Brief Heart Rate Variability Biofeedback for Young Adults Receiving Inpatient Treatment for Substance Use Disorders

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Introduction

- Substance use disorders (SUDs) are precipitously difficult to treat.
- Cognitive and behavioral treatments are effective for many, yet majority of individuals receiving treatment are not able to maintain abstinence after treatment.
- Remains a need for effective treatments that consider physiological, as well as psychological mechanisms contributing to SUDs.
Introduction

- Heart rate variability biofeedback (HRV BFB) is an effective treatment for depression.
- Usually delivered over 10–12 weekly sessions.
- HRV BFB might be an effective addendum to traditional SUD treatments.
- Inpatient SUD treatment, however, is traditionally 4 weeks, not 10–12.
Introduction

- Investigated feasibility and efficacy of brief, 3-session HRV BFB intervention, designed to fit into the confines of traditional 28-day SUD inpatient treatment program.

- Collaborated with Caron Foundation to deliver HRV BFB intervention, along with treatment as usual at 28-day inpatient rehabilitation facility.
Participants

48 ongoing admissions from Young Adult Male unit (ages 20–25) at Caron Treatment Center (Wernersville, PA).

- **Inclusion criteria**
  - At least seventy-two hours since last use of alcohol or other drugs.
  - Completed detox.

- **Exclusion criteria**
  - Having received previous HRV BFB training.
  - Any serious medical condition (pacemaker, cardiac arrhythmia, hypertension, diabetes).
  - Severe psychiatric condition (e.g., psychosis), or neurological condition (e.g., Parkinson’s Disease) that would contraindicate physiological assessment and interpretation.
  - Patients currently taking medications such as MAOIs, alpha/beta blockers, or most detoxification medications (e.g., Librium, methadone) were excluded.
Physiological Measures

- Electrocardiogram (ECG): Pre-amplified electrocardiograph sensors; positive, negative, and ground electrodes attached to participant’s arms and ankle (Thought Technology Infinity).
- Finger pulse: A blood volume pulse (BVP) photoplethysmograph sensor affixed to the right index finger.
- Skin temperature: Thermistor sensor affixed to the right index finger.
- Respiration: High durability strain gauge latex rubber band fixed with velcro respiration belt placed around abdomen.
- Skin Conductance: Two silver-silver chloride electrodes affixed to thenar eminence and hypothenar eminence of the palm of the right hand.
Psychological Measures

- Reasons for Drinking/Using Questionnaire:
  - 29-item questionnaire (Labouvie & Bates, 2002) assesses reasons that an individual engages in substance use.
  - Contains three subscales (social, disinhibition, and suppression). Items coded on a 3-point scale from “Not at all important” to “Very Important.”

- Penn Alcohol Craving Scale (modified; PACS):
  - Five-item instrument for assessing craving (Flannery, Volpicelli, & Pettinati, 1999).
  - Frequency, intensity, and duration of thoughts about substance use assessed along with ability to resist using.
Psychological Measures

- Follow-up questionnaire
  - 23-item questionnaire including measures of craving, depression, anxiety, somnolence, confidence of maintaining sobriety in coming month.
  - Delivered over phone at 1, 2 and 3 months after discharge from treatment.
## Experimental Group

<table>
<thead>
<tr>
<th>Task</th>
<th>Session 1 (Week 1)</th>
<th>Session 2 (Week 2)</th>
<th>Session 3 (Week 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plain Vanilla* (Baseline) ((5\text{min}))</td>
<td>Resonance frequency breathing ((5\text{min}))</td>
<td>Plain Vanilla ((5\text{min}))</td>
</tr>
<tr>
<td>2</td>
<td>6 breaths per minute ((5\text{min}))</td>
<td>Res. freq. breathing with instruction ((5\text{min}))</td>
<td>Resonance frequency breathing ((5\text{min}))</td>
</tr>
<tr>
<td>3</td>
<td>Resonance frequency assessment ((10\text{min}))</td>
<td>HRV BFB instruction ((5\text{min}))</td>
<td>HRV BFB ((5\text{min}))</td>
</tr>
<tr>
<td>4</td>
<td>Resonance frequency breathing ((5\text{min}))</td>
<td>HRV BFB ((5\text{min}))</td>
<td>Plain Vanilla ((5\text{min}))</td>
</tr>
<tr>
<td>5</td>
<td>Plain Vanilla ((5\text{min}))</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Control Group

<table>
<thead>
<tr>
<th>Task</th>
<th>Session 1 (Week 1)</th>
<th>Session 2 (Week 2)</th>
<th>Session 3 (Week 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Plain Vanilla (Baseline) (5min)</td>
<td>X</td>
<td>Plain Vanilla (5min)</td>
</tr>
<tr>
<td>2</td>
<td>6 breaths per minute (5min)</td>
<td>X</td>
<td>6 breaths per minute (5min)</td>
</tr>
</tbody>
</table>
Results

48 initial participants,

5 dropped after leaving the treatment facility for personal reasons.  
(3 experimental & 2 controls)

1 excluded because of arrhythmia.

1 participant’s data excluded from analysis due to an ECG recording error.

No outliers detected.

Final \( n = 41 \)
Results

- All participants had at least 2 SUD diagnoses.
  - All participants met criteria for dependence for at least one substance.
- Experimental participants practiced with EmWave biofeedback device 21.02 minutes a day (SD= 12.02).
Physiological changes in experimental group from baseline to resonance frequency breathing task during session 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline Assessment (SD)</th>
<th>Resonance Freq. Breathing (SD)</th>
<th>( t )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR</td>
<td>76.09 (12.50)</td>
<td>75.90 (10.17)</td>
<td>0.12</td>
<td>.91</td>
</tr>
<tr>
<td>pNN50</td>
<td>19.34 (19.33)</td>
<td>23.47 (17.06)</td>
<td>–2.11*</td>
<td>.05</td>
</tr>
<tr>
<td>SDNN (log)</td>
<td>3.84 (0.45)</td>
<td>4.42 (0.43)</td>
<td>–9.88*</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Rmssd (log)</td>
<td>3.44 (0.71)</td>
<td>3.87 (0.59)</td>
<td>–5.26*</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Hf HRV (log)</td>
<td>5.67 (1.50)</td>
<td>6.09 (1.24)</td>
<td>–1.98</td>
<td>.06</td>
</tr>
<tr>
<td>Lf HRV (log)</td>
<td>6.39 (1.09)</td>
<td>8.45 (0.93)</td>
<td>–9.27*</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Vlf HRV (log)</td>
<td>6.11 (0.80)</td>
<td>5.95 (0.92)</td>
<td>0.66</td>
<td>.52</td>
</tr>
<tr>
<td>Respiration freq.</td>
<td>0.26 (0.08)</td>
<td>0.10 (0.02)</td>
<td>9.76*</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

Notes. \( n = 41 \); HR= heart rate, pNN50= percent of normal-to-normal intervals greater than 50ms, SDNN= standard deviation of normal-to-normal intervals, Rmssd= square root of the mean squared difference of successive normal-to-normal intervals, Hf HRV= high frequency range of the power spectral analysis, Lf HRV= low frequency range of the power spectral analysis, Vlf HRV= very low frequency range of the power spectral analysis.
Session 1, Task 1 (Baseline / Plain Vanilla)

Session 1, Task 2 (breathing at 6 breaths per minute)

Session 1, Task 3 (breathing at resonance frequency - 4.5 breaths per minute)
Physiological changes in experimental group from pre-session to end of session during session 1

<table>
<thead>
<tr>
<th>Variable</th>
<th>Pre-session (SD)</th>
<th>Post-session (SD)</th>
<th>t</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR</td>
<td>76.09 (12.50)</td>
<td>74.03 (10.71)</td>
<td>1.90</td>
<td>.07</td>
</tr>
<tr>
<td>pNN50</td>
<td>19.34 (19.33)</td>
<td>19.64 (19.02)</td>
<td>−0.13</td>
<td>.90</td>
</tr>
<tr>
<td>SDNN (log)</td>
<td>3.84 (0.45)</td>
<td>4.06 (0.41)</td>
<td>−3.33*</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Rmssd (log)</td>
<td>3.44 (0.71)</td>
<td>3.60 (0.66)</td>
<td>−1.67</td>
<td>.11</td>
</tr>
<tr>
<td>Hf HRV (log)</td>
<td>5.67 (1.50)</td>
<td>5.91 (1.45)</td>
<td>−1.42</td>
<td>.17</td>
</tr>
<tr>
<td>Lf HRV (log)</td>
<td>6.39 (1.09)</td>
<td>7.13 (1.04)</td>
<td>−3.48*</td>
<td>&lt;.01</td>
</tr>
<tr>
<td>Vlf HRV (log)</td>
<td>6.11 (0.80)</td>
<td>6.37 (0.73)</td>
<td>−1.36</td>
<td>.19</td>
</tr>
<tr>
<td>Respiration freq.</td>
<td>0.26 (0.08)</td>
<td>0.20 (0.08)</td>
<td>3.31*</td>
<td>&lt;.01</td>
</tr>
</tbody>
</table>

Notes. n = 41
### Physiological differences between experimental and control groups at baseline, session 3

<table>
<thead>
<tr>
<th>Variable</th>
<th>Experimental Group</th>
<th>Control Group</th>
<th>$t$</th>
<th>$p$</th>
<th>$df$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n = 21$</td>
<td>$n = 20$</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HR</td>
<td>82.10 (17.01)</td>
<td>77.20 (12.35)</td>
<td>$-1.05$</td>
<td>$.30$</td>
<td>$39$</td>
</tr>
<tr>
<td>pNN50</td>
<td>14.39 (16.61)</td>
<td>16.19 (13.80)</td>
<td>$-0.25$</td>
<td>$.80$</td>
<td>$39$</td>
</tr>
<tr>
<td>SDNN (log)</td>
<td>3.90 (0.61)</td>
<td>3.86 (0.33)</td>
<td>$0.29$</td>
<td>$.80$</td>
<td>$31$</td>
</tr>
<tr>
<td>Rmssd (log)</td>
<td>3.40 (0.83)</td>
<td>3.47 (0.52)</td>
<td>$0.29$</td>
<td>$.78$</td>
<td>$34$</td>
</tr>
<tr>
<td>Hf HRV (log)</td>
<td>5.60 (1.64)</td>
<td>5.87 (1.06)</td>
<td>$0.61$</td>
<td>$.54$</td>
<td>$39$</td>
</tr>
<tr>
<td>Lf HRV (log)</td>
<td>6.77 (1.44)</td>
<td>6.61 (0.80)</td>
<td>$-0.04$</td>
<td>$.66$</td>
<td>$32$</td>
</tr>
<tr>
<td>Vlf HRV (log)</td>
<td>6.00 (1.10)</td>
<td>6.17 (0.91)</td>
<td>$0.53$</td>
<td>$.60$</td>
<td>$39$</td>
</tr>
<tr>
<td>Respiration freq.</td>
<td>0.24 (0.09)</td>
<td>0.26 (0.06)</td>
<td>$1.14$</td>
<td>$.26$</td>
<td>$33$</td>
</tr>
</tbody>
</table>
Total reduction in alcohol and drug craving from session 1 to session 3, by group.

- **Experimental Group**
  - Change: 18.3%
  - 8 participants saw reduction >50%
  - 95% CI [-7.5, -3.2]

- **Control Group**
  - Change: 12.5%
  - 5 participants saw reduction >50%
  - 95% CI [-6.4, -1.1]

\[ t(39) = .99, \ p = .33, \ d = .35 \]
Results

Follow-up

- Experimental group:
  - 18 completed follow-up 1
  - 15 completed follow-up 2
  - 11 completed follow-up 3

- Control group:
  - 9 completed follow-up 1
  - 2 completed follow-up 2
  - 1 completed follow-up 3
Postscript

- Anecdotal feedback from participants was extremely positive, especially from those with comorbid anxiety/panic disorders.
- Clinical staff noticed a treatment effect and encouraged their patients to participate in the trial.
- HRV BFB is now a standard intervention used in the young adult units at the facility.
  - Patients learn HRV BFB using handheld biofeedback devices one-on-one with counselors and practice in group.
Conclusions

- No significant differences in within treatment craving between groups, but effect size is promising.
- Follow-up was not successful. Unable to determine post-treatment effects.
  - Possible allegiance effects
- Anecdotal feedback was very positive.
  - Brief HRV BFB may have important utility regardless of chronic effects on HRV.
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