ASSOCIATION BETWEEN HRV AND SOCIAL ANXIETY IN A COLLEGE POPULATION

By

Eliza Varjú

A Thesis and Senior Honors Project Presented to the

Honors College

East Carolina University

In Partial Fulfillment of the

Requirements for

Graduation with Honors

and for the Degree

Of Bachelor of Science in Neuroscience

By

Eliza Varjú

With the Mentorship of Dr. Matthew Whited

Greenville, NC

May, 2019

Approved by:

Dr. Matthew C. Whited
Department of Psychology East Carolina University

Introduction

At the start of college, students transition from living at home to a more independent environment. In the case of housing, they are required to live in a dormitory with roommates and other students in close quarters; in the case of classes and activities on campus, it is the onus of the student to seek out opportunities for socialization and entertainment. This shift in responsibility may lead to an increase in social anxiety, with many experiencing large lecture classes and being a part of a student body numbering in the thousands for the first time.

Social anxiety is characterized by a fear in the face of social situations and the potential of embarrassment or judgment, leading to avoidance behaviors in order to escape the threat of anxiety (Gaebler, 2013). The DSM-5 defines social anxiety as a “marked fear or anxiety about one or more social situations in which the individual is exposed to possible scrutiny by others” (DSM-5, 2013). The unfamiliar environment of college, especially during the freshman year, is a time when everyday blunders are common but while living in a dormitory these mistakes have the potential to be fairly public within the student body. For those who may experience a heightened feeling of anxiety in these situations, it can lead to avoidance of circumstances that increase the chances of ridicule or judgment from others. Within college populations, it has been found that social anxiety diagnoses correlate with other mental health issues such as mood disorders, depression and substance abuse problems in relation to marijuana and alcohol (Schry, 2013). In addition to comorbidities in mental health, students with social anxiety show greater difficulties in learning and exhibit a higher chance of dropping out of college (Van Ameringen, 2003). The effects of social anxiety in college students can be felt from stresses in personal to academic life.

In the field of anxiety disorder research, most studies have dealt with clinically diagnosed populations in older age ranges who may exhibit panic disorder (PD), post-traumatic stress disorder (PTSD) or generalized anxiety disorder (GAD) symptoms. There are few studies looking specifically at college students, the new pressures they experience in communal situations and the social anxiety that can result from it. Among undergraduate students, 22-33% of them report displaying symptoms of social anxiety during their first two years in college (Strahan, 2003). Efforts to respond to the adjustment difficulties that students may face upon entering college have so far focused on general anxiety and stress (Licht, 2009; Pittig, 2013; Chaló, 2017). Biofeedback intervention was one approach used to help freshman students with reported high anxiety scores through an eight-week training program, however, this method didn't address the causes of the anxiety and whether social anxiety played a part in their scoring (Chaló, 2017). Participants were scored on anxiety measures pertaining to self-esteem, social anxiety and test anxiety, however no correlations were made between the subsets of anxiety and the effectiveness of treatment nor were follow-ups on severity of anxiety symptoms conducted. This type of treatment addresses the physiological symptoms of anxiety and stress but does not appear to mediate any of the behavioral changes that are part of anxiety, such as avoidance.

On the other hand, social anxiety has provided a link between neuroimaging studies studying brain activation through MRI and PET scans and the HRV of a patient. Several studies have demonstrated the link between heart-rate variability and anxiety or depressive disorders. In the case of children, physiological hyper-arousal has been studied as a precursor to social anxiety by examining electro-dermal activity and heart-rate variability during the stranger-approach task (Nikolic, 2018). The avoidance symptomatology of anxiety has been hypothesized to affect the parasympathetic arousal system of the body, which in turn influences HRV (Thayer, 2012). This assumption in turn has been supported by neuroimaging studies that seek to provide a model of anxiety's appearance in brain activation and the connection to heart-rate variability as a possible transdiagnostic factor.

HRV

Heart-rate variability (HRV) is a measure of the time differences between heart beats and has been used as a way to quantify sympathetic and parasympathetic arousal in patients through noninvasive means (Ahs, 2009). At higher frequencies of heart-rate variability measurements, the parasympathetic nervous system's influence on the intervals is more pronounced as opposed to the combined effect of parasympathetic and sympathetic control at lower frequencies (Thayer, 2012). HRV provides a rapid way to quantify the reaction of the body to stimulus through the change in the heart's responsiveness where subjects can be monitored in a non-invasive manner to collect data that are on the range of milliseconds (Thayer, 2012). HRV serves as a link between the matters of the mind and the matters of the body. In healthy individuals the heart is able to react and respond to stimuli appropriately, resulting in an HRV response befitting the situation whereas anxious or depressed individuals display a withdrawn HRV. In the case of low variability, it indicates an abnormal reaction to situations that would generally lead to healthy accommodation in HRV. Previous research has found that those with generalized anxiety or major depression exhibit lower rates of HRV, an indicator of cardiovascular disease and poorer social engagement (Alvarez, 2013; Thayer, 2000).

Anxiety disorders have been shown to contain an element of impaired inhibition, whereby the patient is incapable of regulating emotional responses, such as anxiety and fear, to situations that do not contain a legitimate threat. The purpose of emotional inhibition is to control strong negative emotions that are inappropriate to the situation, an example is anxiety in the face of social interaction, and to provide a means of flexible responding to ensure a mental balance. A lack of emotional regulation can be linked to HRV in the context of the parasympathetic nervous system and its role in providing the body with a dynamic balance when faced with stressors (Pittig, 2013; Lehrer, 2013). Higher HRV indicates healthy adaptation to the environment and social contexts in contrast to those with anxiety who exhibit a lower HRV due to their reduced parasympathetic response and their fixed anxious reaction to non-threatening situations.

Neuroimaging

In the field of neuroimaging and research into the possibilities for HRV, research conducted by Thayer et al. proves a prolific source of study into many varied areas of application. The areas of note in top-down regulation are proposed to be the ventromedial prefrontal cortex, the anterior cingulate cortex and the amygdala (Thayer, 2012).

The amygdala has been found to play an important role in threat determination, with its neurons responsible for determining and classifying emotionally positive and negative responses, with a marked bias towards negative encoding (Cunningham, 2008). This finding suggests that perceiving situations or stimuli as threats is a “default” reaction that may lead to problems in controlling sympathetic activation (Thayer, 2009). MRI and PET scans have revealed similar results in social anxiety patients with “hyper-responsiveness” in the amygdala during fear conditioning when compared to healthy subjects (Wager, 2007).

In contrast, the ventromedial area of the prefrontal cortex inhibits the amygdala’s threat appraisals in situations deemed safe (Thayer, 2012). This inhibition functions not as a “kill-switch” for any threat responses or fear that a situation elicits, but rather rationalizes the perceived danger in the context of long-term memories (Thayer, 2012). When these inhibitory processes are removed, as was observed in a study on patients with medial prefrontal cortex brain damage, social situations that are "challenging" but otherwise harmless are judged more threatening than for otherwise healthy controls (Buchanan, 2010).

HRV and Neuroimaging

Neuroimaging studies have found a substantial connection between HRV and brain areas associated with "emotional regulation and context dependent reduction of fear behavior" (Thayer, 2012). Specifically, the ventromedial prefrontal cortex plays a role in evaluating feelings of fear and safety in addition to regulating the response to these emotions, causing an increase in HRV as the body adapts to the perceived threat (Thayer, 2012).

Further support for the medial prefrontal cortex's role in emotional responding was found through administration of a public speaking task in order to induce the observational and negative judgement aspect of social anxiety (Ahs, 2009). This indicates the same issues as expressed earlier of difficulties in controlling fear reactions and managing stress responses to strenuous social situations; this reduction in emotional regulation was associated with reduced HRV, leading to the assumption of a positive correlation between HRV and activity in the medial prefrontal and anterior cingulate cortices in patients who exhibit social anxiety (Ahs, 2009).

Despite growing studies in the area of HRV and anxiety disorders such as PTSD and GAD, social anxiety remains a more peripheral subject of research. Generally social anxiety studies involve subjects from the general population who have been diagnosed with social anxiety while the college population is largely underrepresented. Additionally, studies have used stress tasks to induce the appropriate feeling of anxiety in patients who already exhibit social anxiety while baseline measurements of HRV have been used in mostly generalized anxiety research.

By including such tasks, either described or undetermined, the subject's anxiety regarding what the possible upcoming activity is comprised of might affect the results of the experiment itself. The 'baseline' measurements of HRV may be skewed toward an anxious or stressed level instead of reflecting a truly relaxed state of mind. Removing any additional tasks and focusing on ensuring a calm environment during the HRV recording could serve as a platform for demonstrating the true baseline of subjects. An examination of the resting differences between HRV in college students with low or high reported social anxiety can also be beneficial in providing data for a population that is less studied than most.

Methods

Participants

The survey portion of the study was disseminated using the SONA systems services, a directory and platform for currently running experiments open to students in the Introduction to Psychology classes offered at East Carolina University. Compensation was provided to each participant in the form of 1.5 course credits for each completed survey and full laboratory session. A total of 88 participants completed both the survey and lab portion of the study over the course of the Spring and Fall semesters of 2017. Students were asked questions on demographic data such as age, gender, race and social class.

Measures and Questionnaires

Physiological Measures. Blood pressure measurements were taken using an Omron HEM-907XL Professional Blood Pressure Monitor machine. Two readings were recorded in order to calculate an average, with five minutes in between to allow for a return to baseline. The participant was seated and asked which arm was preferred for the blood pressure cuff before the recording was started. Using a Gulick tape measure, waist circumference around the navel was measured twice so as to establish a mean value. Height and weight were determined using a digital height and weight scale. During the ten minute HRV session, respiration rate was measured through the use of a strain gauge position at the participant's solar plexus and adjusted until at a comfortable tightness.

HRV. In a booth, the participants were seated in front of a television screen and walked through the process of attaching electrodes. The Lead II ECG technique was used in order to obtain the best results for measuring HRV (Biopac, 2018). Participants' right wrist and the insides of both ankles were swabbed with alcohol wipes and the area of skin was cleaned using NuPrep, an abrasive gel. Electrodes were attached with the aid of SignaGel in order to facilitate optimal skin conductance. By attaching the lead wires to the inside of the left ankle and the right wrist, the heart rate can be better estimated and monitored. The ground wire was attached to the inside of the right ankle. The participants were instructed to watch a video of neutral stimuli consisting of oceanic scenery for approximately ten minutes, during which time movement was discouraged. The conditions were meant to simulate a resting state baseline for the HRV data and remove distractions or other possibly confounding variables that could lead to altered data.

Social Interaction Anxiety Scale. The Social Interaction Anxiety Scale (SIAS) is a twenty item self-report questionnaire meant to evaluate symptoms of social anxiety. It was included along with numerous other surveys in the online portion of the College Student Health Study. The responses for SIAS were on a scale from 0 meaning 'Not at all' to a 4 or 'Extremely'. The questions asked about nervousness or difficulty in social situations, such as meeting someone's eyes, greeting new acquaintances or talking to people in positions of authority.

SIAS has been studied as an accurate indicator of social anxiety in both undergraduate and clinically diagnosed populations (Rodebaugh, 2006). Reliability of the scale's items was found to have $\alpha \geq 0.90$ and convergent validity was demonstrated with a correlation of 0.6 between SIAS and the brief symptom inventory (Beurs, 2014). Based on a study utilizing 425 patient respondents, the cutoff score for the SIAS questionnaire between clinically diagnosed patients with social anxiety disorder and healthy subjects was found to be 34 (Rodebaugh, 2006). The items include large group dynamics and the stresses incurred by interactions in that setting as well as one-on-one socializing and individual conversational difficulties.

Data Validation

Several validity items were included throughout the College Student Health Study in order to establish a cutoff for respondents. Validity items included “Have you traveled around the world twice in a hot air balloon?” and “Have you ever been abducted by aliens?”. Considerations based on the time taken to complete the survey were also used in order to screen out any additional invalid data.

Procedure

Students initially signed up for the College Student Health Study using the SONA systems site and were given the full battery of questionnaires on Qualtrics, including but not limited to the topics of depression, sleeping quality, physical activity. After providing informed consent, students were led through the questions and the responses were recorded with a laboratory session offered at the end for additional credit. The lab portions of the study generally lasted for thirty to forty minutes and began with a full debriefing of the participant as to the particulars of the measurements taken and the procedure for the HRV recording session.

Data Analysis Plan

Using SPSS software demographic variables will be run through a correlation table, with the exception of gender entered in a t-test, in order to ascertain any bearing they may have on the

SIAS scores or heart rate variability data. In addition, blood pressure and respiration rate have a possibility of being covariates to heart rate variability and will be assessed by calculating a Pearson correlation coefficient so as to ensure variation in SIAS can be feasibly attributed to heart rate variability and not external factors. A linear regression will be run to determine if heart rate variability predicts the score on the Social Interaction Anxiety Scale as isolated variables. Finally, in order to discover the amount of variation caused by secondary factors in relation to the heart rate variability and SIAS correlation, a multiple regression will be run with blood pressure, BMI and gender to account for those differences.

Results

Due to missing College Student Health Study survey data, 12 participants' HRV measurements were not used for the purpose of this study. An additional 8 participants did not satisfy a sufficient number of validity criteria and so were also excluded. The remaining cohort (see Table 1) was composed almost evenly of males (n = 36, 52.9%) and females (n = 32, 47.1%). The average age of participants was 18.84, largely due to the freshman classes that offered extra credit for participation with a few significant outliers.

Table 1. Demographic characteristics and descriptive statistics for social anxiety measure (SIAS), body-mass index (BMI) and high frequency heart-rate variation (HF-HRV).

	Mean (SD)	**n (%)**
Age	18.84 (1.79)	
Gender		
Male		36 (52.9%)
Female		32 (47.1%)
Race/Ethnicity		
		44 (65.7%)

Non-Hispanic White or Caucasian		11 (16.4%)
Black/African American		12 (17.9%)
Other		
Body Mass Index (BMI)*	24.66 (5.81)	
SIAS Total Score	29.5 (15.04)	

The average score on the social anxiety interaction scale was 29.5, which is situated in the range where no appreciable social anxiety or phobia is present. However, within one standard deviation the cutoff for social phobia is reached at 34 (Kobayashi, 2012). The mean of the natural log of HF-HRV was -8.91 (SD = 1.24), which is within the normal range found among college-age populations (Kobayashi, 2012). The majority of the participants had a normal BMI and an overall average in the "normal weight" category.

Initial results looking at SIAS, HRV and the covariates decided beforehand, such as BMI, blood pressure and gender (see Table1), showed no significant correlation ($p > .05$). Age as a covariate was added in order to determine whether it had any effect and was later included in the final regression due to its significance ($p = .016$).

Table 2. Correlation Table between high frequency heart-rate variability (HF-HRV) and social anxiety (SIAS) with additional covariates of blood pressure, age and BMI.

	SIAS Total Score	**HF-HRV**
SIAS Total Score	1	.063
HF-HRV	.063	1
BMI	-.089	.016
Blood Pressure (Systolic)	-.150	.036
Blood Pressure (Dyastolic)	-.028	-.134
Age	-.290*	-.045

*indicates significance

SIAS score was found to be associated with age ($r = -.29$, $p < .05$), suggesting an ancillary connection between reduced social anxiety at older age ranges (see Table 2). SIAS and HRV scores were not found to be correlated ($r = .063$, $p = .608$) while SIAS was also similarly uncorrelated with BMI ($p = .75$), blood pressure measurements ([systolic] $p = .452$, [diastolic] $p = .479$) and gender ($p = .458$). Before controlling for covariates and other possibly confounding factors, the linear regression between SIAS and HF-HRV already proved to have a very low r-square ($r^2 = .001$) indicating little to no relationship between the two variables.

Table 3. Linear regression model of high frequency heart-rate variability (HF-HRV) predicting the social anxiety (SIAS).

	Standardized Beta	t	Sig
Constant			
HF-HRV	.038	.327	.744

A final linear regression was performed to examine any possible effects from confounding variables, with no significant difference (R^2 change = .007). With such a low R^2 change, any additional variance that could be expected is negligible considering the inclusion of HRV resulted in little alteration in the standardized beta values or significance of any of the variables. As before with the preliminary correlation table, age was the only significant covariate of SIAS.

Table 4. Linear regression of social anxiety (SIAS) with Model 1: including demographic covariates, blood pressure, age and BMI; Model 2: including HRV.

	Standardized Beta	t	Sig
Model 1			
Constant			
Blood Pressure			
Systolic	-.151	-.757	.452

Diastolic	.115	.712	.379
Age	-.294*	-2.283	.026
Gender			
Male or Female	.116	.748	.458
BMI	.043	.321	.750
Model 2			
Blood Pressure			
Systolic	-.149	-.744	.460
Diastolic	.129	.785	.435
Age	-.289*	-2.228	.030
Gender			
Male or Female	.129	.818	.416
BMI	.043	.318	.752
HF-HRV	.085	.686	.495

Discussion

The purpose of this study was to examine a link between baseline HRV and social anxiety in college students. This hypothesis was founded on the research literature pertaining to heart rate variability and its indication of parasympathetic activity in the central nervous system. This pathway is an important aspect of stress response as it allows for the body to regulate emotional responses and in the case of anxiety disorders, inappropriate ones as well (Pittig, 2013; Lehrer, 2013). Contrary to previous experiments, the results obtained do not support this hypothesis as no significant relationship was found to suggest HF-HRV predicts SIAS scores.

Race and gender were found to also have no correlation with HF-HRV and so cannot be considered as confounding factors. However, SIAS scores were found to vary inversely with age ($r = -.290$) such that the older participants experienced a lowered SIAS score. This may be due to the lessening of general anxiety as age increases.

The average SIAS score was below the cutoff point for social phobia (34) and social anxiety (43). Even given a range of one standard deviation, it only enters the score range for social anxiety by one point, leading to less than one third of the total participants scoring above the cutoff. Given most of the studies in the literature focused on clinical populations composed of patients diagnosed with anxiety, there is a possibility HRV does not have an effect at the levels of informally reported social anxiety as were present in our study (Gaebler, 2013; Licht, 2009). This may have had an effect on the data by limiting the scope of social anxiety present in the sample studied due to a lack of clinically significant diagnoses.

A possible reason for lack of significance stems from the study's focus on baseline HRV. The literature supports the trend of lowered heart rate variability in those with generalized anxiety and this observation was tested in regards to the more specific social anxiety, although the results do not indicate any support for this hypothesis (Alvarez, 2013; Thayer, 2000). We proposed to focus on the 'poorer social engagement' aspect noted in these previous studies to ascertain whether a link could be find to social anxiety specifically. The reduced sample size due to failed validity criteria and missing survey data may also be a contributing factor as it resulted in 20 excluded participants or over 20% of the original cohort being lost.

Future research should consider not only baseline but also task-related HRV data in order to determine if any relationship can be found under those circumstances. The research into HF-HRV in relation to social anxiety has so far largely focused on clinical populations in the form of adult patients, whereas this study was intended to focus on the understudied segment of college students, especially freshman entering the college environment with novel social experiences and responsibility. The bulk of the literature also included tasks in their experimental designs, such as the camera-public speech setup to encourage observation-anxiety and mathematical problems in order to induce stress.

In conclusion, the unexpected results of this study may be due to a variety of factors. The reduced sample size, small percentage of participants meeting the social anxiety threshold, and the non-clinical nature of the sample are all possible reasons for the lack of findings. However, these aspects do not preclude the possibility that there may still be an association to be found between HF-HRV and social anxiety.

References

Åhs, F., Sollers, J. J., Furmark, T., Fredrikson, M., Thayer, J. F., Institutionen för psykologi, . . . Samhällsvetenskapliga fakulteten. (2009). High-frequency heart rate variability and cortico-striatal activity in men and women with social phobia. *Neuroimage, 47*(3), 815-820. doi:10.1016/j.neuroimage.2009.05.091

Alvares, G. A., Quintana, D. S., Kemp, A. H., Van Zwieten, A., Balleine, B. W., Hickie, I. B., & Guastella, A. J. (2013). Reduced heart rate variability in social anxiety disorder: Associations with gender and symptom severity. *PloS One, 8*(7), e70468. doi:10.1371/journal.pone.0070468

Beurs, E. d., Tielen, D., & Wollmann, L. (2014). The dutch social interaction anxiety scale and the social phobia scale: Reliability, validity, and clinical utility. *Psychiatry Journal, 2014*doi:10.1155/2014/360193

Buchanan, T. W., Driscoll, D., Mowrer, S. M., Sollers, J. J., Thayer, J. F., Kirschbaum, C., & Tranel, D. (2009;2010;). Medial prefrontal cortex damage affects physiological and psychological stress responses differently in men and women.

Chaló, P., Pereira, A., Batista, P., & Sancho, L. (2017). Brief biofeedback intervention on anxious freshman university students. *Applied Psychophysiology and Biofeedback, 42*(3), 163-168. doi:10.1007/s10484-017-9361-5

Cunningham, W. A., Van Bavel, J. J.,Johnsen, I. R., 2008. Affective flexibility: evaluative processing goals shape amygdala activity. Psychol. Schi.: J. Am. Psychol. Soc./APC 19, 152-160

DSM V: Available may 22, 2013. (2013). *Journal of Developmental & Behavioral Pediatrics, 34*(4), 261. doi:10.1097/DBP.0b013e3182978a90

Gaebler, M., Daniels, J. K., Lamke, J., Fydrich, T., & Walter, H. (2013). Heart rate variability and its neural correlates during emotional face processing in social anxiety disorder.*Biological Psychology, 94*(2), 319-330. doi:10.1016/j.biopsycho.2013.06.009

Kobayashi, H., Park, B., & Miyazaki, Y. (2012). Normative references of heart rate variability and salivary alpha-amylase in a healthy young male population. *Journal of Physiological Anthropology, 31*(1), 9-9. doi:10.1186/1880-6805-31-9

Lehrer, P., & Eddie, D. (2013). Dynamic processes in regulation and some implications for biofeedback and biobehavioral interventions. *Applied Psychophysiology and Biofeedback, 38*(2), 143-155. doi:10.1007/s10484-013-9217-6

Licht, C. M. M., de Geus, Eco J. C, van Dyck, R., & Penninx, Brenda W. J. H. (2009). Association between anxiety disorders and heart rate variability in the netherlands study of depression and anxiety (NESDA). *Psychosomatic Medicine, 71*(5), 508-518. doi:10.1097/PSY.0b013e3181a292a6

Nikolić, M., Aktar, E., Bögels, S., Colonnesi, C., & Vente, W. (2018). Bumping heart and sweaty palms: Physiological hyperarousal as a risk factor for child social anxiety. *Journal of Child Psychology and Psychiatry, 59*(2), 119-128. doi:10.1111/jcpp.12813

Pittig, A., Arch, J. J., Lam, C. W. R., & Craske, M. G. (2013). Heart rate and heart rate variability in panic, social anxiety, obsessive–compulsive, and generalized anxiety disorders at baseline and in response to relaxation and hyperventilation. *International Journal of Psychophysiology, 87*(1), 19-27. doi:10.1016/j.ijpsycho.2012.10.012

Rodebaugh, T. L., Woods, C. M., Heimberg, R. G., Liebowitz, M. R., & Schneier, F. R. (2006). The factor structure and screening utility of the social interaction anxiety scale.*Psychological Assessment, 18*(2), 231-237. 10.1037/1040-3590.18.2.231

Schry, A. R., & White, S. W. (2013). Understanding the relationship between social anxiety and alcohol use in college students: A meta-analysis. *Addictive Behaviors, 38*(11), 2690-2706. doi:10.1016/j.addbeh.2013.06.014

Strahan, E. Y. (2003). The effects of social anxiety and social skills on academic performance. Personality and Individual Differences, 34, 347–366. doi:10.1016/S0191–8869(02)00049–1

Thayer, J. F., & Lane, R. D. (2000). A model of neurovisceral integration in emotion regulation and dysregulation. *Journal of Affective Disorders, 61*(3), 201-216. doi:10.1016/S0165-0327(00)00338-4

Thayer, J. F., Hansen, A. L., Saus-Rose, E., & Johnsen, B. H. (2009). Heart rate variability, prefrontal neural function, and cognitive performance: The neurovisceral integration perspective on self-regulation, adaptation, and health. *Annals of Behavioral Medicine, 37*(2), 141-153. doi:10.1007/s12160-009-9101-z

Thayer, J. F., Åhs, F., Fredrikson, M., Sollers, J. J., Wager, T. D., Institutionen för psykologi, . . . Samhällsvetenskapliga fakulteten. (2012). A meta-analysis of heart rate variability and neuroimaging studies: Implications for heart rate variability as a marker of stress and health.*Neuroscience and Biobehavioral Reviews, 36*(2), 747-756. doi:10.1016/j.neubiorev.2011.11.009

Van Ameringen, M., Mancini, C., & Farvolden, P. (2003). The impact of anxiety disorders on educational achievement. Journal of Anxiety Disorders, 17, 561–571. doi:10.1016/S0887–6185(02)00228–1

Wager, T. D., & Etkin, A. (2007). Functional neuroimaging of anxiety: A meta-analysis of emotional processing in PTSD, social anxiety disorder, and specific phobia. *American*

Journal of Psychiatry, 164(10), 1476-1488. doi:10.1176/appi.ajp.2007.07030504

Psychoneuroendocrinology, 35(1), 56-66. doi:10.1016/j.psyneuen.2009.09.006

109 - 3-, 6-, and 12-Lead ECG | BIOPAC. (n.d.). Retrieved April 09, 2018, from https://www.biopac.com/application-note/ecg-ekg-electrocardiography-12-6-3-lead/https://www.biopac.com/application-note/ecg-ekg-electrocardiography-12-6-3-lead/