APPLYING NEUROSCIENCE TO ENHANCE TACTICAL LEADER COGNITIVE PERFORMANCE IN COMBAT

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by

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ABSTRACT

APPLYING NEUROSCIENCE TO ENHANCE TACTICAL LEADER COGNITIVE PERFORMANCE IN COMBAT, by Major Andrew C. Steadman, 111 pages.

The US Army relies on tactical-level leaders, not for their physical warfighting skills, but for their ability to employ cognitive thought during stressful situations. Cognitive tasks include sensing patterns, deciphering complex environments, creating novel solutions, and synchronizing multiple battlefield systems, to name but a few. The physiological response to combat can degrade that cognitive capability, preventing leaders from performing tasks critical to unit success.

This thesis approached tactical combat leadership from a brain-based perspective, seeking ways to enhance leader cognitive performance. To do so, it explored the physiological aspects of threat response and examined the field of neuroscience to understand brain function. Relevant to combat leadership are the principles that: (1) the brain sacrifices cognitive resources to respond emotionally, (2) stress degrades the form of conscious attention know as "working memory," and (3) certain brain areas can be deliberately activated to exert control over emotions. Further research resulted in a menu of techniques that tactical leaders can use to regulate the emotional response and improve cognitive performance in combat.

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Finally, I owe credit to Mr. Gay Robertson, my grandfather, who at age 91 is an inspiring example of lifelong learning. He is living proof that we can grow and change our brains through every age.

TABLE OF CONTENTS

ACRONYMS

BOLD	Blood Oxygen Level Dependence
CAPE	Center for the Army Professional Ethic
DARPA	Defense Advanced Research Projects Agency
EEG	Electroencephalography
fMRI	Functional Magnetic Resonance Imaging
fNIRS	Functional Near-Infrared Spectroscopy
LTP	Long-Term Potentiation
MFTI	Mind Fitness Training Institute
MMFT	Mindfulness-based Mind Fitness Training
MRI	Magnetic Resonance Imaging
NASA	National Aeronautics and Space Administration
NCO	Non-Commissioned Officer
STRONG	Schofield Barracks Training and Research On Neurobehavioral Growth
TRADOC	US Army Training and Doctrine Command
UCLA	University of California, Los Angeles

ILLUSTRATIONS

CHAPTER 1

INTRODUCTION

Through the Leader's Eyes

"I can't believe she wants to go to Disney World for a whole week right after I redeploy," First Lieutenant Wilson wondered from the commander's hatch of his Stryker combat vehicle as it weaved through the streets of Kandahar.

"We're gonna have the money but I don't know if I can handle all that commotion and kids and craziness. After this little venture, I'm just gonna want to rest for a while at home and try to live in the normal world again." 1LT Wilson blinked, and shifted his attention back to the route in front of him.

His platoon of four Strykers passed by familiar produce and clothing stands that sat curbside along their patrol route. It had taken 1LT Wilson several weeks to learn the layout of the five neighborhoods he was responsible for, but he felt like he was finally figuring out the pattern of typical life in this section of the major Afghan city. In between thoughts of his return to the States in six weeks, he occasionally waved back at the local children in the streets.

"And I can't believe we lost Sergeant Talbert. He was such a good NCO. Dependable. I did everything I could to get the platoon out of that mess, but there had to be some way to avoid it in the first place." The day before, the Taliban had initiated an ambush on 2nd Platoon that incorporated rocket-propelled grenades and machine gun fire. The attack was unique for the area because the enemy attacked from the rooftops instead of from the ground, where they could readily escape in vehicles. The fight lasted 35 minutes, killing SGT Talbert and injuring three of his platoon members.

1LT Wilson frustratingly thought, “Doesn’t the company commander know that we’re exhausted from yesterday? I understand that we had to search the area to find out who carried out the attack, but I think three hours would’ve been sufficient to do that instead of ten.” The convoy took a right and entered Sector 4 Charlie. There was now a conspicuously smaller amount of civilian foot and vehicle traffic in this area. 1LT Wilson didn’t notice. He was feeling drained and distracted.

Kneeling down from the commander’s hatch to rummage around the Stryker compartment, 1LT Wilson thought, “Did I bring my snacks with me? I really should’ve eaten something when we got back to base but there was so much to do in the two hours before this patrol. And sleep . . . yeah, right. I wish we infantrymen could get crew-rest like those aviators get.”

The radio crackled and broke Wilson’s stream of random thoughts. “White Six, this is Charlie Command Post. Are you still in Sector 4 Bravo?”

“Negative, CP,” 1LT Wilson replied, knowing he should have called in their new position minutes ago. “We’re in 4 Charlie now. I missed the call, sorry.” The Strykers continued, and a car parked sideways in the middle of the street came into view. As he keyed the handset in the lead Stryker, 1LT Wilson’s eyes actually focused on the car, but its significance did not register. Had he not been tired, emotionally drained, hungry, and distracted, the platoon leader’s brain might have triggered the emotional reaction of danger, manifesting into a sinking feeling in his gut.

Instead, he continued to speak, “Charlie CP, what kind of flexibility do we have for adjusting the length of this patrol?” The Strykers slowed as they approached the car. “The boys here could really use a bre-. . .” A flash of light atop a building interrupted

1LT Wilson mid-sentence and the ensuing rocket descended into the front slope of his Stryker, piercing the engine compartment. Machine gun fire erupted onto the convoy as they attempted to conduct an immediate reaction drill from their disadvantageous position. There was a massive explosion somewhere behind him.

1LT Wilson returned fire to the right as his vehicle came to a stop. His driver, momentarily stunned, yelled into the internal microphone, “Sir, the engine is out! I can’t get it started!” The Stryker’s rear air guards added their reports, “We’ve got enemy on both sides of the streets but most of the fire is from the right. And we can’t see our last Stryker!”

“White Six, this is Charlie CP. Are you in contact? . . . Stand-by for the commander.”

1LT Wilson’s heart was racing, his breathing erratic. His hands shook as he tried to load a fresh magazine into his rifle.

“White Six, this is Charlie Six, what’s your status?” Wilson really wished his commander wasn’t so quick to jump on the radio and demand information. He replied, “We got ambushed again, sir! I’m still trying to figure out what the hell is happening. Our location is . . . ” 1LT Wilson realized that he didn’t know how far down Route Alabama they had traveled; his mind hadn’t been moving as fast as the Stryker had. He stood up to look around for few seconds instead of crouching down inside the vehicle to look at the digital display. The air guard was right. 1LT Wilson couldn’t see the rear vehicle of their convoy, the one with his platoon sergeant in it. Had they been blown up? He’d better call and check.

1LT Wilson felt a tug on his pant leg. The vehicle's gunner was trying to get his attention. Pointing at the video display linked to a camera on the Stryker's .50 caliber machine gun, he said, "Sir, look at the screen. I see movement in this building but I can't tell if they're the enemy or not. What do you think?"

"White Six, I say again, what is your status? I have two aircraft we can put in the fight but I need the location of your dismounts," the company commander barked.

The platoon leader jumped back up in the hatch, not sure of whom to reply to first. "Ok, it's a battle drill. I've got to suppress and flank this building to the right. Maybe that's where White Four went, around to the south." His head was on a swivel now, responding to multiple streams of gunfire, shouting, and ceaseless movement all around him.

"White Six, this is White Three! I've got one wounded back here, gunshot wound! We're assessing him." "Oh jeez, not again," Wilson worried, and hastily replied in a slightly over-frantic voice, "Just deal with it for now, I've got to figure this out!"

1LT Wilson's mind was operating at maximum capacity, already exhausted from the previous day's events and now overloaded with combat stimuli, incoming information, and a series of interruptions that prevented him from developing a plan of action. He had not paid enough attention to their position in the city, so he was slow to determine the array of his own forces and how enemy was attacking him. His lack of sleep and already low blood sugar level prevented his brain from operating efficiently and magnified his growing irritation with the platoon's worsening situation.

Frustrated, Wilson raised his rifle in search of a target. His heart wanted revenge and his mind was in no condition to override the urge.

"White Six, this is Charlie Six. Negative response on the dismounts. I've got digital visibility of your Strykers. I'm sending two Apaches on a gun-run south of the building to your right. I'll push them to your control after the first run. Do you copy? . . ."

Neuroscience for Combat Leaders

Ground combat is physically, mentally, and psychologically unforgiving. Soldiers routinely experience unpredictable combinations of emotions that challenge every aspect of warfighting. The preceding vignette represents a common scenario that US military ground combat leaders face in the current operational environment. 1LT Wilson's mental state was compromised not only by the previous day's tragic events, but also by the long-term impact of eleven months of combat operations. Physical exhaustion drove him to think about rest and recovery in the midst of a combat mission. His lack of adequate nutrition reduced his ability to control his emotional state and stay on task. Wilson's condition also prevented him from appropriately attuning to and processing the most relevant information, like a parked car that placed the platoon in a vulnerable position or the emerging risk of employing attack aircraft while some of his forces were unaccounted for.

This confusion, fear, and uncertainty, along with potentially debilitating physiological reactions, routinely accompany the challenging experience of combat. To be successful, soldiers must moderate their emotional reactions so they can execute their trained tasks. Doing so is especially impressive because it conflicts with the instinctive desire to avoid danger. Fleeing from a threat is a natural instinct and a viable option for survival. Staying to fight is unnatural and brings greater risk to the organism. The ability to override this biological predisposition can ultimately be linked back to some aspect of brain function. “Everything you do in life is based on your brain’s determination to minimize danger or maximize reward” (Rock 2009a, 105). The brain wants to move toward things in life that give it pleasure or ensure survival, and away from things that cause pain or threaten survival (Rock 2009a). From this perspective, succeeding in combat is a measure of how well the brain can perform the required mental tasks despite the threatening environment.

For tactical combat leaders today, the challenge is especially difficult. Not only must they survive their own personal tactical situations, but they must also interpret the multi-faceted operational environment, manage numerous complicated battle systems, and provide their organizations the adequate leadership needed for unit success. These tasks are not reflexive; leaders cannot train them through simple repetition. They are cognitive in nature, requiring a mind that appropriately regulates emotion, filters out distraction, and thinks creatively to generate novel solutions.

The US Army, however, provides very little instruction to tactical leaders regarding how to handle the stress of combat while retaining the ability to solve complex battlefield problems. The Army’s professional military education program teaches operational planning, but not how to conduct those same processes during intense, life-threatening situations. Further, while discussion on the human dimension of war has increased in the last five to ten years, no Army manual covers the mental processes that underlie the combat tasks that leaders will perform. Where, then, can leaders learn to improve their cognitive capability in combat? What research fields are relevant to improving tactical leader performance, thereby aiding 1LT Wilson in maintaining control of his own response to combat and retaining the ability to lead effectively? This thesis explores the brain sciences to find an answer.

The field of neuroscience has seen significant advances in recent years, and the benefits of this knowledge can positively affect numerous disciplines, including tactical combat leadership. Using functional Magnetic Resonance Imaging (fMRI), Positron Emission Topography, electroencephalography (EEG), surgical methods, and experiment-based approaches, researchers have revealed many of the biological processes that underlie emotional and cognitive behavior. These include how and why the brain automatically reacts to threatening situations, how it prioritizes resources to cope with competing demands, and how the emotional reactions can impact higher-level thinking. These discoveries have triggered a wide range of methods for regulating the emotional response and increasing cognitive capability despite potentially debilitating stress.

In seeking to discover how neuroscience can benefit tactical military operations, this thesis asks two key questions. What does neuroscience reveal about how humans react to life-threatening stress and can Army tactical leaders benefit from understanding these reactions? What existing emotion regulation techniques can aid Army tactical leaders to improve cognitive performance in battle? Answering these questions offers Army leaders an informative understanding about their own brain function in battle, providing new opportunities to improve individual leadership.

This thesis analyzes tactical combat leadership from a brain-based perspective. It explains the physiological effects that Army tactical leaders are likely to experience and describes how an excessive emotional response in combat can diminish cognitive capability. It describes several principles of brain function and incorporates them into the combat environment. The thesis concludes by highlighting practical emotion regulation methods that Army tactical leaders can apply to increase cognitive ability.

Significance of the Research

In contemporary academic and popular literature, a wave of interest in brain function is just beginning to form. As neuroscience research reveals more knowledge about the brain, there is an emerging consumer appetite for reading about novel brain facts and discovering how to find lost car keys. Except for a few research efforts, the military currently lags behind this popular curiosity and has failed to incorporate neuroscience into doctrine, operations, training, or leadership. Neuroscience is primarily involved in the development of military technology such as enhancing pilot performance, improving target recognition, and assessing (not strengthening) soldier cognitive capability (DARPA 2011a). Most military studies involving neuroscience focus on subjects like post-traumatic stress and the neurological disabilities resulting from combat wounds (traumatic brain injury). These research areas clearly serve critical purposes, but a research gap exists in applying the brain sciences to military operations.

This thesis is significant because it is among the first efforts to do so. It applies neuroscience research to modern tactical combat leadership, an intensely human endeavor whose cerebral component is too often overlooked. This thesis is unique because it explains what research shows about how the combat experience can degrade the leader's ability to perform his job and how that leader can maintain his effectiveness as a manager of lethal and complicated battlefield systems. Additionally, this thesis presents topics that are written for and explained at the individual level, but also have usefulness as organizational leadership principles. The focus is narrow but the application is broad.

A final area of significance is that the topic of leadership is personal. This thesis differs from research efforts that may propose changes to doctrine, recommend a new weapon system, or convey historical battle lessons. Discovering the underpinnings of the combat experience causes the individual to examine present capability and potential for improvement. The leader who is mindful will identify areas of improvement and consciously (even subconsciously) alter behavior to improve leadership. Doing so can have extremely positive effects for the individual as well as for the organization. Thus, this thesis has the potential to educate, motivate, and develop Army leaders and their units.

As a note to provide contextual background, the development of this thesis came about as the result of several years of personal interest in neuroscience topics. Reading books like *Blink* by Malcolm Gladwell and *How We Decide* by Jonah Lehrer inspired an awareness that neuroscience has direct application to military leadership. As a result, and after twelve months of book, article, and lecture research, this thesis' author published an article in the Army periodical *Military Review* entitled "Neuroscience for Combat Leaders: A Brain-based Approach to Leading on the Modern Battlefield" (Steadman 2011). This thesis uses that article's concepts as a foundation and deepens the discussion by relying more heavily on primary source material, by expanding descriptions of physiological and cognitive processes germane to combat leadership, and by including a wider array of useful emotion regulation techniques.

The next chapter explores relevant literature in the areas of military leadership, combat physiology, and neuroscience. It provides a framework for understanding how the domain of neuroscience applies to modern tactical combat leadership. The chapter highlights which bodies of work are useful in developing an appropriate foundation of neuroscience knowledge and identifies existing research gaps. This thesis targets those gaps and subsequently offers useful techniques that leaders can apply to improve cognitive performance in battle.

CHAPTER 2

LITERATURE REVIEW

This thesis combines the two topics of military leadership and neuroscience. The first subject has a vast and timeless amount of relevant literature, providing both doctrinal and subjective guidance on how to lead in the most challenging of situations. This literature review does not summarize the long history of doctrinal and experiential military thought that has resulted in the current concept of tactical military leadership. Rather, it assumes the reader has a general knowledge of leadership principles and of basic military operations. Supplementing the military leadership literature is the subject area of combat physiology, or what happens to the body in response to combat. Such writing is less common but very relevant because in combat, physical capability must be present for effective leadership to emerge. The second literature area, neuroscience, has broad application to military operations because every action a leader performs has a neural beginning. This chapter narrows the neuroscience literature down to those topics most relevant to stress reaction and cognitive processing. Doing so enables an understanding of the combat experience from a brain-based perspective.

Background Technical Information

In order to accurately analyze how the mind functions in combat, it is necessary to understand certain aspects of cerebral biology. This section provides an overview of the brain regions, systems, and functions that are most relevant in achieving this thesis' purpose of improving tactical combat leadership through neuroscience. These concepts serve as a foundation for subsequent descriptions of brain behavior, cognitive processing, and emotional reactions. The primary benefit of understanding brain function is in linking behavioral indicators to neurological origins. There is value, for example, in gaining an awareness of how the brain recognizes a fearful stimulus and processes that information into an emotional response felt in the body. Thus, when the feeling arises during an actual threatening situation, the leader will be more mindful and attentive to his body's processes.

This thesis primarily references the two major brain functions of cognitive processing and emotion processing. Cognitive processes, like directing attention, generating insight, and forming intentional thought, occur in the outer edges of the brain (called the cerebral cortex) and more specifically in the frontal lobe and prefrontal cortex (Rock 2009a; Sapolsky 2004). While there is no singular brain system that governs emotions, the brain areas generally associated with the emotional response are located in the temporal lobe (Lehrer 2009; Sapolsky 2004).[1] These regions are also known as subcortical because they reside deeper in the brain, as opposed to the outermost cortex (Damasio 2010; Sapolsky 2004). The temporal areas, and also the brain stem, are evolutionarily older, initiate and regulate basic bodily functions, and are common to all animals (Sapolsky 2004).

Deep in the brain is the hippocampus, a temporal region that is crucial in forming memories, recalling memories, and learning new information (Damasio 2010; LeDoux 1996). Importantly, the hippocampus is not the storage vault of memories. Rather, it

[1]This thesis uses the term "temporal" instead of "limbic" to identify those brain areas identified with emotion processing. Decades of research have disproved the limbic notion of a consolidated system that controls emotion, although it has taken decades for the term to fall out of professional use.

receives sensory data from the environment (as well as cognitive and emotional information in response to the environment) and communicates with the cognitive regions of the brain to solidify the memory (LeDoux 1996). That memory is stored in neural networks all across the brain, depending on the type of memory, but the hippocampus is initially responsible for orchestrating its creation (LeDoux 1996). Neuroscience divides permanent memories (long-term) into two basics types, explicit and implicit. Explicit memories involve specific facts and experiences while implicit memories involve learned skills and conditioned responses (LeDoux 2002). Interestingly, well-formed memories (like the ability to play a musical piece) and learned reflexive actions (like quickly reacting to engage an enemy target) are performed in the sensory and motor areas of the cortex, and not within the conscious realm of the prefrontal cortex (Beilock 2010).

One note about forming memories bears mentioning, as it has direct relevance to how Army leaders prepare for and react to combat. Memories (including skill learning) are more permanently stored in the brain when there is an accompanying emotional component. Friedrich Nietzsche's statement about memories seems true, "If something is to stay in the memory it must be burned in; only that which never ceases to hurt stays in the memory" (Lehrer 2008, 142). This fact is intuitively true for traumatic events like car crashes, divorces, or remembering in detail where one was on 11 September 2001. But the principle is also true for daily activities such as training new skills and picking up bad habits (unconscious learning).

The process is called long-term potentiation (LTP) and occurs at the cellular level.[2] When brain cells (neurons) become activated for whatever reason, the brain uses LTP to strengthen those connections, making it easier and faster to activate them in the future (LeDoux 1996). LTP increases through repetition, such as practicing to tie shoelaces or disassembling a weapon. It also associates previously unrelated stimuli, as demonstrated in Pavlov's classic dog experiment (LeDoux 2002).[3] The effect does degrade over time, depending on the strength of the connection; the temporary nature of New Year's resolutions is a good example (LeDoux 1996). However, the presence of emotional stimuli increases LTP and solidifies the neuronal associations, sometimes into permanent memory and learned behavior (LeDoux 1996). This principle is important for Army leaders to understand when structuring individual and unit training with the goal of forming permanent lessons and behavior.

Responding to significant emotional stimuli is the job of an almond-shaped region near the center of the brain called the amygdala (Berkman, Burklund, and Lieberman 2009; LeDoux 1996; Rock 2009a). The amygdala was traditionally thought to respond only to threatening or negative stimuli, but recent research has shown that the intensity of an input matters more than its characterization (Berkman, Burklund, and Lieberman 2009). The amygdala is comparatively small but has neural connections to a vast array of

[2]Reference LeDoux's *The Emotional Brain* and *Synaptic Self* for detailed explanations of LTP, including specific synaptic and neurochemical processes. He defines LTP as, "The production of changes in synaptic strength as a result of brief stimulations" (LeDoux 1996, 216).

[3]For example and from personal experience, one does not naturally associate pain with avocados. However, slicing one's finger open while cutting an avocado will create a neural connection that, for some time, will manifest in an emotional aversion to avocados. The fruit will then activate the pain response even when no knife is present.

cortical areas, allowing it to “influence ongoing perceptions, mental imagery, attention, short-term memory, working memory, and long-term memory, as well as the various higher-order thought processes that these make possible” (LeDoux 1996, 287). Acting like a catalog of “things the organism should pay attention to,” the amygdala compares inputs from the world and provides the quickest (although not always the most accurate) way for the brain to identify danger and initiate appropriate action. It is very good at igniting implicit behavior. For example, when the image of a long, slender, curved object passes from the optic nerve through the visual thalamus, the amygdala receives it, makes a quick assessment, and determines that it could be a snake (LeDoux 1996). It then immediately commands the body into evasive action, including activation of the sympathetic nervous system (discussed later in chapter 4). This reflexive process happens outside of conscious thought and is termed “the low road” because the brain sacrifices accuracy for speed, temporarily bypassing conscious, detailed analysis of the image (LeDoux 1996).

That thorough type of processing occurs a fraction of a second later in the prefrontal cortex, which receives the same visual information as the amygdala.[4] The prefrontal cortex is slower but more precise in its analysis, able to examine the object’s color, surface texture, and movement pattern (Lehrer 2008). Consequently, as the organism (i.e., frightened human) leaps to safety, the prefrontal cortex is able to correctly determine that the potentially dangerous object is simply a stick that looks like a snake (LeDoux 1996). This pathway is called “the high road” and has the ability to override the direct amygdala process, but only after it has had time to evaluate the stimulus (LeDoux

[4]The visual cortex also aids in this process (Lehrer 2009).

1996). As LeDoux points out, however, “It is better to have treated a stick as a possible snake than not to have responded to a possible snake” (LeDoux 1996, 166).

In addition to distinguishing between sticks and snakes, the prefrontal cortex is thought to be the area of executive functions and working memory (LeDoux 2002). It is a thin layer of cells just behind the forehead and gives an individual his concept of the conscious self (Lehrer 2009). Executive functions are the brain’s most advanced processes and are the basis for thinking and reasoning (LeDoux 2002). Executive functions determine what stimulus is attended to, what decisions need to be made, what the consequences will be, and so on (LeDoux 2002). Working memory (also discussed in chapter 4) is a temporary storage area that holds new information while the brain processes it in light of other stored knowledge, cognitive consideration, and emotional preferences (LeDoux 2002; Lehrer 2009).

As mentioned in the snake example, the prefrontal cortex does have the ability override emotional responses. This is evident when controlling one’s anger during an argument or when choosing a nourishing meal over a more desirable, unhealthy one. After responding to a threatening stimulus, the prefrontal cortex will eventually take over to face the danger with cognition and formulate a response plan; but the amygdala determines the initial reaction (LeDoux 1996). In fact, the neural connections flowing from the amygdala to the cortex (not specifically prefrontal) are much stronger than vice versa (LeDoux 2002). It is apparent that the brain is wired to pay immediate attention to whatever stimuli activates the amygdala.

The key technological advancement that has allowed neuroscientists to observe these processes is a method called fMRI. It is akin to the well-known magnetic resonance imaging (MRI) technique, which reads the magnetic polarization of water atoms to create a two-dimensional picture of cerebral structures (Dretsch 2010). Invented in the early 1990s, fMRI creates the ability to observe the brain's function and not just its form. It relies on the principle that the brain shifts blood to areas being used at the time, supplying them with oxygen (Dretsch 2010).[5] fMRI reads this elevated oxygen signal and translates it (near real-time) into what is essentially a map of the brain containing highlighted areas of heavy activity. Scientists design experiments to activate particular mental activities then correlate those activities with their neurobiological signatures. Figure 1 is an example brain map that scientists can create using fMRI data.

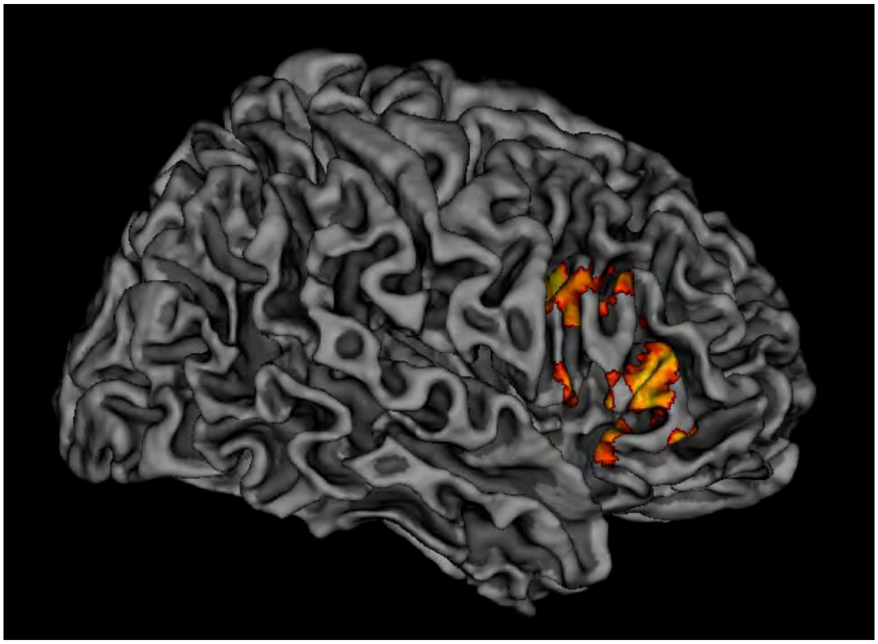

Figure 1. fMRI scan of brain during affect labeling task
Source: Matthew Lieberman, "The brain's braking system (and how to 'use your words' to tap into it)," *NeuroLeadership Journal* 2 (2009), http://www.scn.ucla.edu/papers.html (accessed 1 April 2011), 5.

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[5]The theory is called blood oxygen level dependence, or BOLD (Dretsch 2010).

One disadvantage of relying on scanning technology is that the systems are expensive and stationary, which limits their versatility. Another drawback is that research subjects must remain completely still while being scanned. These characteristics preclude their use for analyzing the cerebral response to actual combat events. Nonetheless, fMRI has contributed greatly to understanding and treating mild traumatic brain injury in veterans and can illuminate the nature of emotional and cognitive processes that occur in soldiers during combat operations (Dretsch 2010).

Military and Combat Physiology Literature

For millennia, military and philosophical authors grappled with how to use reason to balance emotion. Aristotle wrote of managing passions in *The Nicomachean Ethics* (Lehrer 2009). Epictetus was insistent to "know what you can control and what you cannot," and that an event is only what the mind interprets it to be (Lebell 1995, 3). Second century Roman emperor Marcus Aurelius cast the stoic mold by affirming that man is only free when he can control his thoughts and desires (Hicks 2002). These works signify man's enduring desire to govern his passions with the goal of becoming a rational, intelligent, and fruitful being. The ancient writers skewed our modern conception of behavior, creating a polar, often conflicting relationship between emotions and reason. Emotions became something to be subdued so that reason might discover correct insight and direct correct behavior.

In the modern military experience, the impact of emotions has direct relevance to one's ability to effectively accomplish combat tasks. More recently in literature, the World Wars inspired Lord Moran, who served as Winston Churchill's doctor, and US Army Brigadier General S. L. A. Marshall to separately examine the sources of soldiers' fear and seek individual and organizational strategies to overcome combat's emotional impact. The following statement by Lord Moran in *The Anatomy of Courage* summarizes the emerging importance of fear in 1943, "The story of modern war is concerned with the striving of men, eroded by fear, to maintain a precarious [ability to manage that fear]" (Moran 1945, 3).

Marshall asserted that the singular purpose of a training system is "to prepare the combat officer mentally so that he can cope with the unusual and the unexpected as if it were altogether normal and give him poise in a situation where all else is in disequilibrium" (Marshall 1947, 116). Marshall's book, *Men Against Fire*, confronted topics like the debilitating effects of fear in battle, the challenge of command on a hectic battlefield, and the sources of soldiers' strength in combat. One note from Marshall seems to challenge the notion that a warrior must subdue emotion, "In war, the will may triumph only as it is the expression of massive common sense, conditioned by an accurate appreciation of the general emotional situation" (Marshall 1947, 176). His statement implied that emotion can actually be useful in clarifying the combat environment.

Marshall also proposed that speech among soldiers in combat is vital to maintaining individual mental control (1947, 127). Marshall wrote, "A chief fault in our men is that they do not talk. They are not communicative. In combat they are almost tongue-tied . . . many small actions were lost because our men had not learned that speech is as vital a part of combat as is fire" (1947, 127). While Marshall's observations were qualitative, based on interviews and subjective experiences, his comments connect with recent quantitative neuroscience research that has identified a neural link between speech and emotion regulation.

Researchers at the University of California, Los Angeles (UCLA) showed that putting emotions into words (a coping strategy called affect labeling) helped reduce subjects' emotional response to threatening pictures (Berkman and Lieberman 2009; Lieberman 2009). In particular, vocalizing the existence of threatening stimuli was shown to increase cognitive activity and diminish activity in the emotionally reactive regions like the amygdala (Lieberman 2009). This thesis includes affect labeling as but one technique in an array of useful emotional regulation strategies for combat leaders.

In 1996, combat psychology author and retired Army Lieutenant Colonel Dave Grossman provided analyses of the psychological effects of killing in *On Killing: The Psychological Cost of Killing in War and Society*. He later broadened his research to focus on the physiological effects of combat in *On Combat: The Psychology and Physiology of Deadly Conflict in War and in Peace*. *On Combat* drew on scientific and experiential data involving both soldier and law enforcement officer engagements, illuminating how combat can progressively decrease an individual's effectiveness.

Grossman's coauthor, Michael Asken, published a book in 2010 that examined stress physiology and psychology and provided methods to increase mental toughness in military and law enforcement personnel. *Warrior Mindset*'s fifth chapter, entitled "Mental Attack Plan: Tactical Arousal Control Techniques and Mental Toughness," provided a broad summary of stress control techniques including tactical muscle relaxation, breathing exercises, mediation, self-hypnosis, and imagery (Asken 2010). Most of Asken's recommendations were not succinct actions but are learned behaviors that train the body and mind over many hours of practice and focus. An individual may not have the time or the personal interest to fully apply the more mystical practices.

However, portions may be applicable and useful when adapted into one's particular situation. This thesis summarizes and analyzes several performance enhancement exercises methods, and then incorporates aspects of those techniques into a model best suited for the leader in combat.

An experienced US Army special operations Master Sergeant, as well as shooting and tactics instructor for law enforcement, Paul Howe took a reflexive, aggressive approach to surviving the combat experience in *Leadership and Training for the Fight*. He recommended adopting a training mindset that conditions the individual to operate despite the overload of sensory and emotional inputs that accompany battle (Howe 2004). Thousands of shooting repetitions instill accuracy (Howe 2004). Frequent exposure to explosive breaching operations dampens the intensity of the task (Howe 2004). Individual combat actions should shift out of purposeful, conscious thought and into the muscles as reflexive, natural ability.

Howe acknowledged that the warfighter will experience fear, anger, and anxiety, but that one should channel those emotions into a "controlled aggression" that can be put to use (Howe 2004, 29). This approach is a form of acceptance and mental redirection, similar to cognitive control strategies like affect labeling and reappraisal, in which an individual consciously identifies the felt emotion and characterizes it as a positive, useful experience.

Leadership and Training for the Fight also underscored a natural tension between specific combat actions that one can train into permanency, and those tasks that require cognitive thought and novel solutions. On one end of an imaginary spectrum of tasks are basic skills that the warfighter can execute identically in countless situations once certain engagement criteria are met. On the other end are complex actions that involve multiple battlefield systems and several groups of soldiers. The process of orchestrating these systems falls on leaders, like 1LT Wilson in the opening scenario. They must use mental processes to weigh changing conditions against unit capability to create feasible, acceptable courses of action. Howe believed that although leaders cannot train the specifics of every possible decision, they can train the overall process and become accustomed to performing it under stress:

> Simulations should not be limited to the individual level, but must also be required of the command personnel. If we are all affected by the same decision making process during a high stress situation, why not require a leader who makes all encompassing life and death decisions affecting the entire force to also rehearse or practice these decisions? Sadly, there is no requirement for such leadership training. Only extraordinary leaders take the initiative and seek out this training. Generally, most of today's officers feel that they don't need the training or it is too easy. Yet these are the same officers who are overwhelmed in the stress of combat while trying to process all the incoming information under chaotic conditions. Today's combat is fast, intense and lethal requiring leaders to make positive and rapid decisions faster than ever before. (Howe 2004, 17-18)

Howe's statement identified a cognitive training gap in today's military and emphasized the importance of intentionally developing mental leader skills.

Finally, current US Army leadership doctrine, *Army Leadership* (Field Manual 6-22), highlighted only a small portion of what the individual leader could personally experience in combat. Its two-page "Stress in Combat" section emphasized admitting when fear exists and establishing communication lines with soldiers, as well as recognizing that a soldier's endurance has limits (US Army 2006). It further stated, "Leaders must understand this human dimension and anticipate Soldiers' reactions to stress. It takes *mental discipline* [emphasis added] and resilience to overcome the plan going wrong, Soldiers becoming wounded or dying, and the enemy attacking unexpectedly" (US Army 2006, 10-4).[6] This guidance mentioned mental discipline without elaborating on what a "mentally disciplined" leader looks like or how to develop the quality. The statement was representative of a common doctrinal theme that overlooks the specifics of mental performance. Terms like intuition and cognition are used often but rarely developed into useable guidance.

In 2008, however, the *U.S. Army Concept for the Human Dimension in Full Spectrum Operations 2015-2024* (Training and Doctrine Command Pamphlet 535-3-7) made valuable strides towards recognizing the importance of and explaining the mental component of combat. It emphasized flexible learning styles and adaptability, as well as recommended the approach that leaders should take to improve cognitive abilities (US Army 2008). The following paragraph from the pamphlet illustrates a type of discussion that is largely absent from the US Army writing:

> Soldiers must also possess the enduring competencies of self-awareness and adaptability. Self-awareness involves knowing how to assess one's own abilities, knowing one's own strengths and weaknesses in the [operational environment], and learning how to correct these weaknesses. Metacognition (thinking about thinking) skills contribute to self-awareness by enabling learners to think about how they learn and adjust their learning strategies to accomplish their goals. Metacognition is more than an intellectual exercise. It is an ability to relate specific situations to previous experiences and, in turn, to extrapolate parallels that can assist in choosing new informed actions. The greatest value of such thinking may be in discerning new tactical and operational relationships and ideas. (US Army 2008, 29)

Not specifically stated but present in this statement are numerous implications for leader development and unit training. Metacognition is rarely an innate quality. Its development

[6]The National Research Council's Committee on Opportunities in Neuroscience for Future Army Applications defined resilience as "the ability to successfully adapt to stressors, maintaining psychological well being in the face of adversity" (National Research Council 2009, 95).

is intentional, cultivated through experience and mentorship from other leaders. Formally discussing the topic is a step in the right direction, but metacognition has not descended to the tactical level as a desirable leader trait and training concept.

Neuroscience Literature and Research

The neuroscience field includes application areas ranging from disease diagnosis and treatment to genetic discovery and manipulation to mental performance in athletic sports. This literature review focuses on those aspects of neuroscience most involved in combat leadership. Those research areas include stress and threat response, emotion regulation, executive function, and insight generation. Further, this review does not summarize the early foundations of brain science but instead highlights works inspired by neuroscience discoveries in the last twenty years.

In his 1994 book, *Descartes' Error*, neurologist and neuroscientist Antonio Damasio pioneered the belief that emotion is not a superfluous feature of the human body that rationality should subjugate. Instead, he proposed that emotional reactions are the somatic manifestations of the mind's experience and work in a cyclic manner to inform the mind about how to respond to a changing environment. This idea directly challenged the ancient writers by suggesting that reason and emotion are not only interactive but also dependent on one another. Damasio coined the term "somatic marker" to describe those feelings which are learned (as opposed to innate feelings) and are connected to some set of predicted outcomes (1994, 174). This concept is important for this thesis because training for combat (i.e., learning how to apply military power to achieve a particular outcome) is more permanently learned when the training experience is accompanied by an emotional component. Damasio's most recent book, *Self Comes to Mind: Constructing* *the Conscious Brain*, focused on explaining how the brain constructs consciousness, forms mental maps, and generates insight.

New York University neuroscientist Joseph LeDoux, in *The Emotional Brain* and *Synaptic Self*, paralleled Damasio's work and narrowed his focus to the role emotions play in threat response. His work explained the neurological systems at work when reacting to fearful situations, which provides a key understanding into the processes that soldiers experience in combat. *The Emotional Brain* also detailed the concept of working memory, which is vital in explaining how leaders form mental models of their environment and use abstract thinking to generate novel solutions in battle (LeDoux 1996, 267-282). Additionally, LeDoux's writing succinctly explained the parallel pathways, known as the low road and the high road, that the brain uses to interpret and react to incoming stimuli (LeDoux 1996, 164). His analysis contributes to understanding why soldiers often react automatically to combat stimuli.

In 2004 Robert Sapolsky, professor of biology and neurology at Stanford University, wrote his third edition of *Why Zebras Don't Get Ulcers: The Acclaimed Guide to Stress, Stress-Related Diseases, and Coping*. Sapolsky wrote this work for the greater public and in plain, understandable, often humorous language. It explained the sympathetic stress response in detail, then showed how prolonged exposure to stress can increase the risk of cardiovascular disease, memory loss, and mental disorder, as well as shorten life expectancy (Sapolsky 2004). Sapolsky reinforced the concept that stress exposure degrades cognitive ability, particularly after prolonged exposure such as what soldiers experience during sustained combat operations (Sapolsky 2004).

In the research laboratories, the development of fMRI technology provided neuroscientists the extraordinary ability to observe cerebral function like never before. Using fMRI, the Social Cognitive Neuroscience Laboratory at UCLA published studies that identified the right ventrolateral prefrontal cortex as the center of self-control (Lieberman 2009). Further research implicated an associated area (the right inferior frontal cortex) in emotion regulation as well as motor inhibition, such as one experiences when trying to write the new calendar year on a check (Berkman and Lieberman 2009). This thesis highlights such findings to shed light on the mental processes that occur when military leaders specifically try to control their emotions. In a 2009 study entitled “Using neuroscience to broaden emotion Regulation: Theoretical and methodological considerations,” Elliot Berkman and Matthew Lieberman at UCLA summarized the major efforts that neuroscience research labs are making in discovering the neural basis of emotion regulation (Berkman and Lieberman 2009). The study offered a broad analysis of several emotion regulation techniques, including affect labeling, reappraisal, cognitive distancing, suppression, linguistic labeling, and contextualization.

Some contemporary writers successfully explained how brain science factors into everyday life. *The New Yorker* magazine columnist and social psychology author Malcolm Gladwell popularized the concept of intuition in *Blink*, while neuroscientist Jonah Lehrer clarified the cellular processes of decision-making in *How We Decide*. Finally, successful business consultant and Results Coaching CEO David Rock pioneered the merger of brain-based research and corporate leadership in numerous articles and books. His article with Jeffrey Schwartz, “The Neuroscience of Leadership,” outlined only a portion of the substantial application of neuroscience to leadership. Rock’s book, *Your Brain at Work*, applied the concept of mindfulness to business leadership, emphasizing an awareness of the brain's autonomic threat response mechanisms in providing feedback, removing distraction to enable effective decision-making, and physiologically priming the mind for insight generation. Then in a 2008 *NeuroLeadership Journal* article called "SCARF: A brain-based model for collaborating with and influencing others," Rock highlighted how organizational creativity and motivation suffers in the presence of a negative leader or threatening circumstances (Rock 2008). Rock cited neuroscience studies to show that the brain reacts to social threats (like status change or public criticism) in similar ways as it does to survival threats (Rock 2008).

The body of literature specifically related to enhancing military leader performance through neuroscience is small but growing in recent years. From personal experience and related research, the general military population lacks interest the cerebral aspects of leadership. This may be because warfare is often viewed as an interpersonal, very human endeavor that exists outside the realm of scientifically definable parameters. The common belief is that science and research cannot explain or predict battle. However, it is precisely war's human element that makes neuroscience so vital. Success in battle is entirely dependent on how the brain copes with threatening stimuli to perform complex tasks. Viewing combat leadership from a brain-based perspective can illuminate that process.

Paul T. Bartone, widely-recognized psychology writer and Senior Research Fellow at the National Defense University, chaired an anthology of psychology research writing related to military operations called *The 71F Advantage: Applying Army Research Psychology for Health and Performance Gains*. The book's articles covered important topics that impact warfighter mental and physical performance including sleep deprivation, nutrition, traumatic brain injury, and suicide. The book, which seems to have been written for the academic community, was successful in coalescing a breadth of research areas but did not contain articles that resonate with the typical warfighter. This gap is characteristic of science-based military writing. Those at the tactical level need literary works that adequately translate complex science into practical advice.

One study conducted by the National Research Council made contributions to the field by identifying ways in which neuroscience could support Army operations. The 2009 report recommended how the Army could use emerging neuroscience technologies to enhance training and learning as well as better evaluate and predict soldier cognitive performance (National Research Council 2009). It also emphasized that "The Army should adjust its research capabilities to take advantage of the current and emerging advances in neuroscience to augment, evaluate, and extend its approaches to training and learning" (National Research Council 2009, 172). Whether this report affected senior Army leader decision-making is not known, but there has not been a corresponding shift in Army training or doctrinal guidance to incorporate neuroscience.

Other research efforts, like those conducted by the Defense Advanced Research Projects Agency (DARPA), tend to focus neuroscience research on improving human-technology interface and refining warfighter task performance like target acquisition and engagement (DARPA 2011a). DARPA's Accelerated Learning program seeks to "develop quantitative and integrative neuroscience-based approaches for measuring, tracking, and accelerating skill acquisition" (DARPA 2011b). These developments are valuable but focus on specific skills. They do not aid military leaders, who spend most of their time communicating, analyzing, and leading.

The Center for the Army Professional Ethic (CAPE) and Arizona State University are currently conducting quantitative research that examines the neurological signatures of leaders with varying levels of self-complexity, which is “the number of unique roles and attribute structures that they possess” (Hannah et al. 2011, 4). They found that “leader self-complexity was positively associated with demonstrated levels of adaptive decision-making on a complex leadership task” (Hannah et al. 2011, 38). In essence, leaders who are capable of operating in many different situations are also more capable of adapting and making decisions in complex leadership situations. This study, which includes brain mapping to correlate neurobiological processes, is at the foreground of understanding the neurological foundations of military leadership.

A 2010 research report in *Military Medicine* proposed the “military demand-resource model as a comprehensive and integrated model of psychological fitness for the total force” (Bates et al. 2010, 21). The study analyzed psychological fitness along five subdomains (awareness, beliefs and appraisals, coping, decision-making, and engagement) and related them to performance and resilience (Bates et al. 2010, 28). The study is important because it showed evidence that strengthening the subdomains can improve soldier resiliency and cognitive performance. The authors also noted a crucial perspective that tactical leaders could benefit from adopting, that “psychological fitness can be developed using the same training principles as physical fitness” (Bates et al. 2010, 23).

Pioneering an effort to apply neuroscience research at the tactical level are Elizabeth Stanley and Amishi Jha from the Mind Fitness Training Institute (MFTI). Their 2009 article in *Joint Force Quarterly* explained how service members can use mindfulness training to reduce distraction and improve cognitive function in stressful situations (Stanley 2009). The MFTI is also currently conducting a study of 240 soldiers which will help identify what aspects of Mindfulness-based Mind Fitness Training (MMFT) are most effective in increasing soldier resilience, improving cognitive fitness, and diminishing the psychological effects of combat (S.T.R.O.N.G. 2011). Significantly, Stanley and Jha's pilot study of 31 Marine reservists in 2009 showed a correlation between the use of MMFT techniques and improved working memory capacity (Stanley 2009). Their research represented strong justification for approaching combat leadership from a brain-based perspective.

Neuroscience research to date has almost exclusively focused on nonmilitary application, creating a knowledge gap in understanding the neurological systems that underlie Army leader performance. The few military research endeavors that exist were written for the academic community and relate little to the warfighter. Further, the Army educational culture does not display a collective curiosity about the benefits of integrating neuroscience. While historical military writing has adequately described the soldier's physiological experience in combat, there is almost no body of knowledge that explains those processes in the context of leadership or recommends brain-based remedies for overcoming degraded cognitive performance. The next chapter describes the methodology this thesis uses to distill practical principles from neuroscience and translate them for the warfighter.

CHAPTER 3

RESEARCH METHODOLOGY

Examining modern tactical combat from a brain-based perspective requires a keen understanding of two typically unassociated topic areas: the military leader's individual experience in combat and the growing field of neuroscience. This research effort achieves this goal first by citing the combat experience in historical literature, current research, and personal accounts, thereby illuminating how combat stress affects leader performance. Then, by exploring published neuroscience research about brain function, particularly during stressful situations, the methodology provides a qualitative brain-based framework through which to examine combat leadership. The result is a host of insights about how emotion regulation can aid Army leaders to improve cognitive performance during combat.

Research Areas

For an in-depth search of relevant military information, the research included articles and books in the areas of military history, Army doctrine, combat physiology and psychology, and contemporary leadership. Valuable to the study were two background interviews with officers who have held leadership positions at every level up to brigade command.[7] The interviews sought to gain various leaders' views of how combat stress affects individuals and organizations. It also sought to discover effective stress-mitigation

[7]The author attempted to interview several enlisted soldiers but was unable to because of scheduling conflicts. However, input from enlisted soldiers has greatly influenced the formation of this thesis, particularly in understanding that the topics presented here apply to all ranks and skill specialties.

techniques and inquire about mental preparation to determine if any particular training or individual preparatory activities correlated to increased performance in combat. Their experiences represented the outward expression of neurological concepts that the parallel research avenues sought to discover.

In the realm of neuroscience, this research methodology explored the literature on basic brain biology to identify areas relevant to the combat problem. Using the recent efforts of neuroscientists, this thesis highlights the brain areas most impacted by stress in general. The research included a review of laboratory results that identify methods for regulating emotion, and then evaluated the validity in applying those methods to combat scenarios. Particular areas of interest include the cognitive and behavioral impacts of stress, cerebral resource management, emotion regulation, decision-making under stress, insight generation, and organizational leadership under stressful conditions. In addition, this examination included research on what behavioral, environmental, and nutritional traits best enable a leader to maintain cognitive control and perform at maximum potential.

Qualitative interviews with experts in the fields of psychology, neurobiology, and neuropsychology established a factual background for the technical portion of this thesis. This group included medical professionals, authors, and research pioneers from prominent research laboratories like Stanford University, UCLA, and Columbia University. These interviews served several purposes. First, they confirmed the neurobiological processes that occur during threat response, such as amygdala and sympathetic nervous activation. Second, the discussions illuminated valuable considerations for applying neuroscience research findings to the combat scenario.

Among them was the realization that the scale of brain activity would be considerably amplified in combat as compared to the laboratory setting. They agreed, however, that it is valid to apply neuroscience findings in a qualitative, brain-based analysis of combat leadership. Finally, the interviews provided primary source material for the examination of emotion regulation techniques, which this thesis presents as recommendations to tactical leaders.

Limitations

An important limiting factor for this research methodology was the absence of previous neuroscience research specifically related to cognitive performance during combat situations (Ellermann conversation, 2011). While numerous studies have examined the brain's performance in laboratory settings with artificial stressors, there is currently no published research that analyzes the cerebral activity of a soldier during combat. Consequently, this research design rests on the assumption that combat-induced stress affects soldiers in the same general manner that laboratory-induced stress affects research subjects. This assumption permitted an indirect analysis of combat stress.

Comparing laboratory results with actual events has precedence, as numerous works have used actual life events to illustrate brain processes that researchers can only examine in laboratory settings.[8] LeDoux notes on the subject, "For the purpose of understanding how fear is generated, it does not matter so much how we activate the

[8]For example, researchers have concluded in countless laboratory experiments that the amygdala is the brain region primarily responsible for initiating bodily reaction to threatening stimuli. It is now common practice for authors use fictional scenarios to describe the fear-response, such as how one reacts to a snake, even though no experiment has directly observed the cerebral response to a snake encounter (LeDoux 1996).

system or whether we activate the system in a person or a rat. The system will respond in pretty much the same way using a limited set of given defense response strategies available to it" (1996, 134). Dr. Matthew Lieberman at UCLA agreed with this research approach but noted that the scale of emotional responses matters (Lieberman Interview, 2011). He explained, "There are real, important, qualitative differences between the life and death situations of combat, and the stakes that are present in the [laboratory]. It doesn't mean that what we do does not apply, but there will be unanticipated factors that will modulate how things work" (Lieberman Interview, 2011).

Present resource limitations also prevented the ability to conduct a study that directly observes the brain function of Army tactical leaders in combat. The exact capability for such a study does not currently exist, but scientists at the NASA Glenn Research Center in Cleveland, Ohio have made steps in the right direction. They developed a new technology called Functional Near Infrared Spectroscopy (fNIRS) to observe the cortical function of airline pilots in simulator flight scenarios (NASA 2011). With continued development, one day integrating this capability into soldier helmet systems to directly measure cortical reactions is in the realm of the possible (Lieberman Interview, 2011). Such research advances would certainly be beneficial but would likely contain significant challenges. As Colonel Sean Hannah at CAPE pointed out in an interview, "Absolutely everything will have a brain signature" (Hannah Interview, 2011). The problem is discerning specific variables of brain activity amidst all the activity that accompanies a combat scenario. He added, "You have to be precise on what you want to look at and you have to have a strong theoretical basis for why this part of the brain would be doing X at a certain time" (Hannah Interview, 2011).

Despite the lack of specific neuroscience application to combat leadership, this research design was supplemented by the recent growth of neuroscience writing for the corporate workplace, which provided a wider breadth of knowledge from which to draw conclusions about combat leadership. Corporate leadership writing provides analysis and advice for civilian leaders who face fast-paced environments with shifting hazards. Leading in the corporate workplace requires rapid decision-making, focused attention, and consistent ingenuity. While the combat experience is clearly different in its intensity and potential outcome, this research scrutinizes the corporate literature to discover applicable insights that can aid Army leaders. In most cases, where contemporary writing cited neuroscience research, this thesis' author obtained the original source material, most often consisting of published studies by academic laboratories and credentialed authors.

Scope of Analysis

A delimiting parameter of this paper was to focus on tactical combat leadership and avoid operational and strategic topics. While one can certainly apply neuroscience principles to higher levels of Army organizational leadership, the stressors of life-threatening combat are almost exclusive to tactical leaders. Senior field grade and flag officers will rarely experience combat stimuli that threaten cognitive efficiency. The stress that accompanies that level of leadership typically originates from organizational challenges and is comparable to what civilian leaders may face. In this corporate realm, neuroscience writing has focused on managerial and CEO-level efficiency improvements, which Army operational and strategic leaders can readily apply.

Further Considerations

An important consideration of this research is the infinite variation of stress response that exists among all people. Stress-reduction techniques vary according to many factors including personality type, motivation, brain plasticity, prior experience, and so on. A person's resilience also plays a critical role in determining the impact of a traumatic event (Bartone 2006). Resilience can grow over many years of adapting to stressful situations but stems from innate qualities. While this individual variance is inescapable, the principles used here are based on common biological reactions and functions that all healthy humans share. The reader can apply and adapt these recommendations to one's own model, experimenting to discover the appropriate balance of emotional reaction and cognition that enables individual success.

Defining the "Leader"

This thesis provides analysis and recommendations for military leaders. While its perspective is primarily from an Army frame of reference, the principles nonetheless apply to other military branches and disciplines. One benefit of studying leadership from a brain-based perspective is that the results apply to a variety of situations. Enduring an enemy attack in battle is very different from surging to meet a logistics delivery timeline, but the participant's mental and physical reaction to the stress is comparable. Stress is relative to the individual. The process of identifying appropriate emotional reactions to events and the cognitive capabilities needed to perform one's duty is extremely personal. It requires reflection and the ultimate "answer" is completely subjective.

It is necessary, however, to clearly identify who the leader is. The term leader refers to those individuals responsible for leading several groups of soldiers in maneuver against the enemy. Every soldier is certainly at some point a leader, if only to lead himself, even though his primary duty position may be as a rifleman. Leaders differ from soldiers with focused skillsets because they must manage multiple battlefield systems like communications networks, digital infrastructure, and major combat systems. This leader spends most of his battlefield time outside of his weapon's sights and is often required to integrate combined and joint combat units and systems, which increases the complexity of duty position responsibilities.

This thesis does not propose that any service member is more valuable than another, but the reader must recognize that responsibility grows with increasing rank and duty position. Further, each duty position requires the individual to perform a unique mixture of physical, emotional, and cognitive tasks across personal and military domains. It is helpful to examine some relevant duty positions to establish specific reference for the following chapters. Team and squad leaders are unquestionably leaders, but they use battle drills and reflexive training to guide most of their battlefield actions and will not have to rely as heavily on their abstract cognitive abilities during combat unless they are operating as an autonomous element (Steadman 2011). The platoon leader and platoon sergeant are the first leaders who apply more complex problem solving and critical thinking than weapon system engagement. The company-level commander is squarely in the cognitive region, with occasional moments that require reflexive action. The battalion-level commander will rarely perform actions that are not based on premeditated, deliberate cognition. Those soldiers who direct the employment of major combat systems, like aircraft pilots, have the incredibly demanding responsibility to perform both highly cognitive and reflexive tasks.

Balancing Emotion and Cognition

Another key principle of this thesis is that cognition and emotion are not opposing concepts. They are intricately connected and interdependent. It is easy to approach brain-based leadership with the goal of discovering a mental exercise or reciting some stoic mantra that will override the emotional experience and allow unhindered cognitive performance. Such a capability is not only practically impossible but also professionally ill-advised. Emotions are not the enemy of cognition. In fact, as Dr. James Gross at Stanford University put it during an interview,

> Although we find it useful to make a distinction in psychology between cognition and emotion, the brain does not necessarily respect that distinction. The systems are intimately connected. While it is certainly true that the thoughts we have powerfully shape the emotions or stress response that we have, it is also true . . . that the kinds of emotions we have or the stress that we are under can also powerfully shape our cognitive abilities and performance. The links between cognition and emotion are bidirectional and powerful. (Gross Interview, 2011)

Gross' statement implies that tactical leaders must be able to perform their duties while attuning to both cognitive and emotional processes in the body.

And neither is it helpful to view cognition as a "higher" form of brain activity, preferential to emotive response if given a choice. Both body and mind serve the same biological being and as Antonio Damasio described them, "are engaged in a continuous interactive dance. Thoughts implemented in the brain can induce emotional states that are implemented in the body, while the body can change the brain's landscape and thus the substrate for thoughts" (Damasio 2010, 96). Effective military leaders possess the ability to both accurately sense internal and external landscapes and make appropriate decisions in response, all while managing the intensity of mental and physiological reactions. This thesis explains that process and conveys techniques to maximize body and mind performance in combat.

Given the military and neuroscience research data, interview results, and corporate leadership models, this thesis distills what techniques are most effective in reducing leader stress and improving cognitive performance in the tactical combat environment. The strength of this method lies not simply in knowing what techniques work, but in knowing how and why the brain functions as it does. This knowledge creates a foundation of self-awareness that informs behavior, decisions, reactions, and leadership ability. Leaders with this level of mindfulness can create conditions to improve their own performance during high-stress situations and impart similar qualities across their organizations. The next chapter presents the results from research conducted in the areas of historical combat experience, physiological stress reaction, stress-related neuroscience, and military leadership. The chapter relies on the background technical data presented in chapter 2 and expands on certain aspects of brain biology to explain specific cerebral functions. The chapter then relates that knowledge to the modern combat experience.

CHAPTER 4

ANALYSIS

Using neuroscience to inform military leadership provides awareness about how the mind responds to combat stimuli. It also illuminates techniques that leaders can use to improve cognitive performance. The first section of this chapter explains the common physiological and mental reactions that individuals are likely to face in combat, based on decades of research and observations. The chapter then distills three key concepts from existing neuroscience research that can affect combat leaders. They involve how the brain prioritizes neural and metabolic resources, how it uses working memory to process information, and how specific brain areas can inhibit emotional responses to allow enhanced cognitive activities. These concepts are crucial to understanding why an elevated emotional response to stress can degrade cognitive ability, as well as how to moderate the process.

This chapter includes a description of the body's physiological responses for two reasons. First, many of the physical effects associated with stressful situations like combat have neurological origins. For example, one result of the sympathetic nervous response, which occurs in response to threats and is presented later in this chapter, is a rapid increase in heart rate. This change is eventually felt throughout the entire body but begins as a command from the brain to prepare the body for the situation. Thus, to better understand brain activity, it is helpful to accompany neurological facts with a corresponding physical manifestation. The second reason is essentially the reverse process. It is advantageous to know which of those physiological reactions a leader can regulate and, consequently, produce a positive influence on mental capability. Rapid breathing, for example, is common during combat and also a consequence of the sympathetic response. But studies and experience have shown that deep breathing exercises in the midst of a stressful event can have a calming effect and facilitate emotional and cognitive control (Grossman 2004; Love and Maloney 2009). Linking the physiological with the neurological reveals what might be within a leader's control.

The Leader's Response to Combat

The combat experience is individually variable and intensely personal. Soldiers are likely to experience unfamiliar bodily reactions brought on by emotional and psychological responses. Some individuals possess an innate resiliency that allows them to endure combat's effects while others quickly succumb and cannot recover to fighting status. Even one person's reactions across multiple engagements may not predictable, for example finding that direct fire engagements are mentally survivable but the indiscriminate nature of enemy mortar attacks is unbearable. Nonetheless, the basic biological processes that occur in the human body in response to stress are common to all, and it is necessary to highlight them in order to adequately understand the combat leader's mental and physical experience.

Physiological Responses

Whether triggered by explosion, gunfire, or kicking in a door on the target, the body reacts to combat stress first by engaging the sympathetic nervous system.[9] This arousal is the well-known "fight or flight" survival mechanism, proposed by Walter

[9]The neural precursor to this process is the recognition of a threat (or potential threat) by the amygdala (LeDoux 1996; Sapolsky 2004).

Cannon in the 1920s, which humans use in response to threats (LeDoux 1996). Sapolsky stated, "It is the archetypal system that is turned on at times when life gets exciting or alarming, such as during stress" (2004). Contemporary science acknowledges that the sympathetic nervous system is also used in response to frightening stimuli, as well as situations that could potentially result in reproduction, combining to form the common phrase "fight, flight, freeze, and fornicating." The sympathetic nervous system is the half of the autonomic nervous system that mobilizes the body for action and the parasympathetic is the counterpart process that is engaged to initiate calming activities (Grossman 2004; Sapolsky 2004).

The biological purpose of fight or flight is that "the flow of blood is redistributed to the body areas which will be active during an emergency situation so that energy supplies, which are carried in the blood, will reach the critical muscles and organs" (LeDoux 1996, 45). To prepare the body for action in a matter of seconds, the projections of sympathetic nerve endings release epinephrine and norepinephrine directly into various organs and blood vessels (Sapolsky 2004).[10] To reinforce the sympathetic response over a matter of minutes or hours, a brain area called the hypothalamus initiates a chemical signal to the anterior pituitary gland, which further activates the adrenal glands located just above the kidneys (LeDoux 1996; Sapolsky 2004). A type of steroid hormone called glucocorticoid is then released into the bloodstream, creating a majority of the effects that humans feel during stress response and what combat leaders will experience at the outset of enemy contact (Sapolsky 2004). LeDoux notes that "initially, these hormones help the body deal with the stress, but if the stress is prolonged the

[10]The more commonly held term for epinephrine is adrenaline.

hormone can begin to have pathological consequences, interfering with cognitive functions and even causing brain damage" (LeDoux 1996).[11]

The resulting changes serve to prioritize bodily functions that will assist in surviving the situation and deprioritize those functions that are unnecessary for survival. Veins constrict and raise blood pressure; arteries dilate to allow increased blood flow to major muscle groups; sweat glands activate; bronchial tubes in the lungs dilate to provide more oxygen; digestion and absorption of water by the kidneys is inhibited; and sexual arousal is suppressed (Damasio 2010; Grossman 2004; Sapolsky 2004). Fighting functions are readied. Superfluous functions are put on stand-by. During moments of extreme stress, individuals can experience loss of bowel and bladder control, and even become sluggish or frozen in shock (Grossman 2004). Marshall observed this effect in World War II among an alarming number of soldiers and described them as being "mentally pinned" (Marshall 1947). Another easily recognizable and measureable effect of sympathetic activation is the elevation of heart rate, which is discussed later in this section (Grossman 2004, LeDoux 1996; Sapolsky 2004).

Additionally, there is a myriad of auditory, visual, and sensory changes (collectively known as perceptual distortion) that can occur in response to a combat event. Law enforcement officers report the effect of auditory exclusion in an engagement when they, although not wearing hearing protection, fail to hear the deafening booms of gunfire (Siddle 1995). Under stressful moments, the brain can selectively tune out distracting and overpowering noises and hone in on relevant ones like voice commands

[11]Long-term exposure to stress hormones is thought to be one of the major causes of post-traumatic stress disorder in combat veterans (Sapolsky 2004).

and the metal clink a weapon makes when the last round has been fired (Grossman 2004). Visual perception can also narrow during a combat event, creating a tunnel vision effect that blurs out all but the most important parts of the engagement area, like the intended target (Grossman 2004). Grossman notes that extreme visual clarity can accompany the tunnel vision effect. Law enforcement officers report experiencing shooting incidents with unusual precision, as if the event had occurred in slow motion and all the brain's resources were focused on perceiving every possible detail (Grossman 2004).

Experiencing physiological effects like perceptual distortion and bladder emptying during combat can be psychologically distressing, particularly for new or uninformed soldiers. However, research has shown that the impacts of stress-induced arousal also extend to mental and physical task performance. The Yerkes-Dodson Law, shown in figure 2, states that task performance will improve with increased sympathetic arousal, but only up to a point (Lieberman Interview, 2011; Siddle 1995).

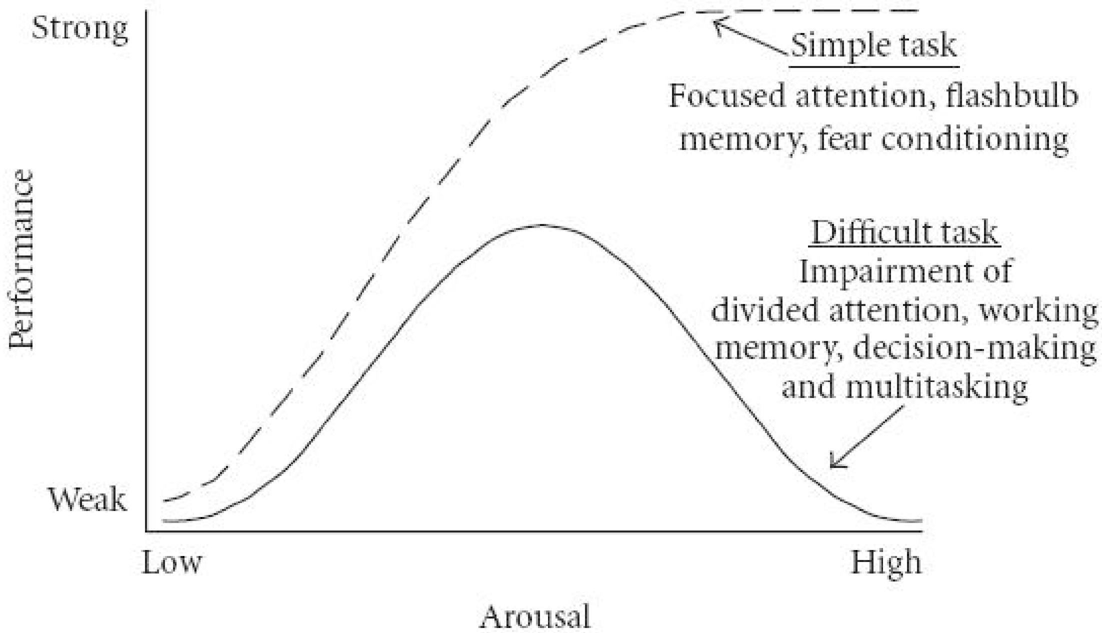

Figure 2. Yerkes-Dodson Law Table
Source: David M. Diamond et al., “The temporal dynamics model of emotional memory processing: A synthesis on the neurobiological basis of stress-induced amnesia, flashbulb and traumatic memories, and the Yerkes-Dodson law,” *Neural Plasticity,* 28 March 2007, http://www.ncbi.nlm.nih.gov/pubmed/17641736?dopt=Abstract (accessed 9 October 2011).

Depending on the individual and the type of arousal, one will begin to experience a decline in complex task performance when arousal exceeds moderate levels (the peak of Yerkes-Dodson’s “Inverted-U”) (Siddle 1995). The basic principle is that at least some stress is needed to optimally perform most tasks, but too much stress is detrimental. The law applies to novel or complex physical movements as well as cognitive tasks and the formation of memories. Lieberman noted an interesting difference between the emotional and the cognitive response to arousal. He explained, “The emotional systems in the brain have a linear sensitivity to arousal. They respond more and more emotionally, whereas the cognitive systems work better up to a point and then fall off a cliff" (Lieberman Interview, 2011). This principle clearly applies to tactical leaders who must retain cognitive capability despite the typically high arousal of combat.

The Yerkes-Dodson model was useful for generally classifying the effect of stress on performance, but further analysis refined the concept for the warfighting profession. One model for classifying types of motor tasks was proposed by B. J. Cratty in 1973 and subsequently accepted by numerous survival, law enforcement, and combat authors (Siddle 1995). Cratty proposed a continuum of motor skills (fine, gross, and complex) that vary in levels of intensity, precision, and coordination (Siddle 1995). Fine motor skills require precise hand-eye coordination, involving small groups of muscles and little movement (Siddle 1995). Snipers, pilots, and explosive technicians rely on fine motor skills. Gross motor skills involve large groups of muscles pulling or pushing, high force application, and large movements (Siddle 1995). Running for cover, dragging a wounded squad mate, and loading tank ammunition are examples of gross motor movements. Finally, complex motor skills use a combination of the two preceding types to perform a multi-action movement like throwing a grenade (Siddle 1995). This classification approach is useful for the soldier because combat demands that he successfully complete tasks of each type, often during the course of a single engagement.

Siddle explained that activation of the sympathetic nervous system will have an impact on performance that generally follows the Yerkes-Dodson principle, although the point of skill deterioration depends on the task complexity (Siddle 1995). Research shows, for example, that fine motor skills have a low tolerance for sympathetic arousal (Siddle 1995). Combat tasks like precise shooting and button manipulation will deteriorate if an individual allows his physiological response to escalate unchecked. However, complex and gross motor skills have a higher tolerance for sympathetic effects before they too deteriorate (Siddle 1995). For example, high sympathetic arousal levels will enhance a soldier's hand-to-hand fighting skills, but he may have trouble manipulating the flex cuffs used to secure the opponent. Figure 3 shows Siddle's graphic representation of these changes compared to increasing heart rate.

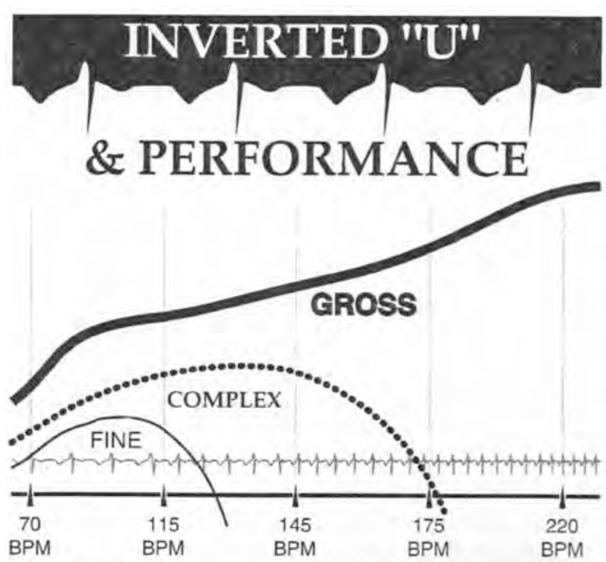

Figure 3. Siddle's Inverted U with skill types
Source: Bruce K. Siddle, *Sharpening the Warrior's Edge: The Psychology and Science of Training* (Belleville: PPCT Research Publications, 1997), 47.

A final but important effect of sympathetic nervous system activation is an increase in heart rate (Grossman 2004; LeDoux 1996; Sapolsky 2004). In most individuals (i.e., those who have limited emotion regulation or meditative discipline experience which allows them to moderate heart rate under stress), heart rate is directly proportional to sympathetic activation and can be used as a general measurement of arousal. The physical effects previously described will progress along the scale of heartbeats per minute, increasing in intensity and overall impact on soldier performance. Grossman denoted this relationship in figure 4.

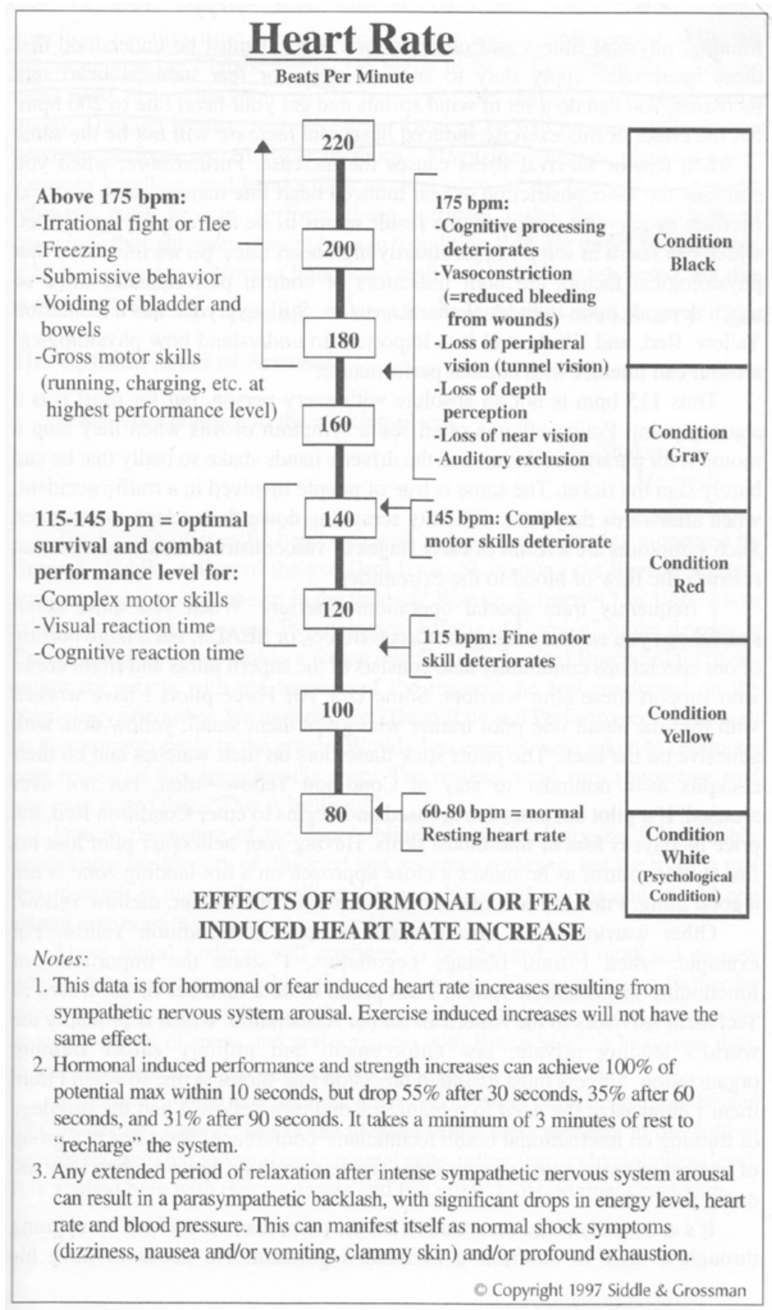

Figure 4. Effects of Hormonal or Fear-Induced Heart Rate Increase
Source: Dave Grossman and Loren W. Christensen, *On Combat: The Psychology and Physiology of Deadly Conflict in War and in Peace* (USA: PPCT Research Publications, 2004), 31.

As arousal causes a rapid increase in heart rate, motor skill performance actually increases up to a point (about 145 beats per minute) and then becomes more difficult for the soldier to perform (Grossman 2004). A soldier who cannot regulate his escalating emotional response will begin to suffer the auditory/visual distortion previously described, as well as loss of depth perception and reduced reaction times (Grossman 2004; LeDoux 1996). Higher than about 175 heartbeats per minute, the soldier enters a zone that Grossman calls "Condition Black." In this state, an individual can lose significant motor behavior to the point of freezing, collapsing, or voiding the bladder or bowels (Grossman 2004). Visual input is significantly reduced and cognitive processing grinds to a halt as the body reverts to a basic, primitive state of survival (Grossman 2004). The emotion regulation and cognitive control techniques discussed in chapter 5 are designed to moderate these types of physiological effects.

When considering that heart rate is an indicator of stress, it is important to note that exercise-induced stress and fear-induced stress are not the same. During exercise, heart rate increases in proportion to the effort required to perform the action. Workout intensity, aerobic fitness, environmental conditions, and many other factors play a part in increasing heart rate on a generally linear scale. The aerobic fitness industry has categorized this process by creating numbered heart rate zones that range from low intensity effort to aerobic endurance and high intensity anaerobic threshold. During a fearful event, however, one can instantly experience extremely high heart rate and blood pressure and undergo many of the physiological side effects previously described (Grossman 2004). Grossman notes that during exercise the face appears red because blood vessels dilate to carry maximum oxygen to the muscles; but during fear-induced stress, the “white faced” appearance is typical because of vasoconstriction, thought to occur to minimize blood loss if injured (Grossman 2004). The difference between exercise-induced and fear-induced stress is important to consider in training for combat. Learning to accurately employ a weapon system following exercise will not equally prepare the soldier to fire that weapon while frightened. Likewise for leaders, conducting planning or decision-making training scenarios in the comfort of an office or a controlled range environment will not achieve the same personal physiological and mental impacts as they will face in combat.

Before discussing the mental reactions that leaders can experience in combat, it is important to emphasize what was mentioned in chapter 3, that an individual’s duty position will influence the type of tasks he will perform. Riflemen in an infantry squad will primarily execute skill-oriented combat tasks while leader and commander tasks will involve making mental assessments and forming original cognitive solutions. They are responsible for more battlefield systems and rely less on moment-to-moment physical ability than “shooters.” Thus, the physical degradations in performance are less applicable. More important are the impacts that combat stress will have on the leader’s mental readiness.

Mental and Neurobiological Responses

In addition to the physical reactions described above, the brain, which is ultimately a survival organ, responds to combat in ways that can degrade the leader’s cognitive performance. Leaders must be primarily concerned with these mental effects for two reasons. (1) They are responsible for making organizational decisions with significant consequences, impacting the lives of dozens, even hundreds of soldiers.

Mental clarity is essential for preserving adequate decision-making ability. (2) Leaders are less likely to experience the extreme, physically debilitating effects of combat that others will face. It is not individual warfighting skills that the Army requires from leaders like platoon sergeants or company commanders. Instead, the Army relies on those leaders for their ability to sort through battlefield complexities, accurately assess the friendly and enemy aspects of a combat event, generate plans to adequately achieve mission goals, and lead the force in reaching them. Combat routinely produces mental reactions that prevent leaders from performing such tasks.

This section describes the brain's behavior in combat by applying the results of neuroscience laboratory research to the battlefield environment. These principles of brain behavior are certainly not the only applicable aspects of neuroscience research, but are most relevant to optimizing cognitive performance in combat. The three primary areas of discussion relate to the brain's prioritization of neural and metabolic resources during threatening circumstances, the brain's capacity for processing multiple streams of information (working memory capacity), and the self-control characteristics of the prefrontal cortex.

Resource Prioritization in the Brain

In the vignette that opened this thesis, 1LT Wilson experienced a cascade of mental and emotional challenges as the situation around him, one for which he was ultimately responsible, tumbled towards chaos. Ideally, a combat leader would expect his brain to appropriately balance the competing demands for energy and allocate resources according to his duty requirements. 1LT Wilson's brain, however, prioritizes survival above all other functions. Thus, it is natural for it to fuel the temporal brain areas to cope with the flood of emerging threats, the sight of injured teammates, and the demands of an authority figure inserting emotional energy into the situation. This facet of brain biology has implications for leaders trying to preserve cognitive function in the face of potentially extreme emotional situations in combat.

The brain operates with a high energy cost, making up only two to three percent of the body's weight but contributing to twenty percent of the oxygen used (Chundler 2011; Sapolsky 2004). Because the brain's 100 billion neurons cannot store glucose, the brain teems with blood vessels that provide a constant supply (Chundler 2011; Franklin Institute 2004; Sapolsky 2004). The brain does not distribute this fuel evenly. Brian Wandell, director of the center of Cognitive and Neurobiological Imaging at Stanford University, succinctly explained, "the blood goes where the action is" (Wandell 2008). It redirects blood to the brain areas that are engaged at the time, a fact which researchers have been able to measure only in the last twenty years (Wandell 2008). For example, while playing soccer with the kids, the motor cortex requires additional resources to coordinate the necessary leg, core, and arm movements. And while driving, the visual cortex is flushed with fresh blood while the person absorbs the fluctuating, advertised landscape of a city street.

This redirection of blood leaves less fuel for other brain functions, like regulating emotions (Rock 2008; Wandell 2008). Neuroscientist Jonah Lehrer noted that even a slight drop in blood sugar can degrade the prefrontal cortex's ability to inhibit temporal (emotional) activation (Lehrer 2009). At Stanford University, one study showed that subjects who were asked to remember a series of seven numbers were more likely to indulge in chocolate cake over healthier fruit, while those subjects asked to remember only two numbers chose fruit more often (Lehrer 2009). Lehrer pointed out, “the effort required to memorize seven digits drew cognitive resources away from the part of the brain that normally controls emotional urges” (Lehrer 2009, 152).

The same principle applies to leaders trying to maintain emotional calm while performing highly cognitive tasks. Figure 5 is a conceptual design intended to demonstrate the effect of combat stress in diminishing metabolic resources. During the fictional platoon’s firefight, 1LT Wilson’s brain must translate the visual input of frenetic combat activity into conceptual models that he can assess, compare, and use to develop responses.

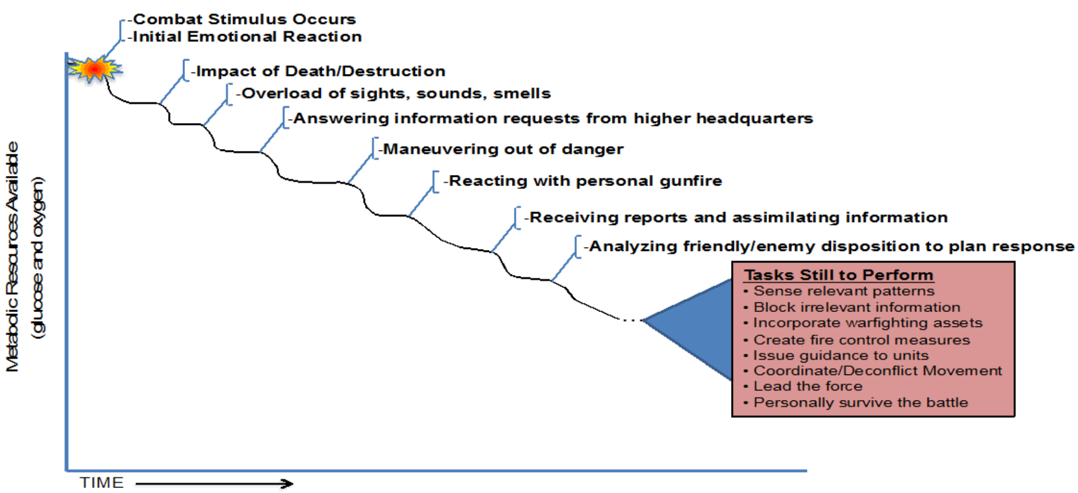

Figure 5. Loss of Cortical Resources in Response to Leader Combat Tasks
Source: Created by author.

He must determine enemy activity, friendly force disposition, the array of weapon systems available to him, the effects of those weapons based on terrain and range, and finally, create novel graphical and verbal guidance to orchestrate the platoon's next action. These are not emotional activities. They are functions of the prefrontal cortex and require vast amounts of fuel to perform. Regulating 1LT Wilson's emotional response may enable his ability to cognitively engage the situation.

In addition to prioritizing resources by metabolic methods, the brain also uses neural processes to engage and disengage certain mental functions during stress (Damasio 2010). In one 2007 study published in the online review forum *Neural Plasticity*, researchers showed that during a strong emotional event, the hippocampus shifts out of its mental mapping role and into a role of memory recording called flashbulb memory (Diamond et al. 2007). As the information is recording and permanent consolidation begins, the formation of subsequent new memories is temporarily suppressed, resulting in the long-lasting but fragmented nature of traumatic memories (Diamond et al. 2007). They also explained that "stress produces an immediate inhibition of the functioning of the prefrontal cortex, which is revealed behaviorally as a narrowing of attention and impaired multitasking, or more globally, as an impairment of complex learning" (Diamond et al. 2007). The research showed that during stress the brain prioritizes the making of memories and sacrifices the cortical process of determining the most appropriate reaction to the situation. The prefrontal cortex's ability to regain proper function depends on the intensity of the stressor and how effectively the individual copes with the situation (Diamond et al. 2007). Thus, it is to a leader's advantage to reduce his sensitivity to the emotional stressor or to develop techniques that aid him in managing the level of emotional response, thereby preserving cognitive function.

These changes in the brain can result in a variety of affects on leader attitudes, actions, and beliefs. Citing a review of New York University neuropsychology studies on the amygdala's effect on emotion, reasoning, learning, and memory, Rock explained, "with the amygdala activated, the tendency is to generalize more, which increases the likelihood of accidental connections. There is a tendency to err on the safe side, shrinking from opportunities, as they are perceived to be more dangerous" (Rock 2008, 3). The implications for combat leadership are clearly evident. One 2006 study published in *Psychological Science* examined how brain states prior to problem solving can impact the formation of insight. In other words, whether or not a person has an "Aha!" moment depends on the neural activity just prior to problem solving (Kounios et al. 2006). This may seem intuitive, but maintaining a mental state that is primed for a flash of brilliance is not an easy task, particularly in the stress of combat. The study showed that those subjects who attained a moment of overall mental quietness were able to solve more problems than those whose frontal cortical regions were more active (Kounios et al. 2006).[12] There seems to be great benefit in momentarily dampening working memory (discussed in the next section) to let the brain's subcortical networks tackle the problem at hand.

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[12]Interestingly, the researchers measured this brain activity using EEG and fMRI to capture the frequency and location of neural activation (Kounios et al. 2006). Those subjects who experienced a surprise moment of insight showed a burst of alpha waves (8-13 Hz) followed by a burst of gamma waves (>30 Hz); alpha waves are associated with quiet, meditative thought processes, and gamma waves are associated with active, cortical thinking and memory matching (Kounios et al. 2006).

To Regulate or Not to Regulate?

These facets of brain function raise a question about cerebral resource management: Does trying to regulate emotions leave less fuel for prefrontal activity? In other words, since trying to regulate the emotional response uses metabolic resources, can a person maximize cortical function by choosing not to control the natural emotional response? Research and interviews indicate that any answer to this question is variable to the individual and presently impossible to quantitatively verify, due to the numerous brain areas using resources during an emotional event. Lieberman agreed with the perspective that a person in a stressful situation could deplete valuable cognitive metabolic resources by trying to override the emotional response (Berkman, Burklund, and Lieberman 2009; Lieberman Interview, 2011). However, individuality plays an important factor. For some people, regulating emotion does not require a high metabolic expenditure, making the process cognitively affordable (Lieberman Interview, 2011). For those whose brains may use more fuel to control emotion, doing so may not be worth the scarcity of glucose and oxygen leftover for cognitive activity (Lieberman Interview, 2011).

These considerations support a foundational concept of training individual military leadership. Negotiating realistic, complex training scenarios challenges leaders to experiment with a limitless array of leadership styles and allows them to experience what techniques are personally effective. The process of balancing emotion and cognition is no different. This fact is crucial for answering this thesis' problem statement of how to apply the most relevant principles of neuroscience to tactical combat leadership and what brain-related techniques a leader can use to appropriately regulate the emotional response and maximize cognitive function.

The Delicate Nature of Working Memory

Recall from the vignette that 1LT Wilson several times struggled with distraction and failed to maintain adequate awareness of his surroundings. He failed to update the company command post with his platoon's position before the ambush; his eyes looked at the parked car blocking their path but the ongoing radio conversation prevented his mind from registering alarm bells; and he failed to personally keep track of how his unit was arrayed during the firefight. Had 1LT Wilson not been exhausted and in the midst of a life or death situation, he might have (and should have) been able to perform those tasks. However, the area of his brain responsible for executing these duties failed to keep pace, resulting in a lapse in command and control and increased risk on the platoon.

Working memory is a conceptual brain process that facilitates the highest order, executive and reasoning functions (LeDoux 1996, 2002). It is most commonly identified in the lateral prefrontal cortex and is also known as the "chalkboard of the mind" (Lehrer 2009). Working memory's primary function is to hold the most relevant information in place while the deeper, long-term (subcortical) networks can analyze and compare that information (LeDoux 1996; Lehrer 2009). As LeDoux states about seeing a round, orange object bouncing at your feet, "Only when the visual pattern is matched with information in long-term memory (stored facts about and stored past experiences with similar objects) does the visual stimulus become recognized as a basketball" (1996, 272).

Working memory is heavily engaged when processing novel information or when focus is needed to perform a task. Figuring out how to drive in Great Britain on the opposite road is almost entirely an exercise in working memory. The car's steering inputs are similar to American cars, so one's brain can still perform those basic movements using long-term, implicit memory systems. However, how those inputs relate to the world outside the windshield are completely different, so working memory must take over to actively interpret the new mental model and direct the appropriate motor inputs to avoid a crash. In a tactical example, a leader relies on working memory when trying to hold eight-digit location coordinates in mind long enough to transmit them over the radio. It is also crucial in forming a mental map of the changing tactical environment, allowing the brain to compare its long-term networks of experience and doctrinal knowledge.

Recall the Yerkes-Dodson Law, which shows that stress initially improves both simple and complex tasks but continued or added stress eventually decreases complex task performance. This principle occurs because working memory is vulnerable in high-pressure situations. During an interview, Lieberman described the neural processes behind working memory (prefrontal cortex) degradation:

> In the lateral prefrontal cortex, which seems to be involved in emotion regulation and self-control, there are two different kinds of adrenaline receptors. At low levels of arousal, one type of receptor tends to pull in all the noradrenaline that is coming into the prefrontal cortex. Those receptors make the prefrontal cortex work more efficiently. But at high levels of arousal, there is a different kind of noradrenaline receptor that starts to respond when there is only a high density of noradrenaline. When they respond, they shut down prefrontal cortex. These things that at low levels help prefrontal cortex, at high levels "frazzle" the prefrontal cortex. A little bit of arousal is usually a good thing. A lot of arousal could be a really bad thing and this seems to be a reason.[13] (Lieberman Interview, 2011)

[13]Lieberman credited Amy Arnsten for the research that supports his comments.

His comments show that being overwhelmed is just not a conceptual state. The brain has a biochemical threshold across which cognitive processing decreases, which is consistent with the Yerkes-Dodson model.

Using the driving example from the previous paragraph, imagine if a passenger was in the car and screaming at the American driver who is trying to avoid a wreck on British roads. In normal individuals, the added external stress might provide a slight bump in performance but would soon trigger a sympathetic nervous response that further degrades performance. Research shows that added stress like "amping-up" a player before a game or imposing time limits only benefits the performance of implicit tasks, those that are familiar and already embedded in long-term memory (driving in America) (Beilock 2010; Lehrer 2009; Ochsner Interview, 2011).[14] This is true even for tasks that should be implicit. Professional golfers who fall out of "the zone" and begin to specifically analyze their swing are dangerously susceptible to "choking" (Beilock 2010). Sian Beilock, author of the performance-oriented book *Choke*, called this concept "paralysis by analysis" (2010, 192). Using conscious attention to execute a task that should be natural is a sure way to derail performance.

This principle applies to combat leaders who often operate in the boundary zone between implicit and explicit tasks. Loading the proper frequency set into a radio is implicit. Doing so while under direct fire requires focus. Calling in artillery fire involves making a series of standardized radio calls, teachable to the reflexive level. But, calling in

[14]The term "muscle memory" is commonly used to describe those tasks which one can automatically perform, like tying a shoelace. However, the term "long-term memory" is more accurate because the muscles do not actually initiate action. Their learned, automatic behavior is the result of neural connections that consistent use has reinforced into permanency. The brain can perform these tasks without engaging working memory.

artillery fire within fifty meters of friendly troops while exhausted from a hillside climb and distracted by injured teammates, demands the focus of working memory to prevent a mistake. Emphasizing the fragile nature of working memory, LeDoux wrote, “Normally, if we are attending to one stimulus, we ignore others. This is selective attention, and it allows us to focus our thoughts on the task at hand. But if a second stimulus is emotionally significant, it can override the selection process and slip into working memory” (LeDoux 2002, 228).

This derailing of attention can easily happen in combat, as experienced by Lieutenant Colonel Hal Moore, commander of 2-7 Cavalry in the Ia Drang Valley, Vietnam. During the course of a desperate battle against 2,000 North Vietnamese Regulars, LTC Moore found himself forward on the battlefield, very close to the front line of his most heavily-engaged company (Moore and Galloway 1993). The gunfire poured onto his position, diverting his attention away from his primary task of leading the entire battalion. Accurately reading the impact of the situation on Moore’s ability to command, the battalion sergeant major urged him to reposition the command post thirty yards to the rear (Moore and Galloway 1993). LTC Moore concurred, which created the mental space needed to better conduct the commander tasks of analysis, problem solving, and leadership. Moore noted, “I might get pinned down and become simply another rifleman. My duty was to *lead* riflemen” (Moore and Galloway 1993, 85). Protecting his own cognitive abilities despite high arousal was a crucial factor in the battalion’s success that day.

Inhibitory Characteristics of the Prefrontal Cortex

In the 1960s, psychologist Walter Mischel at Stanford University began testing the willpower of children. For each of 650 children he has tested, he placed a marshmallow in front of them, explaining that if they could resist indulging in the marshmallow when he left the room, he would let them have a better treat upon his return (Lieberman 2009; Phillips 2008). As one would expect, some children immediately ate the marshmallow, some held out for a time, and some lasted the full fifteen minutes for a better treat. However, the most interesting data emerged in the years and decades to follow. Mischel followed the academic, social, and employment success of those original subjects and found that those children who exhibited the most self-control were predictably more successful in life than those who did not. In particular, children who resisted the marshmallow for the full fifteen minutes scored an average of 200 points higher on the SAT than the other children (Lieberman 2009). The ability to exert self-control has far-reaching implications.

Using fMRI scanning, neuroscience researchers have recently revealed that the right ventrolateral prefrontal cortex is activated in almost every form of self-control, and causally linked to motor self-control (Lieberman 2009).[15] That is, when a person exerts motor control, the brain area always lights up. Motor self-control is important for soldiers while, for example, inhibiting the impulse to fire on a target when noncombatants move across the line of fire. Further studies have also linked this brain region to cognitive self-control, where subjects must suppress inaccurate information or actively avoid thinking

[15]Note that various other brain regions are also activated in these experiments, but the right ventrolateral prefrontal cortex is consistently activated when subjects must exert self-control.

of a particular image (Lieberman 2009). This ability would be useful for a combat leader when trying to put aside the image of a wounded teammate in order to analyze the developing tactical situation. Lieberman calls this region “the brain’s braking system” and its most important function for combat leaders may be its role in emotion regulation.[16] The successful employment of the emotion regulation techniques discussed in chapter 5 involve right ventrolateral prefrontal activation. For example, a method called affect labeling activates this braking system and decreases emotional activity (Lieberman 2009).

Also relevant to the combat response is the finding that the different forms of self-control (motor, cognitive, and emotional) can have overlapping inhibitory effects on the other regions, (Berkman, Burklund, and Lieberman 2009; Lieberman 2009). Berkman Burklund, and Lieberman coined the term “inhibitory spillover” to describe the concept. In their 2009 study that looked at the right inferior frontal cortex, research participants were shown negatively-valenced images that predictably activated an emotional response in the amygdala.[17] However, when those same people were presented the images and also had a go/no-go task that required them to press or refrain from pressing a button (motor choice), their emotional response was diminished (Berkman, Burklund, and Lieberman 2009). The study related, “when participants intentionally inhibited a motor response in the presence of an affective stimulus that would typically activate the amygdala, amygdala activity was dampened to the extent that the [right inferior frontal cortex]

[16]Two other brain regions less frequently associated with emotion regulation are left ventrolateral prefrontal cortex and dorsomedial prefrontal cortex (Lieberman 2009).

[17]The right inferior frontal cortex is closely located to and plays a similar role as ventrolateral prefrontal cortex.

response was stronger" (Berkman, Burklund, and Lieberman 2009, 711). The report further indicated that this inhibition seemed to apply only to negatively-valenced stimuli and not positive stimuli. Evidently, the brain provides multiple ways to decrease the impact of negative emotional events.

How does this information apply to 1LT Wilson as he tries to gain control of his own mental state and the deteriorating situation around him? Finding a way to activate the brain's braking mechanisms could help dampen his emotional state, help him keep composure, and free up cognitive resources to focus on other tasks. Taking a moment in the fight to acknowledge and steady his trembling hands might help. Regulating his breathing is also a helpful motor activity. Adopting a proper shooting stance may trigger a reflexive motor response that spills over into emotional inhibition. Finally, verbally admitting his emotional state, whether it be confidence, fright, or uncertainty, can certainly aid in reducing his emotional reaction.

From the Laboratory to the Battlefield

With the goal of improving tactical leader cognitive performance, this chapter presented an analysis of research focused on the physical and mental components of combat. Research into the physiological response illuminated the broad range of effects that could impact leader performance. Primary among these is the activation of the sympathetic nervous system, which leads to rapid breathing, increased heart rate, physical readiness, and emotional arousal. Extreme or prolonged emotional arousal can have detrimental, even catastrophic effects on leader performance. An analysis of recent neuroscience research revealed aspects of brain function that relate to the combat experience. First, stress can compromise the brain's cognitive abilities, specifically those of the prefrontal cortex. This process occurs because the brain shifts metabolic resources to the emotion-response areas. Second, stress degrades the executive functions of working memory, compromising learning, memory, attentiveness, and problem solving. Lastly, neuroscience recently identified the inhibitory nature of certain brain areas, indicating that individuals can intentionally moderate their emotional responses, possibly through spillover from motor-control efforts. Having identified the relevant aspects of brain function involved in combat, the next chapter describes emotion regulation techniques that could aid tactical leaders in enhancing cognitive performance. It further makes practical recommendations for 1LT Wilson, the tactical leader struggling to balance the emotional arousal of combat with the mental abilities required by his duty position.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

This thesis examined the broad field of neuroscience to provide insight into how tactical leaders can improve cognitive performance in combat. The research identified several aspects of brain function that relate to and impact the mental aspects of battle, particularly concerning cerebral resource allocation, working memory capacity, and self-control. Recent results from neuroscience experiments point to emotion regulation as a viable approach to minimizing cognitive impairment during stress. This chapter identifies emotion regulation techniques that are supported by research and are practical for Army tactical leaders like 1LT Wilson.

Neuroscience in the Combat Response

In many of the neuroscience studies cited in this thesis, researchers used advanced scanning technology to test the effectiveness of emotion modification strategies. Such studies have, in essence, scientifically authenticated well-known leadership advice like "stay cool under pressure" and "keep a level head." From neuroscience research emerge deliberate techniques that have proven to both reduce the emotional response and improve cognitive performance in stressful situations. Even though the traditional practice is for Army leaders to learn stress mitigation during years of training exercises and crucible experiences, they can immediately improve performance by incorporating emotion regulation into their personal leadership approach.

This section offers several of these practices but is by no means an exhaustive summary. The author chose to highlight techniques that are both supported by neuroscience research and are practical for Army tactical leaders to apply in combat scenarios. While it is unlikely that combat leaders in a deployed environment could commit the full time and energy to practices like meditation, yoga, or self-hypnosis (which are not described here), individuals could certainly incorporate portions of these methods into their personal routines to achieve balance.[18] The important concept is for leaders to recognize that they have influence over their emotional states, and to experiment with the combination of methods most suitable to them.

As the Yerkes-Dodson Law indicated, too much arousal is detrimental to performance, but some arousal is actually beneficial. Every leader should seek to discover his own optimal zone of arousal, where the emotional response is regulated and the conditions are set for cognition to function. Figure 6 is a conceptual representation of that process in response to a surprise combat event. It incorporates the chapter 4 research results involving the physiological responses to combat, cerebral resource prioritization, and the Yerkes-Dodson principle of optimal arousal.

[18]According to Asken, self-hypnosis is "the act of concentrating so intently that other distractions are blocked out" (Asken 2010, 98).

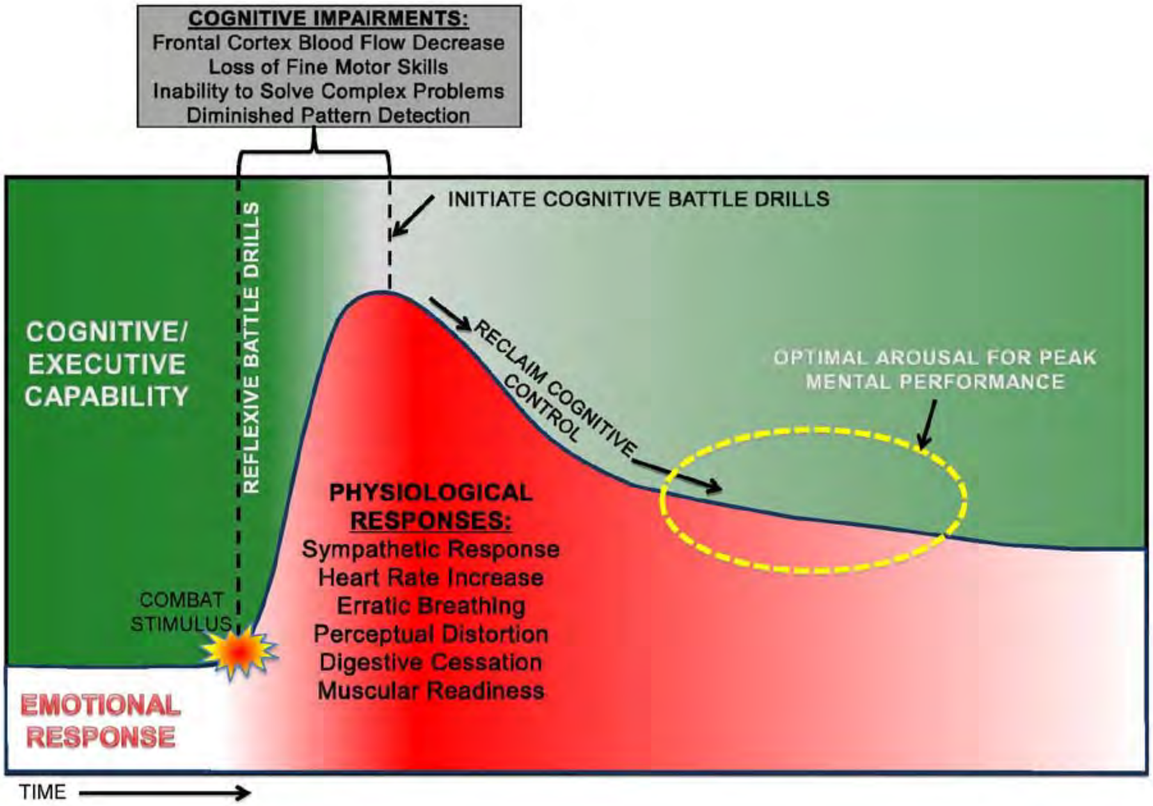

Figure 6. Managing the Response to Combat
Source: Created by author.

Prior to the combat event, the leader is in normal operating mode. He maintains cognitive control with low emotional arousal. When contact occurs, his sympathetic nervous system activates to place the body in a state of high arousal, ready to fight or flee. He may perform reflexive tasks like trained battle drills or a brief radio call to notify adjacent units that his unit is in contact. At this point, however, the brain prioritizes the emotional response, which decreases blood flow to the prefrontal cortex. Cognitive and executive capability diminishes and he can suffer from previously described effects like loss of fine motor skill and shifting attention. The leader's overall goal, and the crux of the thesis' problem statement, is to reclaim that cognitive capability. Neuroscience research supports emotion regulation techniques that do so. The particular combination of methods becomes that leader's personal "cognitive battle drill." Through practice and experimentation, he can discover a procedure to find the optimal level of arousal that allows peak mental performance.

Applying Emotion Regulation Techniques

This section summarizes a selection of mental and physical coping techniques that seek to appropriately regulate the emotional experience while maximizing cognitive faculties. These methods exist on a continuum of time with respect to the moment of emotional reaction, typically the initial combat stimulus. This format gives the leader a familiar frame of reference when considering how and when to employ the techniques.

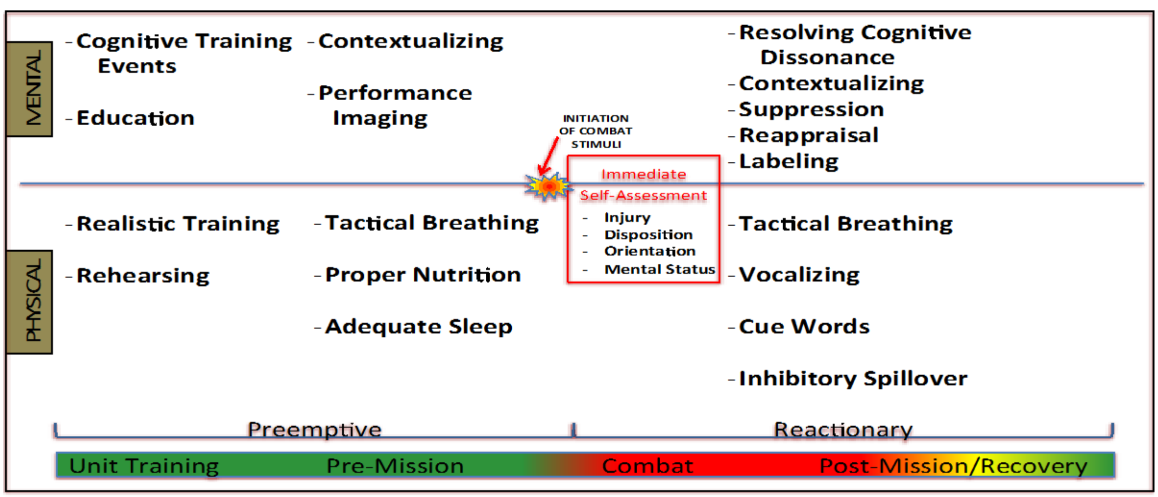

Figure 7. Continuum of Emotion Regulation Techniques
Source: Created by author.

If the middle of the spectrum represents the moment of emotional experience, the left side encompasses actions an individual could perform to shape his stress response before the stimuli occurs (preemptive). To the right side are those actions one might perform to immediately adjust to and cope with the emotional stimuli (reactionary). The figure depicts certain methods, like tactical breathing and contextualizing, which can be effective both before and after a combat event. Further, above the horizontal line are those techniques that are generally considered mental activities, with physical ones below the horizontal line. Additionally, there is a period of immediate self-assessment that every leader should perform at the outset of combat action. These actions include assessing injuries, regaining a grasp of one's physical location and orientation on the battlefield, and determining if any factors have degraded mental capability.

It is important to remember that the effectiveness of these techniques will vary from person to person and across different combat scenarios. Fatigue, operations tempo, recent unit success or loss, nutrition, overall stress, and countless other factors contribute to combat experiences that are unique and demand innovative leader actions. Several key points must be taken into consideration. (1) A leader can benefit from simply the awareness that regulating emotion could enhance cognitive capability. Exposure to coping techniques at least provides that awareness and may improve leader mindfulness. (2) A leader will likely never find the perfect balance of emotion regulation and cognitive functioning, or even discover how to adequately measure that balance. One can only hope to consistently improve performance and subjectively become an overall more capable leader. (3) Performance strategies will be most reliable when leaders internalize and practice them under multiple training conditions. Practice makes permanent.

Preemptive Techniques

Cognition-Minded Education and Training

Units can improve leader cognitive performance by creating training and education events that include mental challenges. As TRADOC Pamphlet 525-3-7 accurately notes, “In the anticipated future era of persistent conflict, Soldiers of all ranks and specialties will have to be intellectually agile” (2008, 28). Incorporating the cognitive component into training requires a deliberate, creative effort by unit leaders. Soldiers and leaders could benefit from a simple series of classes on the physiological and neurological components of battle. By incorporating complex environments into collective training, leaders become habituated to cognitive thinking under stress and develop their personal methods for succeeding.

The unit training and education experience must also teach leaders to maintain an appropriate perspective about these concepts. In an interview with Dr. Kevin Ochsner, director of Columbia University’s Social Cognitive Neuroscience Laboratory, he noted a viewpoint emphasized in chapter 3 of this thesis:

> While I agree in general with [the benefits of regulating emotion], there is the important caveat that cognition and emotion are not enemies of one another. You need to have your thoughts guided and informed by emotional responses. There are certain kinds of judgments we make that are necessarily emotional. The goal is not to be an emotional ice cube that is dispassionate and computer-like. The goal is to not to let emotions overwhelm you to such an extent that you have no cognitive resources leftover. (Ochsner Interview, 2011)

Ochsner’s statement carries an important, underlying assumption about an intellectual quality that must be present before one can attempt to balance emotion and cognition. Leaders must approach their own development with metacognition. This attitude, along with an instructor-mentor relationship, is critical for developing personal techniques to increase cognitive performance.

Performance Imaging

Mental practice is “the cognitive rehearsal of a task in the absence of overt physical movement” (Driskell, Copper, and Moran 1994). High performing athletes routinely use the method as a vital part of competition preparation and decades of research show that mental practice improves performance across multiple activities and domains (Beilock 2010; Driskell, Copper, and Moran 1994; Tanenbaum, Edmonds, and Eccles 2008). Visualizing proper actions creates more permanent neural circuitry that the mind will more readily revert to during performance. Beilock noted a study in the 1980s that found “one big difference between students who succeeded and those who failed in difficult problem-solving situations was the time that they spent thinking about a problem at the outset-*before* they actually attempted to solve it” (Beilock 2010, 30). The same principle applies to combat skillsets and even leader cognitive actions.

Contextualizing

In a 2004 study published in Massachusetts Institute of Technology’s *Journal of Cognitive Neuroscience*, researchers measured brain area activation of subjects exposed to photos of surprised faces. Prior to revealing the each photo, however, the subjects were primed with either positive or negative information about the upcoming photo (e.g., “She just found $500 vs. She just lost $500”) (Kim et al. 2004). Interestingly, the results showed that after being primed (contextualized) with negative information, the subjects exhibited greater amygdala activation as compared to positive information (Kim et al.

2004). The study showed that “amygdala response to surprised facial expression can be modulated by negatively versus positively-valenced verbal contextual information” (Kim et al. 2004).

This is a crucial fact for leaders, and one that seems to lend neurological evidence to the belief that influencing others is a principle goal of effective leadership. A leader can shape the overall resiliency of both himself and the unit by contextualizing the combat events they will encounter. Bartone summarized the concept succinctly:

> The leader who, through example and discussion, communicates a positive construction or reconstruction of shared stressful experiences, may exert an influence on the entire group in the direction of his or her interpretation of experience. Thus, leaders who are high in hardiness likely have a greater impact in their groups under high-stress conditions, when by their example, as well as by the explanations they give to the group, they encourage others to interpret stressful events as interesting challenges that they are capable of meeting, and in any case can learn and benefit from. (Bartone 2006, S141)

For example, an eighteen-year-old new soldier preparing for deployment will most certainly not have encountered an explosive device detonation. Upon the first strike targeting him and his fellow soldiers, his is likely to react with shock and a temporary mental pause as he comes to grips with the disastrous event. However, every day prior to that is an opportunity for his leaders to contextually modulate his reaction by portraying the event in constructive, even positive terms. Realistic training scenarios also serve to modulate the new soldier’s perception and reduce his fearful response during the actual event.

Tactical Breathing

Tactical breathing is a simple method designed to engage the parasympathetic nervous system, calm the nerves, and reduce the deleterious side effects of emotional stress. Brigadier General Sean MacFarland, Deputy Commandant of the Combined Arms Center and veteran brigade commander of Operation Iraqi Freedom, recommended this technique as a primary tool in managing one's response to the stress of combat operations (MacFarland Interview, 2011). One survey of Microsoft leaders showed that deep breathing was the most valuable method for reducing stress and increasing mental focus (Love and Maloney 2009). Grossman emphasized the technique for military and law enforcement personnel, recommending a four-count inhale through the nose, a four-count hold, and a four-count exhale through the mouth (Grossman 2004). It can be used before, during, and following combat events and in any setting, unlike meditative practices which typically require a peaceful, contemplative environment.

Tactical breathing helps retain fine motor skills as well as ensures the brain has an adequate influx of oxygen to perform. In light of research related to inhibitory spillover, taking active control of a bodily function like breathing could have the secondary effect of activating the self-control areas of the prefrontal cortex (right ventrolateral), thereby inhibiting the temporal response and facilitating cognitive processing (Love and Maloney 2009). From personal experience, tactical breathing is the simplest, most effective way to gain composure in the midst of an emotional event. The deep, regular breathing pattern creates a mental state of calmness and control, enables the leader to communicate with composure and clarity, and sets an example of poise and confidence.

Fatigue and Nutrition

Adding to the myriad of combat stimuli that combine to degrade cognitive performance, the general level of environmental hardship and deprivation directly impacts the combat leader's mental resilience. Lack of sleep, poor nutrition, infrequent contact with loved ones, and daily physical exertion all contribute to how a leader will perform in battle (Kellett 1990). One strategy for maintaining sufficient cognitive performance is to maintain an adequate amount of sleep. While the optimal amount of sleep varies by individual, research has shown that sleep deprivation degrades accurate perception of the environment, causes lapses in moral judgment, and impairs the ability to accurately judge risk (Killgore 2010). Specifically, lack of sleep reduces glucose metabolism in the ventromedial prefrontal cortex, an area of the brain correlated with sensing the environment to inform intuitive decision-making (Killgore 2010). Individuals are less able to compare their current situation with their repository of experiences and formulate appropriate decisions. Instead, as shown by research subjects conducting gambling experiments, they avoid risks they would have taken when fully rested and cash-out in only moderately risky situations (Killgore 2010).

These findings have military implications because leaders constantly use intuition to interpret new combat environments, and then formulate battle plans largely based on an assessment of risk. The principle not only applies to leaders conducting rapid, event-driven decision-making processes, but also to unit staff groups who routinely sacrifice sleep to meet compressed planning timelines. Sleep deprivation is likely to impact a staff's interpretation of battlefield conditions, their understanding of key planning inputs like the commander's planning guidance, and their ability to judge the unit's operational capability in the face of risk.

Recent research has also found that caloric deprivation can have similar effects on cognitive functions like decision-making and risk taking (Adam 2010). The US Army Research Institute of Environmental Medicine administered gambling experiments and observed “a different card-choice strategy within the calorie-deficient diet such that it appeared that volunteers consuming a very low calorie diet adopted a more conservative strategy than those consuming full-calorie diets” (Adam 2010). These findings have implications for leaders who miss meals in favor accomplishing more tasks or fail to bring food with them during operational activities. Food is not a luxury item and should not be an afterthought, especially for those who rely on cognitive abilities as well as physical ones.

Reactionary Techniques

Affect Labeling and Vocalizing

Affect labeling is the simple act of identifying the emotional state that one is experiencing at the time. This technique may seem elementary, but putting feelings into conscious thoughts or words has the effect of reclaiming the driver’s seat on the emotional roller coaster. In neuroscience terms, affect labeling has shown to increase right ventrolateral prefrontal activation and reduce the amygdala response, suggesting an “inhibitory relationship between the amygdala and right [ventrolateral prefrontal cortex] that is specifically engaged during the processing of linguistic affective information” (Berkman and Lieberman 2009). During an interview, Dr. Lieberman explained that research subjects performed better on tests when they spent ten minutes writing about their anxiety versus those who wrote about unrelated topics (Lieberman Interview, 2011). Further, his lab showed that subjects with arachnophobia (fear of spiders) were more willing to approach a spider if they had previously described their anxiety in detail (Lieberman Interview, 2011). Interestingly, individuals who were more descriptive, detailing the frightening characteristics of the spider and their intense fear of it, were willing to get closer than those who made generic descriptions (Lieberman Interview, 2011). That effect lasted for a longer period of time, as well (Lieberman Interview, 2011).

For a tactical-level leader, labeling can be as simple as acknowledging (mentally or verbally) emotional states throughout the course of combat operations. Fear of an unseen enemy, anxiety about a complex environment, and concern about wounded teammates, are likely natural emotions that accompany a unit's fight. Intense emotions like the anger that follows a successful enemy attack or the relief (even joy) in killing an opposing fighter, could impair rational thinking and even cause more permanent psychological consequences if left unacknowledged. Affect labeling helps the leader regain emotional initiative and retain a metacognitive perspective.

Reappraisal

Reappraisal is the process of reframing the situation into a different context to alter the emotional reaction that one is experiencing. It is the "cognitive transformation of emotional experience" (Ochsner et al. 2002, 1215). Dr. Gross pointed that reappraising is natural but most effective at lower levels of emotional stress (Gross Interview, 2011). Studies have shown reappraisal to typically occur at 0-4.5 seconds after the emotional stimuli are presented (Berkman and Lieberman 2009). Further, reappraisal can happen consciously and subconsciously, as when one makes a quick emotional assessment of a stimulus based on bias or previous experience.

One tactical example of reappraisal would be to view direct fire contact with the enemy as a fortunate opportunity to reduce their numbers, instead of bemoaning that the enemy action came as a surprise. Reappraising the situation shifts the perspective from prey to predator, which dampens the amygdala response and frees metabolic resources available for the prefrontal cortex (Arnsten 1998; Ochsner et al. 2002). Reappraisal is also useful in today's Army, where a significant number of soldiers are affected by the psychological impact of previous combat experiences. Take, for instance, a previously reliable non-commissioned officer (NCO) who suddenly becomes unmotivated and distant. His platoon leader, himself under pressure and wanting to get the most out of every soldier, might quickly assume that the NCO is simply weakening under the tempo of operations. However, a few moments of reappraising the situation to give the NCO the benefit of the doubt, would allow the platoon leader to consider the alternate possibilities. Maybe the NCO is suffering from post-traumatic stress or that it is near the anniversary of a particularly painful day during a previous deployment.

Suppression

This section includes suppression as a generally ineffective emotion regulation technique. It typically occurs at greater than ten seconds following an emotional stimulus, after the brain has reacted and activated feelings in the body (Berkman and Lieberman 2009). A person suppresses when he actively avoids a specific emotion or forcibly denies its existence. For example, suppression might be the first response a presenter engages when someone publicly challenges the information. Anger wells up inside the presenter, but expressing that anger is not a sensible option. As anyone who has experienced this situation can attest, suppressing that anger takes effort and temporarily disrupts one's attention to the task at hand (i.e., takes prefrontal cortex offline) (Rock 2009a). Dr. Lieberman emphasized that while any emotion regulation strategy uses resources, research subjects exerted more effort in suppression than those who reappraised (Lieberman Interview, 2011). Suppression also compromises memory and learning, which can impact combat leaders trying to make sense of a new, changing environment (Gross Interview, 2011; Lieberman Interview, 2011).

There are times, however, when suppression may be beneficial, such as in the midst of experiencing a severely traumatic experience. A teammate becomes severely wounded, for example, but the tactical situation does not permit a pause to assess or console him. The leader will likely experience a rising emotional response but has time-sensitive, cognitive tasks to perform. In this case, suppressing emotions (adopting a cold or stoic mentality) may be a viable option to preserve mental stability until the conditions allow a healthier emotional response. Consistent suppression of negative or traumatic emotions has been correlated to higher rates of post-traumatic stress and decreased psychological fitness.

Finally, Rock noted a Stanford University experiment where one person tried to suppress while another person simply observed the process. Researchers found "that when someone suppressed the expression of a negative emotion, the observer's blood pressure went up. The observer is expecting to see an emotion but gets nothing. This is odd, and in this way, suppression literally makes other people uncomfortable" (Rock 2009a, 112). For Army leaders who constantly interact with others, suppression can create an unintended stress response in teammates who are also trying to manage their emotional response.

Resolving Cognitive Dissonance

Cognitive dissonance is "an aversive psychological state aroused when there is a discrepancy between actions and attitudes" and is typically experienced when an individual choses a particular action or behavior over another (Jarcho, Berkman, and

Lieberman 2010, 1). Following a decision made between similarly attractive alternatives, such as choosing one good car over another, people often adjust their attitudes to heavily favor the selected option and over time diminish the value of the rejected alternative (Jarcho, Berkman, and Lieberman 2010). This process reduces the psychological distress of second-guessing the choice, has been observed by researchers using fMRI scanners, and can begin to occur in the first several seconds following a decision (Jarcho, Berkman, and Lieberman 2010).

This concept is relevant to leader decision-making in combat. When facing a tactical scenario with risky and often unclear alternatives, any post-decisional emotional distress (cognitive dissonance) detracts from other cognitive processes, like receiving new information, updating mental maps, or formulating new plans. Further, research shows that "top-down inhibition of activity in limbic [temporal] regions of the brain, rapidly restores processing capacity" (Jarcho, Berkman, and Lieberman 2010). Leaders can facilitate subsequent cognitive processing if they purposefully and quickly accept the decisions they have made, and move on to the next combat task.

Speech and Inhibitory Spillover

As mentioned in chapter 4, recent neuroscience research has revealed the principle of inhibitory spillover, whereby a person may calm the emotional response by exerting active control over motor processes. Steadying one's hands or performing the reflexive routine of preparing a weapon system could fit into a combat leader's personal strategy to prepare for or react to a combat event. Cue words are another type of active engagement technique in which a leader choses specific phrases to elicit a particular emotional state. Similar to affect labeling, unit mottos or motivational phrases (e.g.

“Always ready” or “Surprise, Speed, Violence of Action”) can trigger individual or shared resolve and remind warfighters of performance principles.

Recommendations for 1LT Wilson

This section provides recommendations for 1LT Wilson, the overwhelmed platoon leader in the opening vignette. It informs the reader how to assimilate neuroscience principles into the military operational and leadership environment. The result is threefold. (1) Examining neuroscience presents an opportunity to be more aware of the neural underpinnings of individual combat performance. (2) Knowledge of applicable emotion regulation techniques adds to the mental and physical tools that leaders can use in combat. (3) Leaders can expand these individual skillsets and teach them to their units, inspiring new areas of organizational growth and overall combat performance.

1LT Wilson began his day with an emotional and cognitive deficit. The traumatic events of the previous day took their toll on his ability to think clearly and regulate his emotions. The most important quality that 1LT Wilson lacked was a metacognitive perspective. Since the military relies on leaders for high-quality thinking in high-stress situations, those leaders must constantly evaluate the quality of their own thinking. This judgment should occur before, during, and after combat operations so they can identify and correct deficiencies as quickly as possible.

The platoon leader also entered the fight without adequate levels of sleep and nutrition. The Army culture, particularly the combat arms, routinely recognizes high performance despite inadequate rest. Sleep and nutrition are too often an afterthought when preparing for military operations. This belief fosters the attitude in individuals that extreme fatigue in the face of duty is a noble practice, when exactly the opposite is true. Fatigue severely diminishes the most important capability a leader can possess, cognitive readiness. As an experienced combat leader, this author recognizes the strain that high-tempo operations place on personal fitness and readiness. Nonetheless, with intentional and deliberate effort, maintaining these aspects of performance is entirely possible. 1LT Wilson should have recognized his (and his unit's) fatigue and voiced his concerns to his commander. Optimally, the command climate would encourage such a discussion. Further, leaders must employ simple practices like keeping snacks and water quickly available. Food and water are not comfort items; they are fuel. A rush of simple sugars from an energy bar or sports drink (not Red Bull) could provide valuable glucose for a tired mind during a prolonged fight.

1LT Wilson was also responsible for mentally and physically preparing the platoon for combat. Contextualizing, the research-supported concept that leaders can influence the emotional response felt by others, is an important tool. At the heart of contextualizing is a leader who frames threatening events in more positive ways. In training and even during combat operations, leaders should approach combat events as challenges, not threats. Yes, enemy attacks may destroy equipment or injure personnel, but only the most serious circumstances will threaten the unit's ability to accomplish the mission. The same principle applies to soldiers interacting with the local populace. A unit that hears its leaders speak negatively about the locals will be more likely to treat them in a negative or disrespectful manner. Such attitudes are the breeding ground for ethical failure.

Though 1LT Wilson is not personally responsible for directly engaging the enemy, he should structure his environment to perform the duties for which he is responsible. Misplaced items, broken equipment, and poor information management can easily cause unnecessary distraction in the heat of battle. Inoperative communication equipment is a classic distractor, literally taking working memory offline when leaders need it most. 1LT Wilson should have conducted mental rehearsals well before he faced the complex ambush. In these visualization exercises, he could work through the various leader actions required of him and anticipate points of friction.

Just prior to the engagement, 1LT Wilson also lost his frame of reference in the neighborhood he was patrolling. Maintaining his position in time and space is a function of the prefrontal cortex. Whether through daydreaming or because he was talking on the radio, his mental map was not up to date. Consequently, when enemy contact started, he did not have complete visibility of his unit's disposition and had to spend precious minutes updating his mental model. To avoid this, tactical leaders should make a habit of intentionally updating the mind as terrain and conditions change. Mentally rehearsing battle scenarios as terrain changes is also a good practice. Further, leaders should delegate routine tasks to free up working memory. Radio operators should make all routine radio calls and even some calls during combat. Cognition is 1LT Wilson's most effective weapon, one that he should empower and protect.

Like any soldier on the battlefield, when enemy contact begins, leaders should react reflexively to immediate threats. As soon as possible, however, they must find an opportunity to deliberately shift into their role as leaders. As orchestrators of complicated battle systems in complex environments, leaders must control the effect of emotional energy and maximize cognitive performance as quickly as possible. At this point, a personal cognitive battle drill developed and honed in training can be very useful. 1LT Wilson had no such method. Instead of pausing to absorb and analyze the changing situation, he let his emotions control his response. Each event and piece of information distracted his attention and prevented him from adopting a wider perspective of the fight.

1LT Wilson could have engaged any of the techniques described in the first section of this chapter. Tactical breathing is probably the best first response available to leaders. As discussed, this controlled breathing method helps slow the sympathetic nervous response. One can also engage the inhibitory spillover effect by actively steadying the hands (exhibiting motor control), thereby dampening the fear response of the amygdala.

Once the physiological response is reined in, mental techniques can play a role in regaining the cognitive initiative. Suppression is effective in extreme situations but sacrifices learning, memory, and attentiveness. A leader can use affect labeling to bring clarity to his emotional response or even to identify what situation is unfolding. 1LT Wilson unintentionally expressed a form of labeling when he stated, “Ok, it’s a battle drill. I’ve got to suppress and flank this building to the right.” His mind desperately reverted back to the basics to find a point of certainty. However one uses it, labeling helps the mind confront the world and accept it, which opens the door for reappraisal. Reappraisal could have helped 1LT Wilson cope with the platoon’s casualties or it could have shifted his attitude from negative to positive (“we have an opportunity to destroy the enemy” instead of “the enemy is doing this to us”). Regardless, these emotion regulation techniques require a metacognitive mind, which 1LT Wilson did not possess during the engagement.

Finally, 1LT Wilson should have realized the significance of his role as a leader. Especially during combat, a leader's emotional and cognitive state is a barometer and an example for the unit to follow. As a battalion commander in 82d Airborne Division very pointedly told this thesis' author, "The energy comes from you!" (Martin Schweitzer, 2002, conversation with author). Through the issuance of orders, the inflection and volume of speech, movement on the battlefield, and so on, every leader influences his unit's performance. Emotional and unpredictable leader actions create uncertainty, while a composed response to combat inspires confidence.

By failing to maintain his own mental capability, 1LT Wilson was unable to perform his duties, which included recognizing enemy actions, relaying situation updates, providing guidance, and coordinating assets, among many others. Consequently, the two Apache gunships began their gun-run into an area where friendly soldiers were likely maneuvering. Analyzing the situation from a brain-based perspective reveals how 1LT Wilson could have mitigated the situation by regulating his emotional response. Doing so is arguably his, and every leader's, most important job.

Continuing Research

The application of neuroscience research to military operations should expand beyond the scope of this thesis. The brain is the source of individual performance. Similarly, organizational performance is a function of how groups of individual brains interact to achieve collective goals. Neuroscience can contribute not only to military leadership but also to warfighter performance, operational planning, strategic policymaking, and many others. This section notes several areas in which military operations could benefit from continuing neuroscience research.

In the area of tactical performance at the soldier level, neuroscience research should conduct quantitative studies to examine the cerebral signature of soldiers exposed to combat-related threat stimuli like combat pictures, video, or interactive simulators. Such methods could reveal the intensity of cerebral reactions and possibly the degree to which emotionally overloading stimuli diminish the functions of the prefrontal cortex. Future qualitative efforts should survey professionals who must routinely engage emotion regulation techniques to preserve cognitive function in high-threat situations. Fighter aircraft pilots, firefighters, personal security professionals, and the law enforcement community could contribute useful lessons and techniques for emotion regulation. Of course, a sizeable survey of military members would yield success trends that could then be recommended across the force.

Neuroscience research should also try to answer the question of what to do when one cannot regulate his emotions. Is there a way to recover mental stability after one has crossed the proverbial “brink” or has cracked under the pressure of the situation? Is there a different neurological signature when an individual reaches this state, how long does it last, and what can individuals do to create a personal “crisis action plan” to reverse emotional collapse?

Finally, neuroscience has significant potential application to organizational leader environments in the military, including operational and strategic levels. Leaders at those echelons would benefit from personally studying recent corporate neuroscience literature. Such writing includes information about expanding emotional intelligence, removing distractions in the workplace, scheduling tasks to optimize cortical function, creating office environments to encourage creative thinking, and providing constructive feedback to teams.[19] This thesis' author could find no published military guidance, doctrine, or writing that integrates the principles from neuroscience into operational or strategic military leadership. Conducting research to do so has great potential to improve the quality of senior-level leadership.

Summary

1LT Wilson opened this thesis in the midst of a physically demanding, mentally challenging, and emotionally stimulating combat experience. The military certainly expects 1LT Wilson to be a good infantry warfighter, but it primarily relies on him to manage multiple battlefield networks and systems, as well as simultaneously lead several groups of soldiers in a complex and changing environment. His duty position requires cognitive excellence. This thesis examined the field of neuroscience in search of ways to help 1LT Wilson maximize his cognitive performance.

Research into neuroimaging, neurobiology, and neuropsychology revealed three principles of brain function that apply to tactical leader combat performance. First, the brain can shift cerebral resources from the cognitive regions to the emotional regions, thereby degrading the critical mental component on which 1LT Wilson relies. Second, multi-tasking and emotional overload can negatively affect working memory, the brain's center for cognitive processing, attentiveness, executive function, and reasoning. Third, research shows that both motor control and intentional cognitive control can dampen the

[19] See David Rock's *Your Brain at Work* for an analysis of using neuroscience to increase workplace efficiency.

brain areas involved in emotional response. Each of these neuroscience principles has relevance for the tactical combat leader.

This thesis' research methodology sought practical emotion regulation techniques by examining neuroscience research and interviewing neuroscience experts. It also incorporated interviews with experienced Army leaders. The research avenue revealed many techniques that leaders can use to regulate emotion and increase cognition while operating under stressful conditions. Preemptive techniques include performance imaging, contextualizing, and maintaining proper sleep and nutrition. Reactionary techniques include tactical breathing, affect labeling, reappraisal, and inhibitory spillover. When tested and refined during training, leaders can create a personal cognitive battle drill that is useful in multiple situations.

Neuroscience clearly has a place in understanding and improving military operations. This thesis applied neuroscience to a small fraction of that domain, leaving great potential for further neuroscience application and integration. As neuroscience research continues to better understand why the brain functions as it does, the military can benefit from conducting parallel qualitative and quantitative research to discover enhanced ways of applying combat power. Doing so will expand the boundaries of the military profession and, ultimately, reduce risk on its most important asset . . . the American soldier.

APPENDIX A

RESEARCH INTERVIEWS

This Appendix outlines the interviews conducted in support of research for this thesis. The author personally conducted each interview either in person or by telephone and recorded the dialogue using a handheld audio recording device. No transcript of the interview is published, but the author has retained a private copy of the digital audio files for future reference. Each interviewee expressed verbal consent to be interviewed and signed an informed consent notice (Appendix C), agreeing to release the entire discussion for research and publication. A sample of interview questions is available in Appendix B.

The thesis' author sent requests to interview a total of fourteen potential contributors. Eight agreed to an interview and six either did not respond or could not schedule an appropriate time. Five of those interviewed were authorities from varying areas of the neuroscience field and two were US Army leaders with combat command experience through brigade command. The author interviewed one Army officer (LTC Jeffrey LaFace) to support a research area that was later discarded. This interview is included in the Appendix but the content was not used in the formation of the thesis.

Neuroscience Interviews

2 May 2011, Dr. James Gross, Ph.D. in Clinical Psychology, Professor at Stanford University. Dr. Gross conducts research in the affective sciences, focusing on emotion and emotion regulation. During the interview, Dr. Gross explained how his research has aimed to understand human emotion by examining physiologic responses like sympathetic reactions (blood pressure, sweat rate, heart rate, etc.). He elaborated on the

concepts of reappraisal and suppression in emotion regulation, noting that his research has shown that reappraisal is more effective than suppression in regulating amygdala and insula activation.

18 May 2011, Dr. Matthew Lieberman, Ph.D. in Social Psychology, Professor at University of California, Los Angeles. Dr. Lieberman is Co-Director for UCLA's Social Cognitive Neuroscience Laboratory, which focuses on finding the neural basis for automatic and controlled social cognition. This interview was helpful exploring the validity of laboratory research to real world scenarios and in identifying the various emotion regulation techniques like suppression, reappraisal, and affect labeling.

26 May 2011, Dr. Kevin Ochsner, Ph.D. in Psychology, Associate Professor of Psychology at Columbia University and director of Columbia's Social Cognitive Neuroscience Laboratory. The interview with Dr. Ochsner was especially useful in understanding the interactive relationship between cognition and emotion. The discussion provided insight into the mental process of identifying a potential threat and controlling the bodily reaction to it. When asked, Dr. Ochsner agreed that applying basic neurobiological principles to a combat situation is valid, even though there is currently no method available to observe such brain behavior.

28 June 2011, Dr. Joseph LeDoux, Ph.D., Professor at New York University and author of two books, *The Emotional Brain* and *Synaptic Self*. Dr. LeDoux's work has focused on the study of the neurobiological basis of emotions, especially fear and anxiety. This interview reinforced the "Inverted U" concept of stress to performance and Dr. LeDoux elaborated on emotion regulation methods like imagery, controlled breathing, and reappraisal to engage the parasympathetic nervous system during stress.

28 July 2011, Colonel Sean Hannah, US Army, Ph.D. in Management, Director of the Center for the Army Profession and Ethic. COL Hannah has published studies in the areas of leadership and psychology and currently oversees research with the University of Arizona that is studying the relationship between neurological profiles and ethical decision-making. His interview highlighted one of the few research efforts to link neuroscience and military leadership. The interview covered the topics of brain signature, homeostasis, and varying complexity leader personalities and styles.

US Army Leader Interviews

12 May 2011, Colonel Todd McCaffrey, US Army, former battalion and brigade commander in a Stryker Brigade Combat Team during Operation Iraqi Freedom. It provided an operational level leader's perspective on the concept of leader intuition during stressful situations, as well as how to develop intuition in subordinates. COL McCaffrey discussed mental modeling to maximize performance before operations begin, which reinforced the concept as a useful and relevant tool for Army leaders. Importantly, COL McCaffrey introduced the notion that leaders should recognize when intuition is not sufficient to solve the problem at hand, requiring alternative problem solving processes or deliberate planning.

13 May 2011, Lieutenant Colonel Jeffrey LaFace, US Army, writer for Army Field Manual 3-0, Change 1. This interview was conducted in person at Fort Leavenworth, Kansas. This interview discussed the concept of Mission Command and its evolution into Army doctrine.

14 July 2011, Brigadier General Sean MacFarland, US Army, Deputy Commandant for the Command and General Staff College at Fort Leavenworth, Kansas.

This interview was conducted in person at Fort Leavenworth, Kansas. Most notably, BG MacFarland led 1st Brigade Combat Team of the 1st Armored Division during combat operations in Ramadi, Iraq, where the unit greatly facilitated the formation of the Sunni Awakening movement that directly contributed to theater-wide Coalition success. In this interview, BG MacFarland discussed the methods he used to control emotional reactions during combat and the type of leader climate that inspires calm in an organization.

APPENDIX B

EXAMPLE RESEARCH INTERVIEW QUESTIONS

The following questions are a representative sample of the questions posed to interviewees to support this thesis. In some instances, the interviewee covered the topic areas during the course of general discussion, negating the need to specifically reiterate the planned question verbatim.

1. Please briefly explain your current position and your current area of research.

2. Which areas of the brain are most involved in threat-response?

3. Which areas of the brain are most involved in higher-order cognitive processing and executive function?

4. Is the emotional response to threats in a laboratory setting comparable to an actual life-threatening stress response?

5. Do you know of any current research involving the cortical responses of research subjects exposed to actual life threatening situations?

6. Is it accurate to assume that soldiers use the same threat response processes in combat as research subjects use in the laboratory?

7. To what degree does emotional response to life-threatening stress inhibit the cognitive function of the prefrontal cortex?

8. Is it even beneficial to attempt to regulate emotional responses in stressful situations? If so, to what degree can a person actually regulate those emotional responses?

9. Do you have examples where a commander effectively executed the Mission Command model?

10. What role does the commander’s intuition play in understanding the operational environment and creating a vision for the unit’s action?

11. What types of emotional reactions have you observed (good or bad) and how did leaders compensate to maintain their effectiveness as leaders?

12. Do you use any techniques to prepare leaders to remain stable in an emotionally significant combat situation?

APPENDIX C

SAMPLE INFORMED CONSENT

CONSENT AND USE AGREEMENT FOR ORAL HISTORY MATERIALS

You have the right to choose whether or not you will participate in this oral history interview, and once you begin you may cease participating at any time without penalty. The anticipated risk to you in participating is negligible and no direct personal benefit has been offered for your participation. If you have questions about this research study, please contact the student at: Major Andrew Steadman, US Army, (757) 650-7783 or Dr. Robert F. Baumann, Director of Graduate Degree Programs, at (913) 684-2742.

To: Director, Graduate Degree Programs
Room 4508, Lewis & Clark Center
U.S. Army Command and General Staff College

1. I, ________________, participated in an oral history interview conducted by Major Andrew Steadman, a graduate student in the Master of Military Art and Science Degree Program, on the following date [s]: _____, 2011, concerning any/all of the following topics: Neuroscience, Combat Stress, Leadership, Mission Command.

2. I understand that the recording [s] and any transcript resulting from this oral history will belong to the U.S. Government to be used in any manner deemed in the best interests of the Command and General Staff College or the U.S. Army, in accordance with guidelines posted by the Director, Graduate Degree Programs and the Center for Military History. I also understand that subject to security classification restrictions I will be provided with a copy of the recording for my professional records. In addition, prior to the publication of any complete edited transcript of this oral history, I will be afforded an opportunity to verify its accuracy.

3. I hereby expressly and voluntarily relinquish all rights and interests in the recording [s] with the following caveat:

_____ None _____ Other: ____

I understand that my participation in this oral history interview is voluntary and I may stop participating at any time without explanation or penalty. I understand that the tapes and transcripts resulting from this oral history may be subject to the Freedom of Information Act, and therefore, may be releasable to the public contrary to my wishes. I further understand that, within the limits of the law, the U.S. Army will attempt to honor the restrictions I have requested to be placed on these materials.

____

Name of Interviewee Signature Date

Major Andrew Steadman____

Accepted on Behalf of the Army by Date

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