

Effects of Mindfulness and Biofeedback on Executive Function: A balance of sympathetic and parasympathetic activity

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Introduction

- Increased parasympathetic activation is related to increases in attention and executive function, while higher levels of sympathetic function are predictive of distress and poor performance. Mindfulness and heart rate variability (HRV) biofeedback are associated with increased attention and executive functioning. Executive functioning refers to cognitive processes necessary to control and coordinate your thoughts and behaviors to achieve goal-directed activities. Stress management research has been associated with increasing parasympathetic function, measured by high frequency heart rate variability (HF – HRV), as predictive of increased relaxation, enhanced attention, and enhanced executive function.
- A number of small-scale studies have found that increased parasympathetic nervous system function, as measured by HF-HRV, predicts enhanced attention and executive function (Thayer et al., 2009). However, several recently published large scale studies (Jennings et al., 2015, N = 440; Kimhy et al., 2015, N = 817, Mann et al., 2015, N = 533) have failed to find a relationship between executive function and HF-HRV, although HF-HRV does appear to predict improved attention (Kimhy et al., 2015).
- While higher levels of sympathetic function (LF-HRV) are predictive of distress and poor performance, it is possible that sympathetic/parasympathetic (LF-HRV / HF-HRV) balance is more important in executive functioning than solely increased parasympathetic function (HF-HRV) (Lehrer, 2007; Williams, 2010). Interestingly, interventions that have been associated with increased attention and executive function, mindfulness and HRV biofeedback, intended to create balance (LF-HRV / HF-HRV) and not relaxation (HF-HRV) (Eisenberg et al., 2004; Kim et al., 2013; Prinsloo et al., 2013; Sutarto et al., 2013).
- The present study examined how the sympathetic and parasympathetic balance, measured by physiological changes in HRV, ECG, and blood pressure, functioned as a predictor of attention and executive function compared to only parasympathetic function as a predictor. This study also explored whether the effects of a HRV intervention such as mindfulness or biofeedback are mediated by the sympathetic and parasympathetic balance, rather than parasympathetic function alone.
- We hypothesized that (1) autonomic balance in sympathetic and parasympathetic functioning (LF – HRV / HF –HRV) will predict better attention and executive function than parasympathetic functioning (HF – HRV) alone. We also hypothesized that (2) the effects of two interventions known to impact attention, executive function, and autonomic balance, specifically mindfulness and HRV biofeedback, will be more strongly mediated by LF – HRV / HF – HRV balance than HF – HRV alone.

Method

Participants

Adult participants (n=92, female=69, college students=92) took part in three weekly visits. Participants were randomly assigned to either the HRV biofeedback training group, mindfulness group, or the control group. Those learning HRV biofeedback were taught paced breathing at 6 breaths per minute. The mindfulness group listened to a fifteen-minute audio clip of guided mindfulness practice. The control group watched nature videos.

Procedure

The study took place over 3 visits, with approximately one week between each visit. The schedule was as follows:

- Visit 1: 30 minutes testing of attention and executive function and then mood and stress, followed by 30 minutes teaching mindfulness, HRV biofeedback, or watching nature videos for control group.
 - Visit 2: 30 minutes practice of mindfulness or HRV biofeedback or sitting quietly for the control group.
 - Visit 3: 30 minutes practice of mindfulness or HRV biofeedback, or sitting quietly for the control group, followed by 30 minutes of testing of attention and executive function and then mood and stress.
- ECG, respiration, blood pressure, and skin conductance were assessed throughout all three visits
 - HRV, respiration, and skin conductance were measured using the Nexus 10 Mark II biofeedback device
 - Participants were monitored during rest periods and during assessment of attention and executive function
 - Attention and executive functions were assessed using the attention and executive control, processing speed, and working memory modules of the National Institute of Health Cognitive Toolbox

Results

- We used a Repeated Measures ANOVA to analyze the data
- No effect was observed in the data. There were no significant p-values [$p > .05$].

Discussion

- For our first hypothesis that autonomic balance in sympathetic and parasympathetic functioning (LF – HRV / HF –HRV) would predict better attention and executive function than parasympathetic functioning (HF – HRV) alone resulted in $p > .05$.
- Our second hypothesis that executive function and autonomic balance, specifically mindfulness and HRV biofeedback, would be more strongly mediated by LF – HRV / HF – HRV balance than HF – HRV alone resulted in a significance of $p > .05$.
- This finding may be due to a lack of difference in mindfulness and biofeedback.
- Also, this finding may be due to the fact that autonomic balance --the idea of parasympathetic and sympathetic, especially in the LF range of HRV-- is not accurate and has failed to be supported by recent research.

For more information,
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