The Central Autonomic Network and Combat PTSD: Assessment and Intervention

Special Issue: Advances in the Use of Biofeedback and Neurofeedback for Post Traumatic Stress Disorder

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Disclosure

In the spirit of full disclosure I acknowledge that I currently serve on the Scientific Advisory Committee of Biocom Technologies (unpaid) and own a small percentage of the company stock.
Learning Objectives:
Professionals who complete this teleseminar will be able to:
• identify at least two Central Nervous System (CNS) contributions in the development and maintenance of PTSD.
• identify at least two Autonomic Nervous System (ANS) contributions in the development and maintenance of PTSD.
• define the Central Autonomic Network (CAN) in the development and maintenance of PTSD.
• discuss past and current research on the efficacy of biofeedback interventions designed to assess and ameliorate ANS and CNS dysfunction.
Basic ReTraining

https://author.ecu.edu/cs-admin/mktg/basic_retraining_video.cfm
Kilo Company 3rd Battalion 26th Marines
Namo Bridge   Fall, 1969
“It is not the strongest of the species that survive, nor the most intelligent, but the one most responsive to change.”

-Charles Darwin
The overall goal of the ECU Wounded Warrior Program is to increase performance and promote functional independence.

- The program involves methods to help Marines learn how to control physical and emotional reactions to stress (resiliency), as well as techniques to increase strength, endurance, cognitive performance, social and life skills.

- The program involves sessions both at Camp Lejeune and at the Biofeedback Clinic at East Carolina University.
PTSD
When a person is exposed to extreme stress such as sexual abuse, war, or even the extended effects of a natural disaster, clinically significant symptoms often emerge.
The existence, frequency, intensity, and duration of these symptoms are dependent upon many factors, including, gender, age, and ethnic background of the person exposed to the stressor as well as the person’s social environment and ability to employ coping strategies.
Specific emotional and behavioral responses to stress have been observed and studied by mental health professionals in multiple settings, under different circumstances, over time. These symptoms have become the clinical indicators used for identifying the stress related disorder known as posttraumatic stress disorder (PTSD).
APA categorizes PTSD symptoms into three main clusters:

1. A traumatic event that is persistently re-experienced;
2. A persistent avoidance of stimuli associated with the trauma and;
3. A numbing of general responsiveness and persistent symptoms of increased arousal. The symptoms must last at least one month and adversely affect normal functioning.
“the development of characteristic and persistent symptoms along with difficulty functioning after exposure to a life-threatening experience”. These persistent, post trauma symptoms were the basis for the development of the original PTSD diagnosis in 1980 and with some modification still serve as the diagnostic criteria. While this classification system is useful it has some limitations such as the exclusion of some less common cognitive, emotional, behavioral and physiological-somatic symptoms.
PTSD and the ANS

- Inescapable Shock
- Autonomic Nervous System
- Sympathetic
- Parasympathetic
- Learned Helplessness
- Defense Defeat Model

- Possible bipolar effect with parasympathetic becoming dominant and then sympathetic rather than rhythmic
Extreme Biological Rhythms

- Exposure of rhythmic environments to chemical or behavioral stressors can result in increases and decreases in the response (Antleman (1996, 1997))

- Possible innate biological function designed to reset the rhythm
ANS Dysfunction

- Sympathetic Dominance can produce:
  - muscle bracing, bruxism, occular divergence, tachycardia, diaphoresis, pallor, tremor, startle, hypervigilance, panic rage and constipation
ANS Dysfunction

- Symptoms of palpitations, nausea, dizziness, indigestion, abdominal cramps, diarrhea, and incontinence

- Self perpetuating symptoms causing continued dysregulation “free falling”

“The syndrome of trauma has now literally taken control of the body”
ANS and Disease

- The ANS plays an important role in the development and maintenance of a wide range of somatic and mental diseases.

- In general autonomic imbalance and decreased parasympathetic tone may be the final common pathway linking negative affective states and ill health (Thayer & Brosschot, 2005).
Dissociation Symptoms

- Symptoms of dissociation mimic the bipolar nature of the defining symptoms of PTSD (arousal, reexperiencing, avoidance).
Dissociation Symptoms

- Altered perception of time, space, sense of self and reality.
- Emotional Expressions can range from panic to numbing and catatonia.
- Altered sensory perceptions may vary from anesthesia to analgesia to intolerable pain.
- Motor problems include weakness, paralysis, and ataxia as well as tremors, dysarthria, shaking, and convulsions.
Dissociation Symptoms

- Cognitive Symptoms include confusion, dysphasia, dyscalculia, and extreme attentional deficits.
- Perceptual symptoms include ignoral and neglect.
- Memory alterations may appear as hyperamnesia (Flashbacks), fugue states or selective traumatic amnesia.
Memory

- Endogenous opiate reward systems contribute to the establishment of conditioned procedural memory in trauma.
- Exposure to war trauma often results in a sustained period of analgesia (soldiers in wounded in battle require lower doses of morphine than in other non-combat related wounds)
- Stress can induced analgesia in many forms of trauma
Declarative Memory

- Relates to facts and events
- Plays an important role in conscious recall of traumatic events
- Involves the hippocampal and prefrontal cortical pathways (inaccurate and subject to decay)
Procedural Memory

- acquisition of new motor skills and habits to the development of emotional memories and associations, and to the storage of conditioned sensorimotor responses. Unconscious, implicit, and extremely resistant to decay when linked to emotional or threat based interventions. (Scaer, 2001)
Revolutions in Medicine

- Surgical Revolution
  - Anesthesia introduced in 1846
- Antibiotic Revolution
  - Penicillin introduced in 1941
- Endogenous Factor Revolution
  - Personal healing
    - Attacking germs and more importantly “Bad Habits”
Stress and Illness

Walter Cannon (1896)
- Coined “flight or fight response” to stress
- Developed concepts of mind/body model
- Emphasized the importance of the parasympathetic system

Selye (1975)
General Adaptation Syndrome
Stages
  - alarm reaction
  - resistance
  - exhaustion
Body’s Response to Stress

The Defense/Defeat Model
- fight or flight
- immune system suppress

Folkow (1993)
STRESS RESPONSE SYSTEM

HPA AXIS—the interplay among the hypothalamus, the pituitary and the adrenal glands—is a central component of the brain’s neuroendocrine response to stress. The hypothalamus, when stimulated, secretes corticotropin-releasing hormone (CRH) into the hypophyseal portal system, which supplies blood to the anterior pituitary. CRH stimulates the pituitary (red arrows show stimulatory pathways) to secrete adrenocorticotropic hormone (ACTH) into the bloodstream. ACTH causes the adrenal glands to release cortisol, the classic stress hormone that arouses the body to meet a challenging situation. But cortisol then modulates the stress response (blue arrows indicate inhibitory effects) by acting on the hypothalamus to inhibit the continued release of CRH. Also, a potent immunoregulator, cortisol acts on many parts of the immune system to prevent it from overreacting and harming healthy cells and tissue.
Stress and Disease

“environmental demands tax or exceed the adaptive capacity of an organism, resulting in psychological or biological changes that may place persons at risk for disease.”

Measuring Stress
Stress and Disease

“Technically speaking, a stress reaction is a mental and physical response to an adverse situation that mobilizes the body’s emergency resources, the flight or fight mechanism, which floods the body with hormones that arose to meet the challenge. Unfortunately modern life continually triggers this response when we can neither fight or flee, which can lead to chronic heightening of blood pressure and muscle tension, irritability, anxiety, and depression-and a lowering of immune effectiveness”.

(Daniel Brown, 2003. Stress, Trauma and the Body, p. 89).
Stress and Disease

- Stress enhances susceptibility to disease
- Both psychosocial & biological stressors evoke the flight or fight response
- Stress Disinhibition Theory
  - People engage in a broad range of dysfunctional behaviors as a result of stress
Effects of Stress on the Immune System

- commonplace stressful events produce immunological alterations
- chronic stressors have been linked to the longer-term down-regulation of immune function
- immunological changes have negative consequences for health
Psychoneuroimmunology

• Endocrine system
  – facilitates communication between the mind and body
  – acts as an internal intelligence carrying information that regulates the organism
  – receptors for catecholamines (adrenaline) in immune cells
  – nerve fibers go "into virtually every organ of the immune system and form direct contacts with the immune system cells“ (Ader, 1993).
Body’s Response to Stress

The Defense/Defeat Model
- fight or flight
- immune system suppression

Folkov (1993)
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THE ANATOMY OF ANXIETY

WHAT TRIGGERS IT...
When the senses pick up a threat—a loud noise, a scary sight, a creepy feeling—the information takes two different routes through the brain.

A. THE SHORTCUT
When startled, the brain automatically engages an emergency hotline to the body's center, the amygdala. Once activated, the amygdala sends the equivalent of an all-points bulletin that alerts other brain structures. The result is the classic fear response: sweaty palms, rapid heartbeat, increased blood pressure, and a burst of adrenaline. All this happens before the mind is conscious of having sensed or touched anything. Before you know why you're afraid, you are.

B. THE HIGH ROAD
Only after the fear response is activated does the conscious mind kick into gear. Some sensory information, rather than traveling directly to the amygdala, takes a more circuitous route, stopping first at the thalamus—the processing hub for sensory cues—and then the cortex—the outer layer of brain cells. The cortex analyzes the raw data streaming in through the senses and decides whether they require a fear response. If they do, the cortex signals the amygdala, and the body stays on alert.

... AND HOW THE BODY RESPONDS
By putting the brain on alert, the amygdala triggers a series of changes in brain chemicals and hormones that puts the entire body in anxiety mode.

STRESS-HORMONE BOOST
Responding to signals from the hypothalamus and the pituitary gland, the adrenal glands pump out high levels of the stress hormone cortisol. Too much cortisol short-circuits the cells in the hippocampus, making it difficult to organize the memory of a trauma or stressful experience. Memories lose their context and become fragmented.

RACING HEARTBEAT
The body's sympathetic nervous system becomes hyperalert, drinking in every detail of the surroundings and looking for potential new threats. Adrenaline shoots to the muscles, preparing the body to fight or flee.

FIGHT, FLIGHT OR FRIGHT
The senses become hyperalert, drinking in every detail of the surroundings and looking for potential new threats. Adrenaline shoots to the muscles, preparing the body to fight or flee.

DIGESTION SHUTDOWN
The brain stops thinking about things that bring pleasure, shifting its focus instead to identifying potential dangers. To ensure that nothing is wasted on digestion, the body will sometimes respond by emptying the digestive tract through increased vomiting, urination or defecation.

1. Auditory and visual stimuli
Sights and sounds are processed first by the thalamus, which filters the incoming cues and shunts them either directly to the amygdala or to the appropriate parts of the cortex.

2. Olfactory and tactile stimuli
Smells and touch sensations bypass the thalamus altogether, taking a shortcut directly to the amygdala. Smells, therefore, often evoke stronger memories or feelings than do sights or sounds.

3. Thalamus
The hub for sights and sounds, the thalamus breaks down incoming visual cues by size, shape and color, and auditory cues by volume and dissonance, and then signals the appropriate parts of the cortex.

4. Cortex
It gives raw sights and sounds meaning, enabling the brain to become conscious of what it is seeing or hearing. One region, the prefrontal cortex, may be vital to turning off the fear response once a threat has passed.

5. Amygdala
The emotional core of the brain, the amygdala has the primary role of triggering the fear response, information that passes through the amygdala is tagged with emotional significance.

6. Bed nucleus of the stria terminals
Unlike the amygdala, which sets off an immediate burst of fear, the BNST perpetuates the fear response, causing the longer-term unease typical of anxiety.

7. Locus ceruleus
It receives signals from the amygdala and is responsible for initiating many of the classic anxiety responses: rapid breathing, increased blood pressure, sweating, and pupil dilation.

8. Hippocampus
This is the memory center essential to storing the raw information coming from the amygdala, along with the amygdala's engagement attached to the data during its trip through the amygdala.
BRAIN AND IMMUNE SYSTEM can either stimulate (red arrows) or inhibit (blue arrows) each other. Immune cells produce cytokines (chemical signals) that stimulate the hypothalamus through the bloodstream or via nerves elsewhere in the body. The hormone CRH, produced in the hypothalamus, activates the HPA axis. The release of cortisol tunes down the immune system. CRH, acting on the brain stem, stimulates the sympathetic nervous system, which innervates immune organs and regulates inflammatory responses throughout the body. Disruption of these communications in any way leads to greater susceptibility to disease and immune complications.
Central Autonomic Network
(Thayer & Brosschot, 2005)

- The central nervous system that regulates the ANS balance is called the central autonomic network (CAN). The CAN works with networks to regulate the following functions:
  - Executive
  - Social,
  - Affective
  - Attentional
  - Motivational
When negative circuits are compromised positive circuits develop and result in hypervigilance. The symptoms can be devastating and if not ameliorated can develop into permanent conditions.

Inhibitory or negative processes or feedback circuits that permit behavior and redeploy resources needed elsewhere.

Autonomic, cognitive, and affective function assist humans maintaining balance in the face of environmental challenges.
A common subcortico neural system regulates defensive behavior including autonomic, emotional and cognition.

When prefrontal cortex is taken “offline” for whatever reason parasympathetic inhibitory action is withdrawn and relative sympathetic dominance associated with defensive occurs.

This can be measured by assessing parasympathetic contribution to overall HRV.
Hypervigilance

• Growing evidence supports the use of HRV as a predictor of hypervigilance and inefficient allocation of attentional and cognitive resources (Thayer & Brosschot, 2005)
Psychosomatics and Psychopathology
Thayer & Brosschot, 2005, p. 1053

• “Autonomic Imbalance and Decreased Parasympathetic Tone in particular may be the final common pathway linking negative affective states and dispositions, including the indirect effects via poor lifestyles, to numerous diseases and conditions as well as increased mortality, and it may also be implicated in psychopathological conditions”.
Low Heart Rate Variability (parasympathetic withdrawal)

- Low HRV is associated with the following conditions
- Cardiac symptoms of panic attack
- Poor attentional control
- Poor emotional regulation
- Behavior inflexibility

- Friedman and Thayer, 1998
Low Heart Rate Variability (parasympathetic withdrawal)

- Depression (Thayer et al., 1998)
- Generalized anxiety disorders (Thayer et al., 1998)
- PTSD (Cohen et al., 1999)
- Cardiovascular morbidity and mortality
- Diabetes (Ziegler et al., 2001)
Low Heart Rate Variability (parasympathetic withdrawal)

- Immune deficiency and inflammation contributing to:
  - Aging
  - CVD
  - Osteoporosis
  - Arthritis
  - Alzheimer’s
  - Periodontal disease
  - Certain types of cancers as well as muscle decline increased frailty and disability
Training the ANS

• The overall objective of Heart Rate variability training is to decrease ANS hyperarousal and improve its balance.

• Wounded Warriors learn to control ANS responses to stress producing stimuli such as thoughts, memories and images associated with combat.

• Decreasing arousal and maintaining ANS balance for increasing lengths of time is the goal of training.
• Once it was observed that alpha waves were dysfunctional in vulnerable populations protocols were developed to help people learn to train alpha and theta waves as a method of improving function.

• Peniston and Kulkosky showed increased alpha and theta brainwave production resulted in normalized personality measures; and prolonged prevention of relapse in alcoholics. The protocol has also showed efficacy as an intervention in drug addiction, depression and PTSD.
Method

• The graded stress exposure training program used in this study is one month in duration and consist of a pre assessment, 16 biofeedback sessions (four per week) a post session evaluation and a 3 month follow up.

• Each week participants will be exposed to increasing stress producing stimuli: 1. Stroop Color Word Test, Math Stressor; Talk Stressor/Everyday Events 2. Talk Stressor/ Combat Experiences; 3. Images and Sounds of Combat; 4. Virtual Baghdad or Afghanistan (virtual reality exposure).
Method

• Each biofeedback session consists of 5 minutes of baseline followed by 5 minutes of the weekly stressor, followed by 20 minutes of HRV and neurofeedback training, followed by 5 minutes of the stressor; followed by 20 minutes of HRV and neurofeedback and finally 5 minutes of recovery data.
Good Early Indications

- Preliminary clinical data collected so far indicate decreases in ANS hyperarousal and increases in parasympathetic activity. Reports on PHQ-SF 36 indicated positive changes in physical symptoms, and decreases in depression panic attack and anxiety.
Outcome Indicators

• Heart rate variability training changes
• Neurofeedback
• The Posttraumatic Stress Checklist (PCL)
• Deployment and Resilience
• Patient Health Questionnaire short form (PHQ SF-36)
• Profile of Mood States
• Salivary alpha-amylase (sAA) changes.
• Behavioral questionnaire assessing alcohol, drug, nicotine use, nutrition habits etc.
• Self satisfaction inventory
Discussion

• Dysfunction in ANS and CNS flexibility and balance are associated with symptoms of PTSD in combat veterans.
• Methods that are designed to restore balance in these systems are needed to ameliorate these symptoms.
• Biofeedback/Neurofeedback is a safe method to achieve these goals.
Behavioral Medicine and PTSD

• To create an awareness and understanding of the components of effective health improvement programs.

• To explore the specific application of health applications in the treatment of PTSD, anxiety, and depression.
The greatest revolution of our time is the knowledge that human beings, by changing the inner attitudes of their minds, can transform the outer aspects of their lives.

-William James
References


References


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