remove the filter caps on their issued respirators.[32] Undoubtedly, anomalies of attention (including channelized attention, distraction, task saturation, technical errors) but also "negative training" contributed to these unfortunate tragedies. Training that does not include practicing follow through with all needed steps (including in this case the removal of filter caps) can lead to disaster in a real-world event.

Task saturation relates to Hick's Law, which states that the relationship between reaction time and the number of choices is logarithmic;[33,34] simply stated, the more choices, the longer the reaction time. Through proper education and training, one can reduce the number of poor choices one makes and improve efficiency with positive results. Otherwise, numerous stressors can overwhelm the individual and lead to disaster. Understanding human performance is key to improving unexpected outcomes.

Improving Human Performance: In 2009, the concept of improving human performance was introduced into the FCBC course through Team STEPPS (Strategies and Tools to Enhance Performance and Patient Safety)[35] and Crew Resource Management (CRM) concepts as error management tools.[36] This program is based on the very effective aviation model of improving human performance and teamwork by emphasizing communication, situation monitoring, mutual support, and leadership principles. Team leaders are challenged with assigning various team positions; communicating using call outs, call backs; and empowering all to call for a time out when a safety issue is at hand. The emphasis on these concepts proved beneficial in bringing newly formed groups together and helping them to function as cohesive medical teams. In addition, 2010 saw the introduction of a class in "Human Factors in CBRNE Disasters," emphasizing SA, anomalies of attention, and the Human Factors Analysis and Classification System (HFACS).[37]

Summary: The USAMRICD Education, Simulation, and Modeling Center at CCCD supplements the regular didactic lectures in the MCBC, FCBC, and HM-CBRNE courses by approaching education and training from a human-performance perspective and using an integrated multimodal approach that includes human actors, manikins, exercises, and computerized modeling and simulation. This approach utilizes numerous learning-theory concepts to include encoding of information by the brain, emotional-learning theory, the spectrum of stress, the "sweet spot" of the stress-performance curve, situational awareness, human error, anomalies of attention, and negative training. The USAMRICD is committed to train as realistically as possible, exploring new strategies and technologies to avoid unnecessary morbidity and mortality in both the military and civilian sectors from the next CBRNE incident.

REFERENCES

1. Quote: "There is nothing so likely to produce peace as to be well prepared to meet an enemy." George Washington, letter to Elbridge Gerry, Jan. 29, 1780. Available at www.notable-quotes.com; accessed 13 Dec 2010.

2. Letter from Vice Admiral (Upper Half) Brian P. Monahan, M.D., FACP: The Attending Physician, Congress of the United States, H-166, U.S. Capitol, Washington D.C. to Major General James Gilman, MC, USA, U.S. Army Medical Research and Materiel Command, Commanding General, Jun 2, 2010.

3. Government Accountability Office (GAO)-02-38 Report, Chemical and Biological Medical Readiness. p. 25, 2001.

4. The NHP cholinergic crisis exercise conforms to the federally mandated Institutional Animal Care and Use Committee (IACUC) at the USAMRICD and the U.S. Army Medical Research and Materiel Command (MRMC) Animal Care and Use Review Office, the *Guide for the Care and Use of Laboratory Animals*, the Animal Welfare Regulations, and all other applicable federal, Department of Defense, and U.S. Army regulations, and is accredited by the Association of Assessment and Accreditation of Laboratory Animal Care, International (AAALAC), as mandated by paragraph 5.*e*. of AR 40-33 and paragraph II of DoD Instruction 3216.01.

5. DoD policy Department of Defense Instruction (DoDI) 3216.01, Paragraph 4b, Use of Animals in DoD Programs September 13, 2010.

6. Kyle R, Via D, Lowy R, Madsen J, Marty A, Mongan P; A Multidisciplinary Approach to Teach Responses to Weapons of Mass Destruction and Terrorism Using Combined Simulation Modalities. J of Clinical Anesthesia, 2004, 16:152-158.

7. Bloom B (Ed.), Englehard M, Furst E, Hill W, Krathwohl David: Taxonomy of Educational Objectives: The Classification of Educational Goals; p. 201–207. Susan Fauer Company, Inc., 1956.

8. Clark D: Learning Domains, Bloom's Taxonomy. Available at http://www.nwlink.com/~donclark/hrd/bloom.html, accessed Sep 7, 2010.

9. Krathwohl J, Bloom B, Masia B: Taxonomy of Educational Objectives: The Classification of Educational Goals Handbook II: Affective Domain. New York, McKay, 1964.

10. Dave R: Psychomotor Taxonomy, Developing and Writing Behavior Objectives. Tucson. AZ, Educational Innovator Press, 1970.

11. U.S. Army Field Manual 25-100, Chapter 1. Apr 27, 2005.

12. Wiegmann, Douglas A., Shappell, Scott A: A Human Error Approach to Aviation Accident Analysis, Ashgate Publishing Limited, 51, 118, 2003.

13. VARK. (Visual, Aural, Read/rite, Kinesthetic). A Guide to Learning Styles. Available at http://www2.umist.ac.uk.staff/talsc/TaLSC/VARK/default.htm; accessed Aug 9, 2010.

14. Joels M, Pu Z, Wiegert O, Oitzl M, Krugers H; Leaning Under Stress: How Does It Work? Trends in Cognitive Sciences, Apr 2006, Vol 10, Issue 4, 152-158.

15. Lindau M, Almkvist O, Mohammed A: Learning and Memory, Effects of Stress on, Encyclopedia of Stress (2nd ed.), Elsevier Inc. 571-577, 2007.

16. Ward P: Recognition and Alleviation of Distress in Laboratory Animals, National Research Council of the National Academies. The National Academies Press, Washington, D.C., 2008.

17. Scholarpedia, 2(7): 1806. Emotional Memory. LeDoux, J (2007): accessed Sep 8, 2010.

18. Travis T, Major General, USAF, MC, CFS, Commander, 59th Medical Wing, et.al., United States Air Force Medical Service 2008 Capabilities Review and Risk Assessment (CRRA) Operationalize Human Performance for All Airmen. Headquarters, United States Air Force, Assistant Surgeon General For Operations. p. 49, 31 Mar 2008.

19. Ganong W: Review of Medical Physiology, 21st ed. Lange Medical Books/McGraw-Hill, Medical Publishing Division, p. 209-15, 2003.

20. Nixon P: Stress Performance Curve, 1979, Available at www.lessstress.net/stress-affect-performance.htm; accessed Aug 16, 2010.

21. Hans Selye: The Stress of Life. New York: McGraw-Hill, 1956.

22. National Institute of Mental Health, Post-Traumatic Stress Disorder (PTSD) Fact Sheet. Available at http://www.nimh.nih.gov/health/topics/post-traumatic-stress-disorder-ptsd/index.shtml; accessed Sep 7, 2010.

23. Milad M, Quirk G: Neurons in Medial Prefrontal Cortex Signal Memory for Fear Extinction. Nature 7 Nov 2002; 420(6911): 70-74.

24. Grossman D: On Combat. PPCT Research Publications, USA, 30-52, 2004.

25. Unpublished editorial: Performs as Advertised. Litteral, David J: Command Sergeant Major, BS, NREMT-P, Commandant of the AMEDD NCO Academy, 2010.

26. Stein J: Stroke Recovery and Rehabilitation, Task-Oriented Training to Promote Upper Extremity Recovery. Demos Medical Publishing, LLC. 17, 277, 2009.

27. Wiener E, Nagel D, Caro P: Human Factors in Aviation: Flight Training and Simulation. Academic Press, 8: 229-260, 1988.

28. Reason J: Human Error. Cambridge University Press, 2009 (20th printing).

29. Kemeny J, Chairman: President, Dartmouth College, Report: The President's Commission on The Accident at Three Mile Island. Washington, D.C., Sec F-5-B., Oct 1979.

30. Dalrymple M, Schiflett S: Measuring Situational Awareness of AWACS Weapons Directors. Situational Awareness in the Tactical Air Environment: Augmented Proceedings of the Naval Air Warfare Center's First Annual Symposium, CSERIAC SOAR Report# 97-01. Wright-Patterson-AFB: Ohio, 1997.

31. Shappel S, Wiegmann D: The Human Factors Analysis and Classification System - HFACS, DOT/FAA/AM-00/7. Office of Aviation Medicine, Washington, D.C. 20591, p. 7, Feb 2000.

32. Tuorinsky S (Ed): Medical Aspects of Chemical Warfare, United States Dept. of the Army. Office of the Surgeon General, Borden Institute, Walter Reed Army Medical Center, 657, 2008.

33. Hick W: On the Rate of Gain of Information. Quarterly Journal of Experimental Psychology 1952; 11-26.

34. Hyman R: Stimulus Information as a Determinant of Reaction Time. Journal of Experimental Psychology 1953; 45, 423-432.

35. Team STEPPS, Team Strategies and Tools to Enhance Performance and Patient Safety, Agency for Healthcare Research and Quality and the Department of Defense, U.S. Government Printing Office Internet: bookstore.gpo.gov, ISBN 1-58763-192-X.

36. Helmreich R, Merritt A, Wilhelm J: The Evolution of Crew Resource Management Training in Commercial Aviation. International Journal of Aviation Psychology, 9(1), 19-32, University of Texas at Austin Human Factors Research Project 1999; 235.

37. Reason J: Human Error: Models and Management. British Medical Journal, Vol. 320, 2000, pp. 768-770.