

EFFECTS OF HEART-RATE VARIABILITY BIOFEEDBACK TRAINING AND  
EMOTIONAL REGULATION ON MUSIC PERFORMANCE ANXIETY  
IN UNIVERSITY STUDENTS

Myron Ross Thurber, MS, PT, LPC, NCC, BCIAC

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APPROVED:

Cynthia Chandler, Co-Chair Major Professor  
Eugenia Bodenhamer-Davis, Co-Chair Major  
Professor

Steven Harlos, Committee Member  
Jan Holden, Departmental Counseling  
Program Coordinator

Ron Newsom, Interim Chair of the  
Department of Counseling,  
Development and Higher Education

M. Jean Keller, Dean of the College of  
Education

Sandra L. Terrell, Dean of the Robert B.  
Toulouse School of Graduate Studies

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Student musicians were recruited to participate in an experimental repeated measures research design study to identify effects of heart rate variability (HRV) biofeedback training and emotional self-regulation techniques, as recommended by HeartMath® Institute, on music performance anxiety (MPA) and music performance. Fourteen students were randomly assigned to a treatment or control group following a 5 minute unaccompanied baseline performance. Treatment group participants received 4-5 HRV training sessions of 30-50 minutes each. Training included bibliotherapy, using the computerized Freeze-Framer® 2.0 interactive training software, instruction in the Freeze-Frame® and Quick Coherence® techniques of emotional regulation, and also use of an emWave® portable heart rate variability training device for home training. Measures included the State-Trait Anxiety Inventory (STAI), Performance Anxiety Inventory (PAI), Flow State Scale (FSS), average heart rate (HR), and heart rate variability (HRV). Quade's rank transformed ANCOVA was used to evaluate treatment and no-treatment group comparisons. Combined MPA scores showed statistical significance at  $p=.05$  level with large effect size of  $\eta^2=.320$ . Individual measurements of trait anxiety showed a small effect size of  $\eta^2=.001$ . State anxiety measurement showed statistical significance at the  $p=.10$  level with a large effect size  $\eta^2=.291$ . FSS showed no statistical or effect size difference. PAI showed no statistical significance and a large effect size  $\eta^2=.149$ . HR showed no statistical significance and a large effect size  $\eta^2=.143$ . HRV showed statistical significance at  $p=.000$  level and a large

effect size  $\eta^2 = .698$ . This study demonstrated practical/clinical significance of a relatively quick and inexpensive biofeedback training that had large effect at decreasing mental, emotional, and physiological symptoms of MPA for university students.

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Myron Ross Thurber

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## CHAPTER 1

### INTRODUCTION

In the *Nature of Things, Book III circa 55 B.C.*, Lucretius said, “The dominant force in the whole body is that guiding principle which we term mind or intellect. This is firmly lodged in the midregion of the breast. Here is the place where fear and alarm pulsate. Here is felt the caressing touch of joy. Here, then, is the seat of the intellect and the mind” (Armour, 2003 pg. 1). Although many brain researchers in the 19th and 20th century discounted Lucretius, current research has again focused awareness on the role of the heart and brain in forming and perceiving emotion and what may be termed “the mind of the heart” (McCraty, 2006a; McCraty & Childre, 2003; Pribram, 1986).

Emerging research into the complex communication and balance between cognitive, physiological, and emotional states of being has led to innovations in technologies that influence human performance and function (McCraty, 2003a, McCraty, 2003b). Among the emergent understandings that drive technological advancement is the role of the human heart as an endocrine gland, a thalamic pace setter, and an independent seat of learning processing and function (Armour, 2003; Childre, Martin, & Beech, 1999; McCraty, Atkinson, & Tomasino, 2001). With this renaissance understanding has come new approaches and applications of psychophysiological self-regulation techniques to treat long-standing areas of human suffering such as anxiety disorders (Childre & Rozman, 2005).

Social anxiety, and more specifically music performance anxiety (MPA), has been a significant area of debilitating stress probably for as long as there have been musicians (Brodsky, 1996; Clark & Agras, 1991; Cox & Kenardy, 1993; Fishbein et al.,

1988; Kim, 2005; McGinnis & Milling, 2005; Plaut, 1990; Sareen & Stein, 2000; Steptoe, 2001). MPA continues to be a pervasive and significant problem for many professional and student musicians (Currie, 2001; Fishbein, Middlestadt, Ottati, Straus, & Ellis, 1988; van Kemenade, van Son, & van Heesch, 1995). Researchers have studied many coping strategies to decrease MPA. These strategies include pharmacological (Brantigan, Brantigan, & Joseph, 1982; Packer & Packer, 2005), behavior management (Steptoe & Fidler, 1987), cognitive techniques (Currie, 2001; Hipple, 2005), cognitive-behavior therapy (Kendrick, Craig, Lawson & Davidson, 1982), meditation (Chang, 2001), guided imagery (Esplen & Hodnett, 1999), biofeedback (Egner & Gruzelier, 2003; Neimann, Pratt, & Maughan, 1993; Tattenbaum, 2001), Alexander techniques (Valentine, Fitzgerald, Gorton, & Hudson, 1995), music therapy (Kim, 2005), hypnotherapy (Stanton, 1994), and combinations of treatment modalities with cognitive-behavioral intervention such as with medication (Clark & Agras, 1991; Kenny, 2005; Nagel, Himle & Papsdorf, 1989; Otto, 1999).

Anxiety disorders such as MPA can now be addressed with new psychophysiological applications like heart rate variability biofeedback (Armour, 2003; Childre et al., 1999; McCraty, 2003b; McCraty, 2006b). The Freeze-Framer® 2.0 interactive training software (Institute Of HeartMath Corporation, Boulder Creek, CA) (HeartMath, 2005) and Freeze-Frame and Quick Coherence® techniques of emotional regulation (D. Childre, Boulder Creek, CA) facilitate more regulated heart-brain communication and emotional regulation in real time using heart rate variability (HRV) training coupled with emotional management aimed at the mind-body connection. (Childre, 1998; Childre & Rozman, 2005). HRV is a biofeedback modality that uses

awareness of the beat-to-beat variations in heart rate to facilitate change (McCraty, 2002a). As Doc Childre, the founder of the Institute of HeartMath stated, “Since emotional processes can work faster than the mind, it takes a power stronger than the mind to bend perception, override emotional circuitry, and provide us with intuitive feelings instead. It takes the power of the heart” (McCraty et al., 2001 pg. 8).

### Statement of the Problem

Researchers have published findings that indicate positive effects of using HRV biofeedback training for improved work place performance and in decreasing test-taking and other forms of anxiety. However, there is no published research to date on the effects of HRV strategies to reduce MPA or enhance music performance. Brotons (1994), Wolfe (1989), and Chang (2001) stated that an ideal therapeutic intervention for musicians with MPA is one that uses a type of relaxation for calming, yet also keeps the musician’s arousal sufficient to maintain focus and attention. They support the need for a balanced mind-body approach to MPA. Lehrer (1987) concluded his review of approaches to MPA by stating there is a lack of treatments that combine several strategies. There is a need, therefore, for an MPA treatment strategy that can quickly teach the musician to be relaxed and calm while maintaining cognitive focus on their performance. This research study examined HRV biofeedback training as a combined mind-body-emotional strategy for enhancing musical performance and decreasing MPA.

### Purpose of the Study

The purpose of this study was to evaluate the effects of HRV biofeedback

training coupled with emotional regulation techniques on music performance anxiety in university musicians and music students.

## Review of Related Literature

### *Music Performance Anxiety*

Though MPA has been the focus of many studies, there is no clear definition of what constitutes MPA, its prevalence, or effective treatments for various components of music performance anxiety (McGinnis & Milling, 2005). A definition of MPA given by Salmon (1990) is “the experience of persisting, distressful apprehension about and/or actual impairment of, performance skills in a public context, to a degree unwarranted given the individual’s musical aptitude, training, and level of preparation.” (Salmon, 1990 pg. 3). In the *Diagnostic and Statistical Manual of Mental Disorders Fourth Edition, Text Revision*, (DSM-IV-TR), (American Psychiatric Association, 2000 pg. 456), MPA meets criteria for social phobia when it is marked with significant distress, anxiety, and/or avoidance. The criteria for diagnosable social phobia, includes: (a) a marked and persistent fear of one or more social or performance situations in which a performer’s exposure to unfamiliar people or to possible scrutiny may lead to humiliation or embarrassment; (b) exposure to the social situation provokes anxiety; (c) the individual self-identifies the fear as excessive or unreasonable; (d) the individual avoids the social or performance situation or experiences because of intense anxiety or distress; (e) the avoidance, anxiety, or distress experienced significantly interferes with the performer’s normal routine, occupation, school, and or social activities; (f) the distress or anxiety is not due to other substances, medical, or psychological conditions (American

Psychiatric Association, 2000). Though the DSM-IV-TR criteria for social phobia are clear, Osborne and Franklin (2002) reported that the DSM-IV criteria were met in only 27% of musicians reporting high levels of MPA. When Clark and Agras (1991) used a structured interview and surveyed potential subjects for their study of MPA, only 2 of 94 subjects met the DSM-III social phobia criteria when reporting that they experienced performance anxiety that impaired their performance or that their performance anxiety resulted in some avoidance of performance situations (Clark & Agras, 1991).

### *Prevalence of MPA*

Lederman, (1999) reported in his literature review that the prevalence of MPA ranges from 16% to 72% depending on the phrasing of questionnaires, context, and the person asking and answering the question. Steptoe and Fidler (1987) studied aspects of MPA in professional, adult amateur musicians, and college music students. The authors surveyed 65 professional orchestra players, 41 students, and 40 members of an amateur orchestra. The authors reported the mean prevalence of performance anxiety as 42.2 for professional orchestra musicians, 46.4 for amateur orchestra musicians and 50.3 for students. Amount of public performance experience did not appear to be a significant factor in performance anxiety across the subject groups. There was a high correlation between catastrophizing thoughts and high performance anxiety. Neuroticism was also highly correlated to higher performance anxiety. For music students there was a statistically significant correlation between fear of social situations and MPA, but this was not as significant for professional musicians and amateur musicians. Lacking in the study was a clear definition of what constituted high

performance anxiety and low performance anxiety outside of the questionnaires used. No established criteria for performance anxiety were stated. Of interest was the observation that there was a curvilinear pattern between realistic self-appraisal, catastrophizing, and apathy about the performance. The authors indicated that a musician with a medium level of performance anxiety performed better than a musician that had excessive catastrophic thinking or one that was too relaxed and apathetic (Steptoe & Fidler, 1987).

Fishbein et al. (1988) surveyed 2212 members of the International Conference of Symphony and Opera Musicians (ICSOM). Twenty-four percent of ICSOM members reported stage fright to be a problem, with 16% rating stage fright as a severe problem. The authors of this study reported that 19% of the women mentioned stage fright as a severe problem, whereas 14 % of men reported it as a severe problem. Nineteen percent of ICSOM members between the ages of 35 and 45 reported stage fright as a severe problem compared to those under 35 (17%) and those over 45 (11%). Brass musicians reported severe stage fright (22%) as compared to string player (14%), woodwind players (14%), and other instrument (17%). In this survey, Fishbein et al. identified MPA prevalence without clear definitions of what constitutes healthy or normal performance anxiety and unhealthy or disabling performance anxiety.

Van Kemenade et al. (1995) reported on the results of their survey of 155 professional musicians playing in symphonic orchestras in the Netherlands. The authors reported the mean age of their respondents at 42.0 years and a mean professional career of 19.2 years. The authors reported that 58.7% of the musicians experienced performance anxiety with 55% reporting that the anxiety considerably hampered their

professional life. The authors found no correlation between gender and prevalence of performance anxiety. The authors also found no significant correlation between years of experience and performance anxiety. The authors reported anxiety just before a performance in (81%) of respondents and during a performance in (91%) of respondents that reported MPA (van Kemenade et al., 1995).

Wesner, Noyes, and Davis (1990) surveyed 301 university music students and faculty. The authors reported that 21% of respondents reported marked distress while performing, 16.5% reported that their MPA negatively influenced their music performances and 16.1% indicated that it had negatively affected their careers. Women were more likely than men to experience MPA, and this was comparable to the findings of Fishbein et al. (Wesner, Noyes & Davis 1990).

### *Components of MPA*

Researchers have described MPA in many different ways. Salmon (1990) identified MPA as a combination of physiological, behavioral, and cognitive components. He stated that the physiological arousal and behavioral components are associated with conditioning of the autonomic nervous system (ANS), while the cognitive component is associated with anticipation of stressful events and cognitive appraisals that determine an emotional response. Salmon (1990) reported, in a thorough literature review of the psychological perspective on MPA, that the most widely held model of anxiety, developed by Lang, purports that anxiety is the product of interaction between fearful thought, autonomic arousal, and behavioral responses to a perceived threat. Salmon also reported that Beck, a respected cognitive therapist,



acknowledged research that showed physiological arousal might initiate a chain reaction that leads to anxious thoughts (Salmon, 1990). Miller and Chesky (2004) identified a complexity of MPA components, including a behavioral component, a physiological arousal component, and a cognitive-affective component, which included self-esteem of the performer (Miller & Chesky, 2004). The authors reported on the multidimensional nature of anxiety as encompassing cognitive, somatic, and self-confidence sources for symptoms and symptom intensity. Miller and Chesky hypothesized that there are state and trait differences in the three distinct sources of anxiety that require the intervening practitioner or teacher to take into consideration the nature and source of the anxiety before recommending the use of treatments including medication. Cognitive sources of anxiety were more intense than somatic sources and both interplayed with self-confidence. They showed that cognitive anxiety is greater among women and undergraduates and recommend that cognitive-based strategies be the first line of treatment in cognitive anxiety since medication such as beta blockers may not lessen the debilitating impact of physiological symptoms generated through cognitive sources. The authors identified physiological symptoms of somatic stress as possibly responding much better to medication such as SSRI, anxiolytics, and beta blockers (Miller & Chesky, 2004).

Liston, Frost & Mohr (2003) studied 118 graduate and undergraduate music students and concluded that the predominant indicators of MPA were cognitive catastrophizing and self-efficacy beliefs, or fear of judgment. The authors defined catastrophizing as maladaptive and irrational thoughts which give rise to debilitating emotional and ineffective behaviors. The authors suggested that their findings imply use

of cognitive and mental training treatments (Liston et al., 2003). A limitation of their study is the lack of full examination of the physiological and combined mind-body interactions that may also be good predictors of MPA. Research into the impact and connection between mind, body, and emotions indicate that emotions are a complex interchange of heart-brain and hormonal function and treatment that acknowledges this interaction may be superior to isolated or compartmentalized treatment (McCraty, 2006a).

### Coping Strategies for MPA

The largest study on the array of treatments tried by musicians for MPA was reported by Fishbein et al. (1988). The following table summarized their findings for treatments tried for stage fright and the effectiveness of those treatments.

Table 1  
*Summary of Treatments for Stage Fright*

	Percent tried	Success Ratio
Prescribed medication	40%	92%
Psychological counseling	25%	60%
Aerobic exercise	17%	70%
No treatment	14%	26%
Hypnosis	13%	60%
See general practitioner	11%	27%
Yoga	9%	58%
Non-prescription medication	6%	46%
Alexander technique	4%	47%
Massage therapy	4%	38%
Rest-stop playing	3%	100%

*Fishbein et al. (1988). Medical problems among ICSOM musicians: Overview of a national survey.*

### *Pharmacological Coping Strategies*

The use of drugs including alcohol and opiates to reduce social phobia and to alleviate anxiety is well documented in history (Preston, O'Neal, & Talaga, 2005; Lehrer 1987). In a survey taken in 1987, Steptoe and Fidler (1987) asked 65 professional orchestra musicians about their use of medication for stage fright and found 21 % of them used sedatives while 51% stated they used alcohol to cope with performance anxiety. These chemical agents have been used for centuries, but the side effects of sedation and mental foginess have plagued the performers and audiences (Preston et al., 2005). Clark and Agars (1991) studied buspirone as an anti-anxiety medication and found no statistical significance in decreasing MPA. The class of drugs that has been studied with the greatest effect on MPA is beta adrenergic blockers though there are definite pros and cons to their use (Lehrer, 1987; Lederman, 1999).

Brantigan et al. (1979, 1982) studied the effects of beta blockade and beta stimulation drugs on music performance and stage fright. Twenty-nine college students in Nebraska and New York in a cross-over trial, double blind study, were given either 40 milligrams of propranolol as a blockade, or a placebo on two consecutive days. On a third day, seven students tried a beta stimulator terbutaline. Brantigan et al. reported that telemetric electrocardiogram (EKG) and continuous heart rate were measured as well as blood pressure taken to verify physiological arousal, and subjective questionnaires were given to verify state and trait anxiety. Results indicated that taking 40 mg of propranolol 1.5 hours before a performance showed a statistically significant decrease in heart rate and increase in salivation. Those taking a beta stimulation drug showed no statistically significant decrease in physiological symptoms of stage fright

and subjectively reported increased anxiety symptoms. Subjective questionnaires for the students taking a beta-blocker drug showed a statistically significant decrease in the physiological manifestations of stage fright such as decreased nervousness manifested through a fast heart rate, tremors, sweating, accuracy, ease of performance, control, tempo, rhythm, patience, memory, and comfort. The students did not report a significant decrease in the emotional sense of nervousness concerning the overall performance. The authors noted that the students in New York had a higher base-line heart rate and possible stress level. The authors also noted that many of the students may have dropped out early from their studies and never become professional musicians because of the intolerance for stress (Brantigan, Brantigan, & Joseph, 1982; Brantigan, Brantigan, & Joseph, 1978) Lacking in the study was a clear definition of who had significant stage fright versus those who did not. The number of subjects was limited and the very small size of the audience may not be generalizable to performances with larger audiences.

The study by Brantigan et al. (1982) was significant because it influenced the current popularity of taking beta blockers for performance anxiety. In a study of 2122 professional orchestra musicians, 27% reported taking beta blockers, and of those, 70% did so without the direction of a physician (Fishbein et al., 1988). Brantigan and Brantigan (1984) later published two articles that condemned the use of beta blockers outside of medical oversight and reported

beta blockers should be viewed as an educational tool to teach the performer that it is unnecessary to be intimidated by audiences and by the performance itself. Psychological stress management techniques should be combined with drug therapy. Many musicians have found that once they have experienced performance without fear, they can then build the self-confidence necessary to

perform well without the drug. This will never happen without the conscious goal in mind to do so. (Brantigan, 1984 pg. 22)

The authors also later reported their belief that beta blockers will not make someone a better musician and that the practice of passing the drug from musician to musician is dangerous. These drugs most likely will never be FDA approved for MPA. The authors maintain that beta blockers may be effective for situational stress but not for continual stress “manifested by psychological symptoms” (Brantigan & Brantigan, 1984 pg 22). Fontanella also described a case report of significant abuse of self-prescribed propranolol and hypothesized that there may be an increasing informal use of beta blockers for social anxieties disorders and performance anxiety with unknown public health implications (Fontanella, 2003).

In a survey of studies on beta blockers and MPA, Packer and Packer (2005) reported that seven clinical trials of six different beta blocking drugs had been studied. Five studies reported significant decrease in heart rate. Three studies reported a subjective decrease in stage fright while one reported no significant difference in stage fright. One study reported no consistent improvement in technical improvement.

### *Behavioral Management*

In a comprehensive literature review, Kenny (2005) reported on eight different studies of the effects of behavioral interventions on MPA. The author reported that behavioral techniques such as behavioral rehearsal and systematic desensitization may have a minimal effect on MPA, but there is “no consistent evidence indicating the superiority of any one type of behavioral intervention” (p. 5).

### *Cognitive Therapy*

In a comprehensive literature review, Kenny (2005) reported on three different studies of the effects of cognitive therapy alone on MPA. The author reported that “no conclusions can be drawn at this time about the usefulness of cognitive interventions alone in the management of MPA” (p. 6).

In his dissertation, Currie (2001) reported the effects of a cognitive based coping skills seminar to reduce MPA. The author studied 35 students randomly assigned to a treatment and control group. The pre-test/post-test design evaluated MPA and musical performance quality. The students were administered two questionnaires to identify change. The intervention included participation in two fifty minute seminars teaching cognitive therapy principles. The results demonstrated no statistical difference between pre-and post-performance between the treatment and control group. Confounding factors cited included a too short treatment period, contamination of the control group, and the fact that the treatment group did not have a high enough initial level of MPA to show change (Currie, 2001).

### *Cognitive-Behavioral Therapies*

Kendrick et al. (1982) studied the effects of cognitive-behavioral therapy, (CBT) on 53 student pianists. Students were randomly assigned to an attentional training group, a behavioral rehearsal group, or a waiting list control group. Their teachers referred students with MPA who also self reported extreme MPA. The intervention lasted three weeks and included one to two hours of instruction in small groups and homework assignments. Measurements included self-report, videotaping, and telemetric

heart rate measured during performances. The authors concluded that both the cognitive based treatment and the behavioral-rehearsal treatment were effective in decreasing self-reported measures of MPA compared to a control group. Other areas of significant difference included reduction of visual signs of anxiety, improved quality of playing, and a decrease in negative self-talk. There was no statistically significant difference in heart rate (Kendrick et al., 1982). In her literature review, Kenny concluded that CBT therapy shows evidence of decreasing MPA, but there is no evidence that it is better than behavioral or cognitive therapy alone (Kenny, 2005).

### *Meditation*

Chang (2001) studied 19 music students from four universities. The students were randomly assigned to a treatment group who received instruction in meditation and a control group who received no treatment. The treatment consisted of 8 weekly 75 minute meditation classes with a meditation expert. The participants were encouraged to practice meditation daily for 20 minutes. Twice during the meditation classes the students practiced meditation prior to music performances. Chang assessed anxiety using a form of Spielberger's Trait Anxiety Inventory (STAI-Y), the Perceived Anxiety Inventory (PAI), and a Cognitive Interference Questionnaire (CIQ). The author had the participants fill out the questionnaires at the beginning of the study and before and following a single performance after completing the treatment. Analysis showed no statistically significant differences between the treatment and control group on trait anxiety. The author found no statistically significant difference between the treatment and control groups' abilities to concentrate during their performance. The author did find

statistically significant difference in the pre- to post-performance state anxiety for the meditation group of 2.007,  $p < 0.05$ , but found no statistically significant difference pre- to post-performance for the control group. The author found no statistically significant difference in post-performance state anxiety between the treatment and control group using a paired-sample  $t$ -test, but did find a moderate effect size  $t(17) = 1.073$ ,  $p < 0.15$ ,  $d = 0.5$ . (Chang, 2001; Chang, Midlarsky & Lin, 2003). The study lacked a clear definition of performance anxiety that applied to the study and used a small sample. In her dissertation, Chang questioned whether a low heart rate was linked to lower levels of performance anxiety, and questioned when to apply meditation in relation to practice and performance (Chang, 2001).

### *Guided Imagery*

Esplen and Hodnett (1999) studied 21 music students who were trained in using guided imagery as compared to 45 students who declined the intervention to identify the effect of guided imagery to manage performance anxiety. Their design was a one-arm pre-post design. Their result indicated that there was a significant difference in mean state anxiety ratings between an imagined performance and prior to an actual performance. The authors also found no statistically significant difference between pre- and post-performance satisfaction. The authors reported that 95% of the student musicians reported that guided imagery improved their performance after using a guided imagery tape. This study lacked a clear definition of MPA and did not use other measures besides self-report to verify whether MPA was present during the two performances. The authors did not report effect sizes.



### *Alexander Technique*

Valentine et al. (1995) studied the effects of Alexander techniques, a series of relaxation and postural awareness exercises, on twenty-five music students randomly assigned to a treatment or control group. The treatment consisted of 15 lessons in the Alexander technique. During pre- and post-testing, the students reported their MPA, on four occasions, on the Performance Anxiety Inventory and the Eysenck Personality Inventory. The authors also measured heart rate, mood, and experts'-measured musical quality during the four occasions identified as two low stress performances and two high stress performances. The authors reported that the treatment group showed significant improvement in technical quality, musical quality, improved positive mood, and less change in average heart rate as compared to the control group in the low stress performances. The control group showed lower change in average heart rate as compared to the experimental group from audition to recital, which the authors identified as a high stress situation (Valentine et al., 1995). The authors concluded that, in the high stress performance condition, there was some improvement in MPA psychologically, but the opposite was true for physiological measurements in those conditions.

### *Music Therapy*

In a comprehensive literature review, Kenny (2005) reported on two different studies by Montello on the effects of music therapy on MPA. In a 12-week music therapy intervention that included improvisation training, 10 participants showed significant improvement in confidence and decreased anxiety as compared to a wait-list

control group. Kenny noted that this type of treatment may work better for highly trained musicians and performers than for novice students.

Kim (2005) partially replicated Montello's studies of the effects of music therapy using improvisation, rhythmic breathing, and desensitization on six student pianists. The author evaluated the students' pre- and post-training tests. The intervention consisted of six improvisational training practice sessions with breath training and desensitization. The students' MPA was assessed using STAI-Y, Likert Anxiety Scale (LAS), and the Performance Anxiety Response Questionnaire (PARQ). The author reported a significant difference between pretest and posttest on the LAS and STAI Y-1 (state portion only). This study lacked a control group and had a small sample size.

### *Hypnotherapy*

Stanton (1994) studied the effects of two-sessions of hypnotherapy on forty music students. The author assigned students to a treatment or control group. The students self-reported their MPA using the Performance Anxiety Index (PAI). Both groups recorded their PAI at the beginning of the study and after six months. The experimental group recorded their PAI two weeks after the treatment sessions and at six months following treatment. The treatment group showed a statistically significant decrease in MPA as compared to the control group at two weeks and a greater statistically significant decrease in MPA at six months compared to the control group. The study relied only on self-report measures of MPA and did not test the students in an actual performance condition.

## *Biofeedback*

Egner & Gruzelier (2003) reported on two subsequent studies of thirty six and sixty-one students respectively that compared the effects of neurofeedback treatment, exercise and mental training, and a no treatment control group. Neurofeedback is a form of biofeedback that uses real time feedback of brain wave activity to the participant so they can use the information to alter the amount and type of brain wave activity that corresponds to different mental and physical states, using an operant conditioning paradigm. The authors trained students with neurofeedback at scalp location C3 and C4 to enhance the sensory motor rhythm (SMR) and beta frequencies to increase attention, and then trained at the PZ location to increase theta and alpha frequencies during eyes closed deep relaxation (alpha/theta training). The comparative treatment groups used exercise, mental imagery, and postural exercise using the Alexander Techniques (Egner & Gruzelier, 2003). Students rated their performance anxiety using the STAI-Y, the PAI, and expert raters scored the students on the quality of two musical performances. The authors reported that the alpha/theta training group showed statistically significant improvement in quality of performance, whereas the other treatment groups showed no improvement. MPA was reduced in all groups, but the reduction was not statistically significant (Egner & Gruzelier, 2003).

Niemann, Pratt, & Maughan (1993), surveyed twenty-one students either who participated in an integrative approach of biofeedback training and relaxation exercises or who were in a wait-list control group. The treatment consisted of six 35-minute biofeedback sessions and six 1-hour meetings to teach breath awareness, muscle relaxation, and performance-coping imagery. The group session followed

Meichenbaum's (Niemann et al., 2003) three-stage model of stress inoculation of teaching about stress, cognitive rehearsal, and homework assignments using strategies. Biofeedback training included audio cueing of relaxation of the frontalis muscles of the forehead and increased hand temperature of the right index finger. The students recorded measures of anxiety using the STAI-Y and Wolfe's Facilitative/Debilitating Anxiety Scale completed before their music lessons and their jury performances. The authors reported statistically significant reduction in MPA before lessons and jury performances by the treatment group versus the control group, who showed no reduction in MPA (Niemann et al., 1993).

### *Combined Treatments*

Researched coping strategies typically address one or two of the components of MPA but fail to address specifically the connection between mind, body, and emotion in a direct and purposeful manner (Brodsky, 1996; Lehrer et al., 1990). Salmon (1990) stated that the best psychotherapeutic interventions are successful only to the degree that they address multidimensional aspects including physiological, cognitive and behavioral components (Salmon, 1990). For example, a practice such as treatment with beta blockade drugs can decrease physiological symptoms without addressing underlying cognitive or emotional components (Brantigan & Brantigan, 1984). Another example is cognitive therapies that identify and modify irrational thoughts and beliefs as a way to manage anxiety through the belief that poorly controlled negative expectations and thoughts can lead to amplifications or exaggerations that increase physiological manifestations of anxiety and perceived failure, (Kleinke, 1998/2002; Otto, 1999) but fail

to address that negative emotions drive physiology faster than thoughts (McCraty, 2003), decrease prefrontal cortex activation, (Hofmann et al., 2005), and can negatively impact hormonal control (McCraty et al., 1998).

Clark and Agras (1991) studied 94 subjects using an experimental design that compared four different randomly assigned treatment conditions. The first group received six weeks of drug therapy using buspirone. The second group received six weeks of a drug placebo. The third group received five sessions of group cognitive-behavioral therapy with buspirone. The fourth group received five sessions of group cognitive and behavioral therapy with a drug placebo. The authors tested the musicians' heart rate and self-reported anxiety during music performance and in giving speeches. The authors reported that buspirone was not an effective treatment, but reported a statistically significant reduction of self-reported anxiety for the cognitive and behavioral intervention. The authors reported no change in physiological measurement of heart rate between pre- and post-groups and were unable to account for the psychological report change with no physiological change.

Nagel et al. (1989) reported on their pilot study that combined a treatment of cognitive behavioral therapy (CBT), progressive muscle relaxation, and temperature biofeedback training. The authors studied twenty undergraduate music students who were randomly assigned to a treatment or control group. All participants reported twice on multiple questionnaires including the STAI-Y and the PAI. The treatment group met once per week for six weeks and was taught CBT techniques based on work by Meichenbaum and Ellis. Each student in the treatment group also received six individual biofeedback sessions that included progressive muscle relaxation with temperature

biofeedback. The authors reported statistically significant differences between the treatment and control group on MPA reduction as reported in the PAI and the trait portion of the STAI-Y (Nagel et al., 1989). The authors' pilot study included a small sample and did not measure the students during actual performance. The authors did not report on the physiological, temperature training effects of the students. The study also suffered from possible type 1 error by administering five different questionnaires to find statistical significance.

### *Summary of Research on Treatments of MPA*

A review of the literature on the effects of treatment for MPA reveals that beta blockers can reduce some of the physiological components of MPA, but do little to reduce the psychological components. Beta blockers should only be used under medical supervision and currently may be misused and overused (Lehrer, 1987). Some efficacy has been demonstrated with behavioral and cognitive-behavioral techniques, but no conclusion is available for cognitive therapy alone. However, students and musician in general "do not seem to utilize these treatments" (Brodsky, 1996). Studies on hypnosis, music therapy, and Alexander techniques are promising, but further research with larger samples are needed (Kenny, 2005). The studies on meditation and guided imagery alone showed no significant effect on MPA. Electromyography (EMG) and temperature training biofeedback have been effective when combined with other psychological interventions. EEG Biofeedback, or neurofeedback, has been effective in improving performance quality, but further study is needed to demonstrate efficacy in reducing MPA. This review of literature leads to the conclusion that techniques that

combine mental, physical, and emotional components of MPA show greater efficacy in reducing MPA than single modalities that focus on one component of MPA alone.

None of these researchers who have studied the effects of various MPA coping strategies directed at physiology, cognition, and behavior have recognized the importance of the emerging body of research on the nature of emotion and the heart-brain connection. Sinden reported (1999) that helping student musicians with MPA will require better adaptive coping styles than treatments that simply address a set of symptoms.

In light of these findings, it seems worthwhile to explore recent research on heart rate variability biofeedback that combines physiological regulation with emotional shift techniques incorporating imagery and cognitive-behavioral methods.

## Application of New Coping Strategies

### *Concepts in Mind*

Research by Dr. Karl Pribram has introduced the holographic model of mind/brain function (Pribram, 1986) that informed the development of emotional shifting and psycho-physiological instrumentation (McCraty, 2003a). Pribram stated that the brain is constantly sampling the internal and external environment for matching patterns. Neither the structural cause and effect view nor the existential/phenomenological view of how the mind and perception work is sufficient. Pribram stated that when perception or changes to expected patterns are found, regardless of valence, the mind, the senses, and the body systems are all alerted and act in a cooperative pattern to respond and maintain the pre-set pattern (Pribram,

1986). Previous belief that emotions are the by-product of brain function has been replaced with a comprehensive view that the heart, brain, and body work in concert in response to stress from the internal and external environment (HeartMath, 2002).

### *Concepts in Emotion*

Frederickson (2001) described affect as a general concept of consciously accessible feelings and emotion as a subset of affective phenomena. Fredrickson stated that the meaning individuals attach to events influences emotions, and perceptions, and these perceptions and meanings trigger a cascade of responses such as subjective experience, facial expressions, cognitive processing, and physiological changes (Fredrickson, 2001). When a person is functioning at peak capacity, including mind, body, and energetically, the perception is one of well being and timelessness and has been described by Csikszentmihalyi as “flow” (1990). The experience of flow is antithetical to performance anxiety and is a sought-after state by musicians who pursue excellence, self-regulation, optimism, and health (Jackson & Marsh, 1997; Seligman & Csikszentmihalyi, 2000).

### *Concepts in Heart-Brain Communication*

A well-researched method for learning to achieve optimal and positive states of functioning, such as flow, is called “psychophysiological coherence” (McCraty, 2006a). Psychophysiological coherence is characterized by balance in the autonomic nervous system. In the “coherent” state, the emotions, perceptions, and heart-brain communication are synchronized in a joint time/frequency domain (McCraty, 2002a).



The communication between the brain and the heart is transmitted neurologically via nerve impulses, biophysically through pulse wave, biochemically through hormones, and energetically through electromagnetic fields and transmitted to every cell of the body (McCraty, 2001). Bringing these different forms of psychophysiological communication into closer alignment or synchronicity enhances efficiency, increases a sense of well being, promotes health, and improves cognitive function and performance (McCraty, 2006a, Childre & Cryer, 2004). One way to monitor a person's level of stress and their state of psychophysiological coherence is through heart rate variability biofeedback (Tiller, McCraty, & Atkinson, 1996). Heart rate variability is a joint time/frequency analysis of the beat-to-beat changes in the heart rate or rise and fall of heart rate and is a common way to monitor fetal stress during pregnancy (Obstetrics and Neonatal Nurses Association of Women's Healthbook, 1993), autonomic health (Umetani et al., 1998; McCraty et al., 1995), and measure effects of stress on the body (Task force et al., 1996). When a person is in a state of anxiety, confusion, or sustaining prolonged negative emotion, the heart rate variability shows a decrease in coherence (McCraty, Tiller, & Atkinson, 1996).

Heart rate variability biofeedback training is a non-invasive form of biofeedback that monitors the beat-to-beat changes in heart rate and blood volume and displays this information in a graphic form for the participant to see and manipulate (Culbert, 2004). Measurement of beat-to-beat changes are monitored through changes in pulse rate and blood flow using an electrode, for an electrocardiogram (ECG) placed on the chest, or a photoplethysmograph optical sensor (PPT) placed on the ear or finger. Computerized programs can interpret the information of pulse rate (ECG) or blood pulse volume pulse

wave (PPT) into a spectral display of heart rhythm patterns (McCraty, 2002a). These patterns are accurate and powerfully display autonomic nervous system and psychophysiological function (McCraty, 2006a). Training consists of teaching the participant to decrease the chaotic or stress heart patterns, seen as jagged and unorganized patterns on the computer display, and replacing them with organized and smooth patterns (Culbert, 2004). Strategies may include relaxed and rhythmic breathing, letting go of stressful thoughts and feelings, and focusing on sustained neutral or positive emotions like appreciation or care (McCraty, 2002a). The smooth patterns or heart rhythms represent synchronized and organized communication and interaction between body systems such as breathing, heart rate, hormonal control, and brain waves. These synchronized patterns are said to be in psychophysiological coherence (McCraty, 1996). When coherence is accompanied by effective emotional regulation there is a high degree of psychophysiological coherence which is often accompanied by feelings of calmness, mental clarity, and ease (Childre & Cryer, 2004; Childre & Rozman, 2005).

Researchers have studied effective use of emotional shifting and combined use with cognitive techniques as being useful to decrease anxiety related conditions such as panic attacks (Friedman & Thayer, 1998) and test taking anxiety (Aasen & Thurik, 2000). Heart rate variability biofeedback has also been shown to be effective in treating major depressive disorders (Karvidas et al., 2005), decreasing asthma (Lehrer, Smetankin & Potapova, 2000), improving healthy hormonal balance, (McCraty et al., 1998), for treatment of congestive heart failure, (Luskins et al., 2002), and enhancing health in patients with diabetes (McCraty, Atkinson, & Lipsenthal, 2000).

Benefits to HRV training include improved cardiovascular function (Nolan, 1998; Vaschillo et al., 2002), decreased stress response (McCraty, 2006a), improved mental function, and improved student performance (McCraty, 2002b). Researchers have shown the positive effects of HRV biofeedback training on stress response and anxiety similar to MPA (Arguelles, McCraty, & Rees, 2003; Barrios-Chopin, McCraty & Cryer 1997; McCraty et al., 1999a; McCraty et al., 1999b; McCraty et al., 2003; Strack, 2003). Arguelles et al. (2003) reported that using HRV biofeedback training in school help children diminish unhealthy patterns of behavior and thinking and re-establish a new stable baseline that encourages physiological efficiency, mental acuity, and emotional stability. The authors reported that studies in elementary, middle school, high school, and college levels that utilize the HRV training and emotional management techniques demonstrated improved emotional well being, classroom behaviors, learning, and academic performance in students. One study of 60 students in sixth through eighth grade assigned randomly to a treatment or control group assessed HRV immediately prior to and following a structured interview to elicit emotional responses to real-life stressful issues. The authors reported that those children who had practiced the HRV biofeedback training and emotional regulation techniques were able to better modulate their physiological stress responses in comparison to the control group (Arguelles et al., 2003). The significance of this report and similar studies is that HRV biofeedback training can be used effectively to decrease negative emotion and enhance learning across a variety of students and settings.

Barrios-Chopin et al. (1997) studied the effects of HRV and emotional regulation techniques on 48 adult workers in a factory setting. A psychological measure of stress

and well-being were given as pre- and post-measures. The authors assessed physiological measures of HRV and blood pressure. Participants were taught emotional regulation and HRV biofeedback training techniques using Freeze-Frame techniques from the HeartMath Institute. The authors used analysis of variance (ANOVA) and paired sample *t*-test to analyze two groups. One group was comprised of managers and engineers and the other group was comprised of factory workers. The authors reported that the management and engineers' group showed a statistically significant increase in the workers' contentment and a decrease in nervousness and the symptoms of stress. The authors also reported that the factory workers' group had a statistically significant increase in communication and job satisfaction as well as a decrease in tension and anxiety. Physiological measures of blood pressure demonstrated some previously undiagnosed hypertensive participants who were able to significantly reduce hypertension. The authors reported a significant decrease in resting unhealthy autonomic function for the participants (Barrios-Choplin et al., 1997). The significance of this study was that HRV and emotional regulation can improve affective and physiological measures of performance and stress in an adult population.

McCraty et al. (1999a) studied the physiological effects of HRV and emotional regulation training on 65 police officers exposed to stressful scenarios. The officers were divided into a treatment and control group. Twenty-four hour autonomic nervous system assessments and ECGs were studied using telemetric units. Results indicated that the officers that received the training were able to significantly decrease negative emotions, fatigue, and physical stress along with an improved sense of peacefulness, vitality, and performance. The authors reported that the participants were able to

manage and transform “stress-producing perceptions and negative emotional reactive patterns” (McCraty et al., 1999a pg 18). The significance of this study is that musicians, like highly-stressed police officers, can benefit from decreased negative emotional reactive patterns during performance situations.

Assen & Thurik (2000) reported in a pilot study on the effects of HRV and emotional regulation training on test taking anxiety experienced by high school students who had already failed their state-mandated tests in math and reading at least once. Twenty-nine seniors who needed to re-take the reading and math tests were instructed in HRV biofeedback and emotional regulation for three weeks for a total of twenty-five hours. The authors compared the scores of the experimental group to a control group. The reported results of the treatment group included a 14% average gain in reading scores which was nearly twice as great as the expected improvement that students make over a one year’s time in standard academic classes. Students who received the treatment showed a 35% increase in math scores as compared to no improvement in math scores for students for three previous years district wide (Assen & Thurik 2000). This study is significant in showing the ability of emotional management tools and HRV biofeedback training to improve performance similar to MPA in a population similar in age to college students and in a pressured school setting.

### Summary

Music performance anxiety is a significant problem for many musicians. Music performance anxiety is comprised of a combination of physiological, cognitive, behavioral, and emotional components. Researchers do not agree on what constitutes

MPA. The most effective ways to treat each component or combinations of components have not been fully explored or clarified with research although modalities that address multiple components of MPA may be more effective than modalities that address only one component. Emergent research into how the brain functions, the role of the heart-brain interaction, and emotional regulation has given rise to new technology and research potentials. Heart rate variability biofeedback and emotional management tools from the HeartMath Institute have been used successfully to decrease anxiety in work performance and school settings with anxiety components. No research is available on the effects of HRV biofeedback and emotional regulation on musical performance and MPA with music students.

## CHAPTER 2

### METHODS AND PROCEDURES

#### Research Question

What effect does heart rate variability biofeedback training have on music performance anxiety experienced by university musicians and music students?

#### Research Hypotheses

1. The treatment group will show no statistically significant difference in music performance anxiety as measured by a combined standardized score of trait anxiety, state anxiety, the Performance Anxiety Inventory, average heart rate, low coherence HRV, and the Flow State Scale compared to a no-treatment control group
2. The treatment group will show no statistically significant difference in trait and state anxiety in pre- and post-testing at baseline and during a pre- and post-treatment music performance as measured by the STAI-Y compared to a no-treatment control group
3. The treatment group will show no statistically significant difference in music performance or “flow” in pre- and post-testing measured by the Flow State Scale compared to a no-treatment control group
4. The treatment group will show no statistically significant difference in music performance anxiety in pre- and post-testing measured by the Performance Anxiety Inventory Scale compared to a no-treatment control group
5. The treatment group will show no statistically significant difference in heart rate and heart rate variability in pre- and post-music performance as compared to a no-treatment control group
6. The treatment group will show no statistically significant difference in electrodermal activity (EDA) and temperature measured during pre- and post-treatment music performance as compared to a no-treatment control group
7. Participants in the treatment group with high trait anxiety will show no statistically significant difference in ability to train to a criterion using HRV biofeedback training than students with low trait anxiety

8. Musicians with high trait anxiety will show no difference in pre- and post-STAI (trait=TA and state=SA), PAI, FSS, HRV, EDA, or temperature, as measured throughout the research project than musicians with low trait anxiety

## Methods

### *Definition of Terms*

Autonomic nervous system: The portion of the peripheral nervous system that regulates most of the body's involuntary functions (HeartMath®, 2002)

Coherence: for the purpose of this study coherence will be used interchangeable with psychophysiological coherence that is “a state of sustained positive emotion, a high degree of mental and emotional stability, constructive integration of the cognitive and emotional systems and increased synchronization and harmony between cognitive, emotional and physiological systems.” (McCraty 2001 pg. 17)

EDA: Electrodermal activity is a measure of autonomic nervous system arousal based on passing an electrical current between two contacts on the skin and measuring the change in electrical conductivity based on the increase and decrease of sweat response. (Criswell, 1995)

emWave: A portable HRV training biofeedback device.

Flow: A concept of balance between challenge and enjoyment. The concept was promoted by Csikszentmihalyi to identify optimal experience and peak performance. The concept is used widely in sports and other performance venues. (Csikszentmihalyi, 1990)

HRV: Heart rate variability. A measure of the beat-to-beat changes in the heart as used for diagnostic and training purposes as a measure of autonomic health and function (McCraty, 2006a).



MPA: Music performance anxiety is the product of interaction between fearful thought, autonomic arousal, and behavioral responses to a perceived threat.

(Salmon, 1990)

PAI: The performance anxiety Inventory developed by Nagel et al. (1989).

STAI Y-1 The state portion of the STAI-Y assessing transient changes in anxiety (Spielberger, 1983).

STAI Y-2 The trait portion of the STAI-Y assessing persistent personality features of anxiety (Spielberger, 1983).

STAI-Y State Trait Anxiety Inventory for Y developed by Spielberger et al. (1983).

### *Instruments*

#### State-Trait Anxiety Inventory

The State-Trait Anxiety Inventory form Y (STAI-Y) and its derivations are the most widely used instrument for measuring state and trait anxiety (Spielberger, Gorsuch, Lushene, Vagg, & Jacobs, 1983) it has been widely used in studies of MPA (Chang, 2001; Clark & Agras, 1991; Kenny et al., 2003; Lehrer et al., 1990, Miller & Chesky, 2003; Otto, 1999; Stephenson & Quarrier, 2005). The STAI separates the enduring long-term characteristics of predisposition toward anxiety as an indication of a trait versus the shorter duration situational ups and downs of anxiety, or state anxiety. The instrument has well established validity and reliability (Spielberger et al., 1983). Cronbach's coefficient alpha for internal consistency is reported to be .93 for participants reporting on taking an exam.

According to Cox & Kenardy (1993), high trait anxiety, denoted as 42 or higher on the STAI Y-2, predicted higher music performance anxiety across settings of practice, solo performance, and performing in a group. The authors conducted research on 32 music students at the University of Newcastle's Faculty and Conservatorium of Music. Research was conducted by self-report questionnaires including the STAI and the Performance Anxiety Questionnaire (PAQ). ANOVA yielded a main effect for trait anxiety on the level of music performance anxiety as [ $F(1, 30) = 8, p < 0.01$ ]. ANOVA for the level of anxiety in three performance settings [ $F(2, 60) = 62.15, p < 0.0001$ ]. The authors found no statistically significant difference in the interaction between performance setting and trait anxiety; though no effect size calculation was made. Another reported finding was that social phobia was not distinguishable as a separate entity from MPA (Cox & Kenardy, 1993).

For the purpose of this study, I used STAI Y-2 trait portion as a measure of anxiety at pre- and post-baseline to establish anxiety trait and STAI Y-1 pre-performance to identify state changes in anxiety. The STAI-Y is the most widely used instrument reported in research on MPA. For the purpose of this study, any participant whose trait anxiety was one standard deviation above the mean using both gender and age as qualifiers (Spielberger, 1983) was considered as having high anxiety. I identified all students who scored at or below one standard deviation of the mean using both gender and age as qualifiers as low trait anxiety musicians.

### Flow State Scale

The Flow State Scale (FSS) was developed by Jackson and March (1996) based

on the work of Csikszentmihalyi. The instrument has 36 items and represents the concept of “flow” which attempts to quantify peak performance as a positive performance state that balances enjoyability with challenge. The FSS is a self-report measure following a performance or event on a 5 point Likert scale that range from (1) *strongly disagree* to (5) *strongly agree*. A global score or individual item scores can be used in comparison of repeated performance. Cronbach’s coefficient alpha for internal consistency is reported to be .83. For this study this instrument was used at the initial baseline and as a pre- and post-treatment measure to quantify the experience of flow for participants as compared to the control group. I used this measure to indicate the musicians perceived quality of performance and to indicate performance enhancement differences between the treatment and control groups.

#### Performance Anxiety Inventory

The Performance Anxiety Inventory (PAI) was developed by Nagel et al. (1989). The authors relied on the constructs of MPA being influenced by cognitive, behavioral, and physiological components. The authors based the PAI on the general form of Spielberger’s Test Anxiety Inventory. The PAI consists of 20 self report items given before a performance. The PAI contains a 4 point Likert scale that range from (1) *almost never* to (4) *almost always*. Cronbach’s coefficient alpha for internal consistency was reported to be .89. For this study this instrument was used at baseline and as a pre- and post-treatment measure to quantify the amount of MPA experienced before performances as compared to the control group.

## Participants

I recruited participants for the study primarily through the College of Music at the University of North Texas and through flyers distributed on the University of North Texas campus and Texas Women's University (TWU). I gave a short five minute presentation on the study in music history and music theory classes. I also gave presentations in three undergraduate psychology classes that offered extra credit for students that participate in university sponsored research. E-mails were sent to music faculty at TWU and information was placed on the University of North Texas Neurotherapy Lab webpage. The participants were musicians that were at least eighteen years old and signed informed consent to participate in baseline testing, complete anxiety/stress questionnaires, to perform twice an unaccompanied piece of music 5-8 minutes long in front of an audience, and to participate in post- performance testing.

The study included 20 musician volunteers. Five dropped out of the study due to schedule conflicts or illness and one was dropped from the study due to taking beta-blockers for high blood pressure, leaving 7 in the HRV treatment group and 7 in the control group. The groups were diverse. There were 9 males and 5 females.

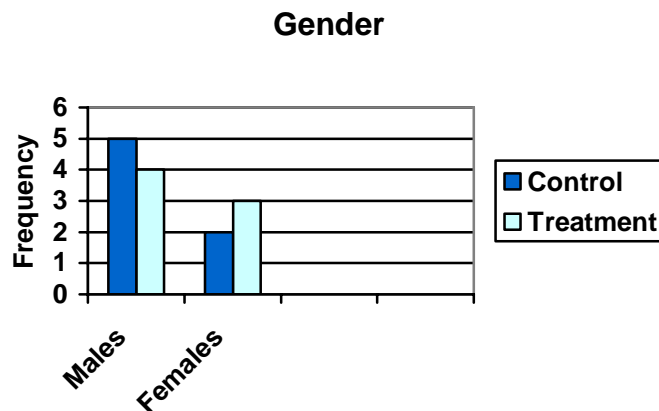


Figure 1. Gender distribution.

The participants identified their ethnicity as 1 African-American, 2 Asians, 8 Whites, 2 Hispanics, and 1 biracial.

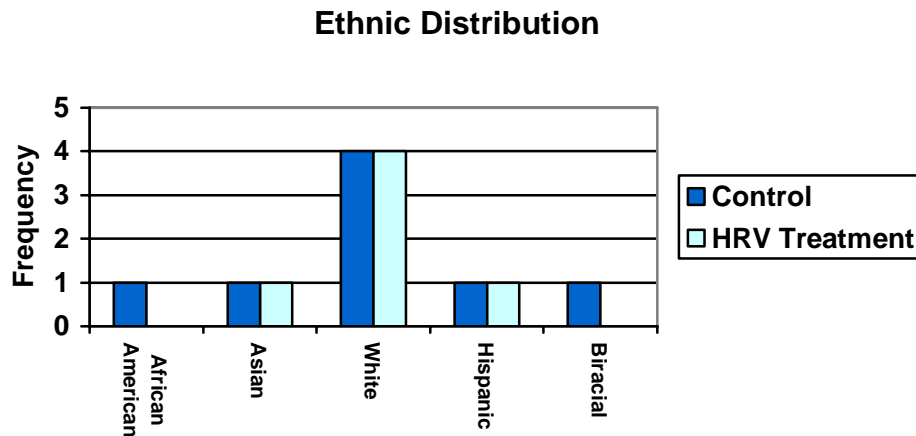


Figure 2. Ethnic distribution.

The mean age was 23.42, and the age range was from 19 to 32. There was a bimodal distribution with 3 persons age 20 and 3 age 25.

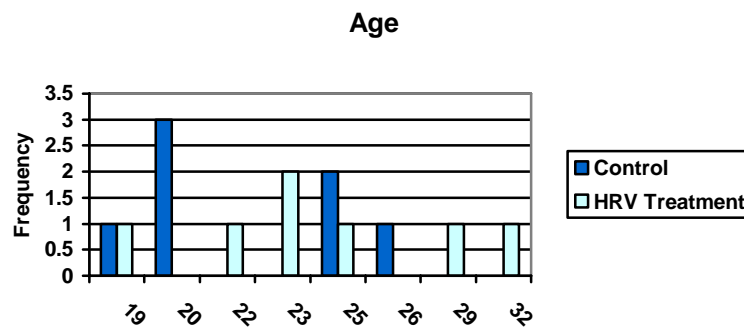


Figure 3. Age distribution.

The musicians were diverse in their primary instruments. There were 4 vocal performers, 3 piano, 2 trumpet, 1 flute, 1 guitar, 1 double bass, 1 percussion, and 1 that performed on a combination of guitar drum and voice.

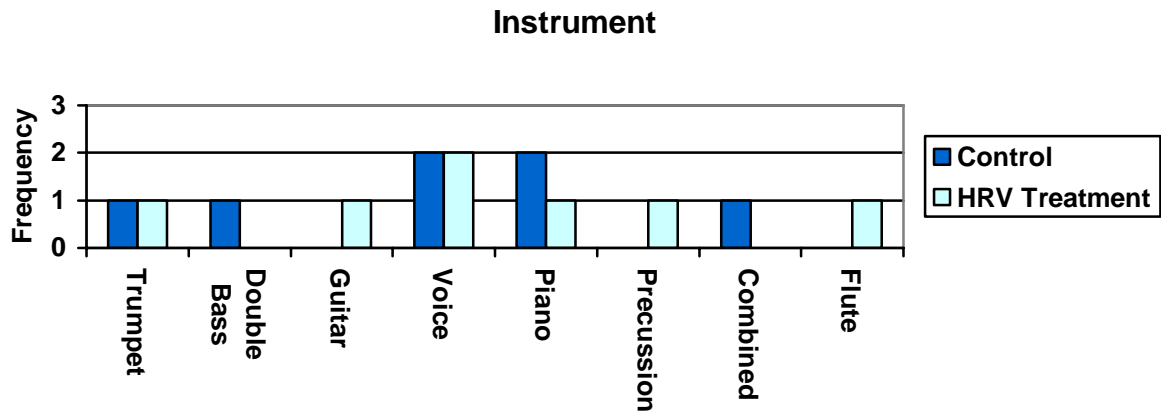


Figure 4. Primary instrument.

The students' degree level included 9 undergraduates, 2 master's level students and 3 doctorate level students.

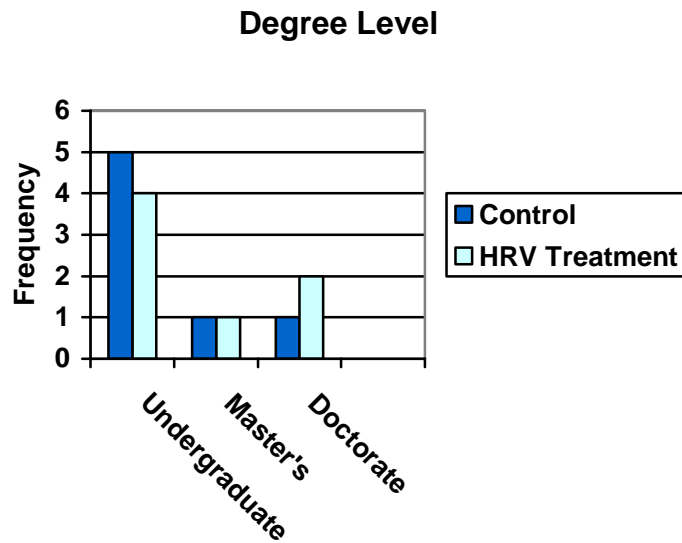


Figure 5. Degree level.

The students' declared majors included 8 in music performance, 2 in music education, 1 music theory, 3 psychology, and 1 early childhood education.

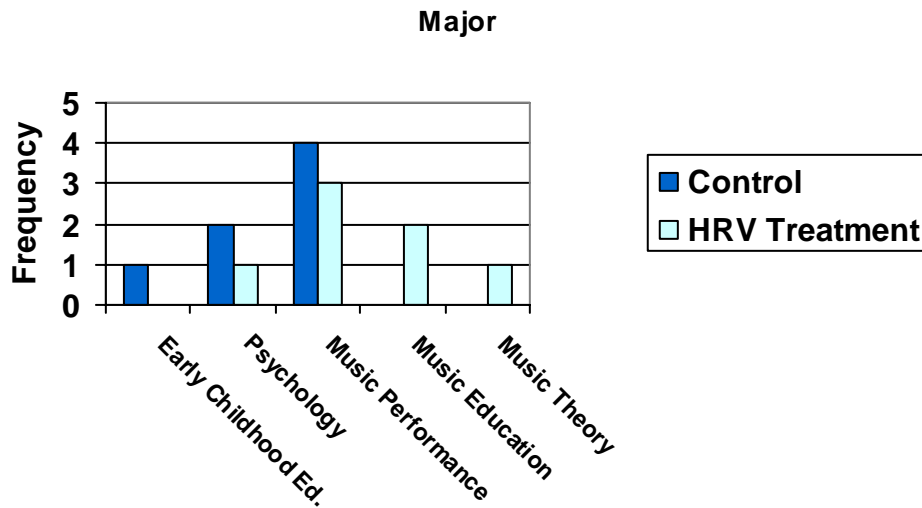


Figure 6. Major.

I excluded volunteers from the study if they were taking beta blockers or other medication that decreased physiological or autonomic arousal. Following the study, I gave all participants in the control group the opportunity to learn the techniques taught to the experimental group. All participants were paid \$20 after completing all aspects of the study.

### *Procedure*

Participants signed an informed consent at an informational meeting or at the first meeting with the researchers before the study began. The participants identified the instrument or voice they used, and selected an unaccompanied piece lasting about 5 minutes long that was already familiar and somewhat challenging for them. Participants also agreed to the dates of their first and second performances so as to keep the time and place of both performances the same. The participants then completed a demographic questionnaire and filled out self-reported psychological measures which

included a Performance Anxiety Inventory (PAI), the State-Trait Anxiety Inventory form Y (STAI Y-1 and STAI Y-2), and the Flow State Scale (FSS). At baseline testing participants filled out a demographic questionnaire and the STAI-Y, PAI, FSS. Four participants, two in the control and two in the treatment groups, scored at least 1 standard deviation above the mean for similar gender and age on the STAI Y-2 and were identified as high trait anxiety students. One student in the treatment group scored 1 standard deviation below the mean for trait anxiety.

I initially instructed participants to put on the SenseWear™ Pro 2 armband physiology collection device (BodyMedia, Inc. Pittsburgh, PA) on the right upper triceps to collect EDA and Temp measures while they also put on an ear sensor to collect heart rate, and HRV information. Though the SenseWear Pro 2 was used in baseline and during most of the first performances, the devices failed to download information into the computer 11% of the time. I decided that the equipment failure rate was too high to continue to collect the data after the first performances; therefore I decided not to continue to use it for the second performances. I assessed HRV and pulse rate with the client using an ear-clip sensor on the right earlobe. The same sensor was used consistently with each performer throughout the research project. I assessed baseline HRV using the Freeze-Framer® 2.0 interactive training software (Institute Of HeartMath Corporation, Boulder Creek, CA) for seven minutes at the default challenge level 2 for seven minutes. I instructed the participants: “You are asked to sit quietly for the next seven minutes while we measure your heart rate variability. During this time, please focus on the music you have chosen to perform as part of the study. Visualize yourself practicing and performing this piece of music.” The participants were not able to see



the computer screen and I turned off the feedback sound so the participants were blind as to their HRV and heart rate. I used this same HRV assessment procedure throughout the study any time the participants had their HRV and heart rate assessed.

The participants came to their first performance approximately 30 minutes early and I gave the performers the order of their performance as well as asked them to fill out the STAI-Y1 (state) and PAI. The performances were held in the Concert Hall or in the Organ Recital Hall at the University of North Texas. The same order of performance and room was used for both performances except for adjustments made due to students who dropped out of the study. I assessed the participants HRV and average heart rate using the procedure described above. I gave the performers a SenseWear Pro 2 armband to wear on their right upper triceps at least 5 minutes before the performance to assure that the device had accommodated to the participants body temperature. As stated above the armband devices were abandoned for the second performances due to equipment failure. The participant performed their music selection in front of an audience of varying size. I hoped to have an audience of at least 20, but the audience number was not consistently maintained, with the audience size varying from between seven and twenty. The participants time-stamped the beginning and end of their performance by pushing the time-stamp button on the SenseWear Pro 2 armband. Immediately following the performance I measured the participants' HRV and average heart rate and then asked participants to fill out the FSS and a self-assessment questionnaire for their perception of their performance and the amount of performance anxiety they experienced. Following the first performance, I told the participants of their assignment to either the treatment or control group, and those in the treatment group

were scheduled to begin their HRV biofeedback training. I used random assignment based on the order of baseline assessment to assign students to either the treatment or control groups.

Three weeks following the initial performance, the participants returned to the same concert hall and performed the same musical number as in the initial performance with the same measures taken as in performance one. The participants then scheduled a final baseline and completed the same questionnaires as were done at the first baseline, with the addition of their impressions of the treatment for those in the treatment group. In order to accommodate the number of student participants, only ten students were asked to perform at one time on any given day (see Appendix B for a Summary of Study Schedule). Participants who completed the study were paid \$20, and those in the control group were given the opportunity to try HRV biofeedback. I also invited all participants to a meeting where I presented the preliminary results of the study. (See Appendix A for a graphic Overview of Research Measures).

### *Apparatus*

BodyMedia SenseWear Pro2.

Electrodermal activity (EDA) is an established biofeedback measure of anxiety. An EDA device is one that passes a microcurrent between two contact points on the skin. When a person sweats, in response to autonomic arousal, changes in the amount of electrical resistance and current across the skin are measured. The change is quantified as a response to stress (Criswell, 1995). For the purpose of the study a BodyMedia SenseWear Pro2 device was worn on the right upper arm during baseline

testing and during musical performance as a measure of physiological response to anxiety and stress. The rate of collection of information was 8 samples per second.

Thermal activity (temp) is an established biofeedback measure of anxiety. Temp is measured by devices that assess changes in temperature on the skin.

Vasoconstriction, the constriction of small blood vessels, is a response to autonomic arousal and is characterized by a decrease in temperature of the skin (Criswell, 1995). For the purpose of the study, a BodyMedia SenseWear Pro2 device was worn on the right upper arm during baseline testing and during musical performance as a measure of physiological response to anxiety and stress. The rate of collection of information was 2 samples per second. After the first performance the devices proved to be unreliable and data collection with these devices was stopped.

Freeze-Framer.

For the purpose of this study, heart rate variability (HRV) was measured using an ear-clip photoplethysmograph. Measurements were for seven minutes at pre- and post-baseline, before and after each performance, and during training for members of the experimental group. I instructed the participants to think of the piece they were going to perform and mentally rehearse that piece during the measurement. These guidelines were decided upon in discussion and e-mail consultation with Rollin McCraty (March 23, 2006). I used the Freeze-Framer® 2.0. For the purpose of this study the coherence measurement designated as low, medium, and high by the Freeze-Framer program were used to qualify as meeting training criteria. A score of 80% in combined medium and high coherence during cognitive rehearsal for seven minutes constituted meeting

training criteria according to an e-mail consultation with Rollin McCraty (March 23, 2006). Low coherence scores were used before each performance and at baseline as a measure of anxiety and sympathetic nervous system arousal correlated to an increase in very low frequency on a the spectral analysis (Culbert, 2004).

#### emWave™

A portable HRV biofeedback training device, emWave™, for home training (Quantum Intech Inc., Boulder Creek, CA), became available the second week of the training period. A unit was given to each participant for at least 10 days of home training. The participants were instructed how to use the units using the ear-clip photoplethysmograph and were encouraged to use them at home and in preparing for and before rehearsals, lessons, and performances. The units assisted participants to identify when they were in sustained psychophysiological coherence. A coherence training software program Quick Coherence Coach® (Quantum Intech Inc., Boulder Creek, CA) was used during training to teach how to effectively use the emWave device.

#### Computers

Three IBM compatible laptop computers with Pentium 4 processors were used to gather information at baseline and performances. An Acer Ferrari, a Prostar, and a PowerNote computer were used. The use of multiple computers permitted us to collect information on several students at the same time and allowed researchers to collect information close to the time of the actual performance. The same computer was used

with each participant from baseline through training and performances with two exceptions.

### *Treatment*

Participants in the experimental group received one-on-one training from me. I am certified by the HeartMath Institute as a Qualified Resilient Educator Instructor and was certified by the Biofeedback Certification Institute of America in general biofeedback. The participants were trained me using bibliotherapy, computerized heart rate variability biofeedback, and in cognitive and emotional shifting techniques to achieve psychophysiological coherence. The participants received between four and five training sessions of 30-50 minutes each. The goal was to train each participant to achieve 80% combined medium and high coherence during cognitive rehearsal for seven minutes at the default challenge level 2 using an ear sensor and Freeze-framer version 2.0 without the benefit of any feedback. All participants met the training criteria by the end of the fourth session and were able to demonstrate and maintain a state of 80% medium to high psychophysiological coherence while focusing on the music they chose to perform as part of the study and visualization of practicing and performing that piece of music. The participants were given the booklet *The Inside Story* (HeartMath, 2002) and instructed in the concepts of physiological arousal, how the brain processes anxious information, emotional memory, emotions and the nervous system, the heart-brain connection, and psychophysiological coherence through practicing Quick Coherence, and the Freeze-Frame techniques (HeartMath, 2002). The participants were also given a copy of *The Appreciative Heart* (McCraty & Childre, 2003) to read.

The participants were given some individual interventions such as discussion of their experience of performance and stress and the role perfectionism and competition played in their MPA. The participants were instructed in relaxed resonant breathing (Lehrer, et al., 2000a), and cognitive rehearsal practice time while observing their HRV. The participants also were given an emWave hand held heart rate variability biofeedback device to use at home and practiced using the Coherence Coach© software program that accompanies the emWave unit. Participants used the Freeze-Framer 2.0 program during the in-clinic training and the trainer trained participants at one of four different challenge levels and using different training screens depending on their current practice level and success of the participant. The determination as to what level and screen to use was up to the discretion of the trainer.

## CHAPTER 3

### RESULTS

This experimental repeated measures research investigation was designed to study the effects of training university student musicians with heart-rate variability (HRV) biofeedback and emotional shifting techniques to decrease music performance anxiety and improve music performance. Components of state and trait anxiety were assessed with the State Trait Anxiety Inventory (STAI-Y). Components of performance were assessed using the Flow State Scale. Components of music performance anxiety (MPA) were assessed using the Performance Anxiety Inventory (PAI). Components of physiological stress response were measured using average heart rate (HR), and HRV. A combined MPA effect was assessed by combining a standardized ranked score for the mental/emotional components, the physiological components, and the performance component. Effect size was assessed using SPSS 12.0  $\eta_p^2$  and Cohen's description of  $\eta^2$  effect size as .0099 = small, .059 = medium, and .13 = large (Cohen, 1988). Alpha level was set at .05 consistent with social science research (Cohen, 1988).

#### Hypothesis 1

Hypothesis 1 states: The treatment group will show no statistically significant difference in music performance anxiety as measured by a combined standardized score of trait anxiety, state anxiety, the Performance Anxiety Inventory, average heart rate, low coherence HRV, and the Flow State Scale compared to a no-treatment control group. The purpose of this hypothesis was to assess the combined aspects of mental/emotional stress, physiological stress response, and a performance rating into a

composite score to see if HRV biofeedback treatment would statistically or practically assist student musicians in decreasing MPA. Higher scores indicate greater MPA. Descriptive statistics for the standardized ranked scores data using SPSS 12.0 were summarized in Table 2

Table 2  
*Combined MPA Standardized Ranked Scores*

	<u>Pre-Baseline</u>				<u>Post-Baseline</u>			
Treatment Levels	Mean	SD	Kurtosis	Skew	Mean	SD	Kurtosis	Skew
Treatment Group ( <i>n</i> =7)	-.928	19.32	.276	.800	-6.50	16.98	-.368	.337
Control Group ( <i>n</i> =7)	.928	13.64	.139	1.170	6.50	13.18	2.212	-1.559

A Quade’s rank-transformed analysis of covariance (ANCOVA) was used to establish standardized scores that could be combined to give a total look at mental, emotional, behavioral, and physiological aspects of MPA. The procedure for Quade’s rank-transformation (Bonate, 2000) began with changing the raw pre- and post-test scores into rank pre- and post-test scores. Next, each ranked score was converted to a standardized deviation score by subtracting the pre- or post-test rank mean from each individual occasion score. An ANCOVA was then run using the post-test as the dependent variable and the pre-test as the covariate on the standardized rank scores (Bonate, 2000). Results of the analysis are in Table 3.



Table 3  
 ANCOVA Summary Table for Combined MPA Scores

Source	SOS	df	MS	F	Sig.	Partial eta <sup>2</sup>
Covariate	1767.353	1	1767.353	19.313	.001	.637
Group	473.528	1	473.528	5.174	.044**	.320 <sup>+++</sup>
Residual	1006.647	11	91.513			
Total	3247.528	13				

\*\* $p < .05$  <sup>+++</sup>  $\eta_p^2 > .13$  = large effect size (Cohen, 1988)

Prior to Quade's rank-transformation the assumptions of independence through random assignment was met. Linearity was met, but the assumption of homogeneity of regression slopes was violated. Homogeneity of variance was met with a Levene's test and a normal distribution was met according to the definition of Field (2000). Bonate (2000) describes the Quade's rank-transformation as robust against deviations of normality and assumptions. Type 1 error rates are approximately  $\alpha$  and remain robust against non-normal data and data that violates homogeneity of within-group regression coefficients (Bonate, 2000).

As seen in table 3, the results of the combined MPA analysis rejected the null hypothesis. There was statistically significant difference in the means and standard deviation scores of MPA between the treatment and control group at pre- and post-treatment music performance with scores on performance two acting as the dependent variable and scores on performance one acting as the covariate with  $F(1,11) = 5.174$  at the .05 level ( $p = .044$ ). There was a large effect size noted with  $\eta_p^2 = .320$  (Cohen, 1988).

## Hypothesis 2

Hypothesis 2 states: The treatment group will show no statistically significant difference in trait and state anxiety in pre- and post-testing at baseline and during a pre- and post-treatment music performance as measured by the STAI-Y compared to a no-treatment control group. There were two purposes with this hypothesis. One was to assess the predisposed underlying personality factors of anxiety, trait anxiety, to see if trait scores were similar between the treatment and control groups at pre- and post-baseline testing. Another purpose of this hypothesis was to assess the transitory factors of anxiety, state anxiety, to see if state anxiety scores were similar between the treatment and control groups preceding a pre- and post-treatment musical performance. Higher scores indicate greater trait or state anxiety. Descriptive statistics for raw data trait anxiety using SPSS 12.0 were summarized in Table 4

Table 4  
*Trait Anxiety Descriptive Statistics before Rank-Transformation*

	<u>Pre-Baseline</u>				<u>Post-Baseline</u>			
Treatment Levels	Mean	SD	Kurtosis	Skew	Mean	SD	Kurtosis	Skew
Treatment Group ( $n=7$ )	37.42	11.44	-.349	-.037	35.57	9.86	-.866	.290
Control Group ( $n=7$ )	41.42	8.40	-1.68	.21	38.14	12.53	-1.36	.48

A Quade's rank-transformed analysis of covariance (ANCOVA) was used. Bonate (2000) describes this procedure as robust against deviations of normality and assumptions. Type 1 error rates are approximately  $\alpha$  and remain robust against non-

normal data and data that violates homogeneity of within-group regression coefficients (Bonate, 2000). Results of analysis are in Table 5.

Table 5  
*ANCOVA Summary Table for Rank-Transformed Trait Anxiety*

Source	SOS	df	MS	F	Sig.	Partial eta <sup>2</sup>
Covariate	174.322	1	174.32	38.59	.000	.778
Group	0.044	1	0.044	.010	.923	.001 <sup>+</sup>
Residual	49.678	11	4.516			
Total	224.044	13				

<sup>+</sup> $\eta_p^2 > .0099$ =small effect size (Cohen, 1988)

Prior to Quade's rank-transformation the assumptions of independence through random assignment was met. Linearity was met, but the assumption of homogeneity of regression slopes was violated. Homogeneity of variance was met with a Levene's test and a normal distribution was met according to the definition of Field (2000). Rank-transformed adjusted mean for trait anxiety for the treatment group= -.056 and the control group= .056

State Anxiety test scores were treated in a similar fashion to the previous trait scores descriptive statistics of rank-transformed data and are summarized in the following Table 6.

Table 6  
*State Anxiety Descriptive Statistics before Rank-Transformation*

Treatment Levels	<u>Pre-Baseline</u>				<u>Post-Baseline</u>			
	Mean	SD	Kurtosis	Skew	Mean	SD	Kurtosis	Skew
Treatment Group ( <i>n</i> =7)	39.42	11.67	-1.04	.737	31.85	7.75	2.00	1.39
Control Group ( <i>n</i> =7)	41.28	11.33	-2.03	.065	39.14	6.46	1.74	-.952

Rank-transformed adjusted means for state anxiety for the treatment group = 1.940 and control group = 1.940. A Quade's rank-transformed analysis of covariance (ANCOVA) was used. Bonate (2000) describes this procedure as robust against deviations of normality and assumptions. An ANCOVA was then run using the post-test as the dependent variable and the pre- test as the covariate on the standardized rank scores. Results of analysis are in Table 7

Table 7  
*ANCOVA Summary Table for Rank-Transformed State Anxiety*

Source	SOS	df	MS	F	Sig.	Partial eta <sup>2</sup>
Covariate	40.528	1	40.528	3.484	.089	.241
Group	52.599	1	52.599	4.521	.057*	.291 <sup>+++</sup>
Residual	127.972	11	11.634			
Total	221.099	13				

\**p* < .10. <sup>+++</sup>  $\eta_p^2 > .13$  = large effect size (Cohen, 1988)

Prior to Quade's rank-transformation the assumptions of independence through random assignment was met. Linearity was met, but the assumption of homogeneity of

regression slopes was violated. Homogeneity of variance was met with a Levene's test and a normal distribution was met according to the definition of Field (2000).

As seen in table 5, the results of the trait anxiety analysis failed to reject the null hypothesis. There was no statistically significant difference in the means and standard deviation scores of trait anxiety between the treatment and control groups at pre- and post-baseline with post-baseline acting as the dependent variable and pre-baseline acting as the covariate with  $F(1,11) = .010$  which was not statistically significant at the .05 level ( $p=.917$ ). Effect size was small with  $\eta_p^2 = .001$  (Cohen, 1988).

As seen in table 7, the results of the state anxiety analysis approached rejection of the null hypothesis at the  $p=.05$  level. Statistically significant difference in the means and standard deviation scores was approached in state anxiety between the treatment and control group preceding musical performances with the second performance scores acting as the dependent variable and the first performance preceding treatment acting as the covariate with  $F(1,11) = 4.521$  at the .05 level ( $p= .057$ ). Effect size was large with  $\eta_p^2 = .291$

### Hypothesis 3

Hypothesis 3 states: The treatment group will show no statistically significant difference in music performance or "flow" in pre- and post-testing measured by the Flow State Scale compared to a no-treatment control group. The purpose of this hypothesis was to assess whether or not HRV treatment would statistically or practically improve a student's perception of performance, described as a balance of challenge and ease.

Higher scores on the FSS indicate a more enjoyable and challenging performance.

Descriptive statistics for raw data FSS data using SPSS 12.0 are summarized in Table 8.

Table 8  
*Flow State Scale Descriptive Statistics before Rank-Transformation*

Treatment Levels	<u>Pre- Baseline</u>				<u>Post-Baseline</u>			
	Mean	SD	Kurtosis	Skew	Mean	SD	Kurtosis	Skew
Treatment Group (n=7)	116.14	18.26	-1.78	-.037	124.0	27.18	-1.227	.331
Control Group (n=7)	124.57	21.71	.528	1.041	131.57	28.66	3.546	-1.60

A Quade's rank-transformed analysis of covariance (ANCOVA) was used.

Rank-transformed adjusted means for FSS for the treatment group = .049 and control group = -.049. Results of the analysis are in Table 9.

Table 9  
*ANCOVA Summary Table for Rank-Transformed FSS*

Source	SOS	df	MS	F	Sig.	Partial eta <sup>2</sup>
Covariate	130.426	1	130.426	16.224	.002	.596
Group	.032	1	.032	.004	.951	.000
Residual	88.431	11	8.039			
Total	218.889	13				

Prior to Quade's rank-transformation the assumptions of independence through random assignment was met. Linearity was met, but the assumption of homogeneity of regression slopes was violated. Homogeneity of variance was met with a Levene's test,

but a normal distribution was not met according to the definition of Field (2000). Bonate (2000) describes the Quade's rank-transformation as robust against deviations of normality and assumptions. Type 1 error rates are approximately  $\alpha$  and remain robust against non-normal data and data that violates homogeneity of within-group regression coefficients (Bonate, 2000).

As seen in table 9, the results of the FSS analysis failed to reject the null hypothesis. There was no statistically significant difference in the means and standard deviation scores of "flow" between the treatment and control group at pre- and post-treatment music performance with scores on performance two acting as the dependent variable and scores on performance one acting as the covariate with  $F(1,11) = .004$  at the .05 level ( $p=.951$ ). There was no effect size noted with  $\eta_p^2 = .000$  (Cohen, 1988).

#### Hypothesis 4

Hypothesis 4 states: The treatment group will show no statistically significant difference in music performance anxiety in pre- and post-testing measured by the Performance Anxiety Inventory compared to a no-treatment control group. The purpose of this hypothesis was to assess whether or not HRV treatment would statistically or practically improve a student's experience of performance anxiety prior to a musical performance pre- and post-treatment. Higher scores on the PAI indicate more MPA. Descriptive statistics for raw data PAI data using SPSS 12.0 were summarized in Table 10.

Table 10  
PAI Descriptive Statistics before Rank Transformation

Treatment Levels	<u>Pre- Baseline</u>				<u>Post-Baseline</u>			
	Mean	SD	Kurtosis	Skew	Mean	SD	Kurtosis	Skew
Treatment Group (n=7)	46.00	14.68	-.730	.275	44.42	15.61	-.593	.375
Control Group (n=7)	38.14	8.39	-1.22	-.845	38.85	8.09	-1.525	-.658

A Quade's rank-transformed analysis of covariance (ANCOVA) was used.

Rank-transformed adjusted means for PAI for the treatment group= -.544 and control group = .544 Results of the analysis are in Table 11.

Table 11  
ANCOVA Summary Table for Rank-Transformed PAI

Source	SOS	df	MS	F	Sig.	Partial eta <sup>2</sup>
Covariate	202.702	1	202.702	98.419	.000	.899
Group	3.979	1	3.979	1.932	.192	.149 <sup>+++</sup>
Residual	22.655	11	2.060			
Total	229.336	13				

<sup>+++</sup>  $\eta_p^2 > .13$ =large effect size (Cohen, 1988)

Prior to Quade's rank-transformation the assumptions of independence through random assignment was met. Linearity was met, but the assumption of homogeneity of regression slopes was violated. Homogeneity of variance was met with a Levene's test, and a normal distribution was also met according to the definition of Field (2000).

Bonate (2000) describes the Quade's rank-transformation as robust against deviations of normality and assumptions. Type 1 error rates are approximately  $\alpha$  and remain robust



against non-normal data and data that violates homogeneity of within-group regression coefficients (Bonate, 2000).

As seen in table 11, the results of the PAI analysis failed to reject the null hypothesis. There was no statistically significant difference in mean and standard deviation scores of PAI between the treatment and control groups at pre- and post-treatment music performance with scores on performance two acting as the dependent variable and scores on performance one acting as the covariate with  $F(1,11) = 1.932$  at the .05 level ( $p=.192$ ). There was a large effect size noted with  $\eta_p^2 = .149$  (Cohen, 1988).

#### Hypothesis 5

Hypothesis 5 states: The treatment group will show no statistically significant difference in heart rate and heart rate variability in pre- and post-music performance as compared to a no-treatment control group. There were two purposes for this hypothesis. The first was to assess whether or not HRV biofeedback training would statistically or practically decrease a musician's heart rate and the second was HRV would improve indicating better psychophysiological coherence before performance. These measures represent the physiological arousal component of MPA. Higher scores indicate greater physiological arousal and may indicate lower psychophysiological coherence. Descriptive statistics for raw data HR data using SPSS 12.0 were summarized in Table 12.

Table 12  
*HR Descriptive Statistics before Rank-Transformation*

Treatment Levels	<u>Pre- Baseline</u>				<u>Post-Baseline</u>			
	Mean	SD	Kurtosis	Skew	Mean	SD	Kurtosis	Skew
Treatment Group ( <i>n</i> =7)	78.85	7.86	.955	.767	75.00	4.43	.592	.000
Control Group ( <i>n</i> =7)	86.00	12.90	-1.15	.755	84.28	12.47	.726	.923

A Quade's rank-transformed analysis of covariance (ANCOVA) was used.

Rank-transformed adjusted means for HR for the treatment group= -1.547 and control group = 1.547 Results of the analysis are in Table 13.

Table 13  
*ANCOVA Summary Table for Rank-Transformed HR*

Source	SOS	df	MS	F	Sig.	Partial eta <sup>2</sup>
Covariate	.145	1	.145	.008	.929	.001
Group	31.732	1	31.732	1.834	.203	.143 <sup>+++</sup>
Residual	190.284	11	17.299			
Total	222.161	13				

<sup>+++</sup>  $\eta_p^2 > .13$  = large effect size (Cohen, 1988)

Prior to Quade's rank-transformation the assumptions of independence through random assignment was met. Linearity was met, but the assumption of homogeneity of regression slopes was violated. Homogeneity of variance was met with a Levene's test, and a normal distribution was also met according to the definition of Field (2000).

Bonate (2000) describes the Quade's rank-transformation as robust against deviations of normality and assumptions. Type 1 error rates are approximately  $\alpha$  and remain robust

against non-normal data and data that violates homogeneity of within-group regression coefficients (Bonate, 2000).

Descriptive statistics for raw data HRV using the score on low coherence from the Freeze-Framer® 2.0 interactive training software (Institute Of HeartMath Corporation, Boulder Creek, CA) data using SPSS 12.0 were summarized in Table 14

Table 14  
*HRV Descriptive Statistics before Rank-Transformation*

Treatment Levels	<u>Pre- Baseline</u>				<u>Post-Baseline</u>			
	Mean	SD	Kurtosis	Skew	Mean	SD	Kurtosis	Skew
Treatment Group ( <i>n</i> =7)	41.57	32.56	-.109	1.221	4.28	8.05	5.65	2.33
Control Group ( <i>n</i> =7)	54.85	23.07	-.994	-.450	53.57	23.35	-1.94	-.134

A Quade's rank-transformed analysis of covariance (ANCOVA) was used.

Rank-transformed adjusted means for HRV for the treatment group= -3.376 and control group = 3.376 Results of the analysis are in Table 15.

Table 15  
*ANCOVA Summary Table for Rank-Transformed HRV*

Source	SOS	df	MS	F	Sig.	Partial eta <sup>2</sup>
Covariate	.075	1	.075	.018	.912	.001
Group	149.715	1	149.715	25.478	.000***	.698***
Residual	64.639	11	5.875			
Total	214.429	13				

\*\*\**p*< .001.\*\*\*  $\eta_p^2$ >.13=large effect size (Cohen, 1988)

Prior to Quade's rank-transformation the assumptions for HR and HRV of independence through random assignment was met. Linearity was met, but the assumption of homogeneity of regression slopes was violated for both HR and HRV. Homogeneity of variance was met with a Levene's test, and a normal distribution was also met for HR but not for HRV according to the definition of Field (2000). Bonate (2000) describes the Quade's rank-transformation as robust against deviations of normality and assumptions. Type 1 error rates are approximately  $\alpha$  and remain robust against non-normal data and data that violates homogeneity of within-group regression coefficients (Bonate, 2000).

As seen in table 13, the results of the HR component of the hypothesis failed to reject the null hypothesis. There was no statistically significant difference in mean and standard deviation scores of HR between the treatment and control group at pre- and post-treatment music performance, with average HR on performance two acting as the dependent variable and average HR on performance one acting as the covariate with  $F(1,11) = 1.834$  at the .05 level ( $p=.203$ ). There was a large effect size noted with  $\eta_p^2 = .143$  (Cohen, 1988).

For the HRV component, as seen in table 15, the results rejected the null hypothesis. There was a statistically significant difference between the treatment and control groups at pre- and post-treatment music performance, with HRV on performance two acting as the dependent variable and HRV on performance one acting as the covariate with  $F(1,11) = 25.478$  at the .05 level ( $p= .000$ ). There was a large effect size noted with  $\eta_p^2 = .698$  (Cohen, 1988).

## Hypothesis 6

Hypothesis 6 states: The treatment group will show no statistically significant difference in electrodermal activity (EDA) and temperature measured during pre- and post-treatment music performance as compared to a no-treatment control group. The purpose of this hypothesis was to measure physiological responses to stress during performance and to assess whether or not HRV biofeedback training would statistically or practically decrease a musician's physiological response during performance. I was unable to test this hypothesis due to an 11% failure rate of equipment at baseline and during the first performance.

## Hypothesis 7

Hypothesis 7 states: Participants in the treatment group with high trait anxiety will show no statistically significant difference in ability to train to a criterion using HRV biofeedback training than students with low trait anxiety. There were two participants in the treatment group with trait anxiety above 1 standard deviation for students and by gender. The difference in group size made it impossible to trust inferential statistics. Descriptively, all of the participants were able to reach the training criterion within 5 treatment sessions. The two students with high trait anxiety reached criterion on the third and fourth sessions respectively with the average of 3.5 sessions to meet criterion. The participants with average or low trait anxiety met criterion within 1-3 sessions with the average of 2 sessions.

## Hypothesis 8

Hypothesis 8 states: Musicians with high trait anxiety will show no difference in pre- and post-STAI (trait=TA and state=SA), PAI, FSS, HRV, EDA, or temperature, as measured throughout the research project than musicians with low trait anxiety.

The purpose of this hypothesis was to assess whether participants with high trait anxiety also showed higher average scores on other measures compared to those without high trait anxiety. Because of equipment failure EDA and temperature are not reported. There were a total of 4 participants with high trait anxiety, 2 from the control and 2 from the treatment group. There were a total of 10 participants with average or low trait anxiety, 5 from the treatment group and 5 from the control group. Table 16 shows the mean scores for all high trait participant to all the average or low trait anxiety participants.

Table 16  
*Mean Scores for High Trait vs. Low Trait Anxiety Participants on Pre-treatment Scores*

Treatment Levels	TA	SA	PAI	FSS	HR	HRV
High Trait Group (n=4)	51.25	52.75	53.75	108.25	86.00	52.75
Average/Low Trait Group (n=10)	34.70	35.40	37.40	125.20	81.00	46.40

*Note.* TA= trait anxiety, SA= state anxiety, PAI= Performance Anxiety Inventory, FSS=Flow State Scale, HR= average heart rate, HRV=low coherence score of heart rate variability

As seen in the table 16, the participants with high trait anxiety also showed a higher combined average score on trait and state anxiety, the Performance Anxiety Inventory, average heart rate, and heart rate variability low coherence. The FSS, flow state scale, was scored so that a higher score is preferred and the high trait anxiety

participants showed lower, or less preferred scores, than the low or average trait anxiety participants. Raw scores for each participant are included in Appendix C.

## Discussion

I assessed music performance anxiety as a combined mental, emotional, behavioral, and physiological phenomenon. I also separated out components of MPA to assess the effect of HRV biofeedback training combined with emotional shifting techniques of Freeze-Frame and Quick Coherence® techniques of emotional regulation (D. Childre, Boulder Creek, CA) as recommended by the HeartMath® Institute out of Boulder Creek California. The training consisted of viewing real time pulse wave activity and learning to modify a chaotic heart rate variability pattern by applying techniques to achieve a more psychophysiological coherent heart rate pattern. Better psychophysiological coherence has been associated with reductions in test taking anxiety, improved health, performance, and wellbeing (McCraty, 2003b).

Results related to the first hypothesis established that, for this limited subject group and research study, the results were statistically significant at the .05 level and treatment had a large effect of  $\eta_p^2 = .320$  on decreasing scores used to describe MPA after four to five training sessions lasting on average 30-50 minutes apiece as compared to a no-treatment control group. The practical/clinical significance of this finding is that for under five hours of training with a trained biofeedback practitioner over three weeks, a student can decrease a significant amount of their MPA. Part of the training included using the emWave™ portable heart rate variability training device for home training (Quantum Intech Inc., Boulder Creek, CA) that costs around \$200. The

emWave is an affordable small portable device roughly the cost of two textbooks. A student can use the emWave to practice in a variety of settings and practice self-regulation of the automatic stress response that is prevalent in musicians as discussed in chapter one. Many of the students who participated in this study asked if they could purchase the emWave units they used following the study.

In writing about their impressions of treatment effectiveness following the study, all of the students in treatment group related that they would recommend this treatment to other students. The treatment participants also rated a statement, on a 10cm Likert scale, "How effective was the treatment (in) decreasing your performance anxiety?" The group average was 7.14 cm on a scale from 0 cm= had no effect at all to 10 cm=completely took away my anxiety. The treatment participants also rated, on a 10 mm Likert scale, "Did the treatment improve your musical performance?" The group average was 6.21cm on a scale from 0 cm= had no effect at all to 10 cm= greatly improved. In a post-study questionnaire, students were asked to responded to "Please, describe any other benefits you have received from the treatment." They responded with the following:

1. Better prepared
2. Hope of being able to have focus during performances
3. It made me more aware of the things I am doing during performance
4. In general, I feel more calm
5. I have been able to stay calm in situations where I normally would of gotten angry. I have also found myself taking deep breaths in stressful situations to help myself stay calm.



6. Improved sleep
7. I know a way that works to calm myself down
8. Awareness of the body's reactions to anxiety
9. Generally relaxing

These responses appear consistent with the large effect size noted in hypothesis 1,2,4, and 5. In hypothesis 2, the large effect size was seen in the treatment group as reported through a reduction in state anxiety scores that preceded the post-treatment performance. There was a small effect size noticed in the scores on the trait anxiety of  $\eta_p^2=.001$  at post-treatment baseline also. The small effect size on trait anxiety and the large one for state anxiety of  $\eta_p^2=.291$  at a statistically significant value at  $p=.10$  level may reflect the hopefulness, self-awareness, and self efficacy noted in the statements above. Another large effect  $\eta_p^2=.149$  was seen in hypothesis four with the reduction of scores on the Performance Anxiety Inventory that preceded the second performance. This is reflected by the students' ratings on the Likert scale that they reported improvement in reduction of performance anxiety of and average 7.14 out of 10.

The large effect size of  $\eta_p^2=.143$  noted in the decrease in heart rate and heart rate variability  $\eta_p^2=.698$  at a statically significant level of .000 identified that HRV biofeedback treatment was quickly learned and used effectively by the treatment group. While the participants used the biofeedback equipment to train through visual and auditory stimuli, before the performance, the treatment group like the control group had their HRV measured without the assistance of feedback. The statistical significance of  $p=000$  along with the visual scatter plot showed a clear difference in the HRV measures between the treatment and control group. The students in the treatment group learned

to generalize the training to a performance setting. The improved psychophysiological coherence and reduced heart rate are characteristic of a reduction in autonomic sympathetic arousal and is similar to indications of reduced physiological response to stress. These findings were consistent with the participant responses and reduced scores on the anxiety measures.

I found hypothesis 3 to be different from the other hypotheses because it did not show any difference in scores between the treatment and the control groups. Alone, the scores on the Flow State Scale were not statistically or practically different in both the treatment and control groups. Possible explanations may include that the treatment did not affect performance, or more than three weeks were needed to significantly increase “flow”, though students on the post-treatment questionnaire indicated that their performances were enhanced by the treatment. Another explanation is that the control group had an unusual improvement reported on their second performance or the FSS instrument is not a sensitive measure for the type of performance change that the students later reported. Another explanation may be that student assessment of music performance includes enough self-criticism that objective measures need to be taken to verify actual changes, such as an expert blind rater viewing the pre- and post-performances for indication of performance improvement. Another explanation is that the number of research participants was too small to show change and that a larger sample size may have demonstrated differences.

#### *Limitations of the Study*

This research study was limited by a small sample size, namely, 10 participants

in the experimental group and 10 in the control group were initially recruited. Four participants dropped out of the study due to schedule conflicts. One student dropped out of the study due to illness and another was dropped from the study because of taking beta-blockers for high blood pressure. This left an  $n=14$  with 7 in each of the treatment and control groups. Another limitation was the varying size of the audiences. Another limitation was that the research was conducted in the summer on a university campus; generalizability of findings to other populations of musicians will be limited. Limitations of instrumentation included using a photoplethysmograph instead of a chest electrocardiogram (Giardino, Lehrer, & Edelberg, 2002), and failure of the SenseWear™ (BodyMedia, Inc. Pittsburgh, PA) Pro2 devices in measuring Temp and EDA. I also used multiple sensors to accommodate the performance schedule of having performances back to back, and there may have been error from using more than one sensor, even though participants were randomly assigned to the sensor they used and kept the sensor they used constant throughout the research project. Another limitation of the study is the possibility of Type I error due to multiple questionnaires used by the research team. There are multiple studies using the same data set happening simultaneously and in order to accommodate the many needs of the research team, multiple measures were administered. Another limitation to the study was a lack of objective measures of performance to verify or refute the student musician's experience of their own performance as improved or not following treatment. A criticism I levied in my literature review against previous research in the field was the lack of a clear definition of what constituted MPA. Though I attempted to operationalize the definition of MPA by identifying high trait anxiety, the present study is still weak in clearly identifying

who does and does not have MPA and what the criteria are for the label.

### *Future Directions*

This study should be replicated on other university and college campuses as well as with other student and professional musicians and measures should be taken in a variety of settings such as recitals, juries, and concert settings. The same idea applied to individuals may be replicated to ensemble groups as well to see if there is a positive effect on group dynamics as well as individual performance. Measures that identify improvement in performance quality would enhance this study. Future research that includes HRV biofeedback training should be done by researchers who have experience in biofeedback and HRV training as well as personal music performance experience. Because students do not tend to seek out counseling or cognitive therapy, the HRV training may be presented as peak performance training rather than amelioration for MPA. Assistance from music educators or other professional musicians may help identify students who would benefit from training. Specific screening tools for MPA have not undergone extensive, large scale trials. Tools are still needed that are easily administered and identify the differences between cognitive, physiological, and emotional sources of MPA. These tools may eventually aid in prevention of or early screening for debilitating MPA and help determine which interventions may be the most useful for specific students.

## Conclusions

The results of this study demonstrated that university student musicians can learn to use heart rate variability biofeedback techniques as effective tools to decrease scores on state anxiety and a performance anxiety inventory taken before a music performance as compared to a control group. Participants in this study showed that physiological effects of training, under a trained biofeedback practitioner, include decreased heart rate and improved psychophysiological coherence before music performance. Combined emotional, mental, physiological and performance measures taken by a group of HRV trained student musicians have been shown to be statistically and practically/clinically different than these same measures taken on a control group in a sample of 14 university students over the summer term. Freeze-Framer and emWave biofeedback devices are relatively inexpensive pieces of equipment that can be used to train music students to lower the effects of MPA and may also lead towards improved performance. I received the following e-mail for a member of the treatment group participant and was reminded of the difficulties and possibilities facing music students in a highly competitive field of music performance.

I think the study really opened my eyes to how easily feelings can affect a performance. But even more important, I think it allowed me to see how a relatively stress reduced life can be. In general, working with the monitor (emWave) was great. However, in the final performance, my taste for control got the better of me. I did not feel in control for a variety of reasons, so my performance was definitely not a typical one with the aid of (beta) blockers. I must concede that it (performance without blockers) was improved, though I noticed my shakiness early on. It's the loss of control that I cannot deal with at the moment. One day I would like to respond better to high stress situations like that, maybe that day will come. However, that experience led me to believe that I cannot afford to lose the edge I know I have, unfortunately, with the blockers. I do plan to use far less of the inderal, because of the stress eraser (emWave). I would love to purchase the stress eraser. I would appreciate knowing when I can buy it...

This study showed that a quickly learned self-regulation skill can provide an effective treatment for MPA and as an alternative to potentially dangerous medication for the reduction of performance anxiety experienced by student musicians.

APPENDIX A  
OVERVIEW OF RESEARCH MEASURES

We are working with a research team and there are many projects coming from the same data set. We are working with a sample of music student with a subjective self-report of performance anxiety. N= $\sim$ 10 in the treatment group and  $\sim$ 10 in the control group. The dependent variable is heart rate variability biofeedback training.

#### Measures taken during the study

1. Demographic information
2. State Trait Anxiety Inventory (STAI) form Y-1 (state) and
3. State Trait Anxiety Inventory Y-2 (trait) Cronbach's alpha .93
4. Beck Depression Inventory-II (BDI-II) Cronbach's alpha .92
5. Performance Anxiety Inventory (PAI) Cronbach's alpha .89
6. Flow State Scale (FSS) Cronbach's alpha .83
7. Heart rate taken over 7 minutes
8. Heart rate variability (HRV) taken over 7 minutes
9. Skin temperature (TEMP) at 2 samples per second for 7 minutes
10. Electrodermal activity (EDA), sweat response, taken at 8 samples per second for 7 minutes



Following performance #1, 10 participants will be trained to a preset criterion using HRV for at least 5 session and no more than 10 session. Each session the participant will be give a pre- and post-measurement of 7 minutes HRV and heart rate as they work toward a criterion. 3 week following performance #1 all participants will play the same piece again. The same measures as in performance 1 will be taken. Post-Intervention Measures: The students will again be scheduled and a quiet baseline will be taken like the initial baseline measures.

**BREAKDOWN OF MEASURES:**

Pre- study Baseline	Pre- Performance #1	During Performance #1	Post - performance #1	Intervention (Treatment group only)	Pre- Performance #2	During Performance #2	Post- Performance #2	Post-study baseline
Demographics								
STAI-1	STAI-1				STAI-1			STAI-1
STAI-2								STAI-2
PAI	PAI				PAI			
FSS self-rated			FSS				FSS	
			FSS (audience rated)				FSS (Audience rated)	
Heart rate(BPM)	BPM		BPM	Pre- and Post-bpm X 5	BPM		BPM	BPM
HRV	HRV		HRV	Pre- and Post -HRV X 5	HRV		HRV	HRV
TEMP		TEMP				TEMP		TEMP
EDA		EDA				EDA		EDA
								Report of perceived treatment efficacy

Statistically we are looking at using a repeated measures ANOVA or ANCOVA with HR, HRV, BPM, TEMP, EDA, FSS, SATI-1, and PAI. We are looking at a rank-transformed combination of the tests scores for an overall measure of MPA.

APPENDIX B  
SUMMARY OF STUDY SCHEDULE

	Treatment Group HRV	Control Group
Week 1	Introductory meeting June 6, 2006 MU 250 5:00-6:30PM	Introductory meeting June 6, 2006 MU 250 5:00-6:30PM
	Signed Informed Consent	Signed Informed Consent
	Initial Baseline Measures Chilton 130	Initial Baseline Measures Chilton 130
Week 2	Performance #1 June 14 UNT Concert Hall 4:00-6:00 PM	Performance #1 June 15 UNT Concert Hall 4:00-6:00 PM
	Set up individual HRV training sessions Chilton 130	
Week 3	Individual HRV sessions Chilton 130	
Week 4	Individual HRV sessions Chilton 130	
Week 5	Performance #2 July 12, 2006 UNT Concert Hall 4:00-6:00 PM	Performance #2 July 13, 2006 UNT Concert Hall 4:00-6:00PM
Week 6	Post-Baseline Measures	Post-Baseline Measures
Week 7		
Week 8	Results of the study MU 262 Aug 2, 2006 4:00-6:00 PM	Results of the study MU 262 Aug 2, 2006 4:00-6:00 PM

APPENDIX C  
INDIVIDUAL RAW SCORES

ID #	Gender 0=male 1=female	Group 0=treatment 1=control	Trait Anxiety pre- study	Trait Anxiety post- Study	State Anxiety pre- perform 1	State Anxiety pre- perform 2	BDI-II pre- study	BDI-II post- study	FSS post- perform 1	FSS Post- perform 2	PAI pre- perform 1	PAI pre- perform 2	HR pre- perform 1	HR post- perform 1
1	0	0	39	29	38	35	8	1	120	126	38	39	79	73
5	0	0	29	34	37	25	1	1	129	129	41	41	76	76
13	0	0	39	38	31	28	4	2	129	164	40	33	83	88
15	1	0	20	22	26	25	3	3	141	152	25	23	69	64
17	0	0	48	46	56	29	8	13	103	91	64	68	80	82
19	1	0	54	50	55	47	38	24	93	98	66	61	93	80
23	1	0	33	30	33	34	2	3	98	108	48	46	72	68
2	0	1	39	35	32	38	3	1	139	140	26	28	107	92
6	1	1	53	53	56	41	14	15	106	126	41	41	97	90
8	0	1	38	32	29	47	4	7	117	143	38	42	76	71
10	0	1	50	56	44	38	19		131	129	44	44	74	67
14	0	1	32	26	29	27	5	2	112	146	27	28	93	84
16	0	1	32	24	46	38	6	2	164	164	46	46	78	83
18	1	1	46	41	53	45	8	2	103	73	45	47	77	72

ID #	HR pre-perform 2	HR post-perform 2	HRV pre-study	HRV pre- perform1	HRV post- perform 1	HRV pre- perform 2	HRV post- perform 2	HRV post-study
1	76	75	37	14	88	0	0	14
5	74	85	32	22	4	0	3	11
13	72	75	13	27	45	3	0	4
15	75	67	40	98	80	0	0	41
17	68	69	91	19	30	22	4	56
19	78	72	68	77	79	5	0	0
23	82	77	66	34	38	0	1	4
2	107	112	10	70	62	76	73	74
6	88	86	65	82	76	21	87	86
8	90	85	70	51	57	51	55	63
10	76	75	30	33	73	44	65	58
14	72	71	37	53	41	27	89	53
16	85	78	67	19	63	24	68	77
18	72	68	43	76	81	72	72	48

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