Vagal Tone: Predicting Psychophysiological Function under Conditions of Fear

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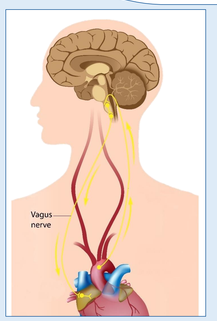
Introduction

- Fear-induced stress is different from that which is induced physically or mentally
  - Emotions begin in the amygdala, mental tasks in the cortex, and physical reactions in other areas (Hayashi et al., 2009)
  - Emotions are separate from mental tasks and physical reactions, though all are capable of inducing a stress response (Hayashi et al., 2009)
- Cranial nerve X, the vagus nerve, is the main input to the parasympathetic nervous system, which slows down physiological actions
  - Causes respiratory sinus arrhythmia (RSA), a normal variability in heart rate
- *Vagal tone* refers to the level of vagus nerve activity (Beauchaine, 2001)
  - Cannot be quantified directly, though RSA can be calculated and used as a marker of vagal tone degree (Grossman & Taylor, 2007)
  - RSA only accounts for half of all heart rate variability (HRV), so many studies calculate HRV as a better marker of vagal tone (Beauchaine, 2001)
- Vagal tone is related to non-emotional stress responses, emotional regulation, and emotional expressiveness (Porges, Arnold, & Forbes, 1973; McLaughlin et al., 2015; Stifter, Fox, & Porges, 1989)
- **Hypothesis: individuals with higher HRV, a marker of higher vagal tone, would have more general feelings of anxiety, faster fear-induced stress reaction and recovery, greater facial expressivity, and better memory**



http://www.bakerchiropractic.org/the-vagus-nerve-immune-system-inflammation/

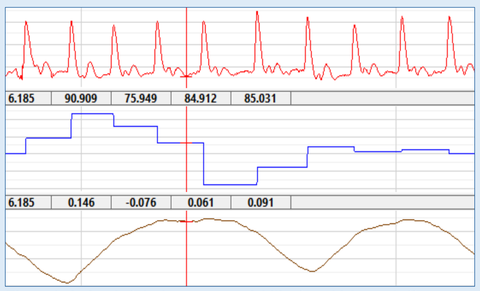


Figure 1: A visual of the heart rate variability for which vagal efference and, in part, respiratory sinus arrhythmia (RSA) are responsible

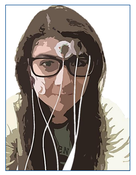
Heart rate (blue) slightly increases and decreases during respiratory inhalation and exhalation (brown), respectively

Method

- 29 adult students participated in this study
- All data was collected using equipment and software from iWorx, Inc.
- Equipment included a plethysmograph for pulse, respiration monitor, and electrodes for the facial electromyography (EMG)
- Participants were shown images, taken from the International Affective Picture System (IAPS), at one image per two seconds, paired with audio stimuli
- HRV was calculated by finding the root mean square of successive differences (RMSSD) of pulse peaks intervals (Giardino, Lehrer, & Edelberg, 2002)
- Since the sample HRV distribution approximated a normal distribution, two-tailed correlational tests were done
- HRV was compared to:
  - Heart rate reaction and recovery (average rate of change)
  - Changes in the EMG signal root mean square (RMS) of the muscle used to frown (*corrugator supercilii)* and the muscle used to smile (*zygomaticus major)*
  - Memory of presented images
  - Reported feelings of anxiety

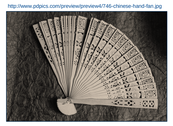
Procedure

Step One



Five-minute baseline recording of pulse, EMG, and respiration

Step Two



http://www.pdpics.com/preview/preview4/746-chinese-hand-fan.jpg

Sixty neutral images paired with neutral audio, followed by a two-minute recovery

Step Three

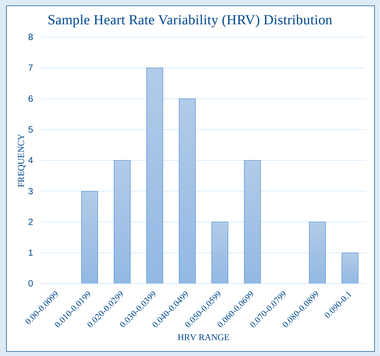
http://www.pd4pic.com/spider-animal-close-cobweb.html

Sixty fear images paired with fear audio, followed by a two-minute recovery

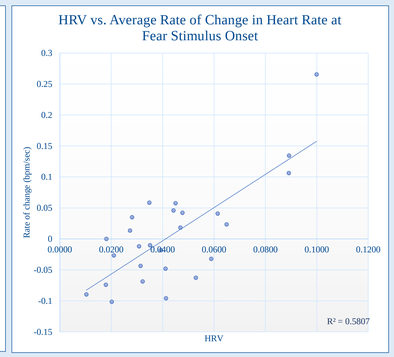
Step Four

Debriefing

Results



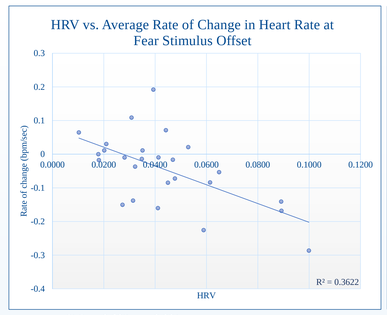
- Mean HRV: 0.0447



- r(24) = 0.762, p < 0.001
- R^2 = 0.581

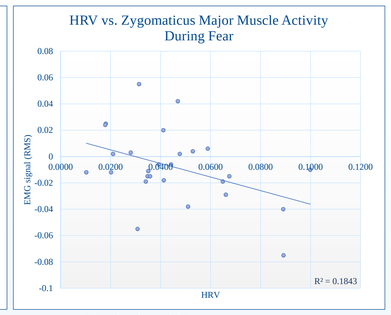
Results are significant

Results (Continued)



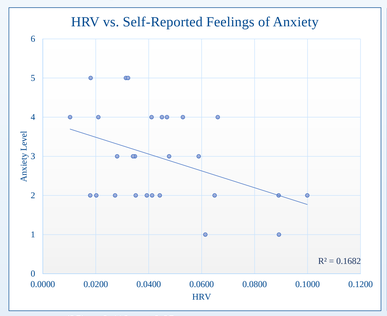
- r(24) = -0.602, p < 0.001
- R^2 = 0.362

Results are significant



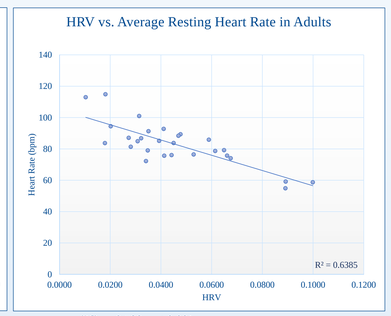
- r(25) = -0.429, p < 0.05
- R^2 = 0.184

Results are significant



- r(25) = -0.410, p < 0.05
- R^2 = 0.168

Results are significant



- r(26) = -0.799, p < 0.001
- R^2 = 0.639

Results are significant

Results were not significant when HRV was correlated with memory of fear-provoking images

- r(25) = 0.152, p > 0.05
- R^2 = 0.0231

Results were not significant when HRV was correlated with *corrugator supercilii* EMG signal

- r(25) = -0.106, p > 0.05
- R^2 = 0.0114

Discussion

- The HRVs calculated in this study were viewed as markers for the degrees of individual vagal tone
- Based on results, higher vagal tone indicates the following: lower resting heart rate, faster reaction to and recovery from fear-provoking stimuli, less activity in the muscle used to smile while afraid, and less reported anxiety than their lower vagal tone counterparts
- HRV, indicating vagal tone, is not correlated with memory capacity, nor with activity in the muscle used to frown while afraid
- Vagal tone can effectively serve as a predictor of resting heart rate, fear-induced stress response magnitude, *zygomaticus major* muscle expression during fear, and reported feelings of anxiety
- These results provide more information about the vagus nerve and how vagal activity can be used to predict the effects of fear before they ever occur. They offer a foundation for further evaluations of individual susceptibilities to anxiety disorders, as well as for additional treatment options for such disorders

References

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