Heart Rate Variability (HRV) Biofeedback in the treatment of Combat-Related Posttraumatic Stress Symptoms

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My Background

**Education**
BA, Psychology  
University of Maryland University College

M.Ed., Counseling & Personnel Services  
University of Maryland at College Park

MSSW, Social Work  
University of Texas at Austin

PhD Social Work  
University of Texas at Arlington

**Credentials**
- Licensed Clinical Social Worker (TX)
- Licensed Professional Counselor (TX)
- BCIA Certified in Biofeedback and Neurofeedback
- HRV specialty certificate

BCIA.org  
AAPB.org  
ISNR.org
Posttraumatic Stress Disorder (PTSD) is a chronic, disabling stress disorder, that results from direct or indirect exposure to actual or threatened death, serious injury, or sexual violence (American Psychiatric Association, 2013)

Prevalence:
❤ 15% Iraq/Afghanistan Veterans (Yarvis, 2011).
❤ ~30% Vietnam Veterans (Kulka et al., 1990).
❤ Many more experience partial or subsyndromal PTSD (Maguen et al., 2013; Pietrzak et al., 2009; Pietrzak et al., 2011).
### Interventions for PTSD

#### Evidence-Based (VA/DoD)
- Prolonged exposure (PE)
- Cognitive processing therapy (CPT)
- Eye movement desensitization and reprocessing (EMDR)
- Stress inoculation training (SIT)

#### Non-Trauma-Focused
- Mindfulness Meditation
- Behavioral Activation
- Yoga
- Acceptance & Commitment Therapy
- Heart Rate Variability (HRV) biofeedback
PTSD: Making Treatment Effective

- Intrusive thoughts
- Avoidance
- Flashbacks/nightmares
- Memory Loss
- Concentration problems

Mind

- Anger
- Sadness/depression

Emotions

Body

- Hyperarousal
- Insomnia/sleep disturbance

Spirit

Shame/Guilt
- Existential numbing
- Despair

- Emotions
- Body
- Mind
- Spirit
Polyvagal Theory: Role of the Vagus

**Vagus**
- 10th Cranial nerve
- Latin for “wanderer”

**Vagal Tone:** measure of functional state of PNS

**Vagal Brake:** myelinated vagus can override SNS

**Vagal Functions**
- ANS balance
- Breathing, HR, BP
- Lowers inflammation
- Mood
- Fear management
- Learning/rewiring
- Social Behavior (facial expression, prosody, eye gaze, facial expression)
Polyvagal Theory: Hierarchical response to challenge in PTSD

1. 

2. 

3.
Polyvagal Theory: Threat Response

Safety
- Social Engagement System

Danger
- Mobilization (Fight or Flight)

Life Threat
- Immobilization (Freeze)

PNS/SNS → HPA → SNS → HPA → PNS

Neural changes
PTSD: HRV and Emotions

- People with flat affect, and blank expression, monotone voice, noise sensitivity are also experiencing low HRV
Where does the heart fit in?

❤️ Contains roughly 40,000 neurons

❤️ Most powerful bioelectrical generator in human body – 50 times more power than brain

❤️ Rhythm of the heart sets the beat for the entire biological system
The Heart Is Not a Metronome
Heart rate is the speed of the heartbeat measured by the number of contractions of the heart per minute (bpm).

Heart rate variability (HRV) is a measure of the beat-to-beat fluctuations in the rhythm of the heart.
What is HRV?

Average Heart Rate = 60 BPM

.85 sec  .90 sec  1 sec  .95 sec

Variation = Good HRV!
What is HRV?

Good HRV is when the intervals between heartbeats vary.

Poor HRV is when the intervals between heartbeats are the same.
HRV: What generates it?
Ways to Measure HRV

Electrocardiogram (ECG)

Chest placement

Pre-gelled electrodes for ECG

Wrist placement

Photoplethysmograph

Blood volume pulse oximeter
HRV: Why Is It So Bad If It’s Low?

Physical:
• Immune system dysfunction and inflammation
• Diabetes
• CVD,
• Premature aging,
• Morbidity and premature death

Psychological:
• Social avoidance,
• Poor self-regulation
• Reductions in psychological flexibility in the face of stressors
• Psychiatric multi-morbidities

(Kemp & Quintana, 2013).
HRV: What Lowers It?
HRV: Why Is It Good If It’s High?

Better physical and psychological health!

Predictor of recovery after myocardial infarct (Carney et al., 2001); increased emotion recognition (Quintana et al., 2012); better performance on executive functioning tasks (Hansen et al., 2003); positive psychological well-being (Boehm and Kubzansky, 2012)
HRV: What Raises It?
Praxagoras
First to write about pulse in ancient literature

Herophilus
First to measure pulse

Galen
First to use pulse as a diagnostic and prognostic indicator

Joseph Fourier
Work contributed to Fast Fourier transform—mathematical technique to separate waves into component parts

Carl Ludwig
Invented Kymograph to measure both heart rate and respiration—RSA

William Enthoven
Produced the first electrocardiogram

HRV Timeline

340 BC
280 BC
129-200 AD
1822
1847
Late 1800s
First clinical use of HRV; fetal distress—changes in beat-to-beat variation

McCraty (HeartMath)
emotions induce a change in the sine wave pattern of the heart without any change in breathing

Tan et al.
HRVB significantly reduced PTSD symptoms in veterans

Lehrer & Gevirtz
Research on HRV biofeedback

Vashillo
Research on Russian Cosmonauts—Resonance Frequency breathing enabled control of heart rate patterns

Holter
Ambulatory ECG

Herzman
Photoplethysmograph
What is HRV Biofeedback (HRVB)?

- Biofeedback is a process that enables an individual to learn how to change physiological activity for the purposes of improving health and performance.

- HRVB refers to a technique for using slow diaphragmatic breathing to increase time and frequency domain parameters in HRV.
HRV: How Does Breathing At Different Rates Affect the Heart?

(Brown and Gerbarg, 2012)
HRV: Respiratory Sinus Arrhythmia

Figure 3. Respiratory Influence on Heart

Heart rate is shown in red and respiration is shown in blue. Heart rate increases during inspiration and decreases upon expiration.
HRV-BF Targets Baroreflex System

- Heart rate variability biofeedback (HRV-BF) targets the baroreflex system

- HRV BF leads to improved Baroreflex sensitivity
HRVB: Phase Angle

In Phase

Out of Phase
Each person has a specific breath rate, or “resonant frequency,” at which heart rate variability is the greatest (Lehrer, 2000).
HRVB: Resonance Frequency Assessment
ECG vs PPG

ECG: measures biopotential generated by electrical activity of the heart, using multiple electrodes.

PPG: optical measure using light-based technology to sense the rate of blood flow (arterial volume) using a single photodiode.
# Interpretation: HRV Statistics

## Time Domain:
- SDNN
- RMSSD
- NN50
- PNN50

## Frequency Domain:
- VLF
- LF
- HF
- LF/HF ratio

## Geometric Measures:
- HRV Triangular Index
- TINN
- Differential Index
- Logarithmic index
HRV: SDNN PTSD vs “Normal”

<table>
<thead>
<tr>
<th></th>
<th>PTSD (n = 20)</th>
<th>Normal (n = 10)</th>
<th>p-Value</th>
<th>Cohen’s d</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
<td>SD</td>
</tr>
<tr>
<td>SDNN</td>
<td>48.10</td>
<td>47.87</td>
<td>138.70</td>
<td>47.87</td>
</tr>
</tbody>
</table>

Cohen’s d calculated using pooled standard deviation and weighted for unequal samples sizes

Data Analysis: HRV

SDNN 3200
HRV: Time Domain & Spectral Measures

All Stats refer to IBI

IBI SAMPLES
HRV: Power Spectral Analysis

**Fast Fourier Transform (FFT)**

FFT converts time domain to frequency domain to analyze a waveform and break it into its component parts.
Autonomic Balance – LF/HF Ratio

Low Frequency (LF): Both Sympathetic and Parasympathetic

High Frequency (HF): Parasympathetic

LF/HF ratio: Higher ratio=sympathetic dominance; smaller values=parasympathetic dominance
HRVB: PTSD

How does HRVB work to counteract symptoms of PTSD?

Stimulating the vagus through HRVB could activate GABA inhibitory processes to regions of the amygdala, thereby reducing over-activation in regions of brain affected by PTSD (Streeter, Gerbarg, Sape, Ciraulo, & Brown, 2012).
Combat veterans with PTSD show reduced HRV (Chang et al., 2013; Ginsberg et al., 2010; Tan et al., 2011).

HRVB is effective in treating ANS dysregulation in combat veterans with PTSD (Tan et al. 2011; Tan et al., 2013; Ginsberg et al., 2010; Zucker et al., 2009).

Compared to other therapies, HRVB shows a robust change in HRV (Wahbeh et al., 2016).
Posttraumatic Stress, Heart-Rate Variability, and the Mediating Role of Behavioral Health Risks

Paul A. Dennis, Ph.D., 1 Lana Watkins, Ph.D., 2 Patrick S. Calhoun, Ph.D., 1,2,3,4 Ania Oddone, B.A., 4 Andrew Sharwood, Ph.D., 5 Michelle F. Dennis, B.A., 1,5 Michelle B. Risling, Ph.D., 5 and Jean C. Beckham, Ph.D., 1,3,5

Heart rate variability: Pre-deployment predictor of post-deployment PTSD symptoms

Jeffrey M. Pine, MD, 5,6,7 Joseph I. Constans, PhD, 5,6,7 Mark D. Wiederhold, MD PhD FACP, 5 Douglas P. Gibson, PsyD MHP MAJ, 9 Timothy Kimball, MD, 2,8 Teresa L. Kramer, PhD, 5 Jeffery A. Pillcock, MPH, 5 Xiaotong Han, MS, 2,8,9 D. Keith Williams, PhD, 5 Don Chartrand, PhD, 7 Richard N. Govitz, PhD, 7 James Spira, PhD, 5 Brenda K. Wiederhold, PhD MBA BCB BCN, 5 Bollin McCraty, PhD, 7 and Thomas R. McCune, MD COL 5

Heart rate variability and the relationship between trauma exposure age, and psychopathology in a post-conflict setting

Belinda J. Iddell, Andrew H. Kemp, Zachary Steele, Angela Nickerson, Richard A. Bryant, Natalino Tam, Abhin Kuowel Tay, and Derrick Silove

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Research on HRVB and PTSD

Heart Rate Variability (HRV) and Posttraumatic Stress Disorder (PTSD): A Pilot Study
Gabriel Tan · Tam K. Dao · Lorrie Farmer · Ray John Sutherland · Richard Gevitz

Cardiac coherence, self-regulation, autonomic stability, and psychosocial well-being
Rollin McCraty* and Maria A. Zayas*
* Institute of HeartMath, Boulder Creek, CA, USA
* Department of Psychology, Boston University, Cambridge, MA, USA

Breathing Biofeedback as an Adjunct to Exposure in Cognitive Behavioral Therapy Hastens the Reduction of PTSD Symptoms: A Pilot Study
A. Rosaura Polak · Anke B. Witteveen · Daniaan Denys · Miranda Off
Background: Veterans with traumatic stress symptoms exhibit reduced heart rate variability characteristic of autonomic nervous system dysregulation. Studies show heart rate variability biofeedback is effective in reducing combat-related posttraumatic stress symptoms by improving autonomic functioning.

Method: In this quasi-experimental pilot study that featured a switching replication design, a comparison group was used to determine if participation in a single-session heart rate variability biofeedback intervention, reinforced by twice daily practice for four weeks, could: (a) reduce posttraumatic stress symptoms in combat veterans (N=12), and (b) yield an intervention that the veterans would find acceptable. Veterans ranged in age from 26 to 50 (M = 36.16, SD = 10.45), with 33% non-White, and 25% women.

Results: Heart rate variability biofeedback significantly reduced global posttraumatic stress symptoms, whereas diaphragmatic breathing did not. Further, veterans found the approach acceptable, as demonstrated by a high degree of compliance with prescribed practice, low study attrition, and continued use over time.

Conclusion: Results contributed cautious evidence that a single-session heart rate variability biofeedback intervention, followed by brief twice-daily mobile app-enabled practice sessions over a four-week period could reduce posttraumatic stress symptoms.
Procedure

Relaxation Breathing & HRVB Training/Assessment Protocol

1. Baseline measures
2. Belly breathing education
3. Resonance Frequency Assessment
4. Respiratory Sinus Arrhythmia training
5. HRVB practice
6. MyCalmBeat App
Results

Global PCL-5: HRVB vs. Relaxation Breathing at 4 weeks

Group A showed a significant reduction in the PCL-5 Global scores from baseline (Mdn = 41.0) to four weeks post-intervention (Mdn = 24.0), $z = -2.2$, $p = .02$, $r = -.64$; Group B did not show a significant reduction from baseline (Mdn = 38.5) to four weeks (Mdn = 28.0), $z = .41$, $p=.41$, $r=.24$
Results

Changes in the primary measures for combined groups from $T_{1/1.5}$ to $T_3$

- $T_1$ to $T_2$: No significant differences
- $T_2$ to $T_3$: No significant differences
- $T_1$ to $T_3$: Significant improvement in RMSSD
Results:

• Initial Assessment: 8 of 12 (66.66%) met dx criteria for PTSD and all had some sxss (min. score >/=15 on PCL-5)

• Only 30% met criteria at the end of the study

• All 10 who completed the study saw significantly improved global scores by T₃

### PCL-5 Scores

<table>
<thead>
<tr>
<th>Group</th>
<th>T₁ (Mean, SD)</th>
<th>T₃ (Mean, SD)</th>
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<tbody>
<tr>
<td>Group A</td>
<td>45.50, 13.30</td>
<td>30.50, 13.39</td>
</tr>
<tr>
<td>Group B</td>
<td>42.50, 21.28</td>
<td>18.50, 14.88</td>
</tr>
<tr>
<td>Combined</td>
<td>44.0, 16.99</td>
<td>25.70, 14.56</td>
</tr>
</tbody>
</table>
HRV: Psychophysiological Research & Clinical Applications

MindMedia NeXus 4, 10, 32
https://stens-biofeedback.com/

Biocomm Heart Rhythm Scanner
https://www.biof.com/heartscann er.asp

Alive Clinical and Alive Pioneer
http://www.somaticvision.com/AlivePioneerIOM

HeartMath
https://www.heartmath.org/#

Unyte
http://unyte.com/
(formerly Wild Divine)

https://www.mybrainsolutions.com/mycalmbeat
Simple Takeaway: You do not need to be a biofeedback clinician! Teaching diaphragmatic breathing and having your clients use a pacing app set to 6 breaths per minute, with twice daily practice for 5-10 minutes will improve their HRV.
HRV: Wearables


