# EFFECTS OF HEART RATE VARIABILITY BIOFEEDBACK-ASSISTED STRESS MANAGEMENT TRAINING ON PREGNANT WOMEN AND FETAL HEART RATE MEASURES

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Dissertation Prepared for the Degree of

DOCTOR OF PHILOSOPHY

UNIVERSITY OF NORTH TEXAS

August 2008

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Keeney, Janice E., Effects of heart rate variability biofeedback-assisted stress management training on pregnant women and fetal heart rate measures. Doctor of Philosophy (Counseling), August 2008, 115 pp., 8 tables, 112 figures, references, 100 titles.

This study examined effectiveness of heart rate variability (HRV) biofeedback-assisted stress management training in reducing anxiety and stress in pregnant women and the effect of maternal stress management skills practice on fetal heart rate measures in real time. Participants were seven working pregnant women who volunteered in response to recruitment announcements and invitations from cooperating midwives. Reported state and trait anxiety and pregnancy specific stress were measured during five 45- to 50-minute training sessions. Training included bibliotherapy, instruction in the use of emotion-focused stress management techniques, and HRV biofeedback. Subjects used portable biofeedback units for home practice and were encouraged to practice the skills for 20 minutes a day and for short periods of time during stressful life events. At the end of training, fetal heart rate was monitored and concurrent maternal HRV measures were recorded.

Repeated measures ANOVA and paired samples *t*-test analysis of study data revealed no statistically significant reductions in state or trait anxiety measures or in pregnancy specific stress measures. Partial eta squared ($n^2$) and Cohen's *d* calculations found small to medium effect sizes on the various test scales. Friedman's analysis of variance of biofeedback measures showed a statistically significant decrease in low HRV coherence scores ($X^2 = 10.53$, $p = .03$) and medium HRV coherence scores ($X^2 = 11.58$, $p = .02$) and a statistically significant increase in high

HRV coherence scores ($X^2$ = 18.16, $p$ = .001). This change is an indication of improved autonomic function. Results of concurrent maternal and fetal HRV recordings were generally inconclusive. A qualitative discussion of individual subject results is included. During follow-up interviews five subjects reported that they felt they were better able to cope with stress at the end of the study than at the beginning, that they used the stress management skills during labor, and that they continue to practice the skills in their daily lives.

## ACKNOWLEDGEMENTS

Many people have assisted me in implementation and completion of this project. I wish to acknowledge the support of my doctoral committee, Dr. Cynthia Chandler, Dr. Eugenia Bodenhamer-Davis, and Dr. Dennis Engels. I would like to thank Jean Sala, MSN, and Lynne Pewterbaugh of INANNA Birth and Women's Care and Patrice Capan, RNC, and the staff of Family Health Care, for use of their facilities and for their kind assistance and encouragement. I thank Dr. DeCarlo Noble for contribution of his time and expertise. I express my thanks also to Dr. Rollin McCraty, Howard Martin, Dr. Tani Shaffer, Kim Allen, and Arthur Stephens of the Institute of HeartMath whose contributions to this project included software, loan of emWave Personal Stress Relievers®, and sharing of their expertise and encouragement. I wish to acknowledge Dr. Myron Thurber for his contribution of the original idea for this research study. I also thank my husband, Rodger, for contributing many hours of computer assistance and for his support and patience.

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# CHAPTER 1

# INTRODUCTION

From ancient times to the present day, traditional beliefs of many different cultures have reflected the idea that emotional states and behavior of a pregnant woman can influence development and personality characteristics in her child. Currently, a growing body of scientific research is devoted to investigation of prenatal influences on pregnancy outcome. Much of the research is focused on factors which are correlated with low birth weight, prematurity, and infant mortality. In a demographic analysis and review of the literature, Cramer (1987) reported that infant mortality is correlated with maternal socioeconomic factors such as being single, being very young or over thirty-five years of age, having a low education level, and being from an ethnic minority. Cramer also reported that infant mortality is highly correlated with low birth weight and postponement of prenatal care; however, he suggested that in order to understand linkages between these variables and poor pregnancy outcome, more information is needed about sociological and physiological intervening variables. Some researchers have considered that prenatal maternal stress may be an intervening variable and possible correlate of poor pregnancy outcome and developmental problems in children.

## Definition of Stress

In the early 1900s, Cannon first used the term stress to describe the body's response to threat (Sapolsky, 1998). He also coined the phrase *fight-or-flight* to describe the stress response and the term *homeostasis* to describe the ability to maintain balance in living organisms (Cannon, 1932). Subsequently, Selye (1978) defined stress as “the nonspecific response of the body to any demand” (p. 74). Selye began to develop his ideas about stress when, as a medical student in 1925, he observed that a diversity of diseases manifested a common set of non-specific symptoms prior to development of any specific disease. Selye posited a process through which non-specific symptoms developed which he termed the General Adaptation Syndrome (GAS), a biological stress response consisting of three-stages. The first stage is an alarm reaction, which is equivalent to the fight-or-flight response. In the second stage, termed the stage of resistance, the body attempts to regain homeostasis. Under prolonged threat, the stage of exhaustion ensues along with the observed “syndrome of just being sick” (p.17). Although the GAS is clearly an adverse process, Selye (1974) maintained that a certain amount of stress is unavoidable and even desirable and that complete absence of stress is death. He used the term distress to describe excessive stress which is associated with the GAS and held that stress which is not excessive has a positive dimension associated with “pleasant experiences of joy, fulfillment, and self-expression” (p. 34). In Selye’s terminology, the literature on prenatal maternal stress reviewed in this dissertation is primarily focused on distress and its effects upon the fetus.

## Stress and Pregnancy

Scientific investigation of possible links between prenatal maternal stress and pregnancy outcomes supports an association with various adverse effects upon the child. Research studies and reviews of this literature corroborate a link between prenatal maternal stress and effects such as preterm birth, low birth weight, and shorter gestational age (Killingsworth-Rini, Dunkel-Schetter, Wadhwa, and Sandman, 1999;

Mancuso, Dunkel-Schetter, Rini, Roesch, & Hobel, 2004; McCubbin et al.,1996; Paarlberg, Vingerhoets, Passchier, Dekker, and Van Geijn, 1995; Wadhwa, Sandman, Porto, Dunkel-Schetter, 1993), behavioral and emotional regulation problems (O'Connor, Heron, Golding, Glover, & the ALSPAC Study Team, 2003; Van den Bergh, Mulder, Mennes, and Glover, 2005), attention deficit disorder symptoms and anxiety (Huizink, Robles de Medina, Mulder, Visser, & Buitelaar, 2002; Van den Bergh and Marcoen, 2004), increased risk of developing schizophrenia (Khashan et al., 2008; Koenig, Kirkpatrick, and Lee, 2002; Imamura, Nakane, Ohta, and Kondo, 1999; Van Os and Selten, 1998), and lower levels of cardiac vagal tone (DiPietro, Hodgson, Costigan, Hilton, and Johnson, 1996; Monk, Myers, Sloan, Ellman, and Fifer, 2003; Sjostrom, Valentin, Thelin, and Marsal, 2002).

Although more research studies support correlations between stress and negative effects on offspring, consistent with Selye's (1974) contention that stress has a positive dimension, some studies show correlations between prenatal stress and improved pregnancy outcomes. In a study of 94 healthy, financially stable women in low risk pregnancies DiPietro, Novak, Costigan, Atella, and Reusing (2006) found non-clinical levels of maternal anxiety, depression, and stress to be associated with better mental and motor development in the children at two years of age. Only pregnancy-specific negativity was significantly associated with poorer developmental outcomes in the children. Fujioka et al. (2003) also found positive effects from mild prenatal stress of short duration in rats. Offspring of mildly stressed rat dams showed improved cognitive performance and less emotional reactivity to stressors as compared to offspring of dams who were subjected to longer and more severe stress.

## Statement of the Problem

Research shows prenatal maternal stress to be a possible contributor to a wide array of adverse outcomes for the fetus and the child; therefore, it seems prudent to find methods to help pregnant women mediate their stress responses. Medical responses to this need frequently involve administration of drugs; however, no psychoactive drugs are currently approved by the Food and Drug Administration for use during pregnancy (Meadows, 2001). Medication use during pregnancy may be necessary, and research with psychotropic drugs for pregnant women continues; but few definitive answers about effects of these drugs on the fetus and child exist, and many women are reluctant to take drugs for this reason. Another common prescription for stress during pregnancy is reduced activity or bed rest (Somers, Gevirtz, Jasin, and Chin, 1989; Institute of Medicine, 1985); however, the effectiveness of this strategy is in question, and compliance is often difficult and has the potential of being perceived by the patient as stressful in itself.

The need for effective prenatal stress management programs seems apparent. Existing studies on this subject which will be reviewed later in this paper have helped define components of effective programs and directions for future research.

## Review of Related Literature

### *Mechanisms of Maternal-Fetal Stress Transfer*

Mechanisms by which maternal psychophysiological distress might influence the fetal environment include reduction in blood flow (DiPietro, 2004; Teixeira, Fisk, & Glover, 1999), transfer of stress hormones through the placenta, poor self-care such as lack of proper nutrition or substance abuse, and weakened immune responses

(Paarlberg et al., 1995). DiPietro, Irizarry, Costigan, and Gurewitsch (2004) postulated another possible avenue of transfer. They observed a positive relationship between maternal and fetal heart rate starting during the 28th week of gestation. They suggested that, although this relationship may be explained by influences of maternal cortisol on the fetus, alternatively, it may be explained by heart rate entrainment.

Some researchers have also investigated fetal programming of the hypothalamic-pituitary-adrenal (HPA) axis as a possible mechanism of maternal-fetal stress transfer (O'Connor et al., 2003; Sandman et al., 2003; Van den Bergh et al., 2005). The HPA axis mediates the amount and type of response the body produces to combat a challenge (Sapolsky, 1998). Interaction between brain and hormonal effects associated with HPA axis dysregulation leads to chronic hypersensitivity of stress responses (Welberg & Seckl, 2001). In a review of animal research literature, Weinstock (2001) reported that prenatally stressed rats with HPA axis dysregulation display severely altered behavior which includes reduced social interaction, anxiety, depression, symptoms of learned helplessness, and sleep problems which persist into adulthood. Weinstock noted behavioral similarities between prenatally stressed rats and humans and also reported that the rats have alterations in brain structure and usage of the neurotransmitter dopamine which is similar to changes seen in humans with schizophrenia.

The fetal programming hypothesis was put forth by Barker, Eriksson, Forsen, and Osmond (2002) based on results of a longitudinal study of 13,517 people born between 1924 and 1944. This study indicated that people who had low birth weight who subsequently gained weight at an accelerated rate between the ages of three and eleven had increased incidences of coronary heart disease, hypertension, and type two diabetes. From a fetal programming point of view, prenatal malnutrition created a lower set point in these individuals, and their bodies were unable to accommodate to the subsequent accelerated growth. Application of the fetal programming hypothesis as a possible developmental dynamic in regard to HPA axis dysregulation is based on the idea that “when disturbing factors act during specific sensitive periods of development, they exercise organizational effects—or program some set point—in a variety of systems by different underlying mechanisms” (Van den Bergh and Marcoen, 2004, p.1087).

Regardless of etiology, an unfavorable prenatal environment may affect the fetus in one or more of three general ways: (1) teratogenesis, (2) perinatal effects, and (3) long-term neurobehavioral effects (Eberhard-Gran, Eskild, and Opjordsmoen, 2005). Teratogenesis refers to the production of malformation in the developing fetus. This process is of particular concern during the first trimester of pregnancy when major organ systems are formed but may also affect more subtle development in the later stages of pregnancy. Perinatal effects develop during the period from approximately 28 weeks gestation to one month after birth and usually resolve within a few weeks after birth. Neurobehavioral effects begin at various prenatal stages but generally lead to long-term and possibly lifelong developmental difficulties (Eberhard-Gran et al.)

Studies of how these influences might affect the human fetus are complicated by methodological problems presented by confounding effects of genetic influences, child rearing practices, and intervening life events (DiPietro, 2004). Animal researchers are able to control more effectively for these factors, but generalization of animal study results to humans is complicated by the fact that gestation is physiologically different in the two species and stress responses are more complex in humans (DiPietro). Nevertheless, researchers continue to study neurobehavioral effects using various methods to control for confounding factors.

Inquiry into possible fetal effects of prenatal maternal stress in humans has focused on many aspects of this question. The present review is concentrated on cardiovascular effects.

*Cardiovascular Correlates of Prenatal Stress in Humans*

Measurement of fetal heart rate and heart rate variability (HRV) is a common method for assessment of fetal condition and functioning (Chung et al., 2001, DiPietro and Irizarry et al., 2004). HRV is a measure of beat-to-beat changes in heart rate. Over the course of normal prenatal development fetal heart rate becomes slower and HRV increases and becomes more coordinated with fetal movement (DiPietro et al., 1996; Van Leeuwen, Lange, Bettermann, Gronemeyer, and Hatzmann, 1999). Significantly lower fetal HRV is found in older mothers (DiPietro et al.). In addition, fetal heart rate and HRV appear to be stable characteristics that endure at least until 12 months of age (DiPietro, Costigan, Pressman, and Doussard-Roosevelt, 2000).

Some studies indicate that slower heart rate and higher HRV is a marker of neural control of the autonomic nervous system and is predictive of better developmental trajectories in childhood. Doussard-Roosevelt, Porges, Scanlon, Alemi, and Scanlon (1997) studied the relationship of cardiac measures and development in 41 low birth weight infants and found lower heart rate and higher HRV to be associated with better behavioral outcomes at three years of age. In a study of 137 children, DiPietro, Bornstein, Hahn, Costigan, and Achy-Brou (2007) found that individual differences in heart rate and HRV patterns which developed in the fetal period continued postnatally, and lower heart rate along with higher HRV was predictive of better developmental outcomes in the infants at 24 and 30 months. In a study of 52 children, Bornstein et al. (2002) found higher HRV in the prenatal period to be correlated with better language development and symbolic play at 27 months postnatally. Acknowledging the many complex factors that influence language and cognitive development, Bornstein et al. hypothesized that the more efficient psychophysiological self-regulation which is associated with higher levels of cardiac function might contribute to improved attentional, cognitive, and social abilities.

Many complex factors influence cardiac development in fetuses and children (Berntson, Cacioppo, and Quigley, 1993). The following articles present evidence for the possible influence of prenatal maternal stress on fetal cardiac development and functioning.

DiPietro et al. (1996) assessed neurobehavioral development in 31 healthy fetuses starting from 20 weeks gestation. Among other measures, fetal heart rate and HRV were assessed. Maternal stress was also assessed using standardized self-report questionnaires. Results indicated that lower fetal HRV was associated with greater maternal stress.

In a study of 27 pregnant adolescents, Ponirakis, Susman, and Stifter (1998) found mixed results. Greater levels of negative trait emotions such as depression, anxiety, anger, and hostility during early pregnancy were positively correlated with better Apgar scores at five minutes post birth. Higher cortisol levels in early pregnancy were positively correlated with lower Apgar scores at one minute and five minutes post birth. Higher levels of maternal negative trait emotions during early pregnancy were correlated with lower levels of cardiac vagal tone in the infants. Ponirakis et al. suggested that the adolescents who experienced negative emotions in early pregnancy may have channeled their feelings into motivation to seek social support and engage in self-care behavior.

Monk et al. (2000) used standardized self-report questionnaires to assess trait anxiety in 17 healthy women between 35 and 38 weeks of pregnancy. Blood pressure, respiration, cardiac function, and fetal heart rate were monitored continuously for a five-minute baseline reading, a five-minute Stroop color-word or arithmetic task, and a three-minute recovery period. Results showed that fetuses of women who scored above average on trait anxiety had significantly increased heart rates during the stressful task, and fetuses of women who scored below average did not. Unexpectedly, the women who scored below average on trait anxiety had significantly higher increases in blood pressure during the stress challenge than the women who scored above average. Neither group showed significant increases in maternal heart rate, but both groups showed significant increases in respiration rate. Monk et al. discussed several possible explanations for these results, but the specific mechanism for increased fetal heart rate during maternal stress in the higher than average trait anxiety group is unknown.

In a larger study, Monk et al. (2003) used a Stroop color-word task to induce stress in 32 healthy pregnant women with gestational ages from 32 to 38 weeks. Subjects were also administered standardized self-report assessments of state and trait anxiety. Results indicated significant positive correlations between the mother's trait anxiety scores and cardiovascular reactivity and elevations in fetal heart rate during the recovery period from the Stroop task.

Monk et al. (2004) conducted a study with 57 women between 36 and 38 weeks of pregnancy. This study was comparable in design to the previous two here reviewed except that in addition to physiological monitoring, subjects were interviewed for determination of psychiatric status. Thirty-five subjects were determined to have no psychiatric diagnosis but were divided into three groups based upon trait anxiety scores. Eleven subjects were diagnosed with depression, and eleven with various anxiety disorders. During baseline measures, there were no significant differences in fetal heart rate between groups. Maternal cardiorespiratory measures showed no statistical difference between groups during baseline or challenge; however, fetuses of depressed subjects had significant heart rate increases during challenge. Fetuses of subjects in the anxiety disorder group and the healthy group showed no significant heart rate increases during challenge. Monk et al. concluded that the differences in fetal heart rate were associated with maternal psychiatric status rather than maternal cardiorespiratory activity.

DiPietro, Costigan, and Gurewitsch (2003) conducted a similar study with 137 healthy pregnant women at 24 and 36 weeks gestation. Consistent with Monk et al. (2003), fetuses showed significant autonomic responses in the period immediately following the Stroop task. Contrary to expected outcome, fetuses responded to maternal stress with reduced movement and increased HRV.

A possible explanation for this unexpected outcome may be found in a study conducted by Sjostrom, et al. (2002). Four different fetal heart rate patterns labeled A, B, C, and D were identified in 41 healthy pregnant women between 37 and 40 weeks gestation. Heart rate pattern D, which was found to be positively associated with high maternal state and trait anxiety scores was described as "unstable, with large and prolonged accelerations often fused into sustained tachycardia" (p. 91). All the fetuses displayed this pattern at some time; however, fetuses of mothers with high stress scores displayed the unstable pattern for longer periods of time. The higher the mother's stress scores, the longer the fetus displayed the unstable heart rate pattern. An interesting finding was that HRV was highest in pattern D, but fetuses of mothers with high state anxiety had lower HRV in patterns A and B both of which identified more stable, quiescent states. This finding is consistent with McCraty and Childre's (2002) observations of adult HRV patterns under conditions of feeling frustrated or appreciative. Amount of HRV may be increased under both conditions, but feelings of frustration are attended by erratic heart rate patterns indicative of dysregulation of the autonomic nervous system. Thus, although research indicates that higher amounts of HRV reflect better autonomic regulation (Doussard-Roosevelt et al., 1997), discrimination between amount of HRV and heart rate coherence may offer an added dimension of analysis.

*Prenatal Stress Management Research*

Research into stress management with pregnant women has focused on various aspects of stress and the stress response. The following studies include a wide range of interventions and research designs which are informed by previous research and theoretical constructs regarding stress.

*Social Support Interventions.*

Considering the strong correlations between socioeconomic factors and poor pregnancy outcomes, it is not surprising that many intervention programs attempt to address socioeconomic problems. In a survey of eight programs which included various types of education and additional social support, Paarlberg et al. (1995) questioned the efficacy of this strategy for preventing low birth weight and pregnancy complications. Results of the survey indicated that emotional support during labor resulted in shorter length of labor, reduced use of anesthesia, and fewer delivery complications; however, the effects of education and psychosocial support during pregnancy had very little influence on fetal development and pregnancy complications. Paarlberg et al. suggested that "as long as the theoretical basis for the effect of maternal exposure to stressful situations on pregnancy complications and birth weight is unclear, psychosocial intervention programmes will lack the basis needed to yield the desired results" (p.587).

Similar results were reflected in a 2003 study by Hodnett and Fredericks who reviewed 16 social support intervention programs for at-risk pregnant women. Social support was positively correlated with fewer Cesarean deliveries and less use of analgesia during delivery but was not positively correlated with fewer preterm deliveries or higher birth weight. Interestingly, additional social support was correlated with an almost threefold increase in elective termination of pregnancy.

*Relaxation Interventions.*

A pilot program for pregnant and parenting adolescents was conducted by de Anda, Darroch, Davidson, Gilly, and Morejon (1990) in which 23 experimental subjects participated in a five week stress management program utilizing cognitive therapy and deep muscle relaxation exercises. The no-treatment control group consisted of 12 adolescents. Standardized self-report questionnaires were used to measure state and trait anxiety, pregnancy stress or parenting stress, and general stress. Results of the study indicated a trend toward better stress coping behavior in the experimental group, but it was not statistically significant. Experimental group subjects did show a significant increase in belief in their ability to handle stress without an equal reduction in physiological and behavioral manifestations of stress.

Moss (1991) tested the effects of progressive relaxation therapy on 20 pregnant women who had experienced previous preterm deliveries of undetermined etiology. Treatment group subjects (n=11) received six progressive relaxation sessions between the 10th and 18th weeks of gestation, and they were encouraged to practice relaxation skills twice a day for at least 15 minutes. Control group subjects (n=9) received an equal number of time and attention contacts. Standardized self-report questionnaires were used to measure state and trait anxiety and stress levels at three different stages of pregnancy, 10-12, 16-20, and 30-32 weeks. Results of the first administration of the assessments showed no significant differences between treatment group and control group scores; however, assessment at 30-32 weeks indicated statistically significant differences in favor of the treatment group on measures of both state and trait anxiety and stress levels. In addition, the control group had a 67% recurrence of preterm delivery which was a significant contrast to the 9% recurrence in the treatment group. The success of this intervention may have been due in part to application of the treatment early in pregnancy; however, results must be interpreted with caution because seven women in the treatment group and three women in the control group smoked tobacco during pregnancy. Tobacco smoking is strongly correlated with preterm delivery (Shah, 2000). Although the greater number of smokers in the treatment group would seem to lend further weight to the results of the study, no information was given about amount or duration of smoking; therefore, it is unclear how the subject's smoking habits affected results.

Less positive results were achieved with the use of progressive relaxation in a study of 21 pregnant women at 30 to 38 weeks gestation (Shaw, 1993); however, the brevity and timing of the intervention may have affected the outcome. Treatment group subjects listened to an introductory audio tape which explained the principles and benefits of progressive relaxation and were asked to use an audio tape to practice the relaxation skills three times during a seven day period. Control group subjects were asked to listen to an audio book tape three times during the same seven day period. Results of pre and post standardized psychometric testing showed statistically significant changes in anxiety and anger in the control group but no changes in the treatment group. Many of the treatment group subjects reported that repeated muscle tension and relaxation required by progressive relaxation heightened the discomfort of advanced pregnancy. Additionally, adequate mastery of self-regulation skills is best accomplished over a period of a few weeks (Schwartz, 2003).

In a pilot study conducted by Urizar Jr. et al. (2004), 41 pregnant low-income Latina women were tested for salivary cortisol levels in the morning and the evening under two different test conditions, non-stress reduction (NSR) and stress reduction (SR). The NSR condition was the normal conditions of the subject's life. Subjects were told to create the SR condition on a given day with the following instruction: “Eliminate things that are stressful and/or participate in things that increase your level of relaxation” (p. 277). Subjects chose various activities that they interpreted to be personally stress-relieving. Results of repeated measures ANOVA analyses showed significantly lower levels of morning cortisol under SR conditions and significantly lower levels of stress, anxiety, and depression under SR conditions as measured by pre and post standardized self-report questionnaires.

Teixeira, Martin, Prendiville, and Glover (2005) tested the effects of one 45-minute period of either passive or directed relaxation in 58 pregnant women. Pre and post assessment included a standardized self-report measure of state and trait anxiety, and measures of heart rate, plasma catecholamines, cortisol, and uterine artery resistance. Passive relaxation consisted of sitting in a comfortable chair reading a magazine, and directed relaxation was conducted by a stress management expert using a relaxation imagery script. Results of this study were mixed. Both methods of relaxation reduced state anxiety and heart rate, but the directed relaxation effect was significantly greater. Significant reductions in noradrenaline levels were seen in the passive relaxation group but not in the active relaxation group. Adrenaline levels were not significantly changed in either group, but cortisol levels were significantly reduced in both groups with a greater effect in the passive relaxation group. Uterine artery blood flow was reduced significantly in the passive relaxation group but was unchanged in the active relaxation group. Teixeira et al. commented on this striking response fractionation and the need for further research on different types of stress and relaxation.

DiPietro, Costigan, Nelson, Gurewitsch, and Laudenslager (2008) conducted a study of real-time fetal HR and HRV effects of induced maternal relaxation in 100 maternal-fetal pairs in the 32nd week of pregnancy. Fetal monitoring was performed for an 18-minute baseline period, an 18-minute taped progressive relaxation exercise, and 18 minutes post-relaxation. Effectiveness of the relaxation procedure for the mothers was confirmed by standardized self-report questionnaires and measurement of HR, respiration, RSA, and skin conductance. Reported results included significant reductions in fetal HR and increases in HRV during the relaxation exercise. DiPietro, et al., posited that these changes may have been due to changes in the uterine environment due to the mother's recumbency and state changes during the entire time of fetal monitoring and may have represented a fetal orienting response to the changes rather than to relaxation alone.

*Biofeedback-Assisted Relaxation Interventions.*

Somers et al. (1989) studied the effects of biofeedback assisted therapy with 45 subjects with mild pregnancy-induced hypertension. Subjects were randomly assigned to one of three groups: (1) standard bed rest with obstetrical monitoring, (2) treatment as in group one along with a cognitive behavioral intervention to enhance treatment compliance, and (3) treatment as in groups one and two along with four hours of thermal biofeedback-assisted relaxation training and instruction in diaphragmatic breathing and blood pressure self-monitoring. Group three had significantly lower mean arterial pressure (MAP) at the end of treatment than groups one and two who both had trends toward higher MAP at the end of treatment. The study also reported no correlation between hours of bed rest and MAP.

Peavey (1996) reported a protocol she used to improve outcomes of pregnancy, labor, and delivery for women whom she treated in her counseling practice. Components of the protocol included education and counseling regarding pregnancy and delivery, behavioral and imagery interventions designed to enhance mother-infant bonding, instruction in diaphragmatic breathing, EMG biofeedback training on calf muscles to teach lower body relaxation, and other forms of biofeedback therapy based on psychophysiological assessment. Peavey reported positive outcomes from use of this protocol during fifteen years of practice; however, her results have not been confirmed by statistical analysis.

Janke (1999) studied effectiveness of biofeedback-assisted relaxation exercises on preterm labor outcome in 107 women. Subjects who were diagnosed with preterm labor by their physicians were assigned to either a treatment group (n=67) or a control group (n=40). Average gestational age at the beginning of participation was 28 weeks. Standardized self-report questionnaires were used to measure state and trait anxiety and preterm labor risk. Treatment group subjects were provided with thermal biofeedback devices and several different taped relaxation exercises from which to choose. They were taught diaphragmatic breathing and were encouraged to use the tapes and biofeedback devices once a day. Before and after relaxation practice they recorded their finger temperature and ratings of their subjective feelings of relaxation on a 0 to 10 scale. After one to two weeks, twenty-three participants in the treatment group reported being unable to relax and stopped practicing. They agreed to continue as members of the control group, and Janke performed a separate statistical analysis on the data from this nonadherent group. All three groups received a home visit at the beginning of the study and weekly phone calls to check on their progress. All subjects continued in the study until delivery. Paired *t*- tests on skin temperature readings and relaxation ratings indicated that treatment group subjects successfully achieved the relaxation response during practice. Analysis of covariance results showed that length of gestation in the experimental group was significantly longer than in either the control group or the non-compliant group.

Chandler, Lawson, Molenaar, and Desalme (1999) studied the effects of maternal biofeedback training on birth weight, gestational age, fetal heart rate (FHR), and Apgar scores of the infants. Nineteen subjects were assigned to a control group which attended prenatal education classes, and 11 subjects were assigned to a treatment group which received five sessions of thermal (TEMP) biofeedback training during which a biofeedback therapist used an autogenic phrases script to induce relaxation. Subjects were also assigned daily homework with relaxation tapes and TEMP biofeedback. Frontalis muscle tension measured by electromyography (EMG), palmar sweat gland activity measured by electrodermal response (EDR), and FHR measured by external tococardiography was also monitored. Results showed that lower maternal EMG was significantly correlated with higher birth weight and gestational age, but TEMP and EDR were not. Predictably, FHR changes were significantly correlated with birth weight and gestational age. Although the treatment group showed improvements over the control group in measures of birth weight, gestational age, and Apgar scores, these differences were not statistically significant possibly due to small sample size.

*Summary of Intervention Research*

A review of the literature on effects of stress management interventions during pregnancy indicates that social support may contribute to improved outcomes during labor and delivery, but show little effect on birth weight, preterm delivery, or fetal development. Low data exists on the effects of relaxation interventions and biofeedback interventions, and some studies have shown mixed results. Further research is needed on specific stress management components which may be effective with this population.

Some of the studies reviewed targeted the cognitive dimension of the stress response. This intervention is predicated on the theoretical assumption that thoughts precede emotions. However, some emotional responses to stressful situations bypass the thinking brain because they are triggered by emotional memories established early in life before development of language or cognitive abilities necessary for rational assessment (LeDoux, 1996). Thus, it would seem prudent to intervene on the cognitive/emotional level, yet none of the reviewed interventions specifically addressed the emotional component of the stress reaction. McCraty (2006) postulated that stress management requires intervention on the emotional level in order to affect enduring change.

Research previously noted in this review has highlighted HRV as an indicator of autonomic regulation. As will be described later in this paper, HRV biofeedback instruments now exist which may be used to help people learn to voluntarily improve autonomic regulation. This literature review found no studies of HRV biofeedback stress management interventions with pregnant women.

The goal of the current study is to expand knowledge of stress management components which may be effective in treating maternal prenatal stress. Specifically, the study tested the effectiveness of HRV biofeedback and cognitive/emotion-focused stress management techniques during pregnancy. The study also assessed real-time changes in fetal heart rate during maternal practice of these techniques.

## Application of New Intervention Components

### *Heart Rate Variability, Positive Emotions, and Stress*

Analysis of HRV and HRV patterns is often a component of stress management research. The relationship of HRV to stress is best explained by the effect of the autonomic nervous system on HRV. The autonomic nervous system, which regulates involuntary vital functions in the body, is composed of two branches, the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS) (Rothenberg and Chapman, 1989). HRV is an expression of beat-to-beat changes in heart rate as the heart is influenced by SNS activation which increases heart rate and PNS activation which decreases heart rate (McCraty, Atkinson, and Tomasino, 2001). Optimal cardiac functioning is characterized by a slight PNS dominance often described as parasympathetic tone or vagal tone (Porges, 1995). The later term reflects the fact that the vagus nerve mediates the PNS. Porges described the role of vagal tone in stress management and stated that the SNS is designed to respond to the outward environment and that the PNS is designed primarily to tend to the internal environment and to maintain homeostasis. When an individual perceives a threat, PNS activity is withdrawn and organismic resources are directed outward. Porges suggested that this withdrawal defines stress, and that the condition of the PNS before perception of a threat occurs is a representation of stress vulnerability.  Lower vagal tone equates to higher stress vulnerability.

Many psychophysiological factors influence the SNS and PNS interplay which is observed in HRV.  The influence of respiration on HRV is expressed in the pattern known as respiratory sinus arrhythmia (RSA) in which the heart rate increases upon inhalation and decreases upon exhalation (Porges, 1995).  Assessment of RSA constitutes a method for quantifying vagal tone.  Porges stated, “The amplitude of respiratory sinus arrhythmia provides a validated and easily obtainable index of parasympathetic tone via the cardiac vagus” (p. 228).

This measure may be displayed on biofeedback monitors in real time to enable people to practice and acquire the skill of voluntary RSA or HRV modulation.  Current applications of biofeedback-assisted stress management include an RSA modality in which the client is trained to increase HRV with paced diaphragmatic breathing (Gevirtz and Lehrer, 2003).  Although research is limited, RSA biofeedback has shown significant positive correlations with increased HRV in cardiac patients (Gevirtz and Lehrer), reduced pain and depression in fibromyalgia patients (Hassett et al. 2007), reduced depression symptoms in patients diagnosed with major depressive disorder (Karavidas et al., 2007), reduced pain in children and teenagers diagnosed with recurrent abdominal pain (Humphreys and Gevirtz, 2000), and improved respiratory function in asthma patients (Lehrer et al., 2004).  Gevirtz and Lehrer reported that hyperventilation is a possible side effect of this therapy, and appropriate preventive measures must be applied.

McCraty and Childre (2002) stated that although breathing has an influence on HRV, paced breathing can be difficult to maintain. Research conducted at the Institute of HeartMath (IHM) shows that different emotional states are associated with different heart rate patterns (McCraty, Atkinson, Tiller, Rein, and Watkins, 1995; McCraty and Childre). Negative emotions such as frustration and anger are correlated with an irregular and chaotic pattern. Positive emotions such as appreciation and care are correlated with a pattern which may be observed on a biofeedback monitor as a smooth, regular sine wave of approximately 0.1 hertz frequency (McCraty and Childre). These two patterns are described as incoherent and coherent respectively. Incoherent heart rate patterns may display as much variability as coherent patterns, thus McCraty and Childre focus primarily on teaching people to increase coherence in HRV patterns by engendering positive emotions rather than on increasing the height of the HRV wave.

The IHM is a research and education organization involved in the study of the interaction between the heart and the brain and its influence on emotions, perceptions, performance, and health (McCraty and Childre). IHM researchers have developed several simple stress management techniques designed to cultivate positive emotions and HRV coherence. Although the IHM has copyrighted the names of these techniques, they are based on well-known components of stress management practices. Each of these techniques incorporates three basic steps: (1) a shift in focus from stressful thoughts to area of the heart, (2) relaxed breathing, and (3) the use of imagery to create a shift in emotional state. Traditional practices such as yoga, qigong, or meditation often include instructions to focus on various parts of the body (Tiller, McCraty, and Atkinson, 1996). Imagery and breathing techniques are also part of traditional stress management practices (Davis, Eshelman, and McKay, 2000). The imagery component of IHM techniques is designed specifically to help people experience positive emotions such as appreciation, care, or compassion rather than simple relaxation.

Frederickson (2001), a researcher in the emerging field of positive psychology, has developed the broaden-and-build theory of positive emotions which presents a rationale for intervention on the emotional level. The broaden-and-build theory holds that experiencing of positive emotions helps people build personal resources and resilience. According to this theory, the adaptive function of the fight-or-flight response requires a narrowing of perspective that helps people address acute and immediate threats to survival. Conversely, positive emotions promote a broader perspective and engender personal growth by building psychological, intellectual, physical, and social resources that help people not only survive but thrive. Positive emotions have also been shown to facilitate recovery from short-term cardiovascular effects of negative emotions (Fredrickson & Levenson, 1998). In addition, research findings indicate that even short periods of experiencing positive emotions can begin to build an “upward spiral” (Fredrickson, p. 223) based on the reciprocal action of better personal resources contributing to positive emotions and positive emotions contributing to personal resources. Fredrickson (2000) hypothesized that stress management techniques such as relaxation therapies, meditation, imagery, and mindfulness may be effective to the extent that each one engenders the positive feeling of contentment.

Although the broaden-and-build theory of positive emotions seems to call for direct intervention on the emotional level Fredrickson (2000) maintained that emotions cannot be directly engendered. McCraty et al. (2001) questioned this widely held assumption and stated that “the emotional system can be developed and brought into coherence” (p. 11) with appropriate tools and practice. In other words, direct control of emotional states can be learned.

Quantum Intech, Inc. produces a biofeedback software system called the emWave PC Stress Relief System® designed for the purpose of learning HRV self-regulation. This system displays the subject’s heart rate and HRV pattern along with an option for a spectral display of heart frequencies. It also provides four levels of challenge for behavioral shaping and several games for variation in practice. Although HeartMath techniques may be learned without biofeedback assistance, use of this system enhances learning (McCraty, Atkinson, and Tiller, 1999)

*Institute of HeartMath Research*

Stress management programs employing IHM techniques have been used extensively in a wide range of settings with subjects ranging in age from elementary school children to the elderly and have been correlated with reduced psychophysiological manifestations of stress and improved quality of life (McCraty et al., 2001). Studies with students have shown use of HeartMath techniques to be positively associated with improved academic performance and test-taking skills (McCraty, et al) and with increased achievement aptitude, interpersonal skills, and mental attitudes (McCraty, Atkinson, Tomasino, Goelitz, and Mayrovitz, 1999). Application of IHM techniques in the workplace has been correlated with enhanced employee job satisfaction and communication and with reduced stress, anxiety, and burnout (Barrios-Choplin, McCraty, and Cryer, 1997).

Research with IHM techniques to address stress-related symptoms of medical illness and physiological manifestations of stress has also shown some positive outcomes. McCraty, Atkinson, and Tomasino (2003) used HeartMath techniques in a 16-hour stress management program with 32 hypertensive employees of an information technology company. Treatment group subjects (n=18) showed clinically and statistically significant reductions in blood pressure similar to reductions achieved with antihypertensive medication. Results in the treatment group also indicated significant reductions in stress symptoms, depression, and anxiety and significant increases in positive outlook, peacefulness, and workplace satisfaction.

Luskin, Reitz, Newell, Quinn and Haskel (2002, Fall) conducted a controlled pilot study with congestive heart failure patients. Treatment group subjects (n=14) received eight 75-minute sessions of stress management training with the use of HeartMath techniques. Results showed significant reductions in perceived stress, depression, and emotional distress and significant improvements in tests of distance walked in six minutes. No significant changes were achieved in measures of cardiac functioning.

After participation in a two-day IHM training workshop and a six month period of skills practice, 22 patients with diabetes showed significant reductions in self-reported measures of stress sensitivity, anxiety, depression, anger, somatization, sleeplessness, and fatigue and significant increases in peacefulness, social support, and vitality (McCraty, Atkinson, and Conforti, 1999). Pre and post measures of mean HbA1c levels (a measure of glycemic control) revealed no statistically significant improvements; however, linear regression analysis showed positive correlations between improved HbA1c levels and amount of practice as reported by the patients.

Rozman, Whitaker, Beckman, and Jones (1996) studied use of HeartMath techniques with 38 patients with human immunodeficiency virus. Subjects attended a total of six days of training and were asked to practice HeartMath techniques for one hour a day. Results of this six-month pilot study indicated significant reductions in stress and psychological and physical symptoms.

In a study with 45 healthy adults, McCraty, Barrios-Chopin, Rozman, Atkinson, and Watkins (1998) trained 30 members of the treatment group to use HeartMath techniques. Treatment group subjects practiced the techniques five times a week for a month. Measures of effectiveness included pre and post self-report psychological questionnaires, HRV analysis, and salivary DHEA and cortisol levels. Cortisol elevation and decreased DHEA are associated with chronic stress (McCraty et al.). After one month, the treatment group showed significant reductions in psychological measures of stress, mean 23% reductions in salivary cortisol, and 100% increases in DHEA. Eighty percent of the treatment group subjects showed increased HRV coherence during practice.

*Entrainment and Interpersonal Effects*

The emphasis on the heart in IHM stress management techniques is based on a contention that the heart, being the strongest oscillator in the body, has potential to entrain coherence in other physiological oscillatory systems such as those in the brain, the craniosacrum, and the digestive tract (McCraty, 2003, Tiller et al. 1996). Thus, through entrainment the heart may potentially enhance coherence and order in the entire organism.

In addition to psychophysiological health benefits afforded by HRV coherence and entrainment, heart rhythms appear to have an interpersonal effect. The heart generates an electromagnetic field which may be measured several feet away from the body and which may also be measured in bodies of other individuals who are in proximity (McCraty, Atkinson, Tomasino, and Tiller, 1998; Russek and Schwartz, 1994). McCraty (2003) reported an experiment in which two women experienced entrainment to each other's heart rhythms during practice of IHM stress management skills. In consideration of this potentiality, an exploratory purpose of the present study was to investigate the possibility that a pregnant woman trained in IHM stress management skills might be able to influence fetal HRV coherence during practice.

## Rationale for the study

In view of the multifaceted psychophysiological nature of the stress response, it is not surprising that many different types of stress assessments exist which range in sophistication from simple stress dots which indicate skin temperature to complex tests of cardiovascular function. Numerous stress management interventions also exist which range in focus from the medical to the metaphysical. The expense of these assessments and interventions seems to rise with their complexity. The personal and societal financial burden of stress and stress-related illnesses calls for cost-effective and accurate stress assessment and intervention. In the case of prenatal stress, this need seems particularly important due to the potential for improving quality of life from the time of formation. Measurement of HRV constitutes a relatively inexpensive stress assessment, and stress management with HRV biofeedback training is a relatively inexpensive intervention.  This researcher found no studies investigating the effect of HRV biofeedback assisted stress management in reducing prenatal stress.

## Purpose of the Study

The purpose of this study is to examine the effectiveness of a stress management program utilizing HRV biofeedback training and intentional generation of positive emotions in reducing the stress of pregnant women and to examine the effect of this practice on fetal HR and HRV.  This study is intended to contribute to current research on stress management with pregnant women.

# CHAPTER 2

# METHODS AND PROCEDURES

## Research Question

What effect, if any, does HRV biofeedback assisted stress management training have on stress symptoms of pregnant women and on fetal heart rate measures?

## Research Hypotheses

1. Subjects will show a significant difference in scores on the State-Trait Anxiety Inventory Form Y1 (STAI Y1) across sessions.
2. Subjects will show a significant difference in pre test versus post test scores on the State-Trait Anxiety Inventory Form Y2 (STAI Y2).
3. Subjects will show a significant difference in pre test versus post test scores on the Pregnancy Experience Scale (PES).
4. Subjects will show a significant difference in scores on the Pregnancy Experience Scale-Brief (PES-Brief) across sessions.
5. Subjects will show significant improvement in measures of HRV coherence across sessions.
6. Fetuses of subjects will show a significant difference in HRV during subject's practice of HRV stress management techniques as compared to baseline conditions.

## Definition of Terms

*Heart rate variability* is defined as beat-to-beat changes in heart rate.

*Coherence* is defined as the smoothness or synchronization of these changes as they are influenced by the autonomic nervous system.

*Low birth weight* is defined as an infant weighing less than 5 pounds, 8 ounces (2500 grams) at birth (Rothenberg and Chapman, 1989).

*Preterm birth (*also called *premature birth* and *low gestational age)* is defined as an infant born before 37 weeks of pregnancy (Rothenberg and Chapman, 1989).

*Gestational age* is defined as the age of a fetus or newborn given in weeks since onset of mother's last menstrual period (Rothenberg and Chapman, 1989).

*Apgar score* is determined at one minute and five minutes post delivery. Infants are rated on a one to ten point scale on assessments of heart rate, muscle tone, respiratory effort, color, and reflex irritability. Scores below 7 indicate distress (Rothenberg and Chapman, 1989).

## Methods

### *Participants*

Participants volunteered in response to recruitment flyers which were made available to the patients of obstetricians, midwives, birthing coaches, childbirth educators, and family service organizations in Denton and Dallas/Ft. Worth, Texas. In addition, the study was advertised in the classified section of the local newspaper. Eligibility was restricted to non-smoking women between the ages of 18 and 45 who had singleton pregnancies between 24 and 28 weeks of gestation, were not on psychoactive drugs, asthma or heart medications or regular antihistamines and who were not receiving psychological treatment to alter anxiety (e.g. psychotherapy, biofeedback, hypnosis, psychotropic medications). Participants gave informed consent to attend five to six individual biofeedback sessions, complete stress assessment questionnaires at each session, practice stress management skills independently for twenty minutes a day and throughout the day in response to stressful situations, and allow fetal monitoring during biofeedback sessions.

Ten pregnant women volunteered for the study. Two dropped out before they began attending sessions, one due to a miscarriage and one due to scheduling problems. One dropped out after the second session due to an adverse reaction to practice of the stress management techniques. This reaction was most likely related to relaxation induced anxiety (Schwartz, Schwartz, & Monastra, 2003).

The seven subjects who remained had uncomplicated pregnancies at the beginning of the study. During their participation, two developed hypertension, one developed gestational diabetes, and one was informed by her obstetrician that ultrasound examination indicated the possibility that the fetus was malformed.

Subject demographics reflect a sample of five whites, two African-Americans, and one Asian. The mean age was 28, and the age range was from 19 to 33. Five subjects were married, and two were single. Six were employed full-time outside the home, and one was a full-time homemaker. Three were nulliparous, and four were multiparous, three having one other child, and one having three other children. Six subjects reported that the sex of their fetuses had been identified by ultrasound. Five fetuses were female, and one was male.

*Assessments*

The State-Trait Anxiety Inventory (STAI) (Spielberger, Gorsuch, Lushene, Vagg, and Jacobs, 1983) was selected for use in this study because it has been widely used in research and clinical practice and is frequently used in studies with pregnant women. It consists of two 20-statement scales, the S-Anxiety scale (STAI Form Y-1) and the T-

Anxiety scale (STAI Form Y-2). Subjects are asked to use a four-point Likert scale to rate their agreement or disagreement with each statement. STAI Form Y-1 assesses subject's immediate feelings of apprehension, tension, nervousness, and worry. STAI Form Y-2 assesses subject's general or more dispositional feelings of anxiety.

The STAI was developed for assessment of college and high school students and adults. Alpha coefficients for the T-Anxiety scales in the normative samples ranged between .89 and .91 with a median of .90. For the S-Anxiety scales, alpha coefficients were between .86 and .95 with a median of .90. During four test conditions, movie, exam, normal, and relax, alpha coefficients for the S-Anxiety scale ranged from .89 to .94 for males and .83 to .93 for females. Test-retest stability is higher for the T-Anxiety scale than for the S-Anxiety scale due to the fact that the S-Anxiety scale measures transient situational anxiety.

The Pregnancy Experience Scale (PES) (DiPietro, Ghera, Costigan, and Hawkins, 2004) was used to measure pregnancy-specific daily hassles and uplifts. The PES was chosen for this study because research reveals the need to assess for pregnancy-specific stress in order to accurately estimate stress levels in pregnant women (DiPietro et al.). Also, in providing measures for uplifts as well as hassles, the PES provides a balanced stress assessment. The PES consists of 41 items to which the subject is asked to respond on both a four-point Likert scale of positive values and a four-point Likert scale of negative values. The internal consistency correlations for the hassles items on the PES range between .91 and .95 and between .85 and .90 for the uplifts items (DiPietro, Hilton, Hawkins, Costigan, and Pressman, 2002). PES scores on frequency and intensity of hassles demonstrated significant correlations with state-trait anxiety, depressive symptoms, and degree of daily hassles (DiPietro et al.).

The Pregnancy Experience Scale-Brief (PES-Brief) was used prior to the second, third, and fourth treatment sessions. In addition, subject's responses from the full scale PES administration during the first and fifth sessions were transferred to the PES-Brief for inclusion in a five-point repeated measures ANOVA statistical analysis.

The PES-Brief is an unpublished 20-question assessment which was derived by selection of ten each of the most frequently elected uplifts and hassles on the full scale PES. The PES-Brief is in the initial testing phase, and limited psychometric information is currently available. The author of the PES-Brief (J. A. DiPietro, personal communication, April 20, 2006) stated that preliminary psychometric data for this test indicates that it is similar to the PES except that the spread of frequency values is narrower due to the smaller number of test items. Validity correlations are in the .3 to .5 range, and alpha coefficients for the hassles and uplifts scales are in the .80 range. The author stated that she was confident in suggesting use of the PES-Brief for this study. DiPietro provided descriptive statistics for four of the six PES-Brief scales on a cohort of 107 women at five stages of pregnancy, 24 to 26 weeks, 27 to 29 weeks, 30 to 32 weeks, 33 to 35 weeks, and 36 to 38 weeks (personal communication, April 4, 2008).

*Apparatuses*

The emWave PC Stress Relief System® software was used to teach subjects to increase their HRV coherence. EmWave PC® feedback options include a trace line showing fluctuations in HRV, an average heart rate indicator, three indicator lights showing low, medium, or high coherence, a line graph display of accumulated coherence scores, a coherence ratio bar graph showing the percentage of time the subject produces low, medium, and high coherence HRV, and a spectral display of the subject's heart rate frequencies. EmWave PC® measures pulse rate utilizing an ear-clip photoplethysmograph connected to the computer through a USB port. The computer used for this research study is a Hewlett Packard Pavilion dv6000 laptop with AMD Turion processor. Subjects were loaned emWave Personal Stress Reliever® portable biofeedback devices (Quantum Intech Inc., Boulder Creek, CA) for use in daily practice to enhance generalization of stress management skills.

Fetal heart rate monitoring was accomplished with the use of a Corometrics 115 fetal monitor. Corometrics 115 measures simultaneous trends of beat-to-beat fetal heart rate and uterine activity plotted on a dual channel strip chart recorder. Fetal HR is measured by continuous wave Doppler with a sampling frequency of 200 Hz and HR range of 50-210 BPM. Uterine contractions are measured by a 0-100 mmHg range strain gauge.

## Procedures

Each subject participated in five sessions of HRV biofeedback-assisted stress management training conducted by this researcher, a certified biofeedback practitioner by the Biofeedback Certification Institute of America. Subjects were provided with verbal informed consent and they signed informed consent forms and intake questionnaires prior to their participation in the study. Subjects completed STAI Form Y1, STAI Form Y2, and the PES at the first and fifth sessions and STAI Form Y1 and the PES-Brief at sessions two, three, and four. In addition, PES-Brief answers were extracted from the first and fifth administrations of the PES for inclusion in repeated measures ANOVA analysis of the PES-Brief. At each session, seven-minute baseline HRV measurements were taken. This procedure was performed by attaching the emWave PC® pulse monitor to the subject's earlobe. The subject was then instructed to sit quietly in an upright position and data was recorded without feedback to the subject. In the first session, subjects were given a short explanation of stress symptoms and habits and stress management with HRV biofeedback training. They were given a copy of the booklet *The Inside Story* (HeartMath, 2002) and were educated to the role of emotion in stress reactions and stress management. Subjects were assigned homework to observe and identify their stress habits and symptoms in order to increase their awareness of opportunities to apply stress management skills. In the second session, subjects were introduced to features of the emWave PC®, and were taught the Quick Coherence® (QC) and Heart Lock In® (HLI) techniques. These techniques involve a focus on the area around the heart, relaxed paced breathing, and the use of imagery to affect an emotional shift to a positive emotion such as care or appreciation. In order to demonstrate immediate practice effects of these techniques, subjects were initially asked to observe feedback on the computer screen during practice and during focus on stress-evoking cognitions. Subjects practiced the skills with feedback for ten minutes during sessions. Additionally, subjects were loaned emWave Personal Stress Reliever® portable biofeedback devices (Quantum Intech Inc., Boulder Creek, CA) and were encouraged to practice the HLI® technique daily for twenty minutes. They were also encouraged to practice the QC® technique during moments of heightened stress in their daily lives and to record the frequency of these practices on log sheets.

During the final session, both maternal and fetal HRV were recorded during baseline and practice conditions. Fetal heart rate was monitored with the Corometrics 115 fetal monitor by attaching an ultrasound transducer to the subject's abdomen with the use of a flexible belt and conducting jelly. A strain gauge was also belted to the subjects abdomen to monitor uterine contractions which might affect fetal heart rate. At the end of the session the pulse monitor, the transducer, the strain gauge, and the conducting jelly were removed and session graphs were saved. This procedure was accomplished in the fifth session with two of the subjects. Five subjects returned for a sixth session due to fetal movements which prevented adequate fetal heart rate monitoring at the fifth session.

Two methods were used to control for experimenter bias. First, a repeated measures design was used in which each subject served as her own control. Second, objective psychophysiological measures were taken at each session.

Compensation

Each of the seven participants who completed the study was paid $100.00 at the final session. Payment was contingent upon completion of tasks requested for the study and return of the emWave Personal Stress Reliever®.

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CHAPTER 3

RESULTS AND DISCUSSION

This chapter will provide statistical analysis of the STAI and PES data collected for this study, information related to changes in subject's HRV, and results of fetal heart monitoring during maternal skills practice. The discussion section of this chapter will provide a qualitative discussion of single-subject characteristics and responses pertinent to the findings along with a graphic display of each subject's scores on the STAI, the PES-Brief, the PES, and baseline coherence scores on the emWave PC®.

A five-point repeated measures analysis of variance (ANOVA) was used to calculate statistical significance of changes in the STAI Y1 and PES-Brief scores, and partial eta squared ($n^2$) was used to calculate effect size. A paired samples *t*-test was used to calculate the statistical significance of changes in the STAI Y2 and PES scores, and Cohen's *d* was used to calculate effect size. An alpha level of .05 was used for all statistical tests. Friedman's analysis of variance was used to calculate the statistical significance of changes in baseline HRV coherence scores.

Hypothesis 1

Hypothesis 1 states: Subjects will show a significant difference in scores on the State-Trait Anxiety Inventory Form Y1 (STAI Y1) across sessions. Repeated measures ANOVA results for STAI Y1 which are given in Table 1 show no significant change, but a small effect size (Cohen, 1988). Hypothesis 1 is rejected.

Table 1

*Repeated Measures ANOVA Summary Table for the State-Trait Anxiety Inventory Form Y1 Across Five Sessions of Biofeedback Therapy*

| Source | *SOS* | *df* | *MS* | *F* | *Sig.* | Partial $eta^2$ |
|---|---|---|---|---|---|---|
| Individuals | 1212.57 | 6 | 202.10 | | | |
| Occasions | 512.74 | 4 | 128.19 | 1.81 | .16 | .23 |
| Residual | 1696.86 | 24 | 70.70 | | | |
| Total | 3422.17 | 34 | | | | |

## Hypothesis 2

Hypothesis 2 states: Subjects will show a significant difference in pre test versus post test scores on the State-Trait Anxiety Inventory Form Y2 (STAI Y2). Subjects in this study showed no significant change in pre test scores ($M$ = 37.71, $SD$ = 4.64) verses post test scores ($M$ = 36.14, $SD$ = 5.08) of trait anxiety, $t(6) = 1.20$, $p = .27$. A small effect size was found ($r = .16$) (Cohen, 1988). Hypothesis 2 is rejected.

## Hypothesis 3

Hypothesis 3 states: Subjects will show a significant difference in pre test versus post test scores on the Pregnancy Experience Scale (PES). The PES contains four scales which measure frequency and intensity of hassles and uplifts and two composite intensity and frequency scales. Subjects showed no significant difference in pre test versus post test scores on any of the six scales. A medium effect size was found on the Frequency Hassles and Frequency Ratio scales (Cohen, 1988). Statistical information is given in Table 2. Hypothesis 3 is rejected.

Table 2

*Summary Table for Pregnancy Experience Scale Paired Samples t-Test.*

| | *M/SD* Pre | *M/SD* Post | *t* | *p* | *ES* |
|---|---|---|---|---|---|
| Intensity Uplifts | 2.03/.26 | 2.04/.38 | (6) = -.059 | .96 | -.02 |
| Intensity Hassles | 1.49/.38 | 1.43/.29 | (6) = .92 | .39 | .08 |
| Frequency Uplifts | 30.29/6.26 | 31.14/5.90 | (6) = -1.11 | .30 | -.07 |
| Frequency Hassles | 19.14/3.39 | 15.43/6.43 | (6) = 1.80 | .12 | .34 |
| Intensity Ratio | .74/.19 | .72/.20 | (6) = .261 | .80 | .04 |
| Frequency Ratio | .65/.16 | .49/.21 | (6) = 1.57 | .16 | .39 |

Hypothesis 4

Hypothesis 4 states: Subjects will show a significant difference in scores on the Pregnancy Experience Scale-Brief (PES-Brief) across sessions. The PES-Brief contains the same six scales as the PES. Repeated measures ANOVA results for the PES-Brief which are given in Tables 3 through 8 show no significant change. Hypothesis 4 is rejected.

Table 3

*Repeated Measures ANOVA Summary Table for the Pregnancy Experience Scale Short Form Intensity Uplifts Across Five Sessions of Biofeedback Therapy*

| Source | *SOS* | *df* | *MS* | *F* | *Sig.* | Partial eta$^2$ |
|---|---|---|---|---|---|---|
| Individuals | 4.14 | 6 | .69 | | | |
| Occasions | .48 | 4 | .12 | 1.36 | .28 | .19* |
| Residual | 2.10 | 24 | .09 | | | |
| Total | 6.72 | 34 | | | | |

* Small effect size (Cohen, 1988).

Results of analysis for Intensity Hassles scale of the PES-Brief showed that Mauchley's *W* was significant, $W(9) = .017$, $p < .05$ indicating that the sphericity assumption was not met. Correction of degrees of freedom was made by Huynh-Feldt procedure.

Table 4

*Repeated Measures ANOVA Summary Table for the Pregnancy Experience Scale-Brief Intensity Hassles Across Five Sessions of Biofeedback Therapy*

| Source | *SOS* | *df* | *MS* | *F* | *Sig.* | Partial eta$^2$ |
|---|---|---|---|---|---|---|
| Individuals | 6.32 | 6 | 1.05 | | | |
| Occasions | .22 | 2.63 | .08 | 2.04 | .15 | .25* |
| Residual | .64 | 15.80 | .04 | | | |
| Total | 7.18 | 24.43 | | | | |

* Medium effect size (Cohen, 1988).

Table 5

*Repeated Measures ANOVA Summary Table for the Pregnancy Experience Scale Short Form Frequency Uplifts Across Five Sessions of Biofeedback Therapy*

| Source | *SOS* | *df* | *MS* | *F* | *Sig.* | Partial eta$^2$ |
|---|---|---|---|---|---|---|
| Individuals | 18.80 | 6 | 3.13 | | | |
| Occasions | 1.89 | 4 | .47 | 1.27 | .31 | .18* |
| Residual | 8.91 | 24 | .37 | | | |
| Total | 29.60 | 34 | | | | |

* Small effect size (Cohen, 1988).

Table 6

*Repeated Measures ANOVA Summary Table for the Pregnancy Experience Scale Short Form Frequency Hassles Across Five Sessions of Biofeedback Therapy*

| Source | *SOS* | *df* | *MS* | *F* | *Sig.* | Partial eta$^2$ |
|---|---|---|---|---|---|---|
| Individuals | 105.60 | 6 | 17.60 | | | |
| Occasions | 13.31 | 4 | 3.33 | 1.46 | .25 | .20* |
| Residual | 54.69 | 24 | 2.28 | | | |
| Total | 173.60 | 34 | | | | |

* Small effect size (Cohen, 1988).

Table 7

*Repeated Measures ANOVA Summary Table for the Pregnancy Experience Scale Short Form Intensity Ratio Across Five Sessions of Biofeedback Therapy*

| Source | *SOS* | *df* | *MS* | *F* | *Sig.* | Partial eta$^2$ |
|---|---|---|---|---|---|---|
| Individuals | 2.25 | 6 | .38 | | | |
| Occasions | .02 | 4 | .01 | .24 | .91 | .04 |
| Residual | .47 | 24 | .02 | | | |
| Total | 2.75 | 34 | | | | |

Table 8

*Repeated Measures ANOVA Summary Table for the Pregnancy Experience Scale Short Form Frequency Ratio Across Five Sessions of Biofeedback Therapy*

| Source | *SOS* | *df* | *MS* | *F* | *Sig.* | Partial eta$^2$ |
|---|---|---|---|---|---|---|
| Individuals | 1.02 | 6 | .17 | | | |
| Occasions | .19 | 4 | .05 | 1.72 | .18 | .22* |
| Residual | .67 | 24 | .03 | | | |
| Total | 1.88 | 34 | | | | |

* Small effect size (Cohen, 1988).

A repeated measures design was used on the STAI Y1 and the PES-Brief in this small sample study as a means of increasing statistical power; however, due to low numbers of volunteers and attrition, this strategy did not afford adequate power to yield statistically significant results. A detailed qualitative discussion of results will follow.

Hypothesis 5

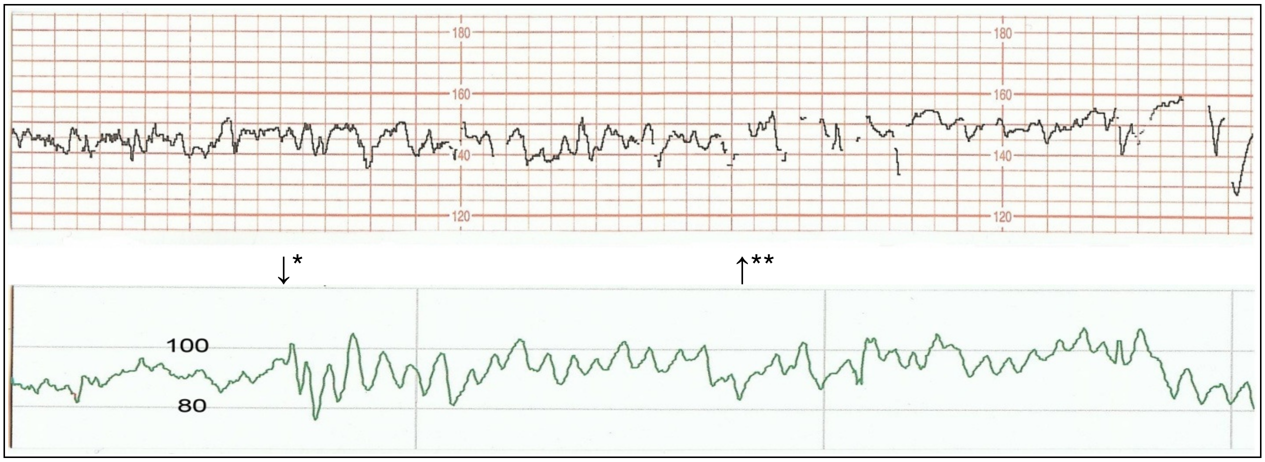
Hypothesis 5 states: Subjects will show significant improvement in measures of HRV coherence across sessions. EmWave PC® measures of HRV coherence is given in percentages of low, medium, and high coherence over the total time of each recording. Friedman's analysis of variance showed a significant decrease in low coherence scores ($X^2$ = 10.53, $p$ = .03), a significant decrease in medium coherence scores ($X^2$ = 11.58, $p$ = .02), and a significant increase in high coherence scores ($X^2$ = 18.16, $p$ = .001). These measures were recorded in seven-minute readings at the beginning of each session. Changes in baseline readings imply generalization of stress management skills (Arena & Schwartz, 2003). In practice sessions, all subjects learned the QC® and HLI® techniques and demonstrated their ability to meet and/or exceed the criterion of 80% combined medium and high HRV coherence at challenge level two. Hypothesis 5 is accepted.

## Hypothesis 6

Hypothesis 6 states: Fetuses of subjects will show a significant difference in HRV during subject's practice of stress management techniques as compared to baseline conditions. Paired fetal-maternal HRV data is shown in Figures 1 through 7. Fetal heart rate tracings and maternal HRV tracings were scanned and adjusted to correspond in the time domain in these figures. Recordings are nine to eleven minutes in length. Baselines were recorded in the first two minutes after which subjects were asked to practice the HLI® technique. Two subjects (B and E) who were successful at maintaining high coherence for five minutes after the baseline were asked to think about something distressing for one minute for the purpose of recording any differences in fetal heart rate response. After one minute, these two subjects were asked to practice the HLI® technique for the remainder of the recording.

For a professional medical opinion of the fetal heart rate data, this researcher consulted with DeCarlo Noble, M. D., a practicing obstetrician who is also the consulting obstetrician for Family Health Care, Inc. (personal communication, March 17, 2008). Dr. Noble stated that the fetal monitor tracings were of good quality. Small gaps in the tracings indicate that the fetus moved away from the monitor momentarily, but this movement did not affect overall quality of the recordings. He stated that some important factors which affect fetal heart rate are gestational age, the mother's age, general health, and health practices including medications taken, smoking, and social conditions which might impact health. Fetal state changes also affect fetal heart rate, and Dr. Noble stated that recordings may look very different on the same fetus at different times such as during different stages of sleep or wakefulness. He said that fetal heart rate reactivity is a sign of wellness in the fetus. Reactivity is distinguished by large heart rate variations, but it may not appear until 30 to 32 weeks gestation. Prior to development of reactivity, somewhat lower fetal HRV may be deemed to be appropriate for gestational age and is a sign of good oxygenation. Dr. Noble stated that quantification of fetal HRV from these recordings may be accomplished by examining the data to determine the approximate baseline from which fetal heart rate varies and noting the height or depth of the variation and the time duration. Numbers on the graph indicate beats per minute (BPM), and spaces between vertical lines represent ten seconds.

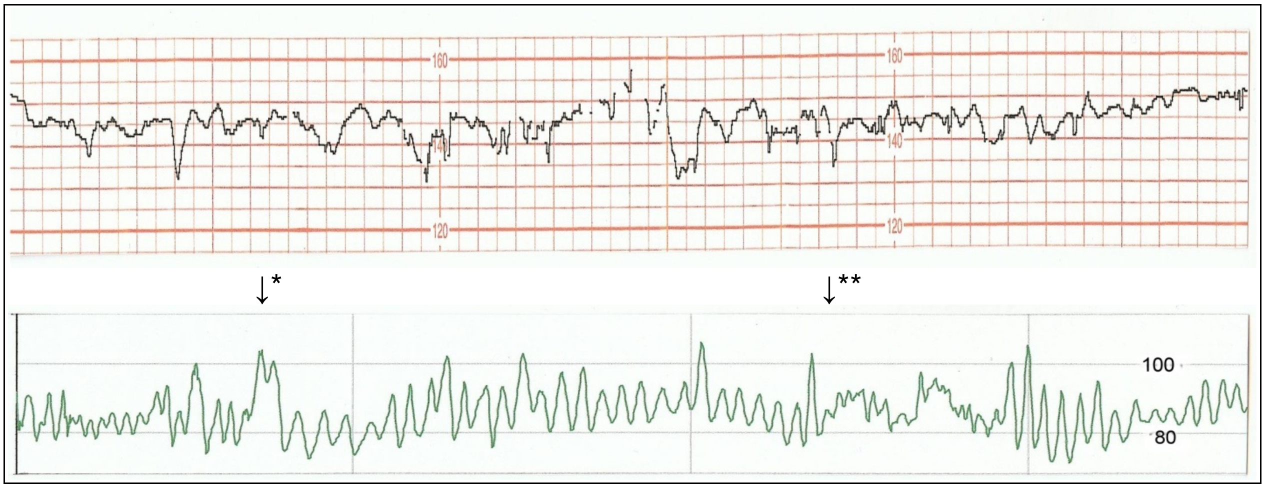
Dr. Noble also discussed each fetal HRV recording individually. Subject A was 19 years old and gestational age was 29 weeks. Dr. Noble stated that the fetal recording was appropriate for gestational age (see Figure 1). He noted that although reactivity was not fully developed, the amount of HRV seen here was an indication of appropriate development and good oxygenation. Utilizing the quantification method described by Dr. Noble, baseline fetal heart rate on this recording appears to be approximately 140 BPM. During the mother's two-minute baseline recording, fetal heart rate varied between approximately 140 to 150 BPM. From two minutes to five minutes, during the mother's practice of HLI®, fetal heart rate continued to vary between approximately 140 to 150 BPM, although some heart rate increases are of longer duration. After five minutes, the mother began to be less successful in achieving HRV coherence, and gaps in the fetal recording indicate that the baby was moving. The relationship of these two factors is not clear. For Subject A, hypothesis 6 is rejected.




↓* End of two-minute baseline ↑** Fetal movement

*Figure 1*. Subject A, concurrent fetal and maternal heart rate measure.

Subject B was 33 years old and gestational age was 31 weeks. Dr. Noble observed that HRV was more developed in this fetus and stated that in his opinion fetal HRV was greater after the two-minute baseline (see Figure 2). From a baseline of approximately 140 BPM, fetal heart rate varied mostly between 140 and 150 BPM during most of the recording. Some higher variations (approximately 131 to 158 BPM) are seen in the middle of the recording. Gaps in the recording before this point indicate fetal movement. As gestation advances, fetal movements and increased fetal HRV become increasingly correlated (DiPietro et al. 1996) a factor which may account for the greater HRV at this point. Some accelerations are of longer duration post two-minute baseline. Dr. Noble asserted that the one-minute period during which the mother stopped doing the HLI® technique and began to think of something distressing was not long enough to see change in the fetus. He also stated that any change in the fetus seen in a one-minute recording might be attributable to the fact that fetal heart rate will naturally return to baseline at some point. For Subject B, Hypothesis 6 is inconclusive.




↓* End of two-minute baseline ↓** Mother thinking about stressful situation

*Figure 2*. Subject B, concurrent fetal and maternal heart rate measure.

Subject C was 29 years of age and gestational age was 34 weeks. Dr. Noble described the fetal HRV recording as reactive indicating that HRV was more developed (see Figure 3). Interestingly, Subject C was feeling very stressed on the morning this data was collected and had difficulty establishing and maintaining coherent HRV. From a baseline of approximately 150 BPM, fetal heart rate varied between 145 and 210 BPM. No apparent correspondences exist between fetal HRV and maternal HRV coherence. For Subject C, Hypothesis 6 is rejected.

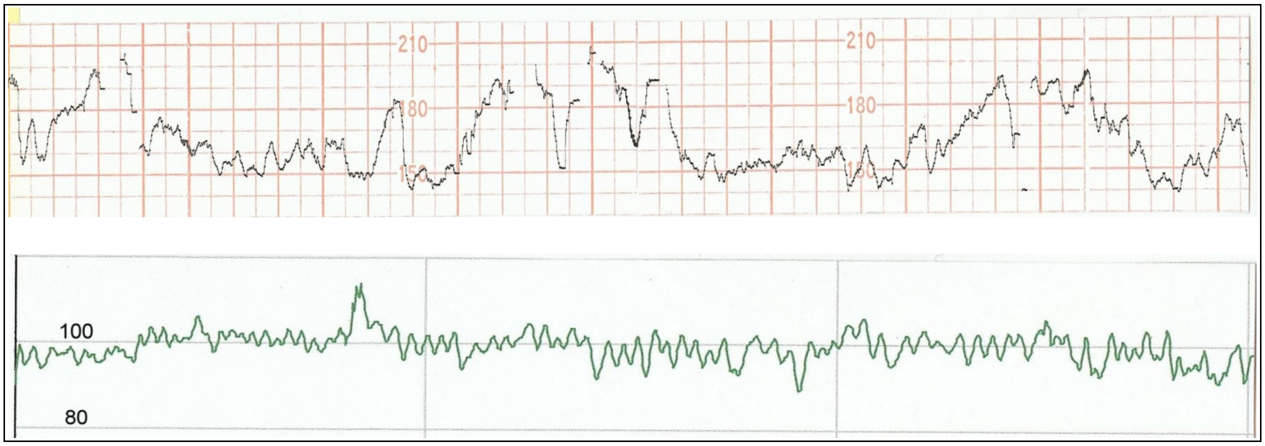
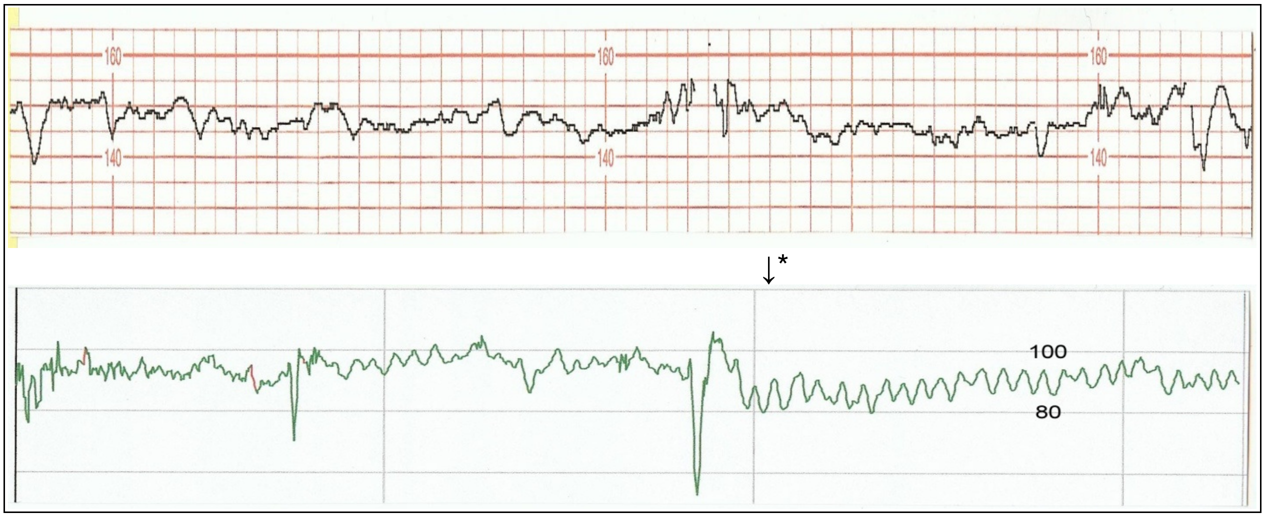



*Figure 3*.  Subject C, concurrent fetal and maternal heart rate measure.

Subject D was 28 years old and gestational age was 31 weeks. Upon first examination of this fetal recording Dr. Noble remarked on the low HRV and postulated that the fetus could be at an earlier state of gestation or could possibly be asleep (see Figure 4).  When informed that the fetus possibly had congenital anomalies, he stated that this also could explain low fetal HRV.  Subject D had recently learned of the possibility of congenital anomalies on the day this data was recorded and was understandably stressed.  She did not maintain consistent HRV coherence until approximately seven minutes into the recording.  From a baseline of approximately 145 BPM, fetal heart rate varied mostly between 145 and 150 BPM with a few accelerations and decelerations.  No apparent correspondences exist between fetal HRV and maternal HRV coherence.  For Subject D, Hypothesis 6 is rejected.




↓* Medium to high maternal HRV coherence established

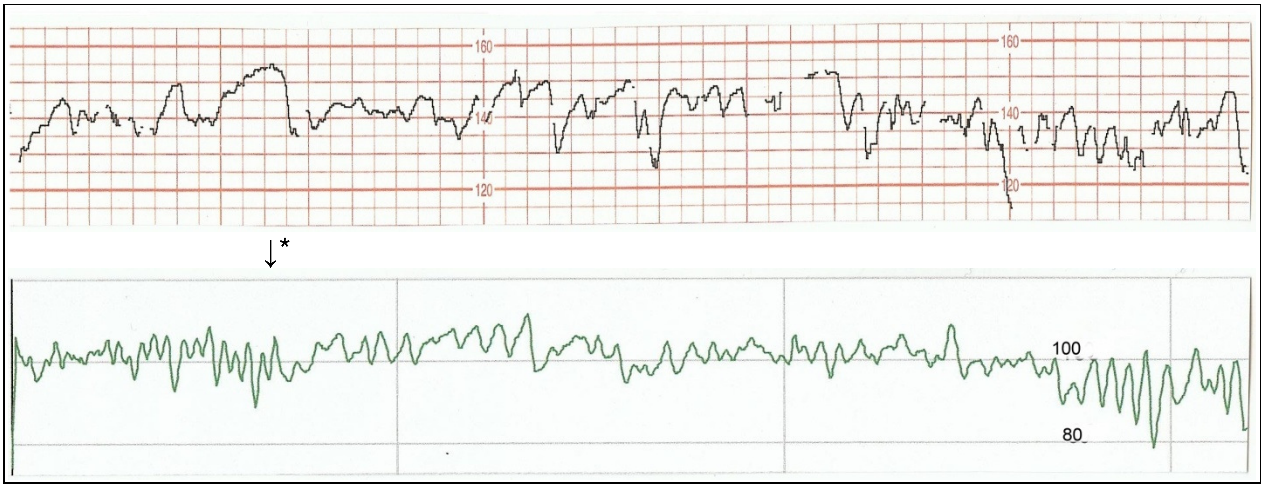
*Figure 4*. Subject D, concurrent fetal and maternal heart rate measure.

Subject E was 24 years of age and gestational age was 33 weeks. Dr. Noble asserted that there is a marked difference in fetal HRV after the mother began doing the HLI® technique (see Figure 5). During maternal two-minute baseline recording, fetal heart rate varied a small amount from a baseline of approximately 135 BPM. During HLI® technique practice, fetal HRV increased in a pattern which appears to accelerate as the session continued. Highest fetal HRV was 120 to 140 BPM and 129 to 145 BPM. Maternal HRV is notably high for Subject E varying from a low of 50 BPM to a high of 90 BPM. For Subject E, Hypothesis 6 is accepted.

↓* End of two-minute baseline

*Figure 5*. Subject E, concurrent fetal and maternal heart rate measure.

Subject F was 31 years old and gestational age was 32 weeks. One month prior to this recording, she was diagnosed with gestational diabetes. Dr. Noble stated that fetal HRV was not bad in the beginning of the recording but was much better after the two-minute baseline (see Figure 6). Fetal heart rate baseline is approximately 140 BPM and varied from a low of approximately 115 BPM to a high of 155 BPM. The pattern of increased HRV begins before the two-minute baseline ended; however, improvements in Subject F's HRV coherence scores began at approximately one minute after the recording started. She struggled to maintain high to medium coherence through the rest of the session, and there appears to be no correspondence between Subject F's periods of high HRV coherence and fetal HRV. For Subject F, Hypothesis 6 is rejected.



↓* End of two-minute baseline

*Figure 6*.  Subject F, concurrent fetal and maternal heart rate measure.

Subject G was 33 years of age and gestational age was 29 weeks.  Dr. Noble stated that the fetal HRV recording was appropriate for gestational age (see Figure 7). Baseline fetal heart rate was approximately 140 BPM and varied from a low of approximately 139 to 162 BPM.  Subject G was very accomplished at the HLI® technique and experienced generalization of HRV coherence.  As a result, the two-minute baseline measure is not significantly different from the rest of the recording except for the one minute when she was asked to think about something distressing. As previously noted, one minute was not an adequate period of time for determination of any resulting fetal HRV changes.  Fetal HRV elevations appear to become higher and to be sustained for longer periods of time as the session progresses; however, due to the fetal HRV acceleration at the beginning of the session, it is not clear whether or not this is part of a larger pattern.  For Subject G, Hypothesis 6 is inconclusive.

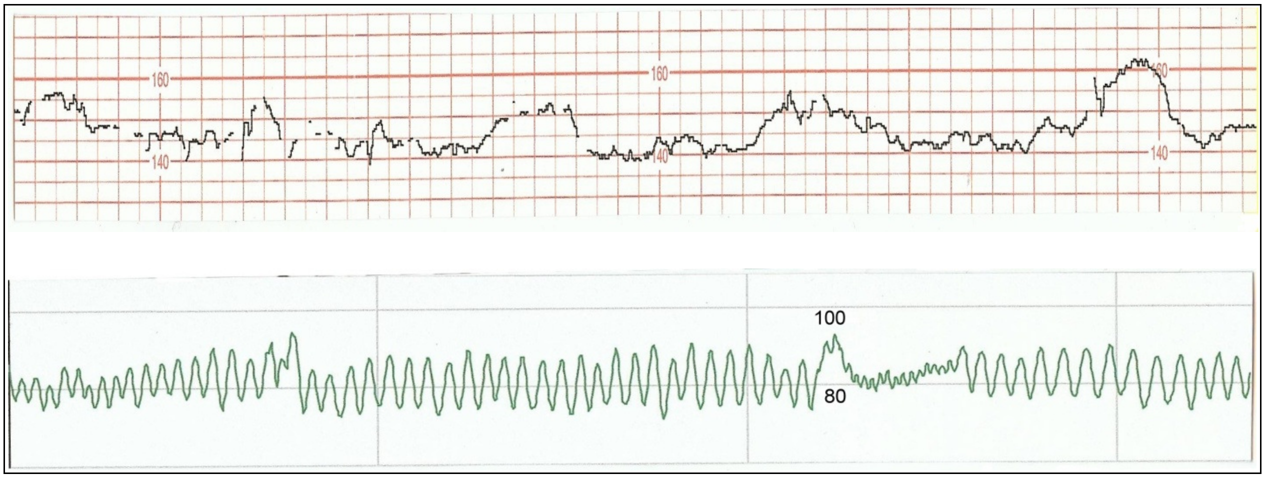



*Figure 7*. Subject G, concurrent fetal and maternal heart rate measure.

Due to varying degrees of maternal skill with the HLI® technique and to the many factors which may influence fetal HRV, results of hypothesis six are inconclusive. Although some of the recordings show greater fetal HRV during maternal skills practice these changes could have been due to fetal state changes or movement.

## Single-Subject Discussion

### *Subject A*

Subject A was a 19 year-old nulliparous single white woman who was self-referred to the study in response to a recruitment flyer she received at a health clinic. She presented with a friendly but somewhat shy demeanor. She was in her 25th week of gestation at the beginning of her participation in the study, and she reported that the fetus had been determined by ultrasound examination to be female. She was engaged to be married to the baby's father and reported that they were both happy about the pregnancy. Subject A co-owned a house cleaning service business with her mother and was concerned primarily about her ability to perform work related activities as her pregnancy advanced. She also expressed increasing apprehension about labor and delivery as reflected in her responses to the PES and PES-Brief item "Thinking about your labor and delivery."  She identified irritability, worry, fatigue, and jaw pain as her usual stress symptoms.

Subject A's scores on the STAI Y1 state anxiety scale reflect an increased level of anxiety from the first to the last session (see Figure 8).  Between the first and second weeks of the study, Subject A experienced a challenge which was particularly difficult for her when her mother went out of town for a two-week business trip and left Subject A in charge of their co-owned business.  Her anxiety is reflected in the difference between her first and second scores on the STAI Y1.  Based upon STAI Y1 norms for female working adults (*M*=35.20, *SD*=10.61) the difference between these two scores is almost two standard deviations.  Trait anxiety scores for Subject A increased (see Figure 9), but according to STAI Y2 norms for female working adults (*M*=34.79, *SD*=9.22) this change is not statistically significant.

State-Trait Anxiety Inventory

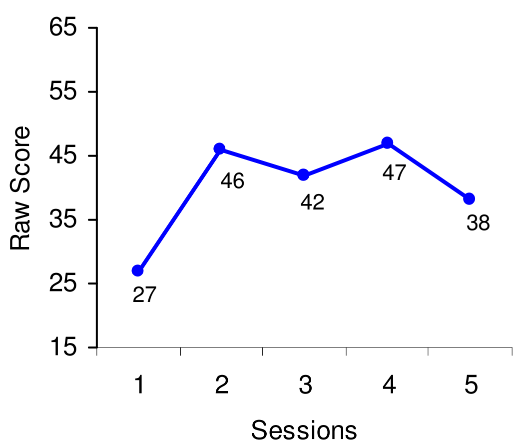



*Figure 8*, Subject A. STAIY1

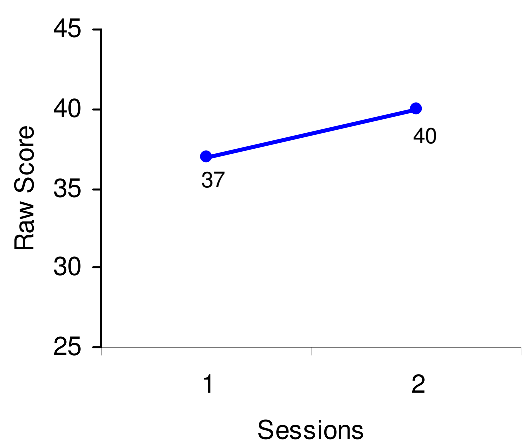



*Figure 9*. Subject A, STAIY2

Subject A's scores on the PES-Brief (see Figures 10 through 15) show a significant increase in Frequency Hassles at session two when compared with the experimental test cohort (*M*=6.54, *SD*=2.3) and significant elevations in Intensity

Hassles at sessions one (*M*=1.38, *SD*=.43), three, and five (*M*=1.36, *SD*=.43). Statistical means and standard deviations are not currently available for Frequency Ratio or Intensity Ratio (J. A. DiPietro, personal communication, April 4, 2008); however, scores below 1.00 on these scales indicate more uplifts than hassles, and scores above 1.00 indicate more hassles than uplifts. At session two, Subject A scored 1.00 on Frequency Ratio. All other ratio scores were below 1.00 indicating a more positive than negative valence toward the pregnancy.

Pregnancy Experience Scale–Brief

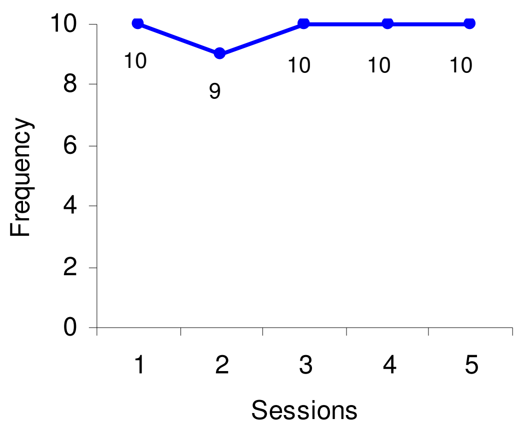



*Figure 10*. Subject A, Frequency Uplifts.

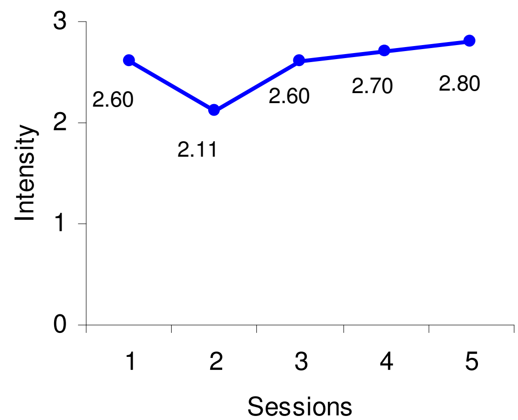



*Figure 11*. Subject A, Intensity Uplifts.

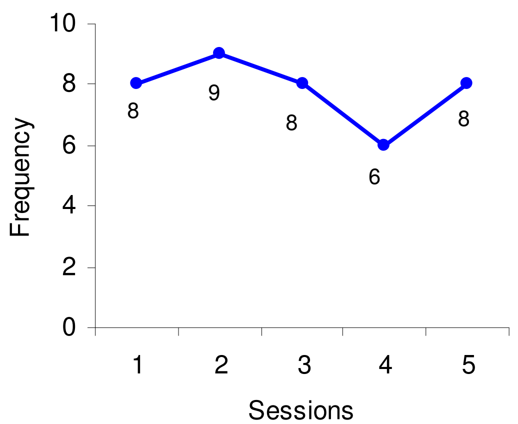



*Figure 12*. Subject A, Frequency Hassles.

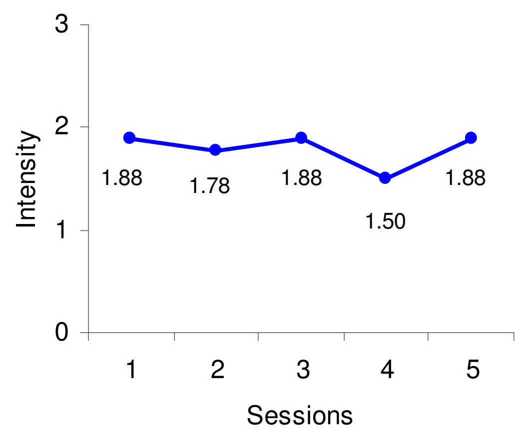



*Figure 13*. Subject A, Intensity Hassles.

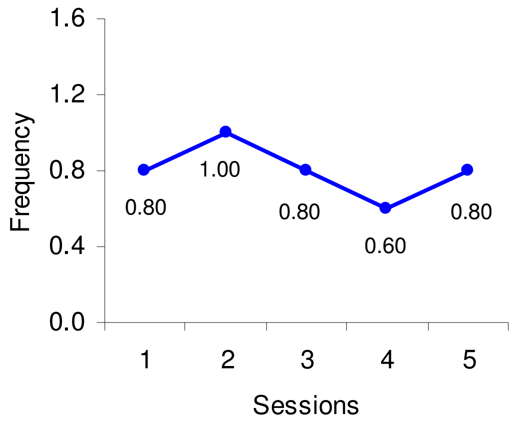



*Figure 14*. Subject A, Frequency Ratio.

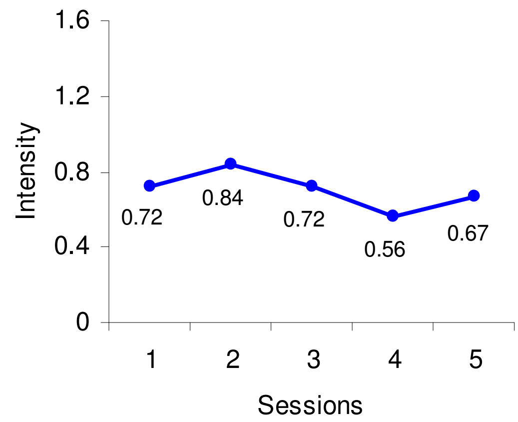



*Figure 15*. Subject A, Intensity Ratio.

PES scores for Subject A did not change significantly from session one to session five (see Figures 16 through 21). None of her scores were significantly different from the test comparison group of working women in low risk pregnancies (*N*=52).

Pregnancy Experience Scale

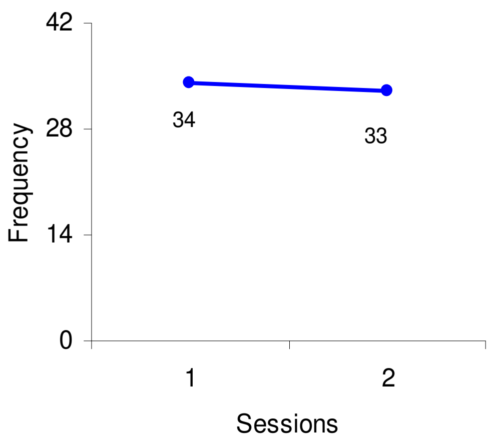



*Figure 16*. Subject A, Frequency Uplifts.

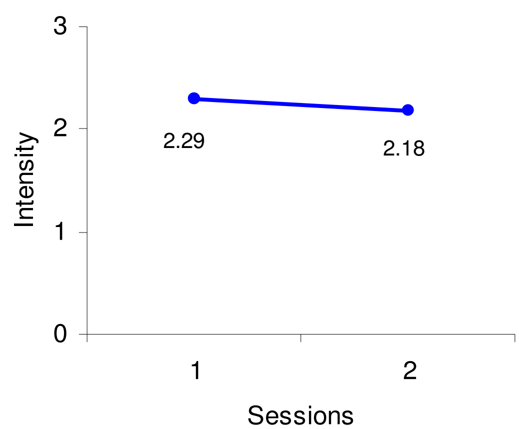



*Figure 17*. Subject A, Intensity Uplifts.

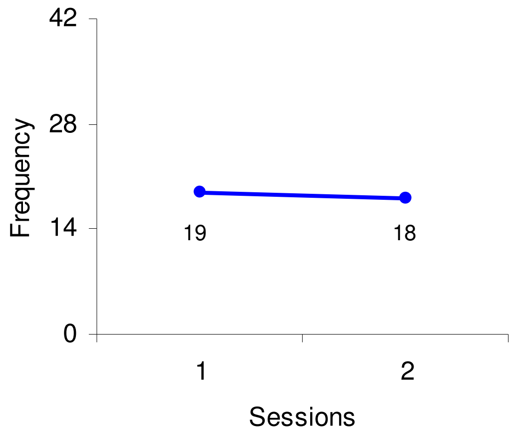



*Figure 18*. Subject A, Frequency Hassles.

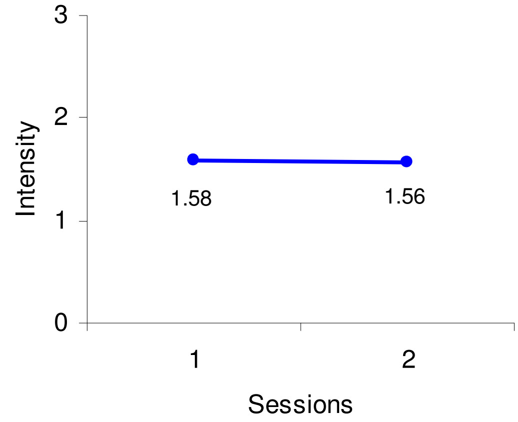



*Figure 19*. Subject A, Intensity Hassles.

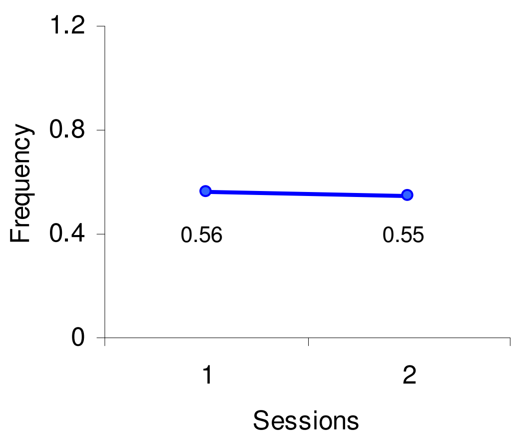



*Figure 20*. Subject A, Frequency Ratio.

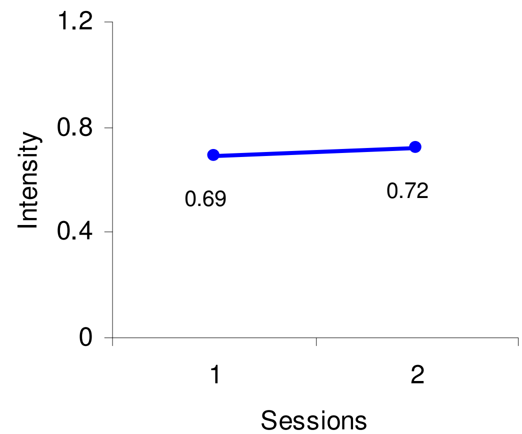



*Figure 21*. Subject A, Intensity Ratio.

Subject A's baseline HRV measures changed very little during the course of her participation in the study (see Figure 22). She recorded a total of 220 minutes of practice outside of sessions and three occasions of using the QC® technique in her daily life. Her practice logs show a pattern of initial consistency but increasing days of little or no practice. This pattern seems to indicate low motivation to participate in the study.

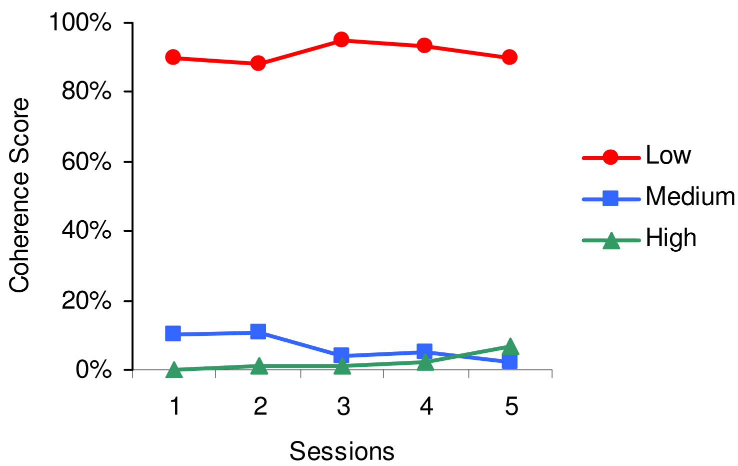



*Figure 22*. Subject A, baseline HRV coherence percentage.

Several factors may have affected Subject A's motivation to participate, but two seem most apparent. During the first session, when asked what prompted her to volunteer for the study, she stated, "I just thought I should," and reported that some of her family members thought so too. This response seems to indicate a somewhat external motivation possibly reflected in the short amount of time she spent in skills practice outside of sessions. Another possible factor in Subject A's response to the study could have been her choice of imagery for generating positive emotions during practice which she reported as her feelings of love and belonging in her family. During the fourth session Subject A expressed distress related to conflict with family members. Her feelings regarding this conflict may have interfered with her ability to generate positive emotions and with her motivation to practice. When asked at the end of the last session if she felt that her participation in the study was beneficial to her, she said that it was but did not identify specific benefits.

During a follow-up telephone interview four and one half months post delivery, Subject A stated that she believed she might have been coping a little better with her stress at the end of the study than she was in the beginning. She also reported that she did not use the stress management skills during labor and that she does not currently use them in her daily life. Delivery of the baby alleviated a significant stressor for Subject A as she was no longer fearful of childbirth. She said that she was enjoying motherhood and had procured a new job which was less physically taxing and which she liked very much. This change alleviated one of her most problematic stressor. She felt physically unable to handle her previous job and lacked the experience to effectively operate a business in her mother's absence. In changing jobs, she took a problem-solving approach which was an appropriate stress management strategy given the nature of her stressor.

*Subject B*

Subject B was a 32 year-old married white woman who volunteer for the study in response to a classified advertisement in the local newspaper. She presented with an outgoing and pleasant manner. She was in her 25$^{th}$ week of gestation at the beginning of her participation in the study, and she reported that the fetus had been determined by ultrasound examination to be female. Subject B had experienced an early miscarriage two years previous to her current pregnancy and her obstetrician had advised her that she would probably not become pregnant again. She reported that both she and her husband were surprised but very happy about the pregnancy.

Subject B was employed in an office environment and stated that she enjoyed her work but that time pressure was sometimes problematic for her. She said that her primary stressor was conflict and parenting difficulties with her 14 year-old step daughter and some concern about the step-daughter's adjustment to the new baby.

She reported her stress responses as increased stress sensitivity, worry, forgetfulness, increased heart rate, gastrointestinal problems, and insomnia when very stressed. She had a history of asthma but stated that it was under control except in the rare instance that she became extremely frightened.

Subject B's five scores on the STAI Y1 state anxiety scale (see Figure 23) showed a small but statistically insignificant decrease over the five sessions and are not significantly different from the comparison group of female working adults (*M*=35.20, *SD*=10.61). The small degree of change seen in these scores may be partly explained by the fact that her scores were close to or better than the means to begin with. Her STAI Y2 trait anxiety scale scores (see Figure 24) showed a statistically insignificant increase from session one to session five. Neither of these scores is significantly different from the comparison group mean (*M*=34.79, *SD*=9.22).

State-Trait Anxiety Inventory

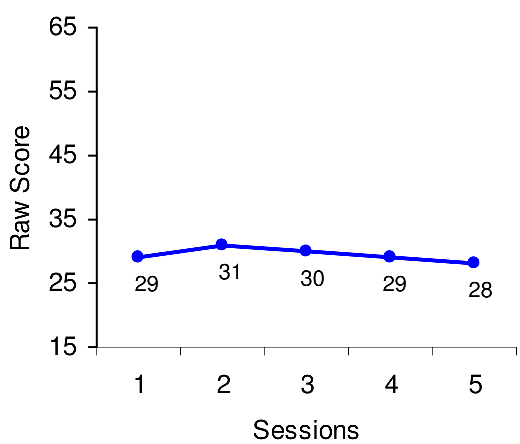



*Figure 23*. Subject B, STAIY1.

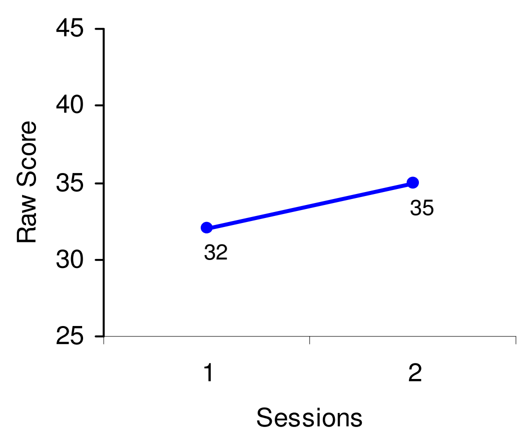



*Figure 24*. Subject B, STAIY2.

PES-Brief scores for Subject B (see Figures 25 through 30) showed a fluctuating pattern on the Intensity Uplifts scale. These scores were significantly higher than the comparison group in session one (*M*=2.31, *SD*=.47) and sessions three and five

(*M*=2.34, *SD*=.46), but they showed a significant drop from week one to week two. The Frequency Hassles scale score at session one was also significantly higher than the comparison group (*M*=6.54, *SD*=2.32), but dropped significantly from session one to session two and were below the comparison group mean at session four (*M*=6.62, *SD*=2.29). With the exception of a session one score of 1.00 on the PES-Brief Frequency Ratio scale, all of Subject B's ratio scores indicate that she considered the pregnancy more uplifting than hassling.

Pregnancy Experience Scale–Brief

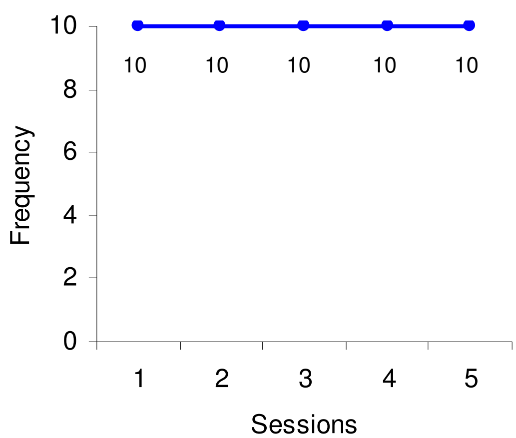



*Figure 25*. Subject B, Frequency Uplifts.

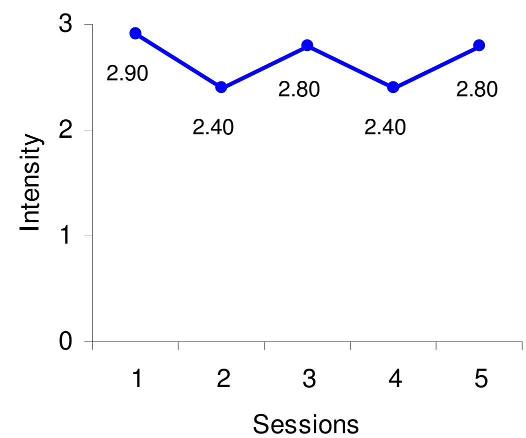



*Figure 26*. Subject B, Intensity Uplifts.

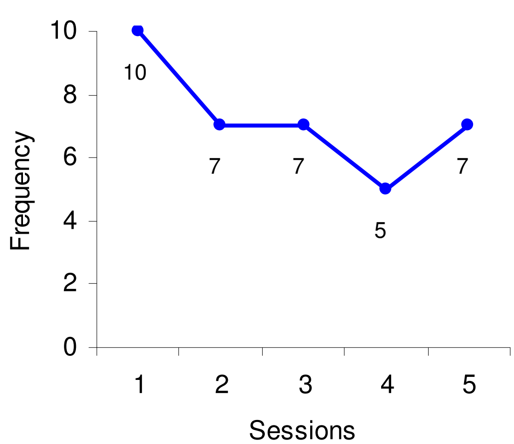



*Figure 27.* Subject B, Frequency Hassles.

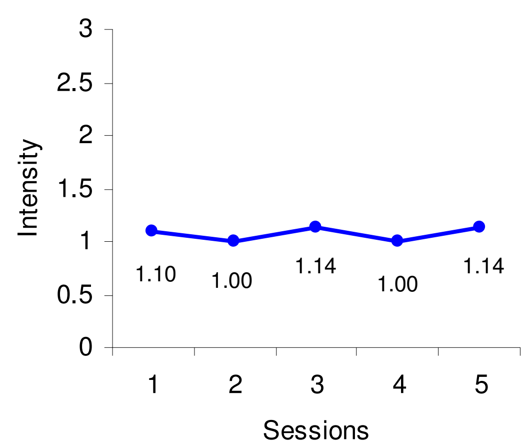



*Figure 28*. Subject B, Intensity Hassles.

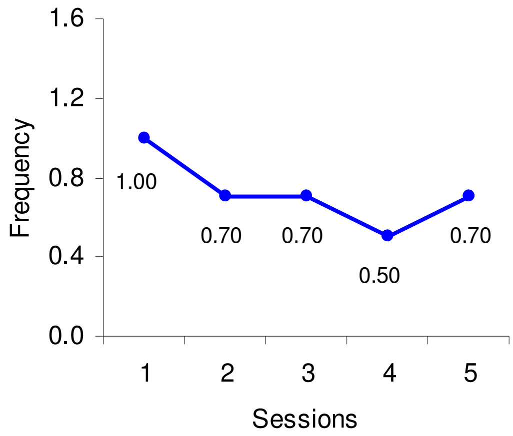



*Figure 29*. Subject B, Frequency Ratio.

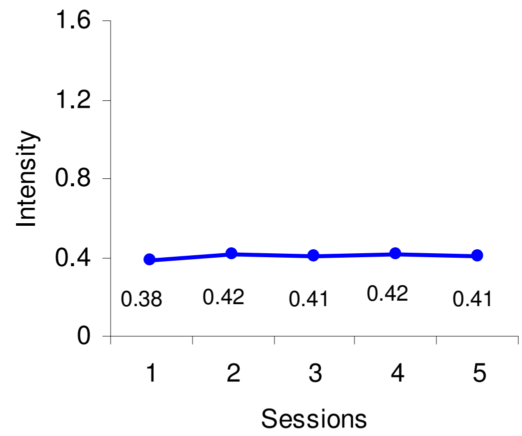



*Figure 30*. Subject B, Intensity Ratio.

Subject B's PES scores (see Figures 31 Through 36) were significantly higher than the comparison group on Frequency Uplifts at sessions one (*M*=27.50, *SD*=7.33) and five (*M*=28.46, *SD*=6.65), significantly lower on Frequency Ratio at session five (*M*=.69, *SD*=.28), and on Intensity Ratio at session one (*M*=.73, *SD*=.18) and five (*M*=.76, *SD*=.22). All other PES scores were in the normal range.

Pregnancy Experience Scale

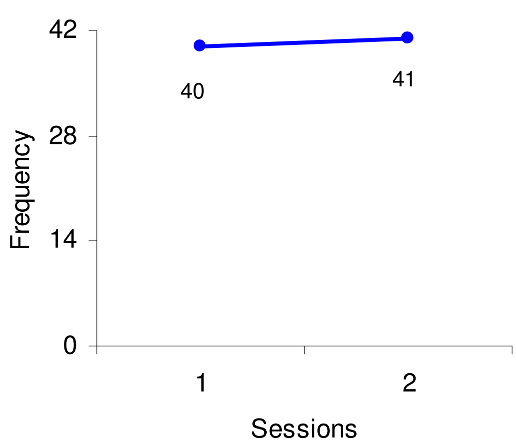



*Figure 31*. Subject B, Frequency Uplifts.

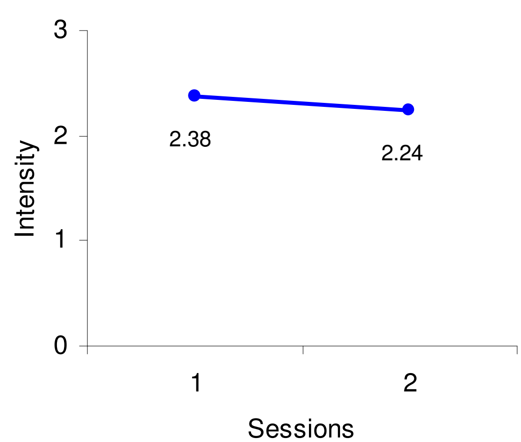



*Figure 32*. Subject B, Intensity Uplifts.

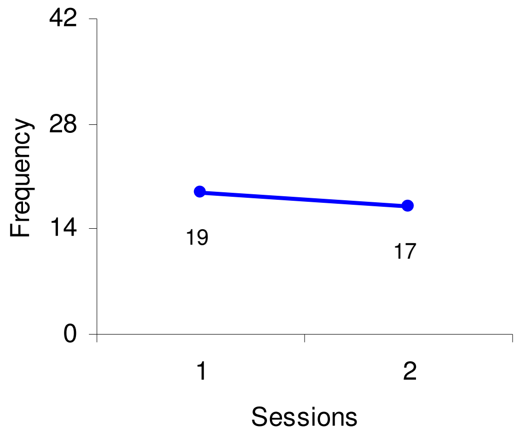



*Figure 33*. Subject B, Frequency Hassles.

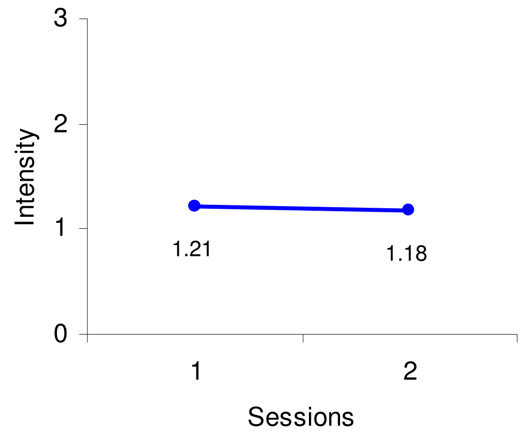



*Figure 34*. Subject B, Intensity Hassles.

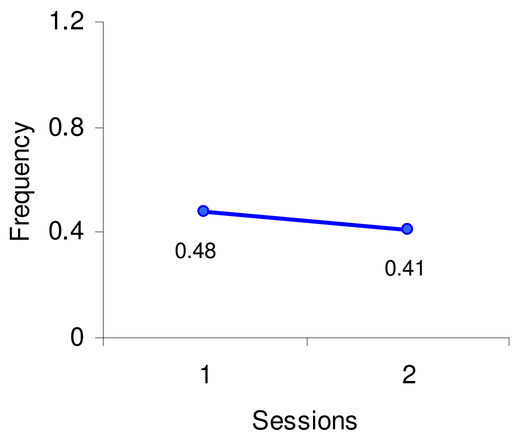



*Figure 35*. Subject B, Frequency Ratio.

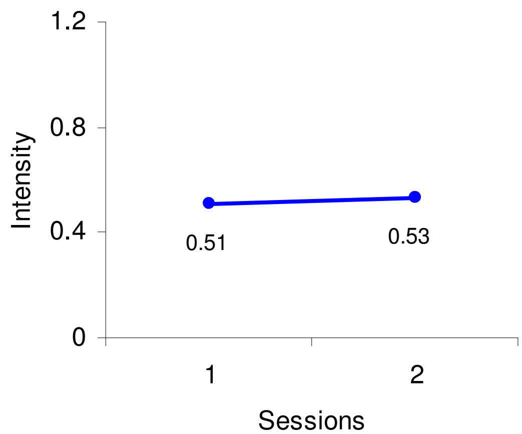



*Figure 36*. Subject B, Intensity Ratio.

Baseline measures of Subject B's high coherence at challenge level one increased from 60% to 99% during the course of her training. She recorded a total of 447 minutes of practice outside of sessions and eight occasions of using the QC® technique in her daily life. In addition, she reported that several times she attached the emWave Personal Stress Reliever® to her clothing while she was at work in order to monitor her stress level when she was seated at her desk.

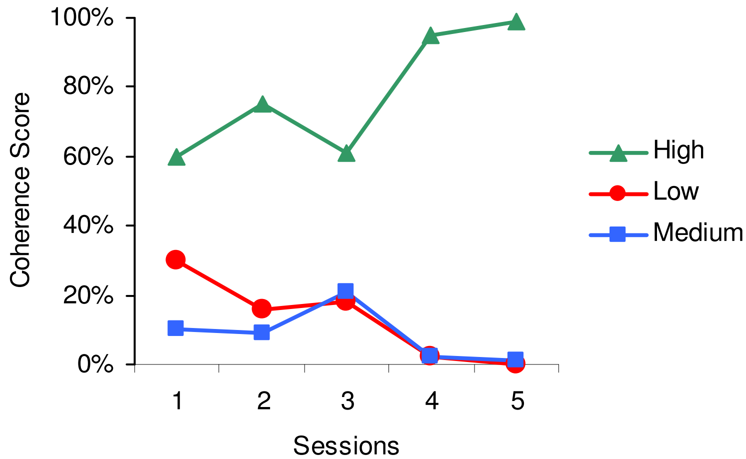



*Figure 37*. Subject B, baseline HRV coherence percentage.

Subject B stated that she was motivated to volunteer for the study when she noticed that a newspaper in the break room at her office was open to the page with the recruitment advertisement. She said she did not normally read the newspaper and considered this incident an indication that her participation was “meant to be.” She also appeared to be motivated to do all she could to care for herself and her unborn child perhaps partly as a strategy to avoid another miscarriage. At the end of her participation, Subject B reported that she was happy to have learned the skills and that she was better able to modify her stress responses at work and to think more clearly during conflict with her step-daughter.

In a follow-up telephone interview almost four months post delivery, Subject B spontaneously volunteered that she continues to use the skills she learned during the study. She reported that she has found the skills especially beneficial when the baby is upset. When she calms herself, the baby calms down also. She reported that she did not attend childbirth classes during her pregnancy, but found that the breathing skills she learned in the study were helpful during labor.

*Subject C*

Subject C was a 29 year-old married African-American woman who volunteered for the study at the recommendation of her midwife. She presented with a shy and deferent manner. She was in her 27th week of gestation at the beginning of her participation in the study, and she reported that the fetus had been determined by ultrasound examination to be female. This was her second pregnancy, and she had one two year-old son. She indicated that she had ambivalent feelings about being pregnant at this time.

Subject C was employed in an office environment, and she reported that one of her stressors was pressure from her supervisor related to her job performance. She considered the supervisor's requirements to be unreasonable and also unattainable, but she felt unable to make a job change at the time due to her pregnancy and to lack of training and opportunity. Subject C reported her stress responses as irritability, back tension, fatigue, sleep disturbance, increased heart rate, increased perspiration, increased fetal movement, and feelings of hopelessness and depression. Her feelings of exhaustion became evident when she had difficulty staying awake during sessions or when sitting quietly for a few minutes in a waiting room. In addition, her midwife informed her that she had mild hypertension.

The difference between Subject C's first STAI Y1 score and her second score is more than one standard deviation higher and represents a sharp increase in her perception of anxiety. The first week's assignment for the study for all subjects was to observe their stress reactions. Subject C's recognition of the severity of her stress reactions along with the diagnosis of hypertension was worrisome to her and could account for the increase in STAI Y1 scores. Her last three scores improved to a level close the mean (35.20) for female working adults (see Figure 38). Subject C's STAI Y2 scores (see Figure 39) are not significantly different from the comparison group (*M*=34.79, *SD*=9.22). These scores decreased from the first to the last session, but not to a significant degree.

State-Trait Anxiety Inventory

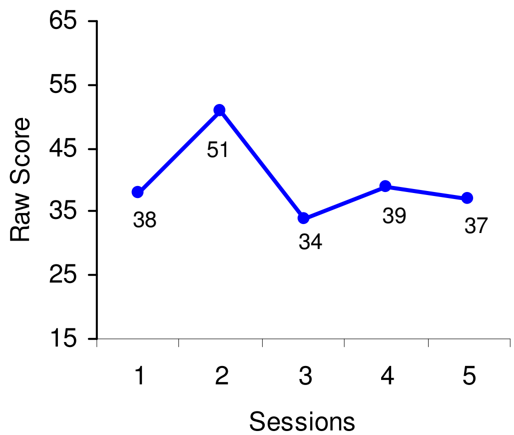



*Figure 38*. Subject C, STAIY1.

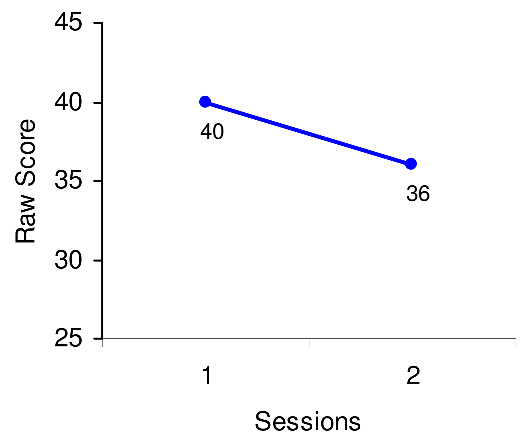



*Figure 39*. Subject C, STAIY2.

PES-Brief scores for Subject C (see Figures 40 through 45) indicate a significant decline in Intensity Uplifts in session two (*M*=2.34, *SD*=.46) and sessions three through five (*M*=2.44, *SD*=.45). She also scored significantly higher than the comparison group on Intensity Hassles at sessions one and two (*M*=1.38, *SD*=.43) and sessions three, four, and five (*M*=1.42, *SD*=.48). Her first session score on Frequency Uplifts was significantly lower than the comparison group (*M*=9.48, *SD*=1.13) but increased to the normal range in the following sessions (*M*=9.55, *SD*=.81). Subject C's ratio scores are mixed indicating a more positive than negative attitude toward her pregnancy with regard to frequency of hassles, but a more negative than positive attitude toward her pregnancy with regard to intensity of hassles. Frequency Ratio scores were all below

1.00, but Intensity Ratio scores increased to greater than 1.00 during the course of the five sessions.

Pregnancy Experience Scale–Brief

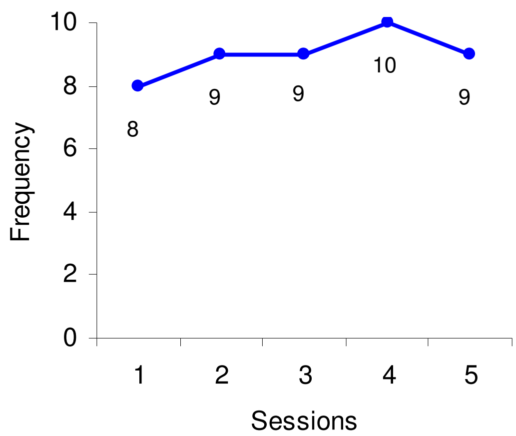



*Figure 40*. Subject C, Frequency Uplifts.

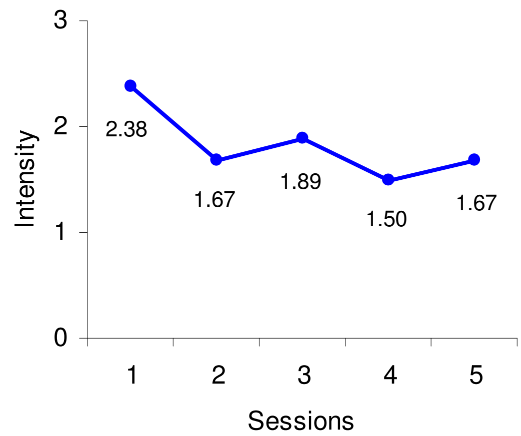



*Figure 41*. Subject C, Intensity Uplifts.

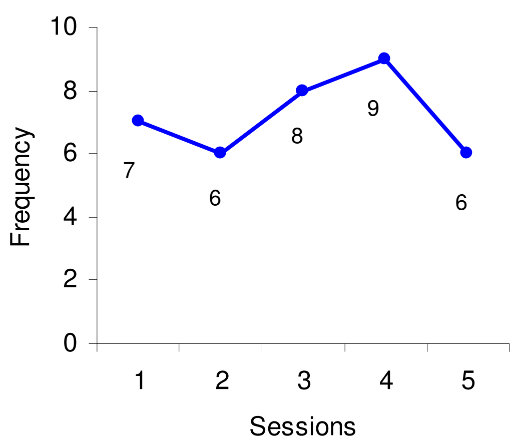



*Figure 42*. Subject C, Frequency Hassles.

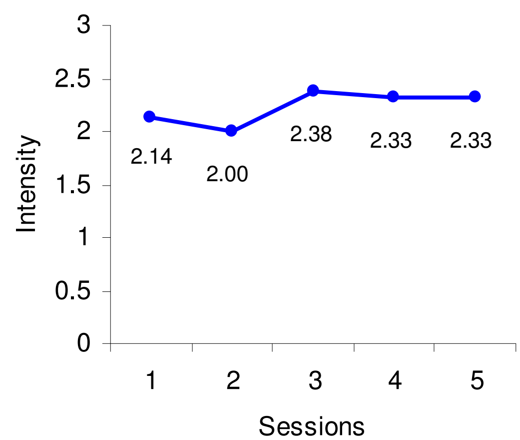



*Figure 43*. Subject C, Intensity Hassles.

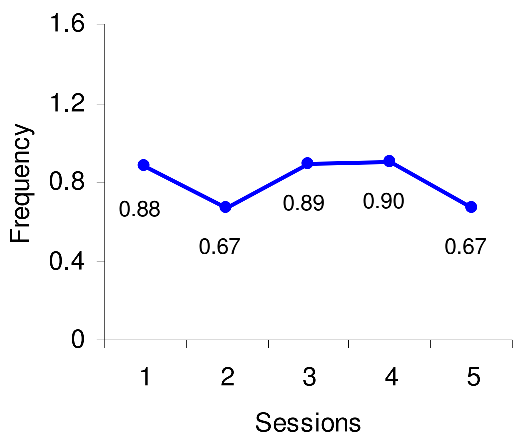



*Figure 44*. Subject C, Frequency Ratio.

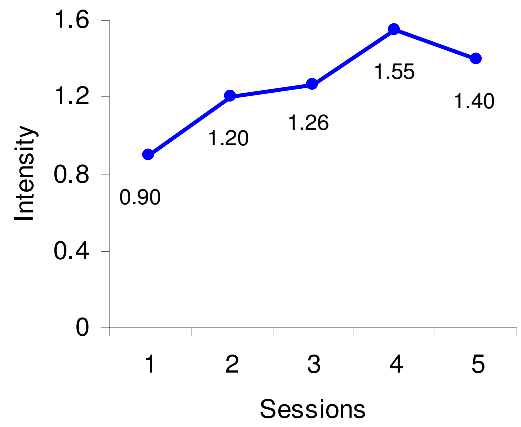



*Figure 45*. Subject C, Intensity Ratio.

Subject C's PES scores (see Figures 46 through 51) were significantly higher than the comparison group on the Intensity Hassles scale at session one (*M*=1.38, *SD*=.28) and session five (*M*=1.43, *SD*=.27). Her Intensity Ratio scale score at session five was also significantly higher than the comparison group (*M*=.78, *SD*=.21). All other PES scores were in the normal range.

Pregnancy Experience Scale

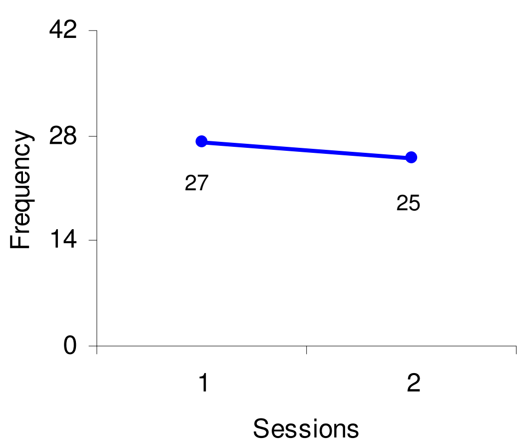



*Figure 46*. Subject C, Frequency Uplifts.

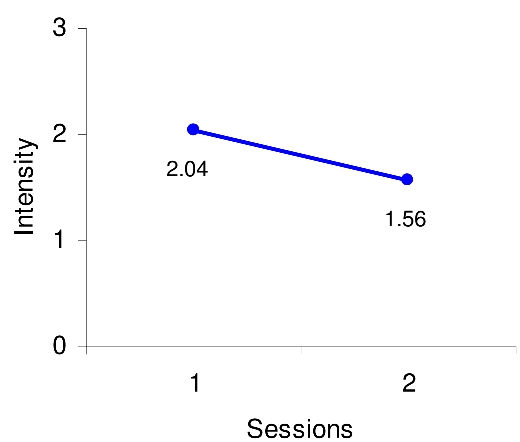



*Figure 47*. Subject C, Intensity Uplifts.

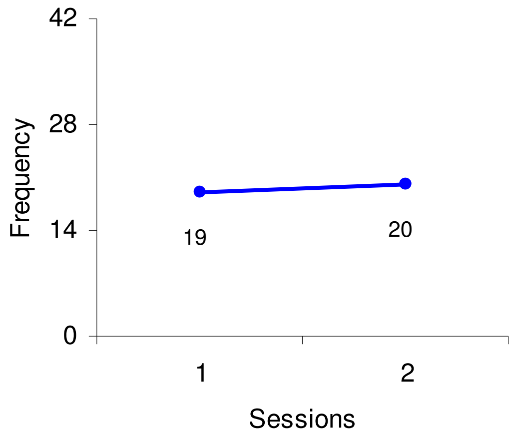



*Figure 48*. Subject C, Frequency Hassles.

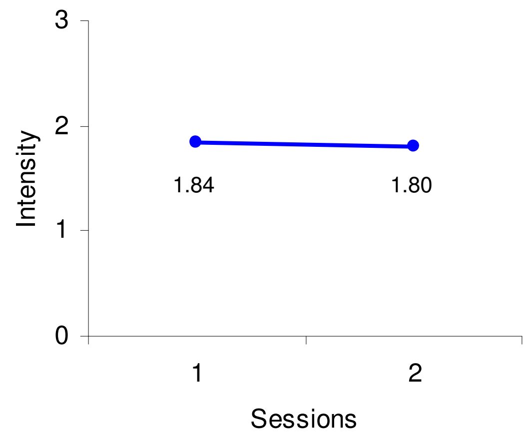



*Figure 49*. Subject C, Intensity Hassles.

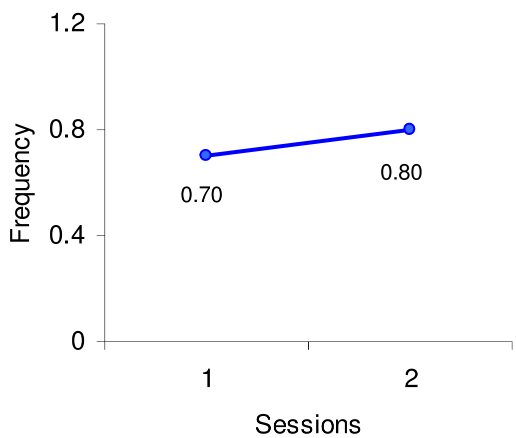



*Figure 50*. Subject C, Frequency Ratio.

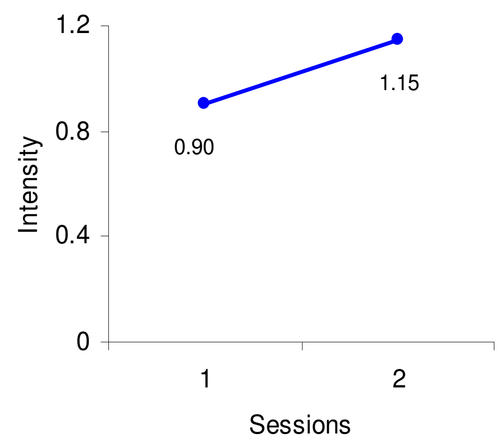



*Figure 51*. Subject C, Intensity Ratio.

Subject C had difficulty learning the QC® and HLI® techniques, but with practice she met and exceeded the criterion of 80% combined medium and high HRV coherence at challenge level two. Her baseline HRV measures improved at the third session to 100 percent high coherence at challenge level one (see Figure 52), and she reported that her midwife said her blood pressure readings were also improved. Prior to session four and five she began to experience increased pressure at work with threats of dismissal, and her baseline HRV measures deteriorated as well as her in-session practice measures. Subject C recorded 605 minutes of practice outside of sessions and nineteen occasions of using the QC® technique in her daily life.  Her practice logs reflect consistent daily 20-minute practice sessions with the use of emWave Personal Stress Reliever®.

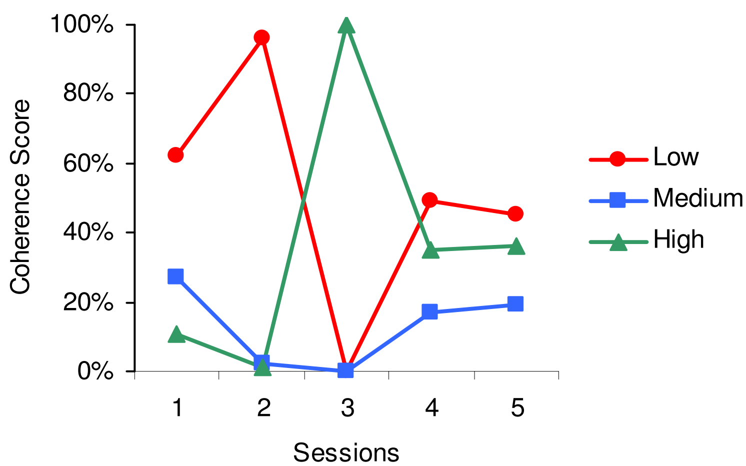



*Figure 52*. Subject C, baseline HRV coherence percentage.

Subject C's stress symptoms were rather severe and widespread affecting her physically, emotionally, and cognitively.  She said that she volunteered for the study because she was aware of her high stress level and needed some relief from the strain of her situation.  Her 605 minutes of practice indicates a substantial time commitment; however, effectiveness may have been compromised by her cognitive appraisal of the practice situation itself.  At the last session, she indicated that she was nervous because she considered it a test.  In view of this appraisal, she may have perceived her participation in the study as an added burden.

In a follow-up telephone interview three and one half months post delivery Subject C's mood was noticeably improved.  She endorsed the idea that even though her stress level increased because of significant stressors in her life during her participation in the study, she believed she was coping better with stress by the end of the study than she had in the beginning. She reported that she used the skills during labor, and she spontaneously volunteered that she continues to use the skills in her daily life. She said that she recently returned to work after pregnancy leave and subsequently made a decision to resign her job and start a day care service in her home. She remarked that although she would earn significantly less money she believed that the quality of her life would be improved. Perhaps Subject C's practice of stress managements skills contributed to her ability to gain clarity for this career change decision.

*Subject D*

Subject D was a 28 year-old unmarried white woman who volunteered for the study at the recommendation of her midwife. She presented with a cheerful and outgoing attitude and was very talkative. She was in her 25th week of gestation at the beginning of her participation in the study, and she reported that the fetus had been determined by ultrasound examination to be male. Subject D had given birth to three other children. She lived with two of her children and her mother in an apartment. Her pregnancy was not planned, and she had no current relationship with the baby's father.

Subject D was employed in an office environment and she reported that she enjoyed her work. She reported her stressors as parenting difficulties and conflict with the father of her third child regarding visitation issues. She also described her living environment as cramped and chaotic. She stated that her stress reactions were increased heart rate, headaches, mental confusion, fatigue, impatience, anger, frustration, and feelings of being overwhelmed.

STAI Y1 scores for Subject D (see Figure 54) increased slightly over the five administrations but did not vary significantly from the norms for female working adults (*M*=35.20, *SD*=10.61). Her STAI Y2 scores (see Figure 54) decreased from 40 to 37 which is not a statistically significant change (*M*=34.79, *SD*=9.22).

State-Trait Anxiety Inventory

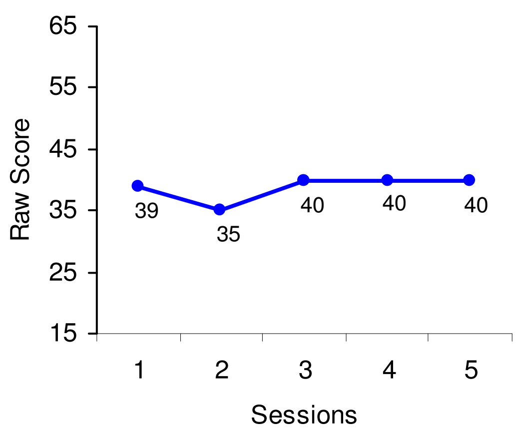



*Figure 53*. Subject D, STAIY1.

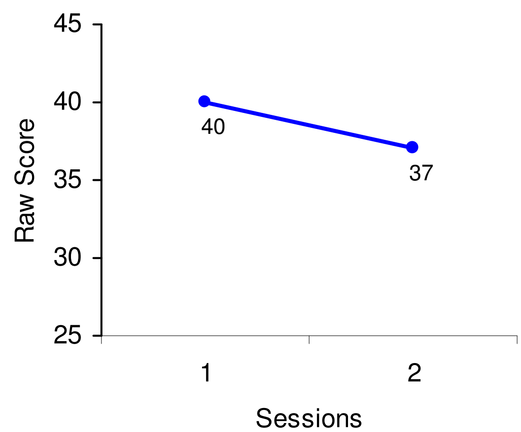



*Figure 54*. Subject D, STAIY2.

PES-Brief scores for Subject D (see Figures 55 through 60) were significantly lower than comparison group scores on the Frequency Uplifts scale at sessions one and two (*M*=9.48, *SD*=1.00) and sessions three, four and five (*M*=9.48, *SD*-1.13). Her scores on Intensity Uplifts scale were significantly lower than comparison group at session two (*M*=2.31, *SD*=.47) and session five. She also scored significantly lower on the Frequency Hassles scale at session two (*M*=6.54, *SD*=2.32) and session three (*M*=6.62, *SD*=2.29). At sessions one, four, and five Subject D's Frequency Ratio scores were 1.00 indicating that her attitude toward the pregnancy in regard to this measure was no more positive than negative.

Pregnancy Experience Scale–Brief

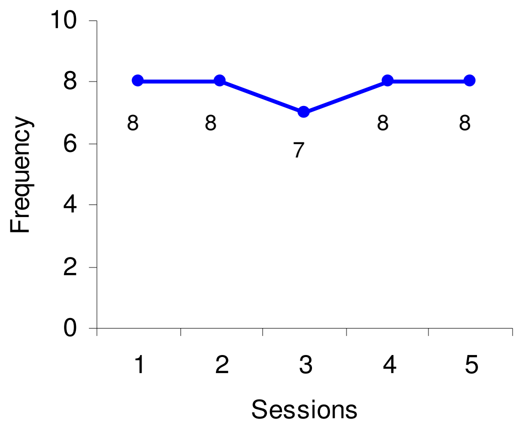



*Figure 55*. Subject D, Frequency Uplifts.

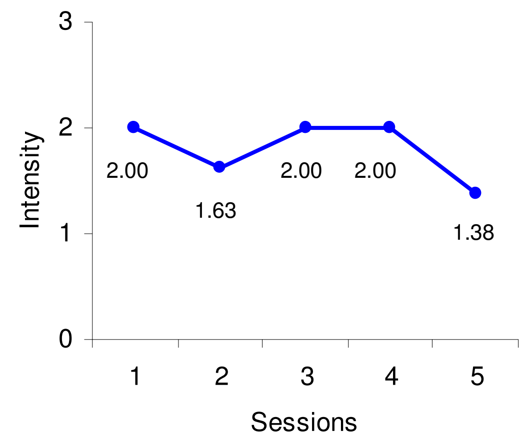



*Figure 56*. Subject D, Intensity Uplifts.

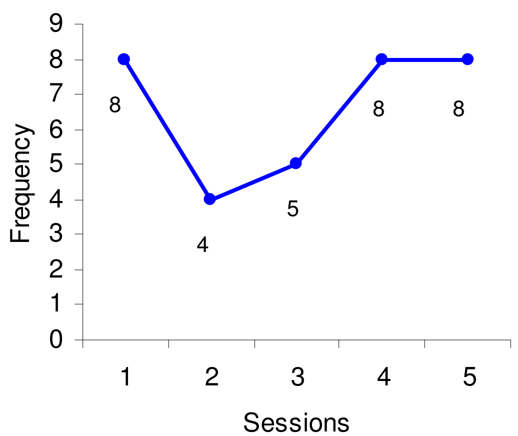



*Figure 57*. Subject D, Frequency Hassles.

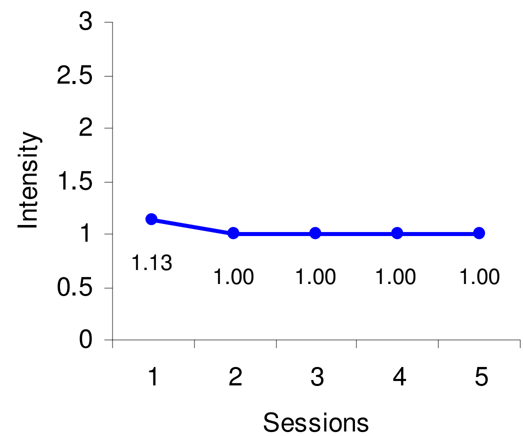



*Figure 58*. Subject D, Intensity Hassles.

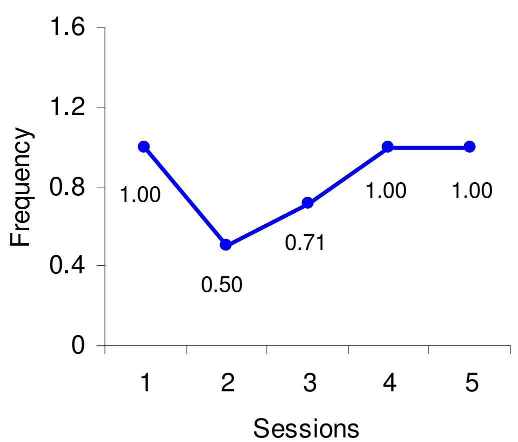



*Figure 59*. Subject D, Frequency Ratio.

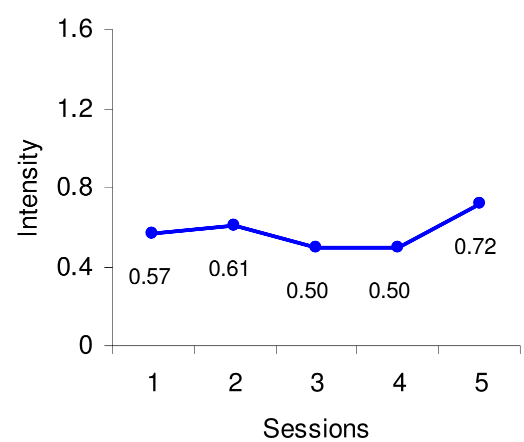



*Figure 60*. Subject D, Intensity Ratio.

Subject D's PES scores (see Figures 61 through 66) were significantly lower than comparison group scores on Intensity Uplifts at session one (*M*=1.91, *SD*=.41), on Frequency Hassles at session five (*M*=18.79, *SD*=7.73), and on Intensity Hassles at session one (*M*=1.38, *SD*=.28) and session five (*M*=1.39, *SD*=.36). In addition her Frequency Ratio score was significantly lower than comparison group at session five (*M*=.69, *SD*=.28). All other PES scores were in the normal range.

Pregnancy Experience Scale

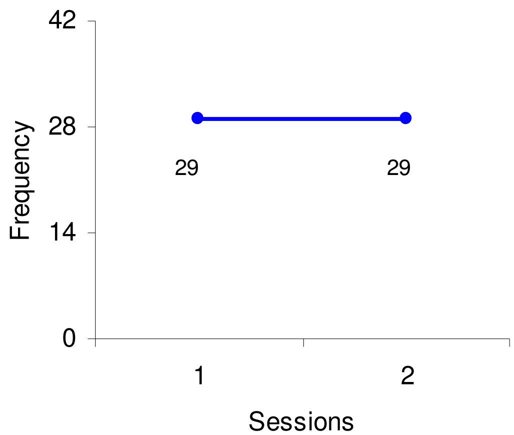



*Figure 61*. Subject D, Frequency Uplifts.

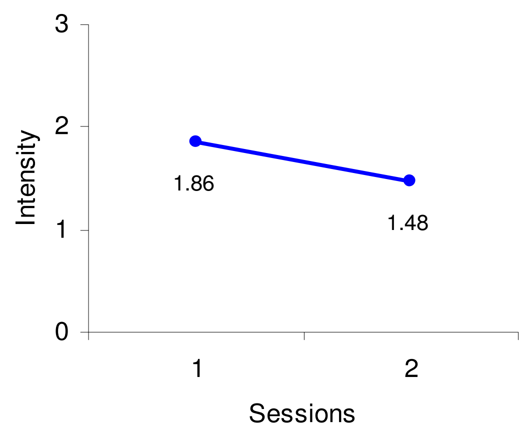



*Figure 62*. Subject D, Intensity Uplifts.

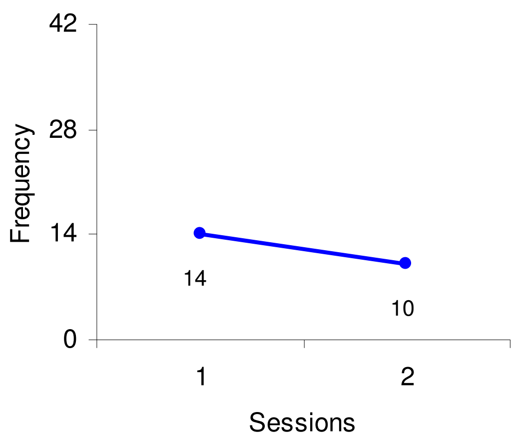



*Figure 63*. Subject D, Frequency Hassles.

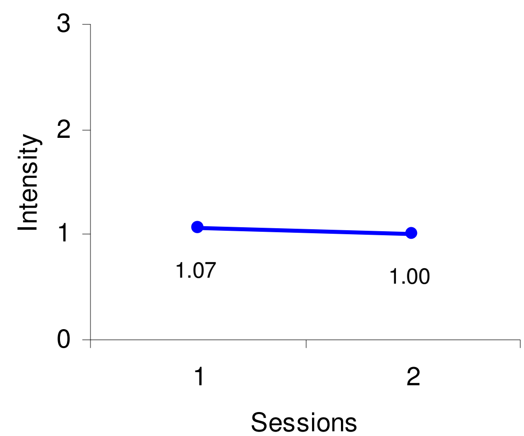



*Figure 64*. Subject D, Intensity Hassles.

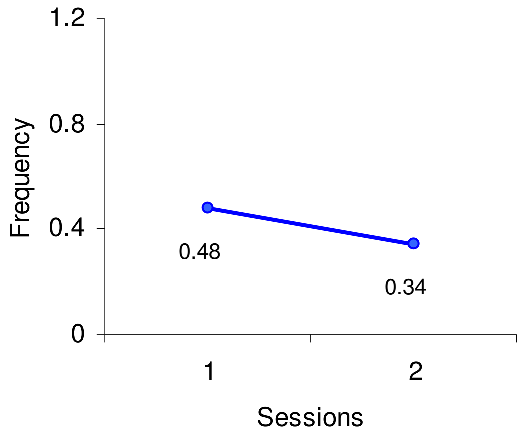



*Figure 65*. Subject D, Frequency Ratio.

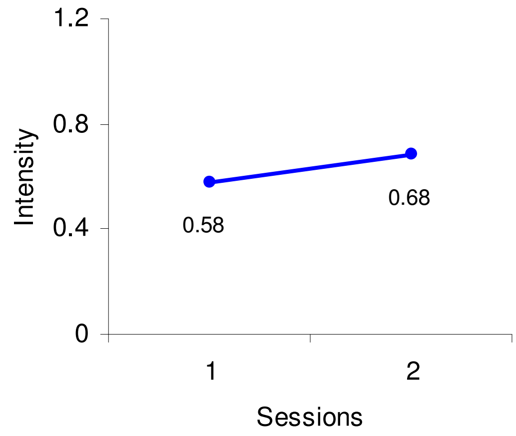



*Figure 66*. Subject D, Intensity Ratio.

Subject D's baseline HRV measures showed initial improvement and then a decline (see Figure 67). She recorded a total of 230 minutes of practice outside of sessions and 37 occasions of using the QC® technique in her daily life.

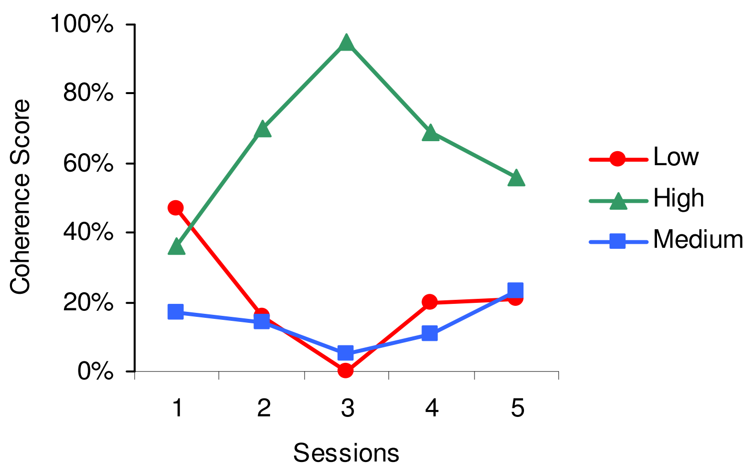



*Figure 67*. Subject D, baseline HRV coherence percentage.

Subject D indicated that she volunteered to participate in the study because she was very stressed. She said that sometimes people commented on her cheerful disposition in the face of her problems, but her response was that since there was not much she could do about her circumstances she might as well be happy. This coping strategy seems to exhibit denial and a feeling of helplessness. Although the emphasis in QC® and HLI® skills is on balancing emotions and physiology in order to affect a more efficient response to stressful situations (Childre & Rosman, 2005), the positive emotion generation component could have been misinterpreted by Subject D as confirmation of the wisdom of simply being cheerful in the face of problems. This researcher deemed that she might benefit from comprehensive counseling and parenting classes. She gladly accepted appropriate referrals and reported at her last session that she was awaiting her first appointment.

Subject D was one of the subjects who came for fetal monitoring at a sixth session due to an inability to successfully record the fetal heart rate at the fifth session. Previous to the sixth session, Subject D learned from her obstetrician that her unborn child might have congenital anomalies. She displayed unmasked anxiety about this possibility and reported that the skills she learned in the study were helping her to cope with her stress. Her appraisal of the usefulness of the stress management skills she learned in the study became apparent upon further examination of her practice logs which indicated that 90 minutes of practice and 21 occasions of using QC® in daily life occurred after she learned of the possibility of fetal anomalies. All STAI Y1, STAI Y2, PES, and PES-Brief administrations were completed by the fifth session and do not reflect her anxiety regarding fetal development. Subject D could not be contacted for a follow-up telephone interview post delivery.

*Subject E*

Subject E was a 24 year-old nulliparous married African-American woman who volunteered for the study at the recommendation of her birth coach. She presented as somewhat anxious but with a friendly demeanor and a sense of humor about her situation and her feelings. She was in her 26$^{th}$ week of gestation at the beginning of her participation in the study, and she reported that the fetus had been determined by ultrasound examination to be female. She reported that her pregnancy was unplanned and that although she and her husband wanted children eventually, they had planned to defer pregnancy for five years.

Subject E and her husband owned their own business, and they were working very hard to establish the business when she discovered that she was pregnant. She stated that the stresses of business ownership were problematic to her and that she was concerned about her ability to parent while tending to her business duties. She also expressed a high level of anxiety about labor and delivery. She reported her stress responses as increased heart rate, crying, and feeling overwhelmed. She attempted to cope with stress by shopping and eating chocolate. At session three, she stated that her obstetrician had diagnosed her with mild pregnancy-induced hypertension.

From the first to the fourth session, Subject E's STAI Y1 scores increased significantly in comparison to norms for female working adults (*M*=35.30, *SD*=10.61) (see Figure 68). Her session five score was in the normal range, but was almost one standard deviation higher than her session one score. Her STAI Y2 scores were in the normal range and decreased from session one to session five, but not to a significant degree (see Figure 69).

State-Trait Anxiety Inventory

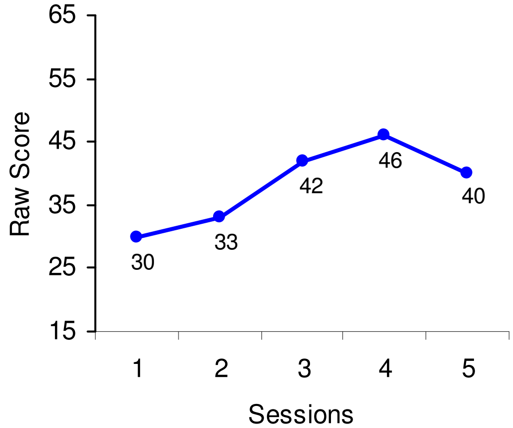



*Figure 68*. Subject E, STAIY1.

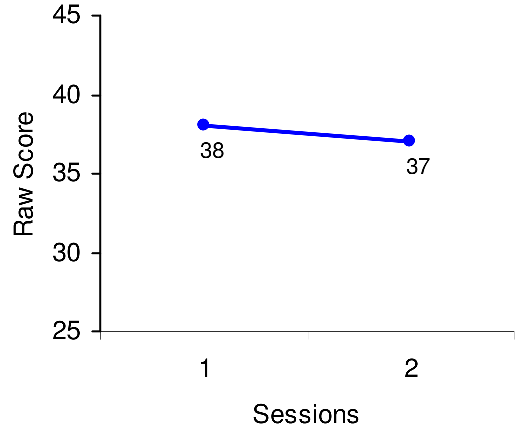



*Figure 69*. Subject E, STAIY2.

Subject E's PES-Brief scores (see Figures 70 through 75) were significantly higher than the comparison group at session five on Intensity Uplifts (*M*=2.44, *SD*=.45). Her Frequency Hassles scores were significantly above the norms at session one (*M*=6.54, *SD*=2.30), sessions, two, three, and four (*M*=6.62, *SD*=2.29), and session five (*M*=7.02, *SD*=2.30). Her Intensity Hassles scores for sessions two and three were also higher than the norms (*M*=1.38, *SD*=.43). Subject E's Intensity Ratio scores decreased, but her Frequency Ratio scores increased from the first to the fifth session. This presumably indicates that Subject E's pregnancy stress regarding the twenty test items of the PES-Brief was more frequent but less intense.

Pregnancy Experience Scale–Brief

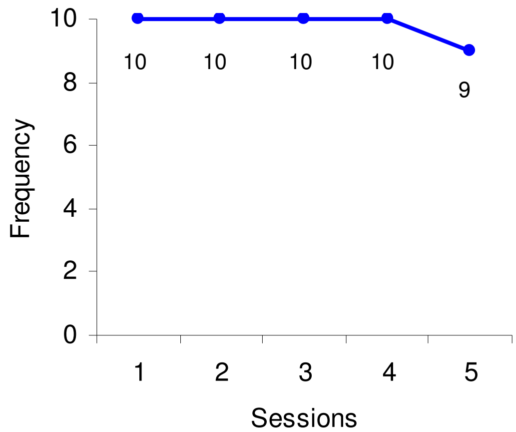



*Figure 70*. Subject E, Frequency Uplifts.

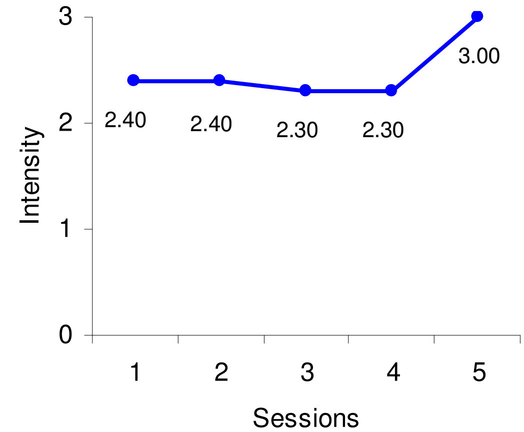



*Figure 71*. Subject E, Intensity Uplifts.

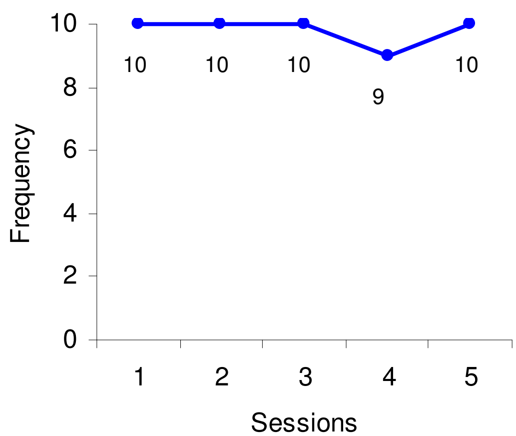



*Figure 72*. Subject E, Frequency Hassles.

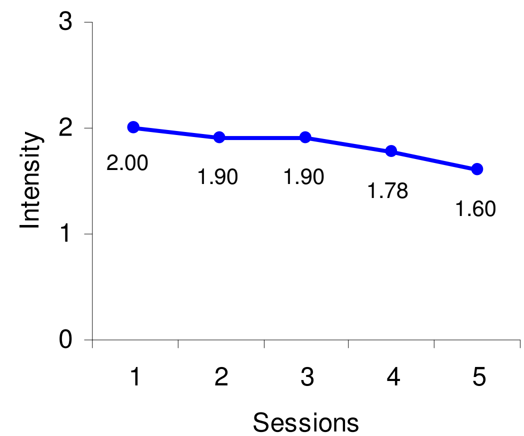



*Figure 73*. Subject E, Intensity Hassles.

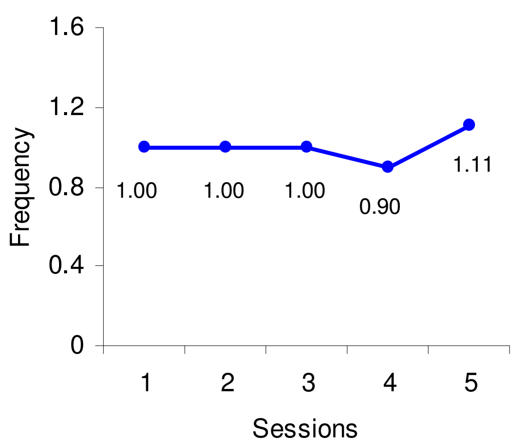



*Figure 74*. Subject E, Frequency Ratio.

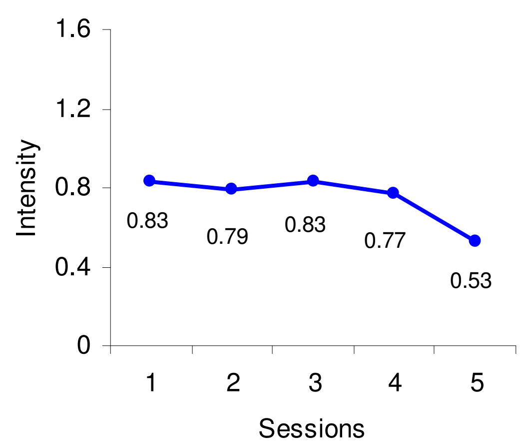



*Figure 75*. Subject E, Intensity Ratio.

PES scores for Subject E changed in the expected direction on all scales (see Figures 76 through 81). At session one, two of her scores were significantly higher than the comparison group, Intensity Hassles (*M*=1.38, *SD*=.28) and Intensity Ratio (*M*=.73, *SD*=.21). At session five, her Intensity Uplifts score was higher than norms (*M*=1.91, *SD*=.41). All other PES scores were in the normal range.

Pregnancy Experience Scale

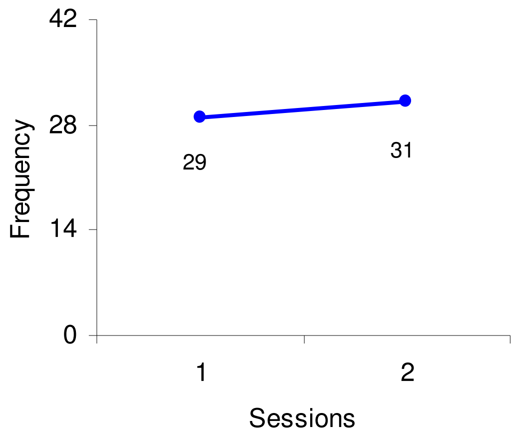



*Figure 76*. Subject E, Frequency Uplifts.

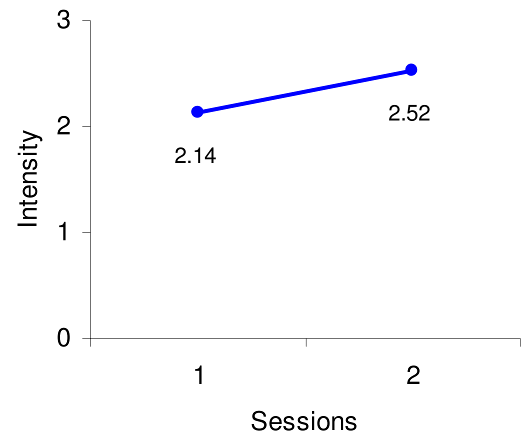



*Figure 77.* Subject E, Intensity Uplifts.

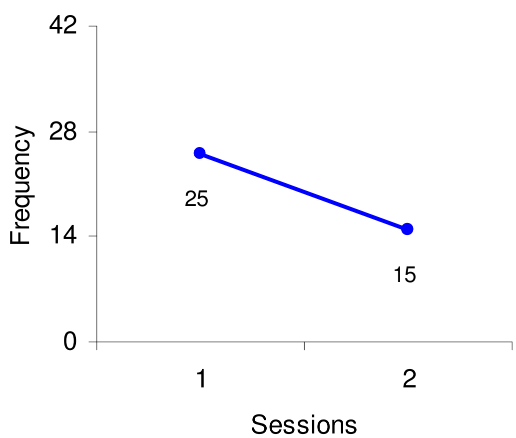



*Figure 78*. Subject E, Frequency Hassles.

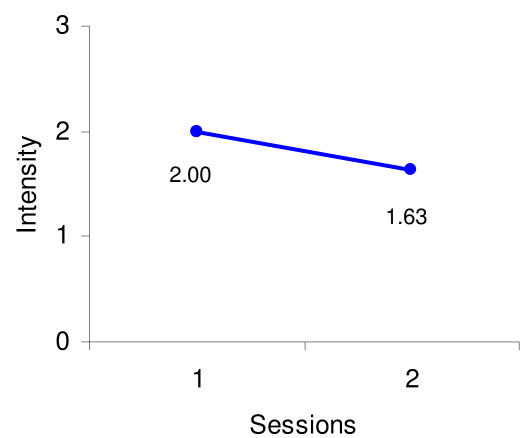



*Figure 79*. Subject E, Intensity Hassles.

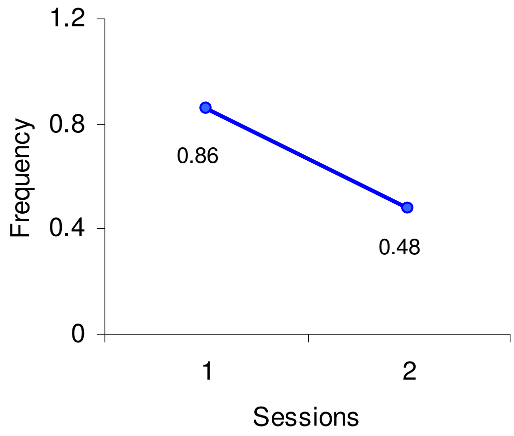



*Figure 80*. Subject E, Frequency Ratio.

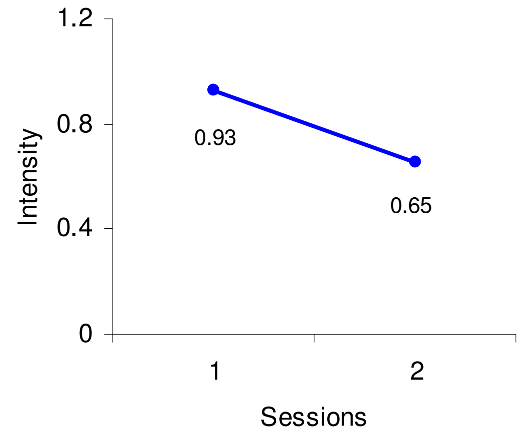



*Figure 81*. Subject E, Intensity Ratio.

HRV coherence measures of Subject E during the initial baseline collection indicated a naturally high HRV previous to any skill instruction, but her high coherence measures at challenge level one increased from 80 percent to 99 percent during the course of her training (see Figure 82). She recorded a total of 350 minutes of practice outside of sessions and 88 occasions of using the QC® technique in her daily life.

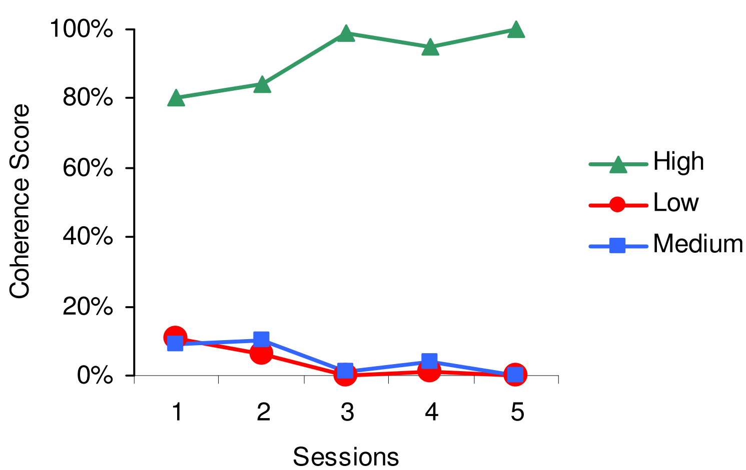



*Figure 82*. Subject E, baseline HRV coherence percentage.

By her final session, Subject E's cognitive appraisal of her pregnancy and approaching parenthood began to change. She expressed feelings of thankfulness that she had had an easy pregnancy and feelings of increased confidence and pleasure regarding her baby. She particularly liked the QC® technique and stated, "It works every time," referring to her new found ability to calm herself when feeling overwhelmed.

During a follow-up telephone interview one month post delivery, Subject E stated that she believes she coped better with stress by the end of her participation in the study as compared with the beginning. She reported that she used the stress management techniques during labor, and she spontaneously volunteered that she continues to use the QC® technique in her daily life.

*Subject F*

Subject F was a 31 year-old married white woman who volunteered for the study at the recommendation of her midwife. She presented with a pleasant and outwardly easy-going personality. She was in her 25$^{th}$ week of gestation at the beginning of her participation in the study, and she reported that the fetus had been determined by ultrasound examination to be female. This was her second pregnancy, and she had one two year-old son. She reported that her current pregnancy was planned.

Subject F was employed in an office environment and she indicated that she enjoyed her work but that she experienced some work related stress. She reported her primary stressor as family of origin issues related to her mother's alcoholism. She expressed a feeling of pride that she had chosen a different life-style than her mother and had established a stable life despite her difficult childhood. Her coping strategy was to concentrate on building and structuring her own life and family and to set limits on time and emotional investment in her relationship with her mother. She reported her stress reactions as fidgetiness, irritability, overeating, and withdrawal.

During her participation in the study, Subject F experienced a series of stress challenges. Between the first and second weeks her mother came to her home for an unexpected overnight visit. At her third session, Subject F stated that she was very worried because she had received a borderline result on a test for gestational diabetes and was scheduled to repeat the test. At the fourth session, she reported that the repeated test was positive. At the fifth session, Subject F stated that she was learning to control her blood sugar by modifying her diet and activities, but she expressed continued anxiety. Her reaction to these events is reflected in her scores on the STAI Y1 (see Figure 83). Her highest score (63) is more than two and one half standard deviations above the mean for female working adults and is the highest score recorded for any other subject in the present study. Her strong stress reaction may be partially explained by the fact that she is an adult child of an alcoholic (ACOA). Some studies indicate that ACOAs experience more stress and have more difficulty coping with stress than non ACOAs (Hall and Webster, 2002; Lindgaard, 2005). Subject F's STAI Y2 scores decreased (see Figure 84) but this change is not statistically significant.

State-Trait Anxiety Inventory

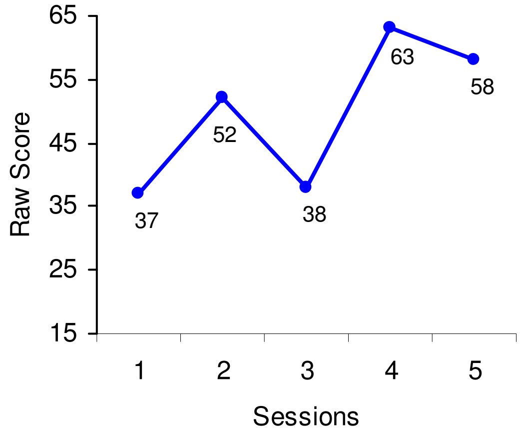



*Figure 83*. Subject F, STAIY1.

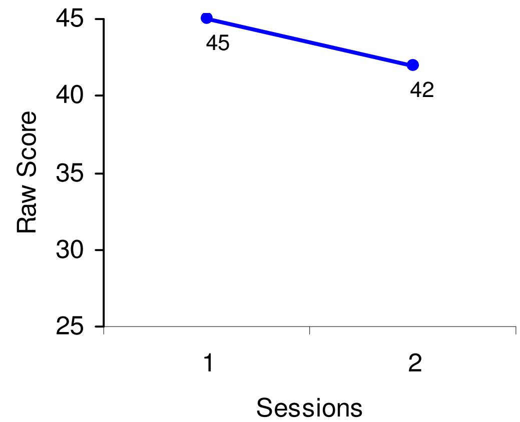



*Figure 84*. Subject F, STAIY2.

Subject F's PES-Brief scores (see Figures 85 through 90) were significantly lower than norms at sessions one and two on Frequency Uplifts (*M*=9.48, *SD*=1.0). Her scores on Intensity Uplifts fluctuated over the five measures and were significantly lower than norms at sessions two (*M*=2.31, *SD*=.47) and four (*M*=2.34, *SD*=.46). Frequency Hassles scores were lower than norms at sessions three and four (*M*=6.62, *SD*=2.3). Other scores on the PES-Brief were in the normal range for Subject F.

Pregnancy Experience Scale–Brief

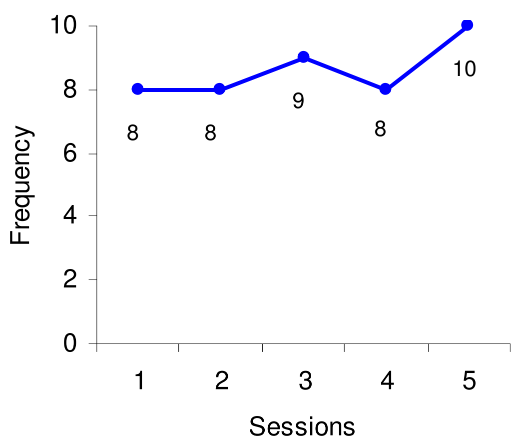



*Figure 85*. Subject F, Frequency Uplifts.

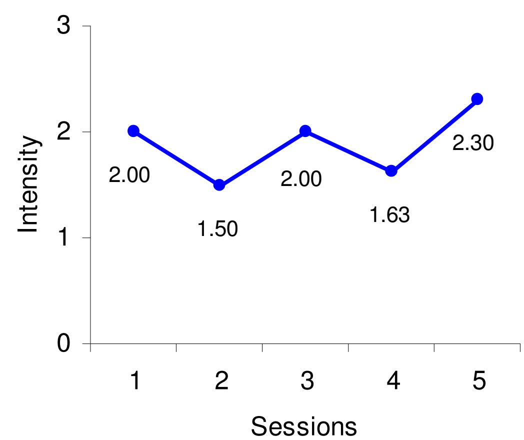



*Figure 86*. Subject F, Intensity Uplifts.

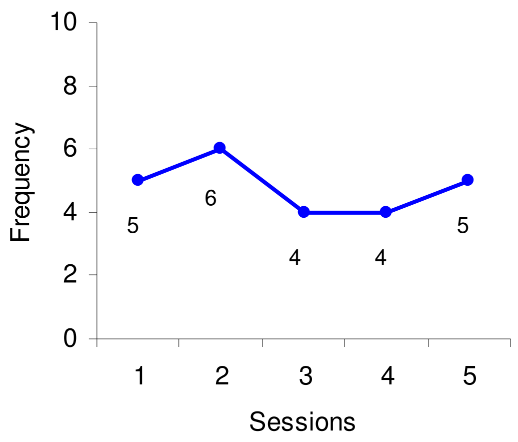



*Figure 87.* Subject F, Frequency Hassles.

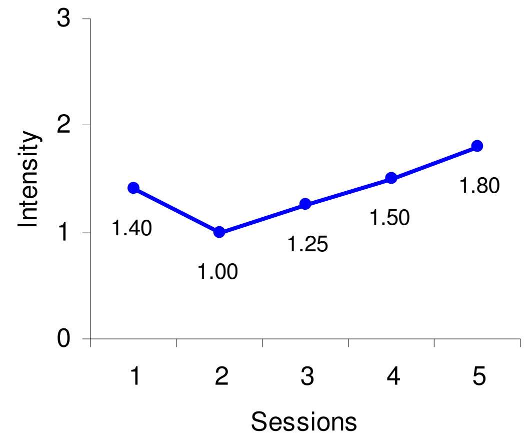



*Figure 88*. Subject F, Intensity Hassles.

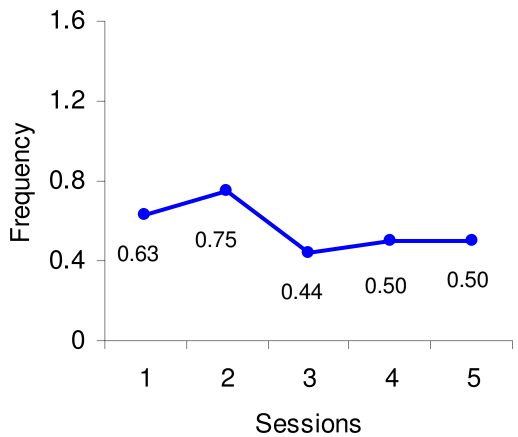



*Figure 89*. Subject F, Frequency Ratio.

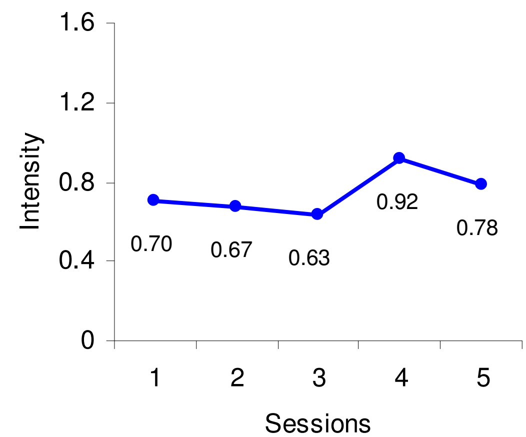



*Figure 90*. Subject F, Intensity Ratio.

PES scores for Subject F (see Figures 91 through 96) were higher than norms at session one on Intensity Hassles (*M*=1.38, *SD*=.28) and on Intensity Ratio (*M*=.73, *SD*=.18). All Subject F's other PES scores were in the normal range.

Pregnancy Experience Scale

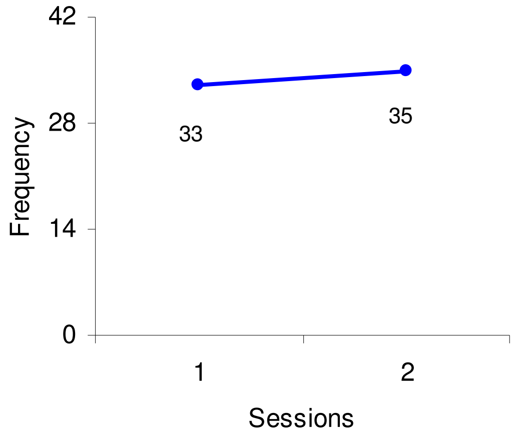



*Figure 91*. Subject F, Frequency Uplifts.

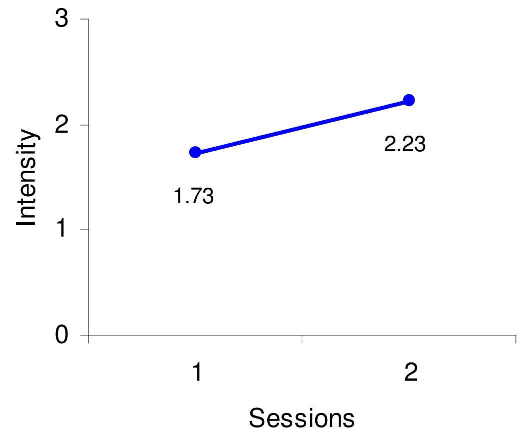



*Figure 92*. Subject F, Intensity Uplifts.

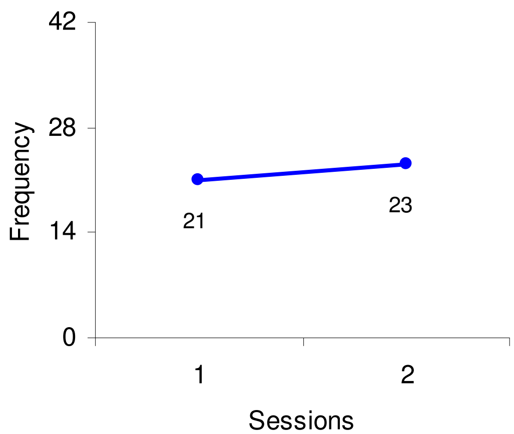



*Figure 93*. Subject F, Frequency Hassles.

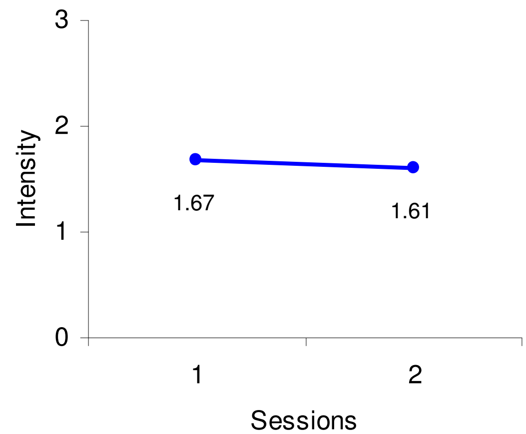



*Figure 94*. Subject F, Intensity Hassles.

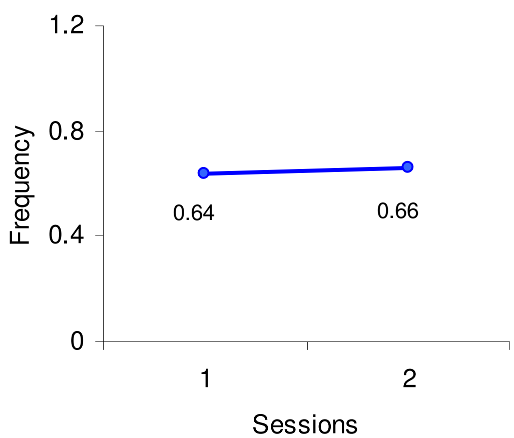



*Figure 95*. Subject F, Frequency Ratio.

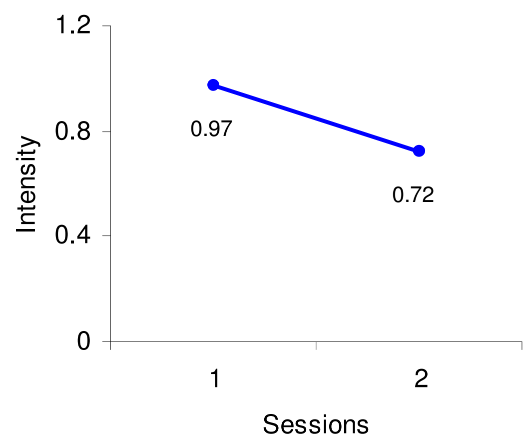



*Figure 96*. Subject F, Intensity Ratio.

Baseline HRV high coherence measures on Subject F increased from 25 percent to 100 percent over five sessions (see Figure 97). She recorded 496 minutes of practice and 39 occasions of using the QC® technique in daily life. At the end of her participation in the study, she expressed her belief that the stress management skills she had learned were beneficial to her as an additional tool to help her cope with her current concerns.

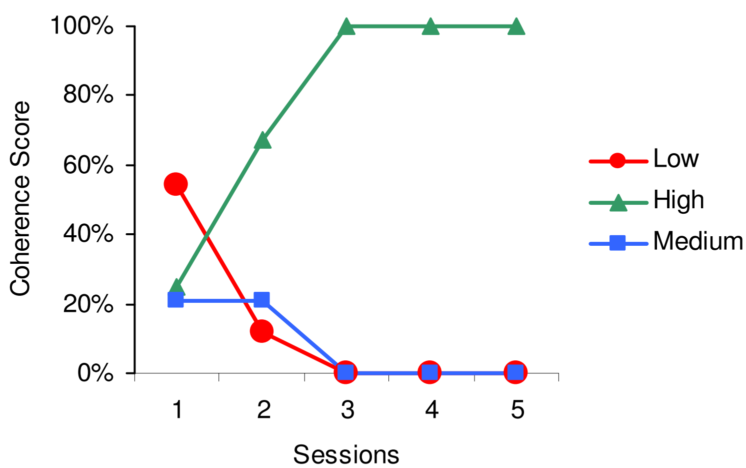



*Figure 97.* Subject F, baseline HRV coherence percentage.

During a follow-up telephone interview two months after delivery, Subject F stated that she continues to use the skills she learned in the study and that she feels she copes better with stress as a result. She reported that due to the fact that her baby was born by scheduled Cesarean section she did not experience active labor but used the skills effectively when she experienced extreme anxiety during preparation for the surgery.

*Subject G*

Subject G was a 33 year-old married Asian-American woman who volunteered for the study in response to a recruitment flyer she received at a birthing center. In the first session, she presented herself as friendly, poised, and very curious about the scientific basis for HRV biofeedback therapy. She was in her $24^{th}$ week of gestation at the beginning of her participation in the study, and she did not yet know fetal gender. This was her second pregnancy, and she had one two year-old daughter. She stated that her pregnancy was planned and that she and her husband were looking forward to a pleasant birth experience.

Subject G was a full-time homemaker and said that she was happy with this role. She reported her primary stressors as conflict with her in-laws, particularly her mother-in-law, and perfectionism. Her stated stress reactions were irritable bowel symptoms, increased perspiration, increased heart rate, shortness of breath, racing thoughts and rumination, and thoughts she described as “shoulds”.

Subject G’s STAI Y1 scores (see Figure 98) reveal her tendency to be highly reactive to stressful situations. The sharp increase in her score between the first and second weeks is more than two standard deviations above the norms for female working adults ($M$= 35.20, $SD$=10.61). This score reflected her anxiety when, two days prior to her second biofeedback session, she learned that her mother-in-law was coming to visit her family for Thanksgiving. Her perspective was that Thanksgiving should be a time of peace and joy in the family, and she said that her mother-in-law had a negative attitude which she found extremely noxious. Subject G’s session one, four, and five scores are significantly lower than norms. Her STAI Y2 scores decreased (see figure 99) but this change is not statistically significant.

State-Trait Anxiety Inventory

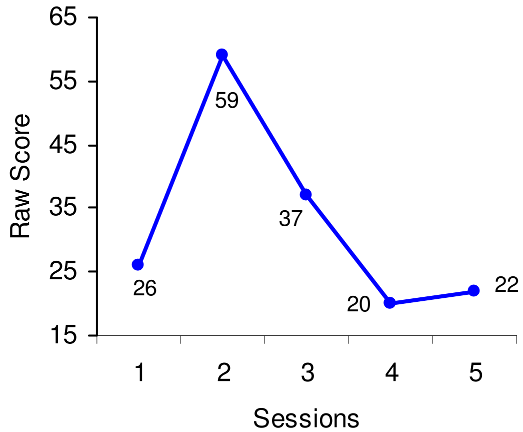



*Figure 98*. Subject G, STAIY1.

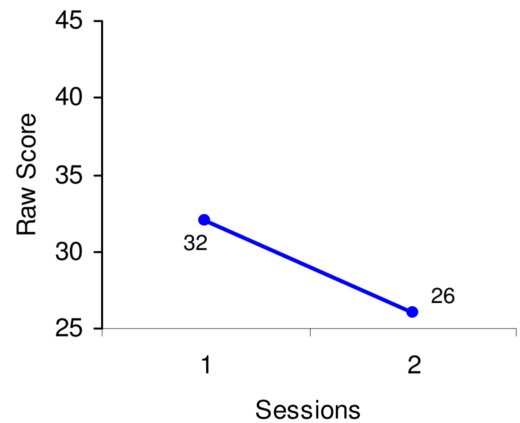



*Figure 99*. Subject G, STAIY2.

PES-Brief scores for Subject G (see Figures 100 through 105) were significantly lower than norms on Frequency Uplifts at session two (*M*=9.48, *SD*=1.00) and on Frequency Hassles at session one (*M*=6.54, *SD*=2.32) and sessions four and five (*M*=6.62, *SD*=2.29). Her Intensity Uplifts score was significantly higher than norms in session four (*M*=2.34, *SD*=.46). Frequency Ratio scores were all below 1.00 and declined over the course of the five sessions. Intensity Ratio scores fluctuated but were also below 1.00 indicating her attitude that the pregnancy was more uplifting than hassling.

Pregnancy Experience Scale–Brief

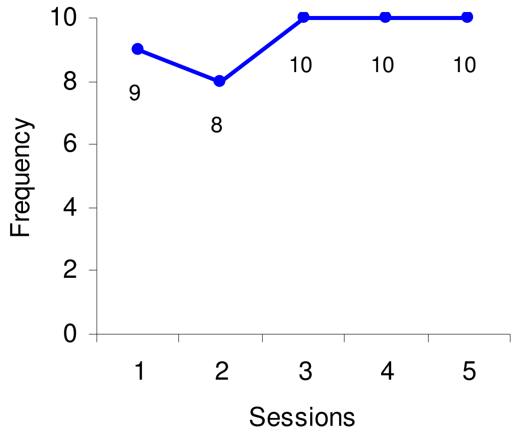



*Figure 100*. Subject G, Frequency Uplifts.

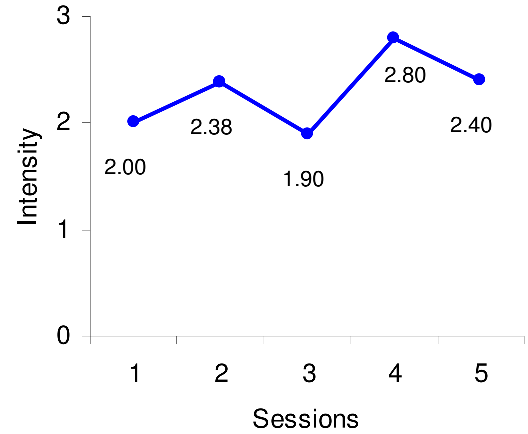



*Figure 101*. Subject G, Intensity Uplifts.

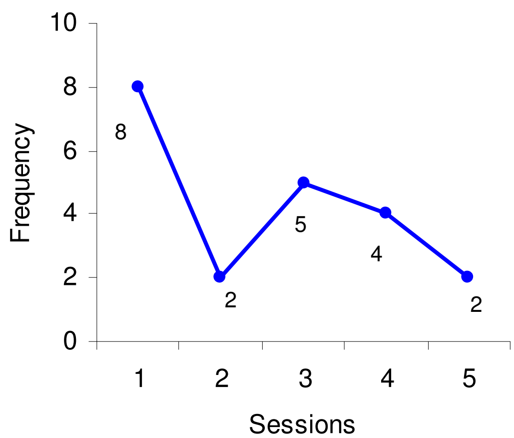



*Figure 102*. Subject G, Frequency Hassles.

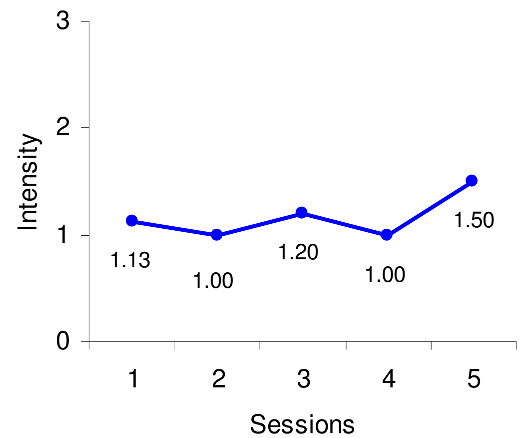



*Figure 103*. Subject G, Intensity Hassles.

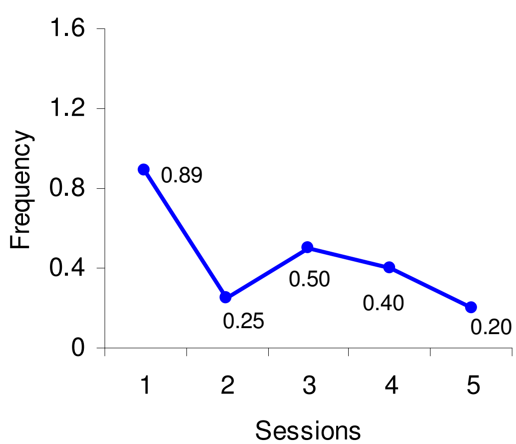



*Figure 104*. Subject G, Frequency Ratio.

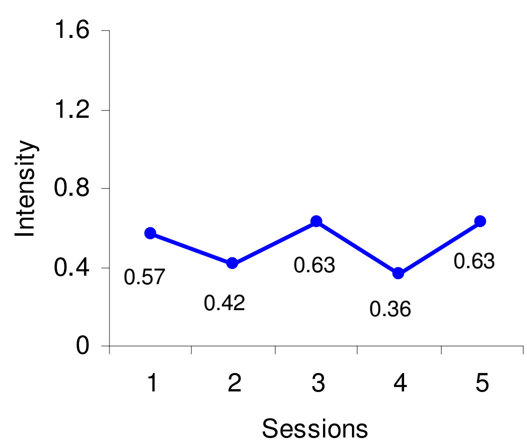



*Figure 105*. Subject G, Intensity Ratio.

At session one, Subject G's PES scores (see Figures 106 through 111) were lower than norms on Frequency Uplifts (*M*=27.50, *SD*=7.33) and on Intensity Hassles (*M*=1.38, *SD*=.28). At session five, her scores were lower than norms on Frequency Hassles (*M*=18.79, *SD*=7.73) and on Frequency Ratio (*M*=.69, *SD*=.28). Subject G's other PES scores were all in the normal range.

Pregnancy Experience Scale

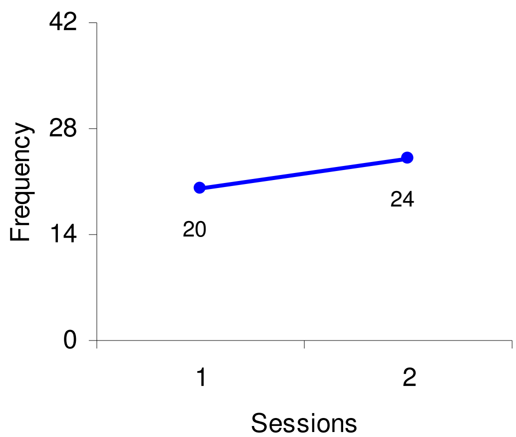



*Figure 106*. Subject G, Frequency Uplifts.

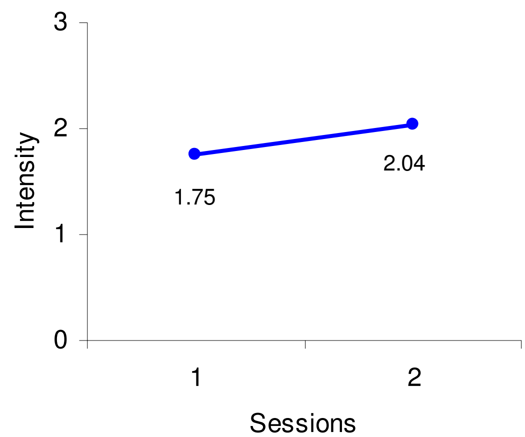



*Figure 107*. Subject G, Intensity Uplifts.

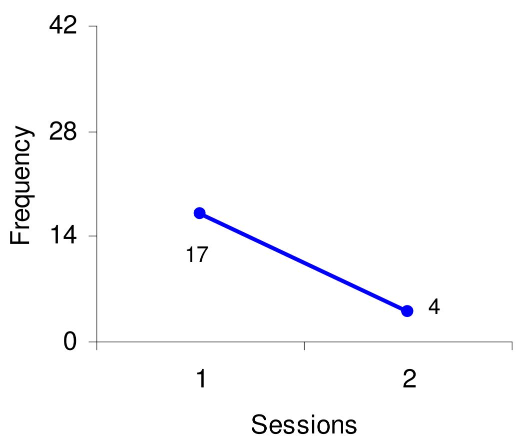



*Figure 108*. Subject G, Frequency Hassles.

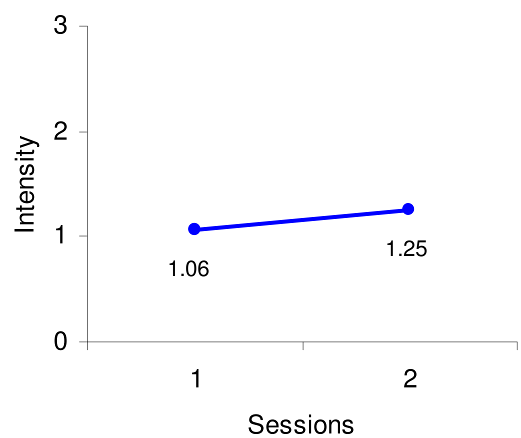



*Figure 109*. Subject G, Intensity Hassles.

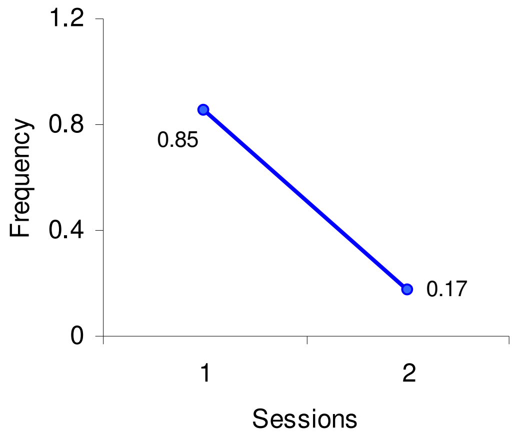



*Figure 110*. Subject G, Frequency Ratio.

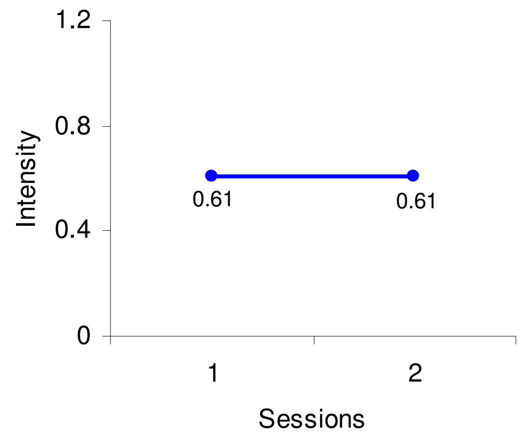



*Figure 111*. Subject G, Intensity Ratio.

Baseline HRV high coherence measures on Subject G increased from 18 percent to 100 percent over five sessions (see Figure 112). She recorded 265 minutes of practice and 4 occasions of using the QC® technique in daily life.

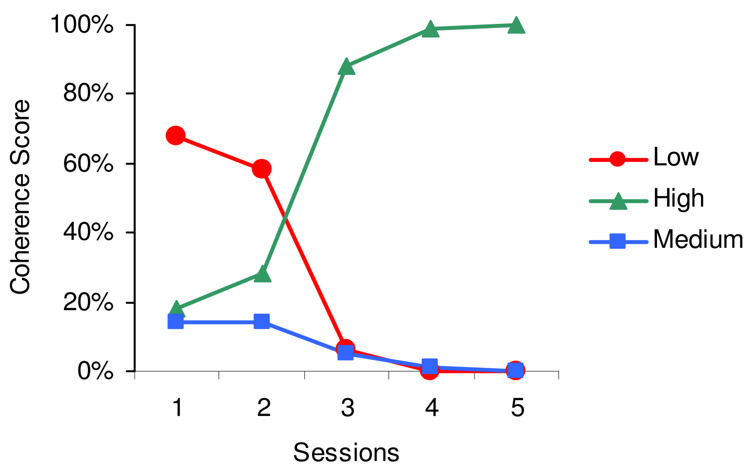



*Figure 112*. Subject G, baseline HRV coherence percentage.

This amount of time in practice is relatively low compared with other women in this study; however, she experienced improvement in most of her scores. Three factors may partially account for this effect. First, Subject G was psychologically minded as became evident when she was asked to observe her stress responses during the first week of the study. She returned the second week with notes detailing stressful situations she encountered during the week, her reactions, numerical ratings of her stress levels, and descriptions of her coping strategies. She also enthusiastically discussed the psychophysiological implications of what she learned from reading the booklet *The Inside Story* (HeartMath, 2002). Among other client variables, Asay and Lambert (1999) identified psychological mindedness as a client characteristic which contributes to successful therapeutic outcomes. Second, Subject G had previous experience in the use of yoga and other meditative techniques. She quickly transferred her meditative skills to learning QC® and HLI® and was the only study participant who successfully practiced at challenge level four during sessions. Third, Subject G identified conflict with her mother-in-law as her most severe stressor. Although in-person visits from the mother-in-law were fairly infrequent, she telephoned repeatedly throughout the day. Subject G did not answer all the phone calls, but she reported feeling invaded and very anxious even when she did not answer. During the third biofeedback session she decided to answer the phone only once a day and to begin using the calls as a trigger to practice the QC® or HLI® technique. This strategy helped Subject G feel more in control and greatly reduced her most problematic stressor. She said that she was very happy to have participated in the study and to have learned a new stress management skill.

During a follow-up telephone interview one month post delivery, Subject G stated that she definitely believed that she coped better with stress by the end of her participation in the study as compared with the beginning. She reported that prior to labor she drew a picture of a heart with an arrow to the words “solar plexus.” During labor she attached this picture to the wall in front of her as a reminder to use the HLI® technique. She also spontaneously volunteered that she continues to use the skills in her daily life and speculated that her increased peacefulness may be contributing to the fact that the baby, a girl, has a peaceful disposition, sleeps well, and seldom cries.

## Conclusions and Implications of Results

Subjects in this study demonstrated a variety of reactions to the experience. Most of the subjects expressed appreciation for being better able to calm themselves in stressful situations. Results of STAI Y1, PES-Brief, and PES were mixed for most subjects. Some subjects were facing life event stressors over which they felt little control, and their scores on some assessments worsened over the course of the study. However, during follow-up interviews most subjects endorsed the idea that they coped better with their stress than they would have if they had not been involved in the study. Five of the seven subjects also reported using the stress management skills during labor. Benefits of breathing and relaxation practices for pain management during labor are well established. The most consistent improvement across sessions was in baseline HRV coherence. This is an indication that subjects learned the stress management skills well enough to affect a positive change in their resting HRV. Improved HRV coherence is an indicator of better interaction between the sympathetic and parasympathetic branches of the autonomic nervous system, and if sustained may potentially lead to a general state of psychophysiological coherence associated with improved functioning in all bodily systems (McCraty, 2006; Tiller et al., 1996). Follow-up interviews indicated that five of the seven subjects continue to practice the stress management skills in their daily lives. This practice may afford longer term psychophysiological benefits not revealed by the short period of training and measurement accomplished during this study.

Continued practice is itself a notable result of this study. Five subjects deemed the skills useful enough to establish them as habitual practices in their daily lives. Four subjects spontaneously volunteered this information, a fact which lends credence to their responses as statements of fact rather that as socially acceptable agreement. Willingness to continue may be due in part to the fact that IHM® stress management techniques are not based upon eliciting the relaxation response per se and thus do not require long periods of disengagement from daily activities (McCraty, 2006). This feature may be particularly attractive to mothers of infants and young children.

## Limitations of the Study

This study was limited by small sample size (N=7) and by lack of a control group. It was also limited by lack of random selection of participants. Subjects volunteered for the study in response to recruitment flyers, newspaper advertisements, or referral from health care professionals. All individuals who volunteered were accepted into the study with the exception of one woman who did not meet the study criteria because she was taking regular antihistamines. The sample reflected a wide range of socioeconomic levels and ethnic backgrounds, a factor which may have affected stress levels in the participants. Another limitation of the study was that some biofeedback sessions were conducted in a birthing center where participants were scheduled to deliver their babies. This setting may have provoked increased anxiety in subjects who were anxious about giving birth. In addition, fetal monitoring was conducted at different weeks of gestation, from 29 to 34 weeks; thus, fetal recordings were influenced by varying degrees of HRV development. Another possible limitation of the study was the use of a photoplethysmograph rather than an electrocardiogram to record maternal HRV. Giardino, Lehrer, and Edelberg, (2002) found measures by the two methods to be highly correlated under baseline conditions, but significantly different under stress challenge. Electrocardiogram provides a more accurate measure of HRV under stress challenge. A further limitation of the study is that Subject D could not be contacted for a follow-up telephone interview. It is hoped that this exploratory study may encourage further research.

## Recommendations for Future Research

In the opinion of this researcher, future studies about HRV biofeedback-assisted stress management in pregnant women should include the following:

First, dimensions of stress such as the duration and intensity of life event stressors, controllability of stressors, and existing coping strategies should be assessed. Stress management intervention might be enhanced by helping subjects develop flexible coping strategies and the ability to discriminate between situations in which problem solving, emotion focused techniques, or a combination of the two are more appropriate (Cheng & Cheung, 2005; Roussi, 2002).

Second, a longer period of training might enhance results. Subjects in the present study were asked to observe their stress responses for the first week of the study. Intervention began in the second week; therefore, only the last three sessions yielded data collected after subjects began practicing stress management skills. More measurements would increase statistical power (Maxwell, 1998) and more sessions might help subjects improve their skills.

Third, in order to control for varying degrees of fetal HRV development, fetal monitoring should be conducted in the same week of gestation for all subjects. In addition, fetal monitoring should be conducted on more than one occasion and for a longer period of time under both baseline and practice conditions in order to control for possible fetal state changes and movement.

## APPENDIX A

## CONFIRMATION OF RECEIPT OF NOTICE OF PRIVACY AND INFORMED CONSENT

# University of North Texas

## Institutional Review Board

Consent to Participate in Research and Authorization to Use
and Disclose Health Information for Research

**Subject Name**__________________________________ **Date**____________

**Title of Study**
Effects of Stress Management and Heart Rate Variability Biofeedback Training on Pregnant Women and Their Infants

**Principal Investigator**
Janice Keeney, a graduate student in the University of North Texas (UNT) Department of Counseling, Development, and Higher Education.

Before agreeing to participate in this research study, it is important that you read and understand the following explanation of the proposed procedures. It describes the procedures, benefits, risks, and discomforts of the study. It also describes your right to withdraw from the study at any time. It is important for you to understand that no guarantees or assurances can be made as to the results of the study.

**Purpose of the Study**

The purpose of the study is to investigate the effects of stress management and heart rate variability (HRV) biofeedback training on pregnant women and their infants.

**Procedures to be used**

If you are selected as a research volunteer you will be asked to attend five to six sessions of biofeedback-assisted stress management therapy during which you will sit or recline in a quiet room with a pulse monitor attached to your ear lobe and a fetal heart monitor attached to your abdomen. During these sessions you will be instructed in relaxed breathing and stress reduction. Each of the biofeedback sessions will last approximately 45 minutes. You will be asked to practice the stress management skills daily for a minimum of 20 minutes, and you will be asked to keep a log of your practice. During the weeks that you are attending biofeedback sessions, you will be loaned a small hand-held biofeedback device to use in home practice. This practice should be carried out when you have quiet time and not when you are driving a vehicle or operating heavy machinery. You will be asked to complete some short pencil-and-paper self-report psychological assessments prior to each biofeedback session which will take approximately 10 to 20 minutes of your time.

**Description of the foreseeable risks**

The potential risks involved in this study are that blood pressure may temporarily decrease during biofeedback training sessions which might cause a slight dizziness or disorientation for a few moments if the participant rises too quickly. Participants will be cautioned to rise slowly after sessions.

**Benefits to the subjects or others**

This research project is expected to benefit you by providing you the opportunity to learn a stress management technique. Practice of this technique may possibly enhance your ability to manage your stress reactions and may possibly improve outcomes for your infant. This study will contribute to understanding effects of prenatal maternal stress reduction on heart rate responses in unborn infants.

**Compensation for Participants**

Volunteers who are selected to participate in this study will be paid $100 at the end of their participation in the study and completion of all tasks requested for the study and return of the hand-held biofeedback device.

**Procedures for Maintaining Confidentiality of Research Records**

In order to protect confidentiality and identity, each volunteer will be assigned a unique identification number. This number will be the only identification utilized on paper and computer files associated with the volunteer and on the data collected. For the duration of the experiment a master list of volunteer subject names, research identification number assigned to each volunteer, and contact information will be kept in a locked cabinet by the primary investigator. Signed consent forms and coded survey results will be kept in separate locations. No individual data will be made public. The confidentiality of your individual information will be maintained in any publications or presentations regarding this study.

**<u>Use and Disclosure of Health Information</u>**

**Information that will be used or disclosed**

The information you disclose to the Principal Investigator, Janice Keeney, prior to and during the study is the only information that will be used.

**Who may use or disclose the information**

You are the only person who may disclose this information and the Principal Investigator, Janice Keeney, is the only one who may use the information.

**Who may receive the information**

The Principal Investigator, Janice Keeney, may receive the information.

**Purpose of each use or disclosure**

The purpose of this disclosure is to provide information for statistical analysis to determine the results of the research study.

**Expiration of the authorization**

The authorization will expire at the end of the research study.

**Right to revoke authorization**

You have the right to revoke this authorization at any time. Should you choose to do so, please inform Janice Keeney in person or by phone at XXX-XXX-XXXX and submit your revocation request in writing. Mail the request to Janice Keeney, at XXXXXXXXXXX XXXXXXX.

**Potential for re-disclosure**

Personal health data collected for this study will be used only for the purposes of the study and will not be redisclosed to any third parties.

**Questions about the Study**

If you have any questions about the study, you may contact Janice Keeney at telephone number XXX-XXX-XXXX or Dr. Cynthia Chandler, UNT Department of Counseling, Development, and Higher Education, at telephone number XXX-XXX-XXXX.

**Review for the Protection of Participants**

This research project has been reviewed and approved by the UNT Institutional Review Board XXX-XXX-XXXX. Contact the UNT IRB with any questions regarding your rights as a research subject.

**Research Subject's Rights**

I have read or have had read to me all of the above. Janice Keeney has explained the study to me and answered all of my questions. I have been told the risks and/or discomforts as well as the possible benefits of the study. I have been told how my health information will be used and disclosed for the study. I understand that I do not have to take part in this study or authorize use and disclosure of my health information, and my refusal to participate or my decision to withdraw will involve no penalty, loss of rights, loss of benefits, or legal recourse to which I am entitled. If I decide to withdraw from the study, the study personnel may only use and disclose my health information already collected. If I decide to revoke my authorization to use and disclose my health information, I may not be allowed to continue in the study. The study personnel may choose to stop my participation at any time. In case problems or questions arise, I have been told I can contact Janice Keeney at telephone number XXX-XXX-XXXX. I understand my rights as a research subject and I voluntarily consent to participate in this study. I understand what the study is about, how the study is conducted, and why it is being performed. I will receive a signed copy of this consent and authorization after it has been signed.

__________________________________________ ________________
Signature of Subject or Subject's Legal Representative* Date

__________________________________________
Printed Name of Subject

*Description of Legal Representative's authority to act on behalf of Subject

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__________________________________________ ________________
Signature of Witness Date

**For the Investigator or Designee:**
I certify that I have reviewed the contents of this form with the subject signing above. I have explained the known benefits and risks of the research and the use and disclosure of health information. It is my opinion that the subject understood the explanation.

__________________________________________ ________________
Signature of Principal Investigator Date

# APPENDIX B

# DAILY PRACTICE LOG

**Practice Log** **ID No_______**

| Date | Minutes | With Biofeedback | Short Practice X's |
|---|---|---|---|
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |
| | | Yes/No | |

REFERENCES

Arena, J. G. & Schwartz, M. S. (2003). Psychophysiological assessment and biofeedback baselines. In M. S. Schwartz & F. Andrasik (Eds.), *Biofeedback: A practitioner's guide* (pp. 159-177). New York: Guilford.

Asay, T. P. & Lambert, M. J. (1999). The empirical case for the common factors in therapy: Quantitative findings. In M. A. Hubble, B. L. Duncan, & S. D. Miller (Eds.), *The heart and soul of change.* Washington, DC: American Psychological Association.

Barker, D. J. P., Eriksson, J. G., Forsen, T., & Osmond, C. (2002). Fetal origins of adult disease: Strength of effects and biological basis. *International Journal of Epidemiology, 31*(6), 1235-1239.

Barrios-Choplin, B., McCraty, R., & Cryer, B. (1997). An inner quality approach to reducing stress and improving physical and emotional well-being at work. *Stress Medicine, 13*, 193-201.

Berntson, G. G., Cacioppo, J. T., & Quigley, K. S. (1993). Respiratory sinus arrhythmia: Autonomic origins, physiological mechanisms, and psychophysiological implications. *Psychophysiology, 30,* 183-196.

Bornstein, M. H., DiPietro, J. A., Hahn, C., Painter, K., Haynes, O. M., & Costigan, K. (2002). Prenatal cardiac function and postnatal cognitive development: An exploratory study. *Infancy, 3*(4), 475-494.

Cannon, W. B. (1932). *The wisdom of the body.* New York: W. W. Norton & Co.

Chandler, C., Lawson, E., Molenaar, L., & DeSalme, A. (1999). *The relationship* *between maternal biofeedback and infant outcomes*. Paper presented at the Association for Applied Psychophysiology and Biofeedback Conference, Vancouver, British Columbia.

Cheng, C. & Cheung, M. W. L. (2005). Cognitive processes underlying coping flexibility: Differentiation and integration. *Journal of Personality, 73*(4), 859-886.

Childre, D. & Rozman, D. (2005). *Transforming stress.* Oakland, CA: New Harbinger Publications, Inc.

Chung, D. Y., Sim, Y. B., Park, K. T., Yi, S. H., Shin, J. C., & Kim, S. P. (2001). Spectral analysis of fetal heart rate variability as a predictor of intrapartum fetal distress. *International Journal of Gynecology & Obstetrics, 73*, 109-116.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences (2nd ed.).* Hillsdale, NJ: Lawrence Erlbaum Associates.

Cramer, J. C. (1987). Social factors and infant mortality: Identifying high-risk groups and proximate causes. *Demography, 24*(3), 299-322.

de Anda, D., Darrock, P., Davidson, M., Gilly, J., & Morejon, A. (1990). Stress management for pregnant adolescents and adolescent mothers: A pilot study. *Child and Adolescent Social Work, 7*(1), 53-67.

Davis, M., Eshelman, E., & McKay, M. (2000). *The relaxation and stress reduction workbook.* Oakland, CA: New Harbinger Publications, Inc.

DiPietro, J. A. (2004). The role of prenatal maternal stress in child development. *Current Directions in Psychological Science, 13*(2), 71-74.

DiPietro, J. A., Bornstein, M. H., Hahn, C., Costigan, K., Achy-Brou, A., (2007). Fetal heart rate and variability: Stability and prediction to developmental outcomes in early childhood. *Child Development, 78*(6), 1788-1798.

DiPietro, J. A., Costigan, K. A., & Gurewitsch, E. D. (2003). Fetal response to induced maternal stress. *Early Human Development, 74*(2), 125-138.

DiPietro, J. A., Costigan, K. A., Nelson, P., Gurewitsch, E. D., & Laudenslager, M. L. (2008). Fetal responses to induced maternal relaxation during pregnancy. *Biological Psychology, 77*, 11-19.

DiPietro, J. A., Costigan, K. A., Pressman, E. K., & Doussard-Roosevelt, J. A. (2000). Antenatal origins of individual differences in heart rate. *Developmental Psychobiology, 37*(4), 221-228.

DiPietro, J. A., Ghera, M. M., Costigan, K., & Hawkins, M. (2004). Measuring the ups and downs of pregnancy stress. *Journal of Psychosomatic Obstetrics and Gynecology, 25,* 189-201.

DiPietro, J. A., Hilton, S. C., Hawkins, M., Costigan, K. A., & Pressman, E. K. (2002). Maternal stress and affect influence fetal neurobehavioral development. *Developmental Psychology, 38*(5), 659-668.

DiPietro, J. A., Hodgson, D. M., Costigan, K. A., Hilton, S. C., & Johnson, R. R. B. (1996). Fetal neurobehavioral development. *Child Development, 67*, 2553-2567.

DiPietro, J. A., Irizarry, R. A., Costigan, K. A., & Gurewitsch, E. D. (2004). The psychophysiology of the maternal-fetal relationship. *Psychophysiology, 41*, 510-520.

DiPietro, J. A., Novak, F. S. X., Costigan, K. A., Atella, L. D., & Reusing, S. P.

(2006). Maternal psychological distress during pregnancy in relation to child development at age two. *Child Development, 77,* 573-587.

Doussard-Roosevelt, J. A., Porges, S. W., Scanlon, J. W., Alemi, B., & Scalon, K. B. (1997). Vagal regulation of heart rate in the prediction of developmental outcome for very low birth weight preterm infants. *Child Development, 68*(2), p. 173-186.

Eberhard-Gran, M., Eskild, A., & Opjordsmoen, S. (2005). Treating mood disorders during pregnancy. *Drug Safety, 28*(8), 695-706.

Fredrickson, B. L. (2000). Cultivating positive emotions to optimize health and well-being. *Prevention & Treatment, 3,* item 1.

Fredrickson, B. L. (2001). The role of positive emotions in positive psychology: The broaden-and-build theory of positive emotions. *American Psychologist, 56*(3), 218-226.

Fredrickson, B. L. & Levenson, R. W. (1998). Positive emotions speed recovery from the cardiovascular sequelae of negative emotions. *Cognition and Emotion, 12,* 191-220.

Fujioka, T., Fujioka, A., Endoh, H., Sakata, Y., Furukawa, S., & Nakamura, S. (2003). *Neuroscience, 118,* 409-415.

Giardino, N. D., Lehrer, P. M., & Edelberg, R. (2002). Comparison of finger plethysmograph to ECG in the measurement of heart rate variability. *Psychophysiology, 39,* 246-253.

Gevirtz, R. N. & Lehrer, P. (2003). Resonant frequency heart rate biofeedback. In M. S. Schwartz & F. Andrasik (Eds.), *Biofeedback: A practitioner's guide* (pp. 245-250). New York: Guilford.

Hall, C. W., & Webster, R. E. (2002). Traumatic symptomatology characteristics of adult children of alcoholics. *Journal of Drug Education, 32*(3), 195-211.

Hassett, A. L., Radvanski, D. C., Vaschillo, E. G., Vaschillo, B., Signal, L. H., & Karavidas, M. K. et al. (2007). A pilot study of the efficacy of heart rate variability (HRV) biofeedback in patients with fibromyalgia. *Applied Psychophysiology and Biofeedback, 32*(1), 1-10.

HeartMath (2002). *The inside story.* Boulder Creek, CA: Author HeartMath (2006). *emWave PC Stress Relief System® and emWave Personal Stress Reliever®* Boulder Creek, CA: HeartMath, intellectual property of Quantum Intech Inc

Hodnett, E. D. & Fredericks, S. (2003). Support during pregnancy for women at increased risk of low birthweight babies. *The Cochrane Database of Systematic Reviews, 3,* Art. No.: CD000198. DOI: 10.1002/14651858.Cdooo198.

Huizink, A. C., Robles de Medina, P. G., Mulder, E. J. H., Visser, G. H. A., & Buitelaar, J. K. (2002). Psychological measures of prenatal stress as predictors of infant temperament. *Journal of the American Academy of Child and Adolescent Psychiatry, 41*(9), 1078-1085.

Humphreys, P. & Gevirtz, R. (2000). Treatment of recurrent abdominal pain: Components analysis of four treatment protocols. *Journal of Pediatric and Gastroenterology and Nutrition, 31,* 47-51.

Imamura, Y., Nakane, Y., Ohta, Y., and Kondo, H. (1999). Lifetime prevalence of schizophrenia among individuals prenatally exposed to atomic bomb radiation in Nagasaki City. *Acta Psychiatrica Scandinavica, 100,* 344-349.

Institute of Medicine. (1985). *Preventing low birth weight*. National Academy Press, Washington, D. C.

Janke, J. (1999). The effect of relaxation therapy on preterm labor outcomes. *Journal of Obstetric, Gynecologic, and Neonatal Nursing, 28,* 255-263.

Karavidas, M. K., Lehrer, P. M., Vaschillo, E., Vaschillo, B., Marin, H., & Buyske et al. (2007). Preliminary results of an open label study of heart rate variability biofeedback for the treatment of major depression. *Applied Psychophysiology and Biofeedback, 32*(1), 19-30.

Khashan, A. S., Abel, K. M., McNamee, R., Pedersen, M. G., Webb, R. T., & Baker, P. N. et al. (2008). Higher risk of offspring schizophrenia following antenatal maternal exposure to severe adverse life events. *Archives of General Psychiatry, 65*(2), 146-152.

Killingsworth-Rini, C., Dunkel-Schetter, C., Wadhwa, P. D., & Sandman, C. A. (1999). Psychological adaptation and birth outcomes: The role of personal resources, stress, and sociocultural context in pregnancy. *Health Psychology, 18*(4), 333-345.

Koenig, J. I., Kirkpatrick, B., & Lee, P. (2002). *Neuropsychopharmacology, 27*(2), 309-318.

LeDoux, J. (1996). *The emotional brain: The mysterious underpinnings of emotional life.* New York: Touchstone.

Lehrer, P. M., Vaschillo, E., Vaschillo, B., Lu, S., Scardella, A., & Siddique, M. et al. (2004). Biofeedback treatment for asthma. *Chest, 126,* 352-361.

Lindgaard, H. (2005). Adult children of alcoholics: Are they different? *Nordisk Psykologi, 57*(2), 1007-129.

Luskin, F., Reitz, M., Newell, K., Quinn, T. G., & Haskell, W. (2002, Fall). A controlled pilot study of stress management training of elderly patients with congestive heart failure. *Preventive Cardiology,* 168-176.

Mancuso, R. A., Dunkel-Schetter, C., Rini, C. M., Roesch, S. C., & Hobel, C. J. (2004). *Psychosomatic Medicine, 66*, 762-769.

Maxwell, S. E. (1998). Longitudinal designs in randomized group comparisons: When will intermediate observations increase statistical power? *Psychological Methods, 3*(3), 275-290.

McCraty, R. (2006). Emotional stress, positive emotions, and psychophysiological coherence. In B. B. Arnetz & R. Ekman (Eds.), *Shaping the brain to health and disease.* Weinheim, Germany: Wiley-VCH.

McCraty, R. (2003). *The energetic heart: Bioelectromagnetic interactions within and between people.* Boulder Creek, CA: Institute of HeartMath.

McCraty, R., Atkinson, M., & Conforti, K. (1999). *Heart rate variability, hemoglobin A1c, and psychological health in Type 1 and 2 diabetes following an emotional self-management program.* Paper presented at the Society of Behavioral Medicine 20th Annual Scientific Sessions, San Diego, CA.

McCraty, R., Atkinson, M., & Tiller, W. (1999). *The Freeze-Framer: A stress management training and heart rhythm education system for increasing physiological coherence.* Proceedings of the Tenth International Montreux Congress on Stress, Montreux, Switzerland.

McCraty, R., Atkinson, M., Tiller, W. A., Rein, G., & Watkins, A. D. (1995). The effects of emotions on short-term power spectral analysis of heart rate variability. *American Journal of Cardiology, 76*(14), 1089-1093.

McCraty, R., Atkinson, M., & Tomasino, D. (2001). *Science of the heart Exploring the role of the heart in human performance.* Boulder Creek, CA: Institute of HeartMath.

McCraty, R., Atkinson, M., & Tomasino, D. (2003). Impact of a workplace stress reduction program on blood pressure and emotional health in hypertensive employees. *The Journal of Alternative and Complementary Medicine, 9*(3), 355-369.

McCraty, R., Atkinson, M., Tomasino, D., Goelitz, J, & Mayrovitz, H. N. (1999). The impact of an emotional self-management skills course on psychosocial functioning and autonomic recovery to stress in middle school children. *Integrative Physiological and Behavioral Science, 34*(4), 246-248.

McCraty, R., Barrios-Choplin, B., Rozman, D., Atkinson, M., Watkins, A. D. (1998). The impact of a new emotional self-management program on stress, emotions, heart rate variability, DHEA and cortisol. *Integrative Physiological and Behavioral Science, 33*(2), 151-170.

McCraty, R. Atkinson, M., Tomasino, D., & Tiller, W. A. (1998). The electricity of touch: Detection and measurement of cardiac energy exchange between people. In K. H. Pribram (Ed.), *Brain and values: Is a biological science of values possible.* Mahwah, NJ: Lawrence Erlbaum Associates.

McCraty, R. & Childre, D. (2002). *The appreciative heart: The psychophysiology* *of positive emotions and optimal functioning.* Boulder Creek, CA: Institute of HeartMath.

McCubbin, J. A., Lawson, E. J., Cox, S., Sherman, J. J., Norton, J. A., & Read, J. A. (1996). Prenatal maternal blood pressure response to stress predicts birth weight and gestational age: A preliminary study. *American Journal of Obstetrics and Gynecology, 175*(3), 706-712.

Meadows, M. (2001). Pregnancy and the drug dilemma. [Electronic version]. *U. S. Food and Drug Administration, FDA Consumer, (35*(3).

Monk, C., Fifer, W. P., Myers, M. M., Sloan, R. P., Trien, L., & Hurtado, A. (2000). Maternal stress responses and anxiety during pregnancy: Effects on fetal heart rate. *Developmental Psychobiology, 36*, 67-77.

Monk, C., Myers, M. M., Sloan, R. P., Ellman, L. M., & Fifer, W. P. (2003). Effects of women's stress-elicited physiological activity and chronic anxiety on fetal heart rate. *Journal of Developmental & Behavioral Pediatrics, 24*(1), 32-38.

Monk, C., Sloan, R. P., Myers, M. M., Ellman, L., Werner, E., & Jeon, J. et al., (2004). Fetal heart rate reactivity differs by women's psychiatric status: An early marker for developmental risk? *Journal of the American Academy of Child and Adolescent Psychiatry, 43*(3), 283-290.

Moss, N. E. (1991). The effect of stress management on the recurrence of preterm delivery (Doctoral dissertation, University of Utah, 1991). Digital Dissertations via Proquest, AAT 9128092.

O'Connor, T., Heron, J., Golding, J., Glover, V., & the ALSPAC Study Team

(2003). Maternal antenatal anxiety and behavioural/emotional problems in children: a test of a programming hypothesis. *Journal of Child Psychology and Psychiatry, 44,*(7), p. 1025-1036).

Paarlberg, K. M., Vingerhoets, A., Passchier, J., Dekker, G., & Van Geijn, H. (1995). Psychosocial factors and pregnancy outcome: A review with emphasis on methodological issues. *Journal of Psychosomatic Research, 39*(5), 563-595.

Peavey, B. S. (1996). The dance of mother and baby: Biofeedback treatment with pregnancy, labor and delivery. *Biofeedback,* winter, 6-11 & 20.

Ponirakis, A., Susman, E. J., & Stifter, C. A. (1998). Negative emotionality and cortisol during adolescent pregnancy and its effects on infant health and autonomic nervous system reactivity. *Developmental Psychobiology, 33*, 163-174.

Porges, S. W. (1995). Cardiac vagal tone: A physiological index of stress. *Neuroscience and Biobehavioral Reviews, 19*(2), 225-233.

Rothenberg, M. A. & Chapman, C. F. (1989). *Dictionary of medical terms* (2nd ed.). Hauppauge, New York: Barrons Educational Series.

Roussi, P. (2002). Discriminative facility in perceptions of control and its relation to psychological distress. *Anxiety, Stress, & Coping, 1*5(2), 179-191.

Rozman, D., Whitaker, R., Beckman, T., & Jones, D. (1996). A pilot intervention program that reduces psychological symptomatology in individuals with human immunodeficiency virus. *Complimentary Therapies in Medicine, 4*, 226-232.

Russek, L. G. & Schwartz, G. E. (1994). Interpersonal heart-brain registration and the perception of parental love: A 42 year follow-up of the Harvard Mastery of Stress study. *Subtle Energies, 5*(3), 195-208.

Sandman, C. A., Glynn, L., Wadhwa, P. D., Chicz-DeMet, A., Porto, M., & Garite, T. (2003). Maternal hypothalamic-pituitary-adrenal dysregulation during the third trimester influences human fetal responses. *Developmental Neuroscience, 25,* 41-49.

Sapolsky, R. M. (1998). *Why zebras don't get ulcers: An updated guide to stress, stress-related diseases, and coping.* New York: W. H. Freeman.

Schwartz, M. S. (2003). Compliance. In M. S. Schwartz & F. Andrasik (Eds.), *Biofeedback: A practitioner's guide* (pp. 159-177). New York: Guilford.

Schwartz, M. S., Schwartz, N. M., & Monastra, V. J. (2003). Problems with relaxation and biofeedback-assisted relaxation, and guidelines for management. In M. S. Schwartz & F. Andrasik (Eds.), *Biofeedback: A practitioner's guide* (pp. 251-264). New York: Guilford.

Selye, H. (1974). *Stress without distress.* New York: J. B. Lippincott.

Selye, H. (1978). *The stress of life* (2nd ed.). New York: McGraw-Hill.

Shah, N. R., & Bracken, M. B. (2000). A systematic review and meta-analysis of prospective studies on the association between maternal cigarette smoking and preterm delivery. *American Journal of Obstetrics and Gynecology, 182*(2), 465-472.

Shaw, E. R. (1993). Effect of therapeutic relaxation on anxiety and mood states in primiparous women (Doctoral dissertation, University of South Carolina, 1993). Digital Dissertations via Proquest, AAT 9321993.

Sjostrom, K., Valentin, L., Thelin, T., & Marsal, K. (2002). Maternal anxiety in late pregnancy: Effect on fetal movements and fetal heart rate. *Early Human Development, 67,* 87-100.

Somers, P. J., Gevirts, R. N., Jasin, S. E., & Chin, H. G. (1989). The efficacy of biobehavioral and compliance interventions in the adjunctive treatment of mild pregnancy-induced hypertension. *Biofeedback and Self-Regulation, 14*(4), 309-318.

Spielberger, C. D., Gorsuch, R. L., Vagg, P. R., & Jacobs, G. A. (1983). *Manual for the state-trait anxiety inventory (Form Y) (Self-evaluation questionnaire).* Palo Alto, CA: Consulting Psychologists Press, Inc.

Teixeira, J., Fisk, N. M., & Glover, V. (1999). Association between maternal anxiety in pregnancy and increased uterine artery resistance index: Cohort based study. *British Medical Journal, 318,* 153-157.

Teixeira, J., Martin, D., Prendiville, O., & Glover, V. (2005). The effects of acute relaxation on indices of anxiety during pregnancy. *Journal of Psychosomatic Obstetrics & Gynecology, 26*(4), 271-276.

Tiller, W. A., McCraty, R., & Atkinson, M. (1996). Cardiac coherence: A new, noninvasive measure of autonomic nervous system order. *Alternative Therapies, 2*(1), 52-65.

Urizar Jr., G. G., Milazzo, M., Le, H., Delucchi, K., Sotelo, R., and Munoz, R. F. (2004). The impact of stress reduction instructions on stress and cortisol levels during pregnancy. *Biological Psychology, 67*, 275-282.

Van den Bergh, B. R. H. & Marcoen, A. (2004). High antenatal maternal anxiety is related to ADHD symptoms, externalizing problems, and anxiety in 8- and 9-year-olds. *Child Development, 75*(4), 1085-1097.

Van den Bergh, B. R. H., Mulder, E. J. H., Mennes, M., & Glover, V. (2005). Antenatal maternal anxiety and stress and the neurobehavioural development of the fetus and child: Links and possible mechanisms. A review. *Neuroscience and Biobehavioral Reviews, 29,* 237-258.

Van Leeuwen, P., Lange, S., Bettermann, H., Gronemeyer, D., & Hatzmann, W. (1999). Fetal heart rate variability and complexity in the course of pregnancy. *Early Human Development, 54*, 259-269.

Van Os, J. & Selten, J. (1998). Prenatal exposure to maternal stress and subsequent schizophrenia: The May 1940 invasion of the Netherlands. *British Journal of Psychiatry, 172,* 324-326.

Wadhwa, D., Sandman, C. A., Porto, M., Dunkel-Schetter, C., & Garite, T. J. (1993). The association between prenatal stress and infant birth weight and gestational age at birth: A prospective investigation. *American Journal of Obstetrics and Gynecology, 169,* 858-865.

Weinstock, M. (2001). Alterations induced by gestational stress in brain morphology and behavior of the offspring. *Progress in Neurobiology, 65*, 427-451.

Welberg, L. A. M. & Seckl, J. R. (2001). Prenatal stress, glucocorticoids and the programming of the brain. *Journal of Neuroendocrinology, 13*, 113-128.