THE ROLE OF BRIEF MINDFULNESS MEDITATION INSTRUCTION AND PRACTICE IN CHANGING BIOPHYSICAL INDICATORS IN PREGNANT WOMEN AND THEIR BABIES

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Abstract

Pregnancy is a time of change that has the potential to be a stressful experience for some women. There is evidence from animal and human studies that long-term exposure to maternal stress can be detrimental to the unborn baby, both before and after birth. Non-pharmacological interventions that are aimed at assisting pregnant women to mediate the way they respond to stress are particularly relevant for the pregnant population, due to the potential teratogenic risks associated with drug therapy. Mindfulness-based therapies have the potential to be beneficial for pregnant women. The aim of this study was to explore the effect of a brief biofeedback-assisted mindfulness meditation procedure on the physiological responses of pregnant women and their babies. Six women in the last trimester of pregnancy completed a brief mindfulness meditation procedure. Each participant's physiological responses (heart rate, respiration rate and galvanic skin response), and her baby's heart rate, were measured across baseline, teaching and practice conditions. The results indicated that the procedure was associated with a physiological change in at least one of the variables for all of the participants. The procedure was not, however, associated with a change in all of the variables for any of the participants. The procedure was associated with a decrease in the mean fetal heart rate in four of the six babies. There was no clear association between maternal physiological responses and fetal responses for five of the six participants. The findings suggest that biofeedback is helpful in assisting participants to learn and practice a brief mindfulness meditation procedure.

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This thesis is dedicated to the memory of my father, Bob Clark. He was a wise and naturally mindful man who coped with a lifetime of pain with total acceptance and an ability always to focus on the moment.

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Chapter 1: Introduction

Pregnancy marks a significant period of change for a woman. For many women this is not a time of calm and mental well-being. Rather, pregnancy can be a time when the individual may experience significant stress and worry (Austin, 2004). A pregnant woman in the first world can encounter an often-bewildering amount of information concerning pregnancy and birth. The media frequently reports, in detail, accounts of births that have had poor outcomes, and there are seldom reports of positive birth outcomes. A recent article in the New Zealand popular press went so far as to suggest that humans were not designed to give birth naturally and without intervention. This was asserted to be as a result of the evolutionary processes allowing humans to humans walk upright (Chisholm, 2011). Alarmist articles such as this, in combination with other wider sources of environmental stress such as lack of social support, intimate partner violence or demands such as financial difficulties may be associated with increasing levels of stress and anxiety that pregnant women living in middle income countries similar to New Zealand appear to report (Vythilingum et al., 2010). Stress and anxiety occurring at this pivotal time in a woman's life not only have repercussions for her own mental health, but mounting evidence from both animal and human research suggests that there are significant consequences for the offspring of antenatally stressed mothers (O'Conner, Ben-Shlomo, Heron, Golding, Adams, & Glover, 2005).

One of the challenges for researchers in this field is to develop anxiety-reducing interventions that are effective, safe and appropriate for the pregnant woman, and at the same time can be shown to have a positive effect on her baby.

There is currently limited understanding of how the unborn baby responds to maternal relaxation and stress reduction interventions (DiPietro et al., 2008), and more research is needed to increase knowledge in this area. It is anticipated that more information about effects of maternal relaxation will, over time, lead to effective intervention strategies for stressed pregnant women that are underpinned by sound science.

1.1 Animal research and the impact of stress in pregnancy

There is a significant body of evidence related to prenatal stress arising from research conducted using a variety of animal species. The advantages of using animals to examine prenatal stress include the ability randomly to assign subjects to stress groups, and to control intensity, duration, timing and form of the stressor. The offspring of mothers that have been stressed prenatally can then be sacrificed at differing ages, and any effects on the brain can be directly observed (Charil, Laplante, Vaillancourt & King, 2010).

The way in which prenatal stress comes to affect the fetus has been attributed to changes in the maternal and fetal hypothalamic-pituitary-adrenal (HPA) axes, and the placenta (Charil et al., 2010). The HPA axis is primarily concerned with the production of cortisol, a glucocorticoid that plays a major role in responding to stress. Cortisol production is elevated in pregnancy to facilitate fetal growth and the production of vital enzymes. If stress levels are elevated in pregnancy, maternal cortisol levels can exceed the range where it can be converted into an inactive form (cortisone) via the placenta. The excess cortisol can then spill over to the fetus in high concentrations; this may precipitate a range of detrimental effects, particularly in the developing brain (Charil et al., 2010).

It has been hypothesized that prenatal stress can also induce changes in the placental phenotype that may affect fetal brain development. The placenta releases hormones that are under the control of the maternal HPA axis. Placental corticotrophin-releasing hormone (CRH) is regulated in this way. Excess CRH, related to maternal stress, has been correlated with effects such as preterm birth and intrauterine growth retardation as well as possible effects in the fetal hippocampus and limbic area, which have large numbers of CRH receptors (Charil et al., 2010). In addition to these effects, maternal stress has been implicated in altering the way in which the placental enzymes protect the fetus and placental tissue from excess glucocorticoid exposure. This has two effects: the fetus is less protected and the placental production of essential proteins and hormones may be affected (Charil et al., 2010).

A significant amount of the evidence for these proposed mechanisms has been established via animal research involving rats and primates. Maccari et al., (2003) exposed pregnant rats to three stress sessions per day, consisting of 45 minutes of bright light exposure while being contained in a clear plastic cylinder. These sessions took place between the 11^{th} and 15^{th} days of a 21-day pregnancy. Their results showed that the offspring of the stressed rats had both behavioural and neurological differences when compared to a control group that was not exposed to the antenatal stress sessions. The observed behavioural differences were noted over the entire lifespan of the offspring, and included behavioural expressions of increased ‘anxiety’ and ‘depressive-like’ behaviours. In addition, the experimental group demonstrated recognition impairment and altered working memory in maze tasks as well as disturbances of circadian rhythms in relation to light.

Neurobiological findings included a reduction in glucocorticoid type I and type II receptors in the hippocampus of rat pups born to stressed mothers. Maccari et al. (2003) postulate that this may be the mechanism that mediates long-lasting effects on the hypothalamic-pituitary-adrenal axis (HPA) axis, and in particular HPA axis hyperactivity. These authors note that there is evidence that endocrinological systems are affected in prenatally stressed rats, including findings of increased activation of the sympathetic nervous system leading to possible long term changes in the way the sympathoadrenal system of the animal responds to stress.

Maccari et al. (2003) state that the neurobiological changes of an increased stress response and abnormalities of circadian function that occur in antenatally stressed rats are similar to some of the neurological changes that have been noted in depressed humans. Both groups have been shown to have abnormalities in returning corticosterone secretion to basal levels after exposure to stress. Depressed individuals also report circadian rhythm disturbances in the form of changes to sleep patterns and basal body temperature (Maccari et al., 2003).

These neurobiological findings accord with the findings from the work of Coe et al. (2003), who used rhesus monkeys to examine prenatal stress effects on neural, hormonal and behavioural functioning. This study used a group of 20 monkeys in three conditions: a control group, and two experimental groups. The two experimental groups were both stressed for 25% of their 24-week pregnancies on a daily basis, using an acoustical startle procedure (intermittent exposure to three 1 second soundings of a 110 dB horn). One of the experimental groups was exposed to the stress in early pregnancy, and the other was exposed in late pregnancy. In the postnatal period the behaviour and neurological functioning of the offspring of the two experimental groups was compared with the control group. The behavioural observations focussed on behaviour that is said to demonstrate emotionality (non-directed motoric activity). The prenatally stressed monkeys collectively demonstrated less focussed exploratory behaviour. As a group, the stressed monkeys also demonstrated more non-directed locomotive behaviour such as pacing (22% more of the time than the control group); this was not statistically significant in this small sample size. However, Coe et al. (2003) state that their findings are consistent with prior non-human primate research involving the use of prenatal stress procedures.

The neurobiological findings in the experimental groups did not differ significantly between the early stress group and the later stress group. However, there were significant differences between the control and experimental groups. Both experimental groups showed significant reduction in the hippocampal volume and an inhibition of neurogenesis in the dentate gyrus. It is suggested that these differences resulted in changes in regulation of the HPA axis, including hyperactivity leading to increase cortisol production.

Both the Maccari et al. (2003) and Coe et al. (2003) studies involved procedures that the animal subjects essentially had no control over. This form of stress has been shown to be more detrimental than stress procedures where the animal has some way of attempting to mitigate its situation (Charil, 2010). Examples of this less detrimental form of stress include enforced swimming and overcrowding. These types of stressors allow the animal to respond to the stress in ways that may increase its repertoire of behaviour, possibly increasing its ability to cope with future stressors. The research would suggest that when the animal's ability to respond in an active way to stress is increased, the potentially detrimental physiological responses in both the mother and offspring are less (Charil, 2010).

In discussing how their primate research may be applicable to humans, Coe et al. (2003) noted that the development of the hippocampal dentate gyrus in monkeys and humans is relatively similar. They forward the idea that humans with disturbed structural plasticity due to a change in hippocampal neurogenesis related to prenatal or early life stress may have a greater potential risk for developing a range of psychiatric disorders, especially mood disorders. They do, however, concede that the human brain grows a significant amount in the post-partum period, as it is only 24% of the adult size at birth, in contrast to the monkey brain, which is 60% of the adult size at birth. This extended period of postnatal brain growth could potentially allow time for reversal, or at least minimization, of any negative prenatal effects on neurological development (Coe et al., 2003).

1.2 Effects of prenatal stress on humans

It has been hypothesized that activation of the HPA axis underlies mechanisms associated with preterm labour and delivery in human mothers (Dunkel-Schetter, 1998). Preterm delivery is associated with a range of physical and psychological, often ongoing, risks for the offspring. The complex association of maternal stress, HPA activation and maternal fetal hormones is yet to be fully understood in relation to preterm delivery. However, research by Glyn, Dunkel-Shetter, Hobel and Sandman (2008) found that patterns of stress and perceived anxiety were associated with gestational length. They examined the relationship between the self-reported stress and anxiety in 415 pregnant women at 18-20 and

30-32 weeks gestation, related to the overall length of their pregnancy. The authors found that although self-reports of perceived stress and anxiety did not predict preterm delivery, patterns of stress and anxiety are associated with the timing of delivery. They reported that in the women that delivered at or near full term, the majority reported a decline in perceived stress and anxiety. This contrasted with the findings for the women who delivered preterm, the majority of whom reported increases in stress and anxiety over the middle trimester period. The authors postulate that a protective factor against preterm delivery may be a reduction in stress responses during pregnancy (Glyn et al., 2008).

O'Connor et al. (2005) assert that pregnancy stress in humans is associated with far-reaching physiological effects for their offspring beyond the pregnancy. These researchers used a subset of children from the Avon Longitudinal Study of Parents and Children. The wider prospective study drew from all pregnant women living within the area of Avon who were to give birth to a baby between 1 April 1991 and 31 December 1992. During their pregnancies, at 18 and 32 weeks gestation, the participants were assessed for symptoms of anxiety and depression. The assessments were conducted using anxiety items from the Crown Crisp Index, a validated self-rating sale targeting symptoms associated with anxiety, and the Edinburgh Post Natal Depression scale, a self-report questionnaire that has demonstrated validity both within the antennal as well as the postnatal period.

The whole cohort of women was followed up via questionnaires, and from age 7 years their children were seen yearly for clinic visits. The subset of 70 children in O'Connor et al.'s study was drawn from children attending the 10-year clinic. This group had salivary cortisol levels measured 4 times per day for a consecutive 3-day period. Analysis of these samples demonstrated the usual range of substantial diurnal variation. However, when the data was analysed to assess any association with prenatal reports of depression and anxiety, it was found that prenatal anxiety, but not depression, was associated with higher levels of waking cortisol (a specific index of HPA functioning). This association was strongest for anxiety reported at 32-week gestation. This effect was sustained after controlling for postnatal anxiety, depression and socio-demographic risk factors. O'Connor et al. (2005) conclude that their study provides the first human evidence that prenatal stress may affect the long term functioning of the HPA axis. This aligns with the animal research findings in this area.

There is also some evidence concerning possible behavioural differences in offspring of mothers that have been stressed or anxious in pregnancy. O'Connor, Heron, Golding, Beveridge, and Glover (2002) collected data related to anxiety and depression at 18 and 32 weeks gestation, using the previously mentioned validated self-report measures in a sample of 7448 women (all participants in the Avon Longitudinal Study of Parents and Children). After controlling for key antenatal, obstetric and socio-demographic risks, the antenatal data was analysed in relation to the children's recorded emotional/behavioural difficulties at age 4 years.

The findings demonstrated relationships between antenatal stress and a variety of parent-reported behavioural difficulties in children, for both boys and girls. One of O'Connor et al.'s (2002) strongest findings was that higher levels of anxiety in late pregnancy were associated with hyperactivity/inattention in boys and total behavioural/emotional difficulties for both genders. These authors suggest that, as this finding remained significant after controlling for the effects of multiple postnatal reports of anxiety, the antenatal prediction is not affected by maternal difficulties in the postnatal period. This finding does not preclude the notion of postnatal difficulties having an effect on childhood behavioural difficulties; however, postnatal difficulties alone cannot account for the total effect found in the study. O'Connor et al. (2002) assert that this gives weight to the theory that there is a direct antenatal causal mechanism involved. This finding would accord with the animal research findings related to behaviour changes in offspring of antenatally stressed mothers. O'Connor et al.'s (2002) study has considerable power in that it is prospective and has a large sample. The authors do note that there are some methodological difficulties related to self-reports, in particular the accuracy of maternal reporting of behavioural difficulties in children. They suggest that this can be balanced against the finding that the effect was found across a large range of individual differences.

A prospective study of the impact of prenatal stress was conducted by Field et al. (2003). They divided a sample of 166 pregnant women into either a high or low anxiety group at 20 weeks gestation, based on a median split on a trait anxiety scale. They also completed measures of depression and anger. Fetal activity was measured between 18 and 24 weeks gestation via ultrasound scanning. Data relating to obstetric and postnatal complications was collected post delivery using 2 scales, one to assess pre- and post-natal complications, and another to assess complications in the newborn. Sleep/wake behaviour of the newborn was recorded via time-lapse videotaping and a neonatal assessment was conducted on the first afternoon following birth. The assessment was conducted using the Brazelton Neonatal Assessment Scale, which is made up of 20 neurological reflex items and 27 other items related to habituation, orientation, motor behaviour, range of state, regulation of state, autonomic stability, and abnormal reflexes (Brazelton, 1973). Vagal activity was measured via EKG, in addition to the infant's motor activity. Maternal EKG data was also collected at the same time. EEG recordings for both infants and mothers were conducted. Urine samples were collected antenatally from the mothers and postnatally from both the mothers and their infants, and subsequently analysed for norepinephrine, dopamine, serotonin and cortisol.

The results of this study were that the women who reported having higher levels of anxiety were also more likely to report higher scores on scales of depression and anger. During the pregnancy, the babies of the women in the anxious group grew at a slower rate and were more active than the babies of the women who reported lower anxiety levels. In the prenatal period, the high anxiety mothers were found to have elevated norepinephrine levels and low dopamine levels. When the levels of these neurotransmitters were recorded in their newborns, they were both found to be low in comparison to infants of less anxious mothers The newborns of anxious mothers also had increased relative right frontal EEG activation, and lower vagal tone. They also differed from the lower maternal anxiety group in that they spent more time in deep sleep and less time in quiet and alert states. Results from the Brazelton Neonatal Assessment scale demonstrated poorer performance in the domains of motor maturity, autonomic stability and withdrawal.

This study demonstrates that the infants of mothers reporting high levels of anxiety antenatally have measurable differences across the domains of physical, neurological and behavioural functioning. In attempting to tease out the relative importance of reports of anxiety in relation to depression and anger, the authors of this study concluded that anger was a relatively unimportant variable;

however, they suggest that further research is needed to separate out the specific effects of prenatal anxiety and depression. As these two conditions are often co-morbid, they suggest that any antenatal intervention aimed at treating depression should include a component aimed at lowering anxiety levels. This study's strength lies in the fact that it does not rely on retrospective self-report data; rather, the data was collected at several points throughout the pregnancy, and includes both self-report and physiological data for both the mother and her offspring.

What this type of study is unable to do is to quantify the effects, if any, that the infant's genetic profile may have on its neurological functioning and behaviour. Future research into the effects on infants of maternal relaxation-enhancing intervention strategies may particularly beneficial, especially if a matched control group of similarly high risk, anxious women were to be used.

The possible effects of antenatal, and specifically pregnancy-related, stress on a later period of infant development (at 3 months and 8 months) were investigated by Buitelaar, Huizink, Mulder, Robles de Medina and Visser (2003). They conducted a prospective study using 170 first-time healthy pregnant women. Anxiety related specifically to pregnancy, and more general anxiety were both rated at 15-17, 27-28, and 37-38 weeks gestation. In addition, salivary cortisol concentration levels were also measured at these times, to give an endocrinological indication of maternal stress. Cognitive measures in the infants were collected at 3 and 8 months using the Bayley Scales of Infant Development. The mothers rated infant temperament using the Infant Characteristics questionnaire. Infant behaviour was also independently observed and recorded within the developmental testing sessions.

The results of this study indicated that stress in pregnancy was related to cognitive, motor and temperament differences and delays at 3 and 8 months. Specifically, lower cognitive and motor scores at 8 months were found to be related to greater pregnancy-specific anxiety in the mid pregnancy period. Early morning cortisol values in the late pregnancy period were negatively related to both the mental and motor development at both 3 and 8 months of age. Pregnancy related fears were related to a decrease in attention and regulation during standard testing situations at 8 months. These effects were found to remain significant after adjusting for the effects of possible confounders such as socioeconomic levels, age, maternal postnatal depression and stress, birth weight and gestational age. These findings suggest that effects of prenatal stress are discernable in the first year of life. It is interesting to note that the findings of psychomotor and cognitive delay were more evident in the infant at 8 months of age than at 3 months. The authors of this study note that these effects may be transient and further research is needed to investigate possible long term effects past the first year of life. A variable not referred to in this study is the possible effect of pregnancy-specific anxiety related to pregnancy complications that in themselves have the potential to impact fetal and later infant development. For example, having a condition such as pre-eclampsia may affect a range of physiological factors such as placental function; this in turn may have the potential to impact fetal and infant development. Once such a condition is diagnosed during pregnancy it may or may not trigger a reaction that is described by the mother as stress and anxiety.

In their review of the literature addressing both animal and human studies of the possible effects on offspring of stress in pregnancy, Huizink, Mulder and Buitelaar (2004) conclude that the animal evidence for the detrimental effects of stress in pregnancy is stronger than the human evidence. They assert that the evidence would suggest that prenatal stress might cause general effects on a number of developing physiological systems. These changes may then ‘set the scene’ (through early programming of neurological structures) for later development of psychopathology, rather than acting as a direct causal mechanism for the development of psychopathology. A more recent review by Glover (2011) suggests that fetal programming (the concept that what happens at various times throughout a pregnancy can have long-lasting effects on the structure and function of developing organs), and the predictive adaptive response (the way the fetal development may change in a way that attempts to prepare the baby for its future environment) are key concepts in understanding prenatal stress in humans. Glover (2011) suggests that taking an evolutionary perspective may increase understanding of the role prenatal stress may play in potential psychopathology. This author forwards the concept that findings of various effects of prenatal stress, such as higher rates of ADHD, conduct disorder and anxiety in offspring, may suggest that these disorders have evolutionary values, such as greater sensitivity to danger signals, a greater willingness to explore new environments, and an increased ability to fight off predators. In this way, Glover (2011) suggests that the baby responds to the uterine environment in a way that helps it prepare for the conditions it is likely to experience after birth. The uterine environment is determined by a wide range of factors including nutrients, hormones and chemicals that cross the placenta from the mother to the baby. All of these factors are superimposed upon genetic factors that can increase or decrease how vulnerable an individual may be to negative effects of stress. The repeated research finding of effects of prenatal stress, independent of postnatal stress, make it more likely that stress, and stress at differing times during pregnancy has a role to play in mediation of later psychopathology aside from genetics (Glover, 2011). Although the evidence is not conclusive, it suggests that maternal stress and anxiety, rather than any associated mood disorder, are implicated in adverse outcomes for the offspring (Glover, 2011).

This hypothesis is supported in the findings from research conducted by Huizink, Mulder, Roubles de Medina, Visser and Buietaar (2004), who suggest that anxiety related to pregnancy is different from other forms of anxiety, and by its nature is specific to pregnancy. Their findings indicate that anxiety related specifically to pregnancy is associated with greater detrimental effects for the infant. Pregnancy specific anxiety was assessed using a 34-item questionnaire. A three-factor model was derived using confirmatory factor analysis. Under this model, pregnancy-specific anxiety was found to reflect three main factors: fear of giving birth, fear of having a child with physical or intellectual disability, and concern regarding appearance. As noted previously, but not identified as a variable in this study, is the possibility that a range of physiological effects relating to a complication of the pregnancy, for example poor placental attachment and function or fetal intrauterine growth retardation, could affect direct outcomes for the infant as well as potentially precipitating or exacerbating maternal anxiety.

Based on their findings, Huizink et al. (2004) suggest that intervention that focuses on pregnancy-specific anxiety rather than on more general anxiety may better impact postnatal outcomes and reduce risk for both the mother and the infant. This view accords with the suggestion by Austin (2004) that evidence to date indicates that maternal mental functioning in pregnancy has ramifications for the development and behaviour of the offspring and that developing effective interventions aimed at decreasing the effects of distress anxiety and depression in pregnancy is therefore a potentially significant area for focus.

1.3 Effects of maternal psychophysiology on the developing fetus

Assessment of fetal functioning in relation to maternal psychophysiology relies on examining accessible indicators of fetal functioning. The most accessible and commonly observed measure is the fetal heart rate (HR) and the fetal HR variability. A normal fetal HR is between 120 to 160 beats per minute during pregnancy, and between 100 and 160 beats per minute towards the end of pregnancy. Spontaneous HR variability reflects both the fetus's developing coordination of sympathetic and parasympathetic innervation and its immediate well-being (DiPietro et al., 2010; Murray, Huelsmann & Romo, 2007).

To date, much of the small amount of research that has been conducted in the area of how maternal psychophysiology directly impacts fetal functioning has been focused on what occurs if the mother is exposed to a stressful situation (DiPietro, Costigan, Nelson, Gurewitsch, & Laudenslager, 2008). DiPietro et al. (2003) used a stressful activity (the Stoop colour-word task) to induce a stress response in 137 low-risk pregnant women at 24 and 36 weeks gestation. Their results demonstrated a greater maternal sympathetic response at 24 weeks than at 36 weeks gestation. The fetal data indicated an increased variability in HR and a suppression of motor activity when maternal stress increased, and this was more marked at 36 weeks gestation than at 24. DiPietro et al. (2003) concluded from their results that fetal neurobehavioral regulation is affected on a regular basis by changes in maternal stress responding. These authors suggest that, over time, each fetal maternal dyad will develop a pattern. This pattern influences neurological development of the fetus and subsequent response patterns in the baby, and may extend well beyond the period *in utero*.

Monk, Fifer, Myers, Sloan, Trien and Hurtado (2000) examined acute maternal stress responses (assessed by measuring changes in HR, respiratory rate and blood pressure) induced by participating in a high-speed arithmetic task or a Stroop colour word test in relation to fetal HR. The women were divided into a high or low anxiety group based on a self-report measure of state anxiety. The results showed that the women in the high anxiety group, on average, had lower blood pressure responses and their babies had greater HR increases when compared to the low anxiety group. In the low anxiety group the mothers had, on average, greater blood pressure changes than the high anxiety group, and their babies had non-significant lowering of their heart rates. Monk et al. (2000) concluded that the overall maternal stress response influences fetal HR; however, maternal blood pressure in isolation was not a primary influencing variable. The data indicated that fetal HR reactivity might be relatively independent of maternal blood pressure. This is somewhat surprising as increases in maternal blood pressure can be associated with maternal vasoconstriction and therefore a decrease in uroplacental blood flow, which in turn could affect fetal HR reactivity. However, the data did not rule out the possibility of changes in maternal blood pressure triggering increases in fetal HR, if it were to occur in the context of other stress related changes in maternal physiology (Monk et al., 2000)

There are relatively few studies that have attempted to examine how stress reduction or relaxation impacts on pregnant women and their babies. A study conducted in India by Satyapiya, Nagendra, Nagarathna and Padmalatha (2009) examined the effect on maternal HR and HR variability, in addition to self-reported stress levels, of an integrated yoga and guided meditation/relaxation programme designed specifically for pregnant women. The programme was conducted daily from the 20th to the 36th week of pregnancy. This was a randomised controlled study in which the control group participated in standard antenatal stretching exercises. The results indicated that both maternal HR variability and reported stress levels were positively affected by the yoga/meditation programme when compared to a standard pregnancy stretching exercise programme. This study did not, however, attempt to examine the impact of this intervention on the baby.

Teixeira, Martin, Prendiville and Glover (2005) examined whether a short period of active or passive relaxation changed maternal self-reports and physiological indices of stress. In addition to measures of self-reported anxiety and HR, they also examined plasma catecholamines, plasma cortisol, and uterine artery resistance. Reduced uterine artery flow has been associated with elevated levels of maternal anxiety, and has been implicated in adverse outcomes for babies (Teixeira et al., 2005). The results of their study demonstrated that both active and passive relaxation effectively reduced self-reports of anxiety and maternal HR. However, active relaxation in the form of a hypnotherapeutic intervention guided by a stress management expert was more effective in reducing state anxiety and maternal HR than passive relaxation, which took the form of sitting and reading a magazine. Both methods reduced cortisol levels, while noradrenalin levels were only reduced in the passive relaxation group. Adrenaline levels were not reduced by either intervention. Mean uterine blood flow was not impacted by active relaxation; it was raised slightly in the passive relaxation group, but this was not clinically significant. This study demonstrates the complexity of how pregnant women respond to stress. It also indicates that self-reports do not necessarily align with physiological data, and maternal physiological changes cannot be assumed automatically to change conditions for the fetus.

A similar study conducted by Urech, Fink, Hoslie, Wilhelm, Bitzer and Alder (2010) examined the effects of two brief (10-minute duration) active relaxation procedures (progressive muscle relaxation or guided imagery) and one passive relaxation procedure (the control condition) on both self-reported and physiological indicators of relaxation and stress in a group of women between the 32nd and the 34th week of pregnancy. This study found that that guided imagery was significantly more effective in increasing self-reports of relaxation than progressive muscle relaxation, and that together the active interventions were more effective than the control passive condition. Both of the active relaxation procedures were associated with significant decreases in HR. Both the passive and the active relaxation procedures were associated with decreases in endocrine measures, with the exception of epinephrine. As in the previous study by Teixeira et al., (2005), there was a discrepancy between the self-reported effects and the observed physiological effects. In this study, the guided imagery condition and not the progressive muscle relaxation condition was associated with increased self-reports of relaxation, whist the physiological data (HR) was virtually the same for both groups. Although the progressive muscle relaxation procedure was effective in decreasing HR, it was not considered to be particularly relaxing by the participants. This finding demonstrates the importance of including both subjective and physiological measures of stress and relaxation in attempting to assess both the possible effect of any intervention and whether or not the procedure is appealing and therefore likely to be practiced.

To date there have been only two studies found in the literature that have attempted to ascertain fetal responses, in addition to maternal responses, to a relaxation procedure. DiPietro, Costigan, Nelson, Gurewitsch and Laudenslager (2008) observed maternal and fetal responses during an 18-minute "guided imagery, progressive relaxation audio recording" (p.3). The procedure was conducted following an eighteen-minute baseline period, and was in turn followed by an additional 18-minute post-relaxation period in which the participants listened to music. The participants were 100 pregnant women in the 32nd week of their pregnancy. The maternal physiological measures of responsivity included HR, skin conductance and respiration. In addition to these measures, maternal cortisol levels were collected at six points throughout the procedure. Psychological responses were obtained from a self-report inventory (the Psychological Tension and Physical Assessment Subscales of Relaxation Inventory). This was filled out prior to the procedure and following it. Maternal and fetal blood flow was observed via ultrasound. Fetal movements, HR and HR variability were measured via fetal actocardiograph. The results show significant changes in fetal responding over time in response to the relaxation procedure. These included a decrease in HR, an increase in HR variability, and an increase in fetal movement HR coupling. Coupling of fetal HR and movement is hypothesized to demonstrate maturity of the central nervous system and general fetal well-being (Monk et al., 2000). The maternal responses included a self-reported decrease in tension, a decrease in HR, skin conductance, respiration and serum cortisol levels, and increased respiratory sinus arrhythmia (RSA). RSA can be defined as the variation in HR that occurs naturally during the breathing cycle. The ability to generate RSA normally declines with age, but is enhanced by cardiovascular fitness and an ability to control breathing and generate relaxation (as is intended by practices such as Yoga and meditation) (Yasuma & Hayano, 2004). DiPietro et al. (2008) are cautious in concluding that maternal relaxation elicits a "relaxation" response in the fetus; however, they do conclude that there is a significant demonstrated fetal response elicited by presentation of an auditory stimulus to the mother. DiPietro et al. (2008) note that it is difficult to account for all possible mediators of fetal responding, and they conclude that some of the response they observed may have been due to the effects of other aspects of maternal behaviour, such as maternal postural changes or intrauterine auditory changes.

Fink et al. (2011) examined the effects of maternal relaxation on fetal behaviour as well as uterine activity, using a progressive muscle relaxation and a guided imagery protocol. Thirty-three women with healthy singleton pregnancies between 32 and 34 weeks gestation participated in the study. They were randomly assigned to one of two intervention groups, (guided imagery (GI) or progressive muscle relaxation (PMR) or a control group that rested quietly. The data collected to examine fetal responses included fetal HR and HR variability, as well as fetal behavioural states (sleep/awake/movement). Hormonal assays were conducted to determine maternal cortisol levels. Other maternal measures included uterine activity, HR, and blood pressure.

This study is the only one to date that has examined fetal behavioural states in the context of relaxation interventions. Fink et al. (2011) found that the fetuses were in an active sleep state for most of the time. Having the fetus in this state was considered to be an essential component of this study design; the authors noted that a state of quiet sleep could be misinterpreted as a positive effect of the relaxation intervention.

When comparing the findings for the intervention condition (GI and PMR combined), Fink et al. (2011) found that the fetuses of the mothers in the intervention group had higher fetal HR long-term variation, and that this was particularly notable in the ten-minute post intervention period. More fetal HR accelerations were noted in the control group than the intervention group. When assessing the differences between the two intervention groups it was found that guided imagery was associated with higher short-term fetal HR variability than the progressive muscle relaxation. More fetal movement was reported in the guided imagery group compared to the progressive muscle relaxation group or the control group. There were no correlations found between maternal HR, blood pressure and cortisol levels, and fetal behaviour.

From their findings, Fink et al. (2011) concluded that fetuses may be "participating" in maternal relaxation. They suggested that GI might be superior to PMR, as higher relaxation levels were reported in the GI intervention group than the PMR group. The lack of correlation between the maternal HR, blood pressure and cortisol levels and fetal measures left the mechanism of maternal-fetal communication during relaxation undetermined.

1.4 Mind-body stress and anxiety intervention approaches

In approaching the development of intervention strategies aimed at ameliorating stress and anxiety responses in pregnant women, there are some significant factors that need to be considered. Of primary importance is the need to focus on non-pharmacological solutions due to the possible teratagenic risks associated with drug use in pregnancy. Another obvious requirement for any intervention for use during pregnancy is that it has an immediate effect, as pregnancy, by its very nature, is time limited.

As there is a developing body of evidence that maternal psychophysiology affects the offspring in a variety of ways, it is also important to determine if any proposed intervention strategy is not only immediately effective in changing any maternal stress response but also can be shown to affect fetal responding. There are a number of studies related to intervention strategies designed to target maternal stress in pregnancy that have used validated self-report measures only; however, this approach may literally only be telling half the story.

Mind-body approaches such as yoga and meditation have shown promising positive effects on both maternal reports of stress and birth outcomes (Vieten & Astin, 2008). There is a growing body of evidence to support the effectiveness of mindfulness-based interventions to treat a wide range of psychological conditions, including anxiety in non-pregnant populations (Crossman, Neiman, Schmidt & Walch, 2004).

Mindfulness can be defined as using focused attention to become more aware of experiences (thoughts, feelings, sensations) in the here and now. Along with increased focus and awareness, the moment-by-moment experiences are not judged but simply accepted for what they are (Leigh, Bowen & Marlatt, 2005). Bishop et al., (2004) proposed a model of mindfulness that is made up of two elements, the first being self-regulation of attention and the second being the cultivation of a specific stance towards one's own experiences. The first element, self-regulation of attention, is the process of attending to all thoughts, feelings, and sensations that are occurring in the present moment. This is achieved most commonly, although not necessarily exclusively, through meditation focussed on breathing. Keeping attention focused on the breath helps the person stay focussed on the immediate moment-by-moment experience. The thoughts that inevitably occur throughout the meditative process are in no way suppressed; instead, they are considered to be a subject to be observed for a short time before attention is refocused back upon the breath (Bishop et al., 2004). Mindfulness practice has its roots within ancient contemplative traditions, such as Buddhism, that utilise meditation (Shapiro, Carlson, Astin & Freedman, 2006). Although mindfulness most frequently utilizes meditation, and can induce a state of relaxation, it is more than just learning and practicing relaxation techniques; rather, it can be considered to be a skill that, once developed and practised, can be used intentionally to respond to cognitive processes that may be contributing to emotional distress or behavioural difficulties (Bishop et al., 2004).

Kabat-Zinn and colleagues developed mindfulness-based stress reduction as a treatment programme in the early 1980s. Kabat-Zinn et al., (1992) examined the effectiveness of this original treatment programme in reducing anxiety in a group of people who met the DSM-III-R criteria for generalized anxiety or panic disorder. They found significant reductions in anxiety and depression scores following participation in the programme for 20 of the 22 participants. Over time, this original programme and variations of it has been shown to be effective for stress-related difficulties associated with a wide range of medical conditions, across differing populations (Vieten & Astin, 2008). Changes in physiological functioning have been demonstrated in response to mindfulness meditation. In a randomized controlled trial, Davidson et al. (2003) reported positive changes in brain electrical activity and immune function (assessed through antibody titres to influenza vaccine) following an eight-week mindfulness meditation programme.

The use of a mindfulness-based intervention for prenatal stress and mood was examined in an eight-week mindfulness stress reduction programme conducted by Vieten and Astin (2007). They conducted a small randomized and controlled trial comparing 13 women who received mindfulness intervention teaching to a wait-list control group of 18 women. As well as being between 12 and 30 weeks pregnant, the participants were required to respond affirmatively to the question "Have you had a history of mood concerns for which you sought some form of treatment, such as psychotherapy, counselling, or medication?" (p.69) (Vieten & Astin, 2007). They used self-report measures of perceived stress, positive and negative affect, and depressed and anxious mood and affect regulation. The measures were taken prior to, immediately following, and three months after the programme. When compared to the control group, the women who received the intervention showed a 20-25% post-intervention improvement in self-reported levels of anxiety, negative affect, positive affect and stress. In addition, the authors of this study suggest that the brief non-pharmacological nature of mindfulness interventions makes this approach appropriate for pregnant women.

Beddoe, Yang, Powell Kennedy, Weiss and Lee (2009) conducted a similar intervention programme, examining the effectiveness of a 7-week mindfulness-based yoga programme on a small group of 16 pregnant women between 12 and 32 weeks gestation. In addition to measures of self-reported stress and anxiety, the authors also examined pain levels. Their results showed that practicing mindfulness-based yoga was associated with reductions in pain in the second trimester but not in the third trimester. However, women in the third trimester of their pregnancy experienced greater reductions in perceived stress and anxiety when compared to those completing the programme in the second trimester.

Mindfulness-based interventions have been delivered in a variety of ways, with group instruction being most often used to teach the Mindfulness-Based Stress Reduction Programme developed by Kabat-Zinn and colleagues (1982). Vieten and Astin (2007) also used a group approach to deliver their “Mindful Motherhood intervention” to pregnant women. Advancing technology has allowed intervention strategies to be delivered via electronic means. Kleen and Rietsma (2011) explored the concept of enhancing mindfulness instruction via biofeedback. They examined the effect of combined mindfulness training (as part of an Acceptance and Commitment Therapy package) and HR variability (HRV) biofeedback. This small study involved seven non-pregnant participants, all hospital outpatients with a DSM-IV-TR Axis I disorder within the mild to moderate range. An element of experiential avoidance was identified as significant in maintaining psychological difficulties of all the participants. HRV is a measure of the time interval between heartbeats. An increase in HRV is linked to mindfulness and more general ability in being able respond to stimuli quickly and induce a state of calm more quickly. Participants in this study were assessed for HRV prior to mindfulness training, and then exposed to breathing meditation training while watching a biofeedback computer programme. The first phase, skill training, ended when the participants were able to elicit high levels of HRV within a minute. The next phase of the intervention involved the participants attempting to induce an increased HRV while being exposed to conditioned stimuli that the participant had previously identified as being associated with past avoidant behaviour. Kleen and Reisma's (2011) results demonstrated a pattern of increased HRV from baseline to the end of the skill training stage, a decrease of HRV at the beginning of the exposure phase, and an increase in HRV at the end of training, when exposed to distressing stimuli. In addition to being able to induce increases in HRV, all of the participants reported increases in the use of mindfulness in daily life as measured by scores on the Mindful Attention Awareness Scale (MAAS; Brown & Ryan, 2003).

Given the overall research findings related to psychological distress during pregnancy and the possible detrimental effects for the fetus, the type of treatment package detailed by Kleen and Reisma's (2011) study could be of value for pregnant women. The study described a brief (important given that pregnancy is time-limited) and individually tailored (as defined by the client's own biofeedback HRV performance) intervention. In addition, the mindfulness component was part of a more detailed acceptance and commitment therapy package. These factors could make this intervention well suited to pregnant women suffering from either pregnancy-related stress or more serious psychopathology (such as depression with co-morbid anxiety).

1.5 Summary and overall objectives

While the studies by Vieten and Astin (2007), and Beddoe et al. (2009), are encouraging in pointing to a possible beneficial effect of mindfulness-based interventions for pregnant women, neither of these studies examined the effects that mindfulness-based practices have on the developing fetus.

The aim of the current study is, first, to examine maternal physiological responses to a brief mindfulness-based meditation intervention that includes a baseline period, a teaching component and a biofeedback-assisted practice segment. The second aim is to examine fetal physiological responses to any changes in maternal physiological responses. Although there is only a small amount of evidence to date concerning fetal responses in relation to maternal physiological responses, it is expected that maternal engagement in a brief mindfulness procedure will impact maternal autonomic responses in a similar way to other relaxation procedures, such as the one previously used by DiPietro et al. (2008). It is expected that when the mother is exposed to and practices a brief mindfulness-based meditation, a reduced maternal HR, respiratory rate and decreased skin conductance will be observed. HRV would be expected to increase. The subsequent fetal response is expected to follow the maternal response, indicated by a decreased fetal HR baseline and an increase in HR variability.

It is expected that there will be a difference in the maternal and fetal responding across the three different conditions (baseline, teaching and practice). It is expected that the addition of the biofeedback component in the practice condition will positively affect the participants' ability to influence their physiology.

Chapter 2: Method

2.1 Participants

Prior to recruitment of participants the proposed project was reviewed and approved by the Waikato School of Psychology ethics committee. Seven participants were recruited for this study through a private antenatal class and two specialist pregnancy massage therapists. Information about the project was supplied to the director of the antenatal class programme, who informed class participants of the project. Information and flyers were supplied to the massage therapists. In both cases, interested pregnant women were invited to approach the researcher directly. Due to the low number of participants obtained in the initial recruitment effort, it was decided to offer a $20 petrol voucher to participants to assist with travel costs. Permission was obtained through the School of Psychology ethics committee for this change and the recruitment flyer was amended to take account of this. A reproduction of the recruitment flyer is included in Appendix A. The criteria for participant involvement in the study required the women to be in good general health and have an uncomplicated pregnancy of at least 32 weeks gestation.

Participant characteristics are displayed in Table 1. As this study is focussed on the participant’s and her baby’s physiology, rather than psychosocial variables, other demographic data was not collected.

Table 1

Participant characteristics

Participant	Pregnancy no.	Weeks' gestation
1	3	36
2	1	36
3	1	37.5
4	1	37
5	1	36
6	2	36
7	1	37

2.2 Setting description

The procedure took place in a birthing room at a suburban birthing centre. The centre provides antenatal, birthing and postnatal services to women with a low risk of complications.

The room used for the procedure was one of the centre's birthing rooms and contained a bed and a bedside table. A photograph of the room, with the apparatus set up, is shown in Appendix B. Participants were asked to choose a comfortable position on the bed and the curtains were drawn to provide dim natural light. The birthing room was essentially soundproof and this diminished the possibility of distraction related to sound from the normal activity taking place at the centre. A midwife from the birthing centre was present at the beginning of each session to attach the fetal ultrasound transducer and she returned following the completion of the session to remove the transducer. During the session, the only people present were the participant and the researcher. A photograph of the apparatus setup and in use is shown in Appendix C.

2.3 Ethical considerations

Upon arrival at the birthing centre, participants were given an information sheet explaining the procedure in full and an opportunity for any further explanation was allowed. Written consent was obtained and the right to withdraw at any time was explained. Participants were asked if they wanted their data returned to them or destroyed at the completion of the study.

2.4 Study design

This study employs a single subject design. Each participant experienced a baseline condition and two treatment conditions. Treatment condition #1 followed the baseline condition and involved a teaching session. Treatment condition #2 followed the teaching session and involved a biofeedback-assisted practice session. A full explanation of the baseline and treatment conditions is provided in the Procedure section.

2.5 Apparatus and materials

2.5.1 Maternal physiological data collection. Physiological data was gathered via a multi-channel, portable physiograph PowerLab 8ST, with amplifiers, extensions, and transducers, along with a portable laptop computer with the compatible software ‘Chart 7.0 for Windows’ application programme. The physiograph and laptop are visible in the photograph in Appendix B. Materials for collecting physiological data included disposable, self-adhesive electrodes for electrocardiography (ECG) recordings, a finger plethysmograph for recording pulsatile blood flow in the finger, bipolar finger electrodermal transducers to measure galvanic skin response (GSR), and a respiratory belt transducer for measuring respiration.

2.5.2 Audiovisual teaching and practice material. A separate laptop computer was used to present the teaching session and biofeedback-aided practice session. Three finger sensors were linked to this computer to provide the biofeedback link to the audiovisual programme. A picture of the laptop and finger sensors is shown in Appendix D. The teaching session was taken from the software package Healing Rhythms, Step 2: Observe Your Thoughts- Mind/Body Practice#2: Mindfulness, Breathing - *Learn to follow your Breath.* The Healing Rhythms Step 13: Take A Daily Supplement, Biofeedback event - *Lotus Blossoms*, facilitated the practice session. Screenshots from these two segments are contained in Appendix E.

2.5.3 Fetal physiological data. An electronic fetal ultrasound Cardiograph monitor: Baby Doplex BD 4000 Huntliegh Diagnostics was used to record the fetal HR and variability. The ultrasound transducer was applied to the woman's abdomen using an elasticized belt. Coupling gel was used on the transducer to facilitate the detection of the fetal heart sounds.

2.6 Procedure

2.6.1 Preparation phase. Participants completed the experiment in a single session. As noted above, prior to the session commencing, the participant was provided with an information sheet containing a full explanation of the procedure, and was informed that they could withdraw from the research at any time, and written consent was obtained. A copy of the information sheet is provided in Appendix F, and a copy of the consent form is provided in Appendix G.

2.6.2 Physiological application. Participants were accompanied to the birthing room and asked to choose a comfortable position on the bed. They were then connected to the PowerLab Physiograph via three disposable electrodes in accordance with the PowerLab manual (AD Instruments, 1999). The positive and negative electrodes were secured on the left and right side of the participant's chest respectively; the ground electrode was placed on the lower right leg just above the ankle. Participants were then asked to fasten the respiratory belt transducer around their diaphragm to sit comfortably above the abdomen and below the bust line. A finger plethysmograph sensor was applied to thumb of the right hand. The bipolar finger electrodermal transducers were applied to the middle and ring finger of the right hand to enable GSR data to be collected.

The tocograph belt and transducer was fastened around the participant's abdomen over the region of the baby's chest. This was carried out by one of the birthing centre's midwives to ensure accurate placement.

2.6.3 Biofeedback application. Three sensors were placed on the first three fingers of the left hand of the participant to allow operating access to the two segments of the Healing Rhythms software package. The first segment was designed to teach a basic mindfulness-based meditation procedure, and the second designed to provide a biofeedback-assisted opportunity to practice the meditation skill.

2.7 Order of procedure

2.7.1 Baseline, approximately 10 minutes. During the baseline phase, the participant was asked to just sit and rest. Participants were instructed to think about anything they wished to, with no attempt to relax or influence their thoughts, physiological, or emotional responses.

2.7.2 Teaching segment, approximately 10 minutes. The teaching instruction used in this segment was taken from Step 2 of the Healing Rhythms software package, and takes the form of a basic introduction to a mindfulness meditation. Instruction is provided via a narrator who appears on the screen. The instruction involves directing attention to the breath-cycle. The narrator explains that it is natural for thoughts to wander; however, when this happens the participant should not attempt to interact with their thoughts, but to simply notice that they are occurring, and redirect attention back to the breath. The audiovisual instruction package has an added component of a subtle biofeedback element. The more successful the participant is in inducing a pattern of physiological responding consistent with relaxation, the more the animated graphic on the screen changes (more birds fly across the sky over a lake scene). However, the participant was not told about this effect directly.

2.7.3 Practice segment, approximately 10 minutes. The practice session used Step 13 of Healing Rhythms, featuring an animated scene (birds flying over a rippling pool). This graphic changed in response to the participant's physiology. The more the participant relaxed (consistent with a decreasing HR and GSR), the more the birds dropped flowers into the pool. The participant was informed of this. Below this scene was an animated graphic of a butterfly moving its wings in a rhythm set at the optimal pace to prompt a slow even, breathing pattern. The participant was advised to use this prompt if they found it helpful. There was no audio component to this segment; this was removed after the feedback gained during pilot trials, where participants reported that it was distracting and interfered with attempting to remember and follow the teaching instructions.

2.8 Physiological data recording

Physiological data was collected from each participant (both mother and baby) throughout the procedure. Each phase of the procedure was marked on maternal and the fetal physiological data recording output.

2.9 Dependent variables

2.9.1 Maternal physiological measures. The application programme used seven channel settings during the maternal data recording:

- Electrocardiograph
- HR calculated from the ECG.
- Finger plethysmograph
- HR calculated from the finger plethysmograph
- Respiration
- Respiration rate (RR).
- GSR.

2.9.1.1 Heart rate. HR was calculated in beats per minute. This measure was taken from both the ECG and the finger plethysmograph. The ECG was considered to be the main measure of HR, with the finger plethysmograph as back up if there were any difficulties with the ECG. The ECG provides a robust measure of the electrical activity of the heart, provided the electrodes are correctly placed on the skin surface on either side of the chest. Due to the strength of bioelectrical signal, the ECG is considered to provide an extremely accurate measure of HR (Kranz & Falconer, 1995). The plethysmograph provides a potentially less accurate measure of HR than the ECG, as it is measuring blood volume in the periphery. Peripheral vessels are sensitive to a range of influences and may constrict or dilate as a result of movement or temperature changes (Kranz & Falconer, 1995). An additional potential influence on peripheral blood vessels is stress or an emotional change, as peripheral blood vessels are innervated by the sympathetic nervous system (Grings & Dawson, 1978).

2.9.1.2 Respiration rate. The rate of respiration is considered to be a useful and common measure of breathing (Grings & Dawson, 1978). It was calculated as breaths per minute from the respiratory output. Respiration is regulated by both the autonomic and the central nervous system. HR may also influence respiration (Grings & Dawson, 1978).

2.9.1.3 Galvanic skin response. Psychological processes such as attention and emotion are related to the electrical properties contained within the skin. The electrical property of the skin that is most commonly measured is the skin's resistance response, usually expressed as its reciprocal skin conductance and termed skin conductance level (SCL) (Grings & Dawson, 1978). When there is a change in intensity of emotional responding, there is usually a corresponding change in both the size and frequency of the skin conductance responses (Grings & Dawson, 1978). GSR is the electrodermal response related to sweat gland activity and is measured as skin resistance in micro-Siemens (micros). GSR was measured on the middle and index finger of the right hand. This enabled changes in the relative conductance of a small electrical current between two electrodes to be recorded. In response to stimulation via the sympathetic nervous system, activity in the sweat glands results in a change in conductance.

2.9.2 Fetal physiological measures.

2.9.2.1 Fetal heart rate. The fetal HR is detected via an ultrasound transducer. Ultrasound technology detects the movement of the baby's heart valves and converts this to a waveform, the frequency of which can be counted. A baseline fetal HR is created by the influence of the vagus and sympathetic nerves on the heart. The baseline fetal HR can also be affected by hormonal, pharmacological and maternal influences. The normal baseline for a healthy well-oxygenated fetus from 35 weeks until 40 weeks gestation is between 110-160 beats per minute, and in an individual healthy fetus the baseline is expected to vary within a 20 beat per minute range (Murray et al., 2007).

2.9.2.2 Fetal heart rate variability. Fetal HR variability is defined as the difference between the heartbeat rates. Variability is a normal characteristic that can be observed and assessed from the output trace of Cardiotocography monitor (CTG) (Murray et al., 2007). There are two types of variability - short-term and long-term. Short-term variability is determined by the change in time interval between consecutive beats and can be termed beat-to-beat variability (BTBV). The CTG trace appears as irregular and fluctuating. Short-term variability, as recorded from one beat per minute to the next, rarely exceeds 8 beats per minute. Short-term variability reflects the time fluctuations between heartbeats and is controlled by the sinoatrial (SA) node of the heart. The SA node is under the control of the right branch of the vagal nerve and is the pacemaker for the heart: it controls the time fluctuation between the heartbeats. Variability also occurs in long-term cycles. Long-term variability is made up of a series of cycles, usually at a rate of 2 or more cycles per minute. Long-term variability can be seen on the CTG trace and appears as a series of fluctuating waves and can used as a measure of fetal well-being over an extended period of time.

2.10 Data management and statistical analysis

The final maternal raw data used was taken from two consecutive three-minute segments at the end of each phase (baseline, teaching, and practice). A screenshot of a sample of the raw data is provided in Appendix H. The raw data for each participant were inspected and mean values for each 3-minute segment were calculated. Either the ECG HR or HR finger data was used for the HR measure (the data set with the least contamination or lost values was selected). RR and GSR mean values were also calculated for each 3-minute segment using PowerLab software. The means and standard deviations of the physiological measures across the three conditions for each participant (where data was usable) were transferred from Chart 7.0 Data pad into an Excel spreadsheet.

The fetal raw data used was taken from the same two consecutive three-minute segments at the end of each phase (baseline, teaching, and practice). The CTG printouts were photocopied, annotated by hand to mark up the target three-minute sections, and then scanned and digitised. Using Photoshop image editing software, points were plotted along the printed trace line at high magnification. A computer programme was then created that measured the distance, at each time interval, from the 0-point on the vertical axis to each plotted point. This value was then used to generate a reading of the fetal HR at each time interval. Mean values and standard deviations were then calculated over each 3-minute segment. HR variability was assessed from the standard deviation values and visually from the raw data (CTG trace).

Chapter 3: Results

3.1 Sample

Seven pregnant women participated in the experimental procedure described in section 2.6. All of the participants were pregnant with a single fetus, reported themselves to be in good general health, and have not experienced any complications relating to the pregnancy. Pregnancy gestation times ranged between 36 and 37.5 weeks.

3.1.1 Technical difficulties and lost data. Participant 7 did not complete the procedure as the CTG monitor failed consistently to detect and record the fetal HR. In addition to this technical difficulty, during the baseline condition the fetal HR was observed to drop to an abnormal level for a period of time. This required assessment by the attendant midwife. This occurrence, in association with the difficulty in detecting the HR, led to a decision to abandon the procedure. A print out of the CTG trace for participant 7 is provided in Appendix I.

The initial data for Participant 5 were not saved correctly and could not be recovered. To address this, Participant 5 repeated the procedure at a later date at her home (fetal data was not collected again, but was available from the first session). This data was analysed in the same way as the data obtained for the other participants; however, it could not be matched with the previously obtained fetal data.

Case by case results will be presented in this section for all of the dependent variables for each participant and her baby.

3.2 Participant 1

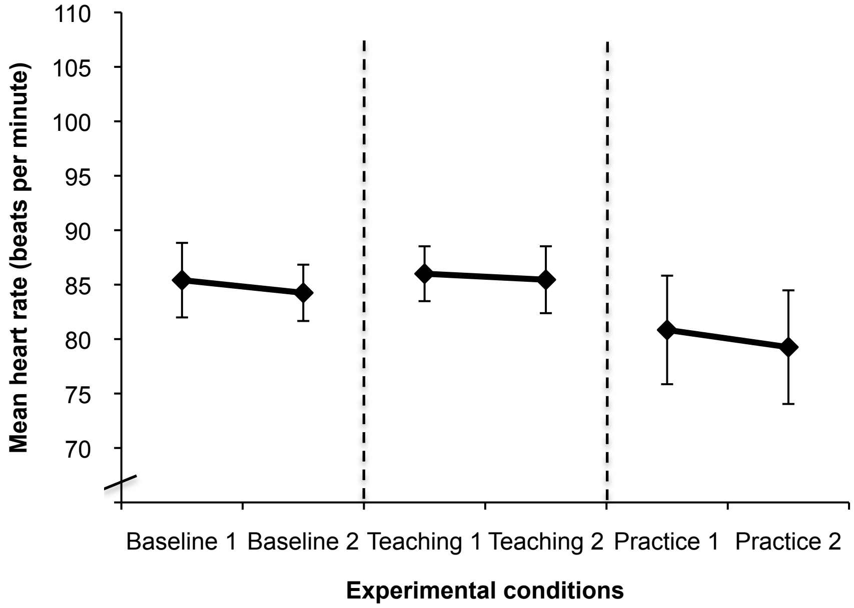

Figure 1. Participant 1 mean and standard deviation of maternal HR over two time segments for each of three conditions.

The mean HR varied between 86 and 79 beats per minute over the three conditions. The mean HR increased slightly from the baseline to the teaching period, and then reduced to lower level than the baseline in the teaching condition. The standard deviation (a measure of HR variability) increased in the practice condition, when compared to the baseline or teaching condition, indicating greater variation in the HR within this condition.

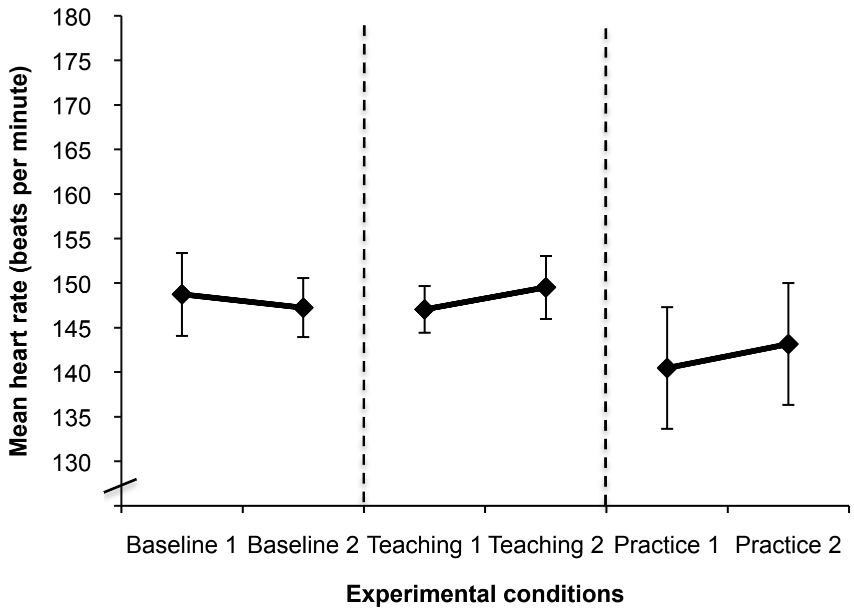

Figure 2. Participant 1 mean and standard deviation of fetal HR over three conditions.

The mean fetal HR varied between 140 and 149 BPM over the three conditions. The fetal pattern loosely followed the maternal pattern in that the mean fetal HR increased during the teaching condition, when compared to the baseline, and decreased in the practice session, trending up at the end of the practice condition but remaining lower than in the baseline condition. The standard deviation increased in the practice condition when compared to the baseline and teaching conditions.

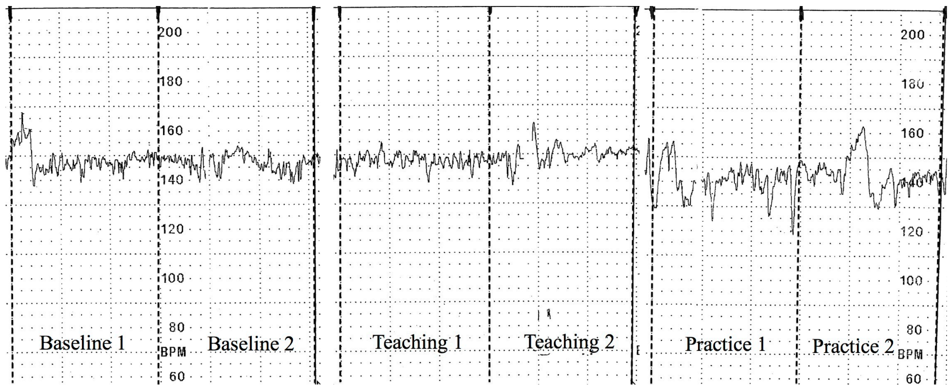

Figure 3. Participant 1 CTG display of fetal HR.

This figure provides a graphic display of the changes in fetal HR variability over the three conditions. There was little change in variability from baseline to the teaching condition. The variability increased in the practice condition with an increase in both the short-term (beat to beat) and the long-term variability as seen by the large clear accelerations in HR in both segments of the practice condition.

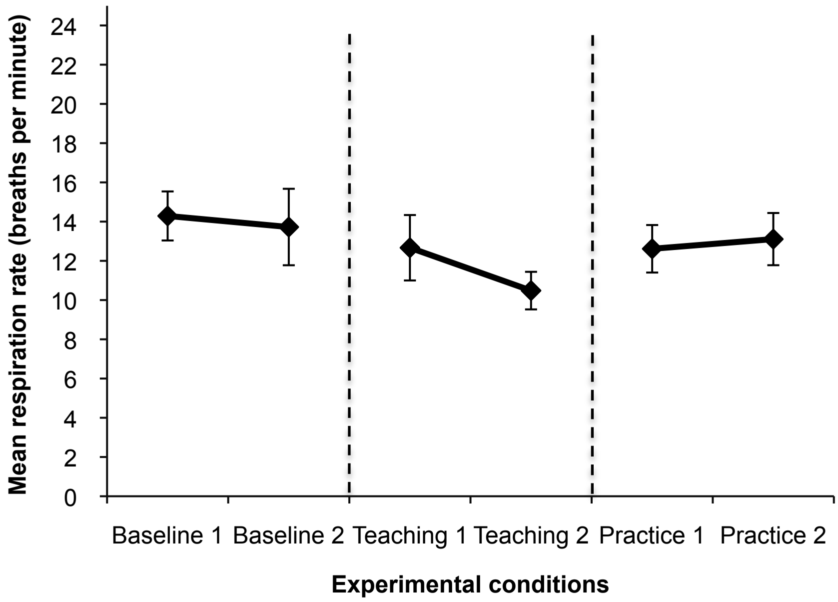

Figure 4. Participant 1 mean and standard deviation of RR over three conditions.

The mean RR varied between 10 and 14 breaths per minute over the three conditions. The mean RR slowed in the teaching condition when compared to the baseline condition. During the practice condition the RR trended back up to the baseline rate. The greatest variation RR is indicated by the greater standard deviation at the end of the baseline period and the first selected segment of the teaching condition.

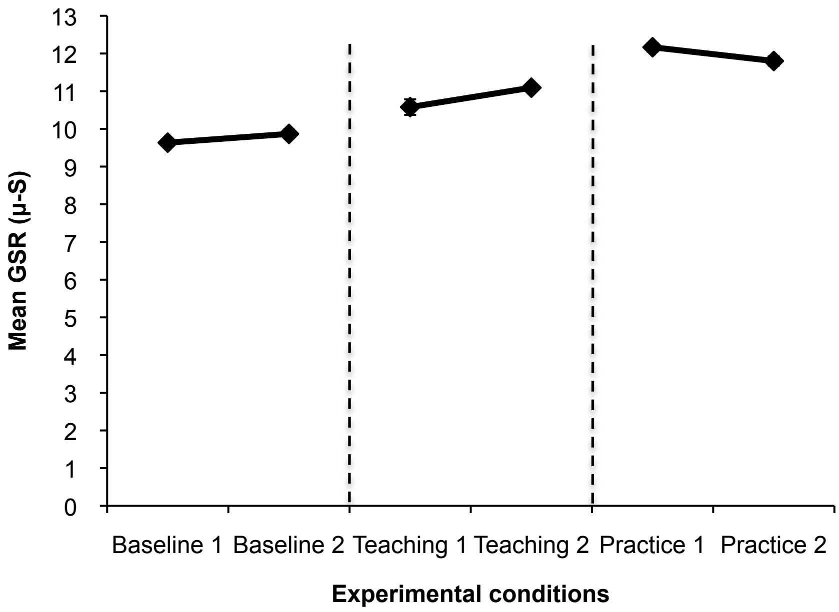

Figure 5. Participant 1 mean and standard deviation of GSR over three conditions.

The mean GSR increased over the three conditions, peaking in the first selected segment of the practice condition and not returning to the base line rate. There was minimal change in standard deviation over the three conditions.

3.3 Participant 2

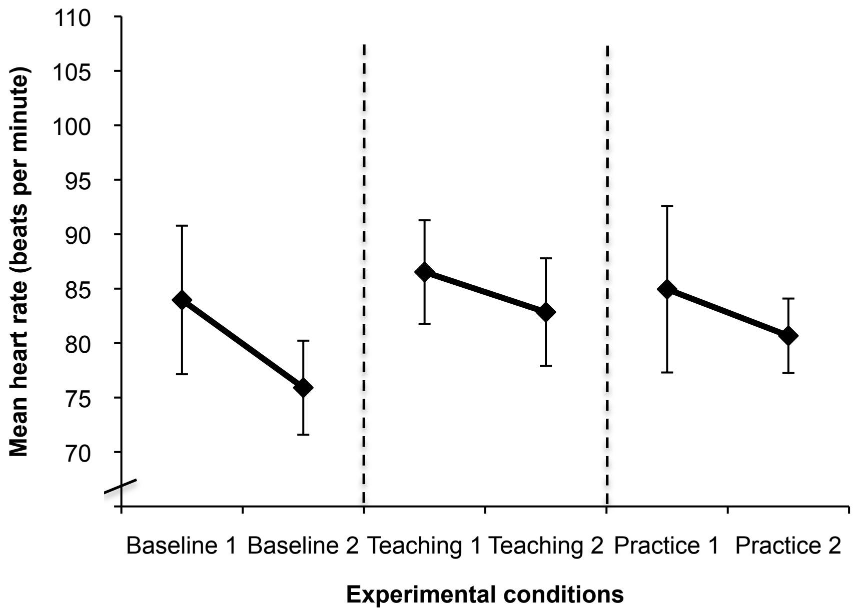

Figure 6. Participant 2 mean and standard deviation of maternal HR over three conditions.

The mean HR varied between 75 and 86 beats per minute over the three conditions. The mean HR was higher in the first selected segment of each condition and trended down in the second segment. The mean HR in the last segment of the practice condition was 80 beats per minute, which was lower than all of the other measures except for the last baseline segment. The greatest variability in the data is indicated by the largest standard deviation in the first segment of the practice condition, followed by the first segment of the baseline condition.

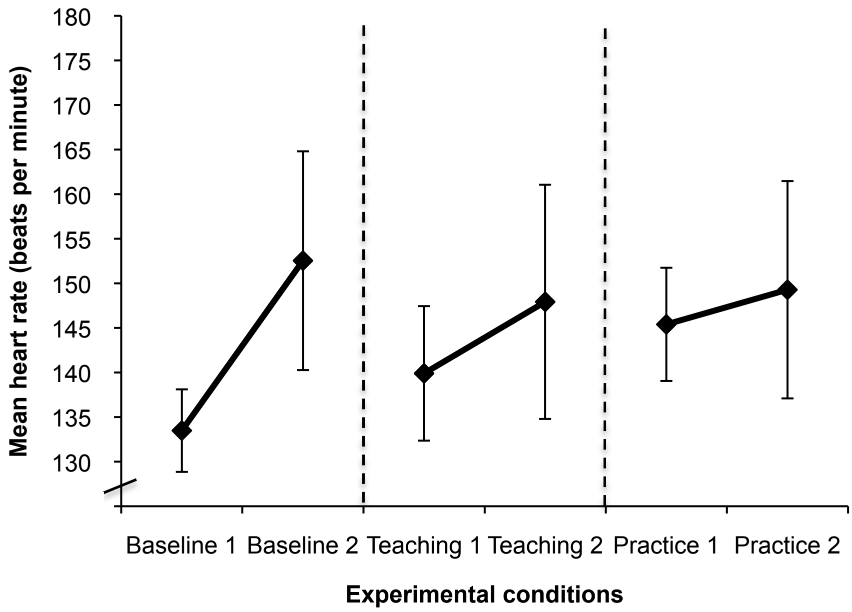

Figure 7. Participant 2 mean and standard deviation of fetal HR over three conditions.

The mean fetal HR over the three conditions ranged between 133 and 152 beats per minute. The fetal pattern in this case was the inverse of the maternal pattern in that the mean HR was lower at in the first segment of each condition and was higher in the second segment of each condition. The highest mean HR occurred in the second segment of the baseline period. The greatest variation in data occurred within the second segment of each condition.

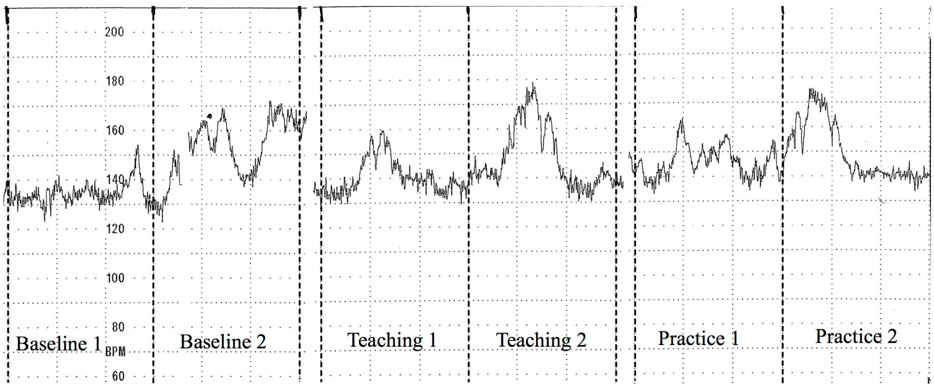

Figure 8. Participant 2 CTG display of fetal HR.

There was a pattern of increased variability from the first segment of the baseline period to the second baseline period. This pattern repeated for both the teaching and practice condition. However overall this CTG shows significant short-term and long-term variability with clear accelerations in HR in each of the three conditions.

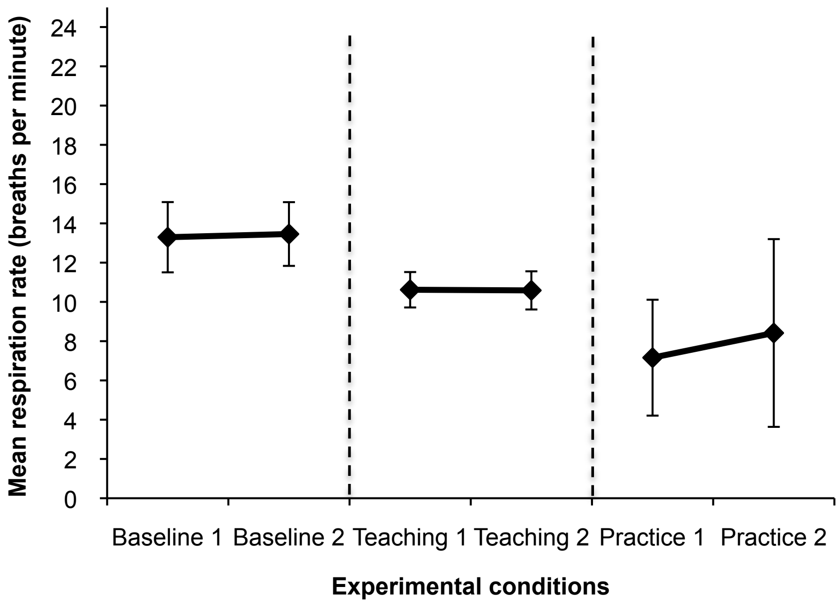

Figure 9. Participant 2 mean and standard deviation of RR over three conditions.

The mean RR ranged between 13 and 8 breaths per minute. The highest mean rate occurred in the baseline condition and the lowest over the practice condition, with a slight rise in the last segment of the practice condition. The greatest variation in the data occurred during the practice condition.

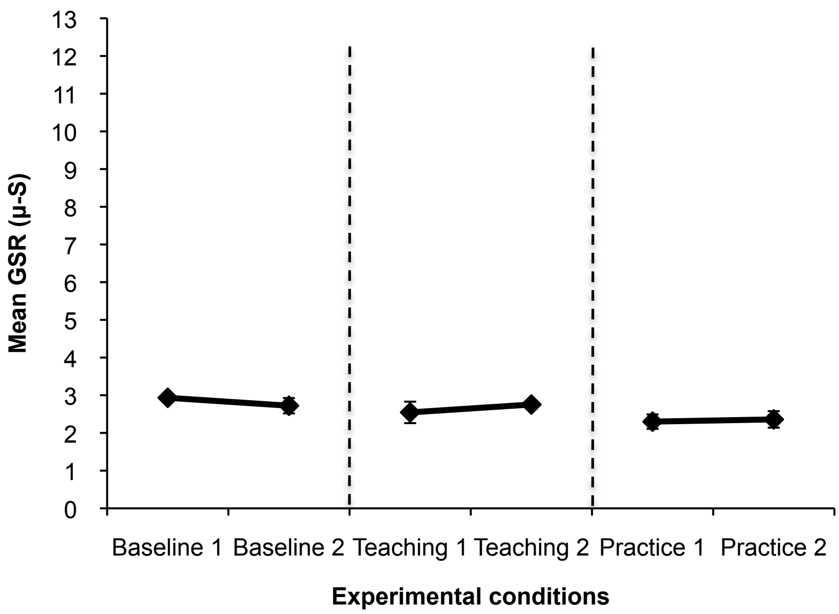

Figure 10. Participant 2 mean and standard deviation of GSR over three conditions.

The mean GSR ranged between 2.3 and 2.9 over the three conditions, indicating very little change in relation to the differing conditions. However, there was a slight trending down of the GSR from baseline through teaching and practice.

3.4 Participant 3

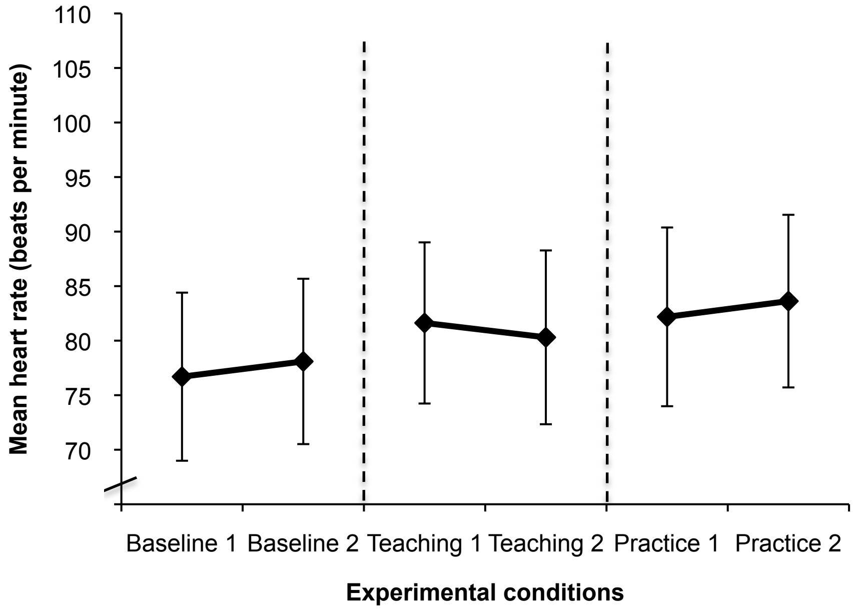

Figure 11. Participant 3 mean and standard deviation of maternal HR over three conditions.

The mean HR participant 3 ranged between 76 and 83 beats per minute. A slight trending up of the mean HR occurred over the three conditions. All three conditions showed similar, and relatively high standard deviations.

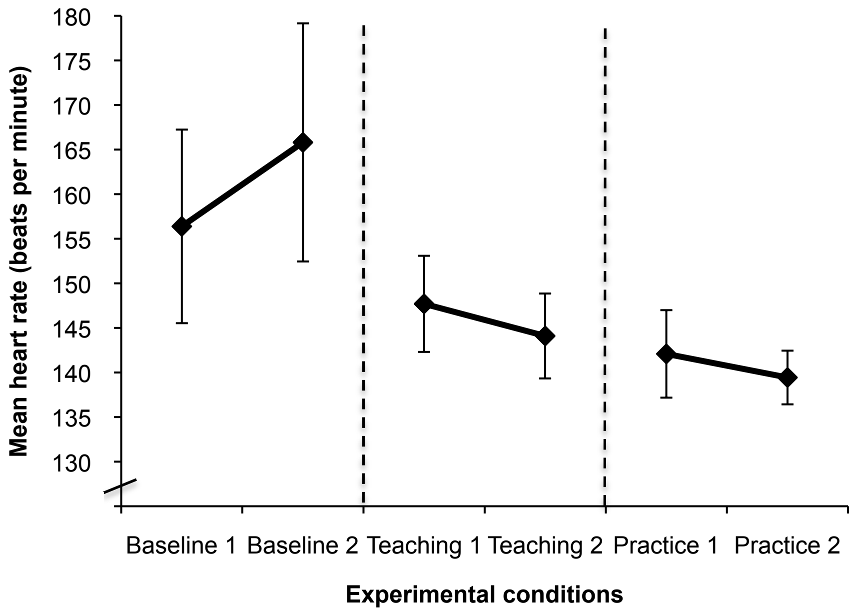

Figure 12. Participant 3 mean and standard deviation of fetal HR over three conditions.

The fetal HR mean ranged between 139 and 156 beats per minute over the three conditions. The mean HR was highest at the end of the baseline condition and trended down over the teaching and practice conditions. The fetal HR pattern trended in the opposite direction to the maternal HR pattern. The greatest variability occurred in the data in the baseline condition.

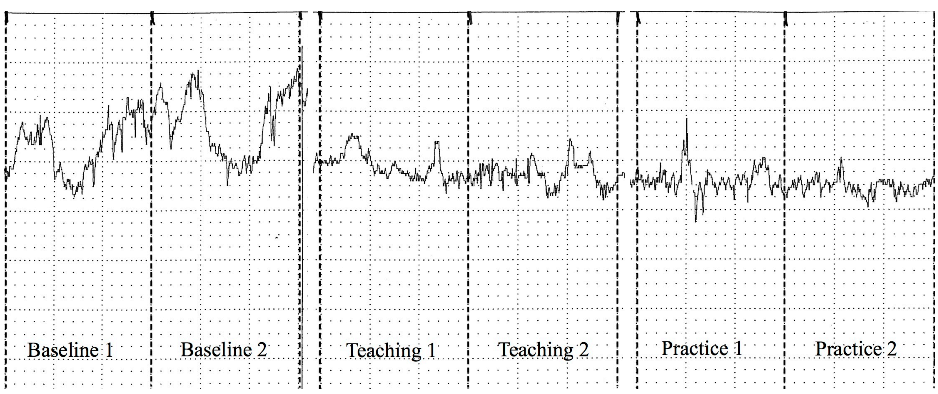

Figure 13. Participant 3 CTG display of fetal HR.

The greatest variability in HR for this participant is seen in the baseline condition for both short and long-term variation with frequent accelerations in HR occurring over the baseline condition. The HR is less variable in both the teaching and practice conditions; however despite being less variable than the baseline, there is evidence of moderate to high short- and long-term variability in both the later conditions.

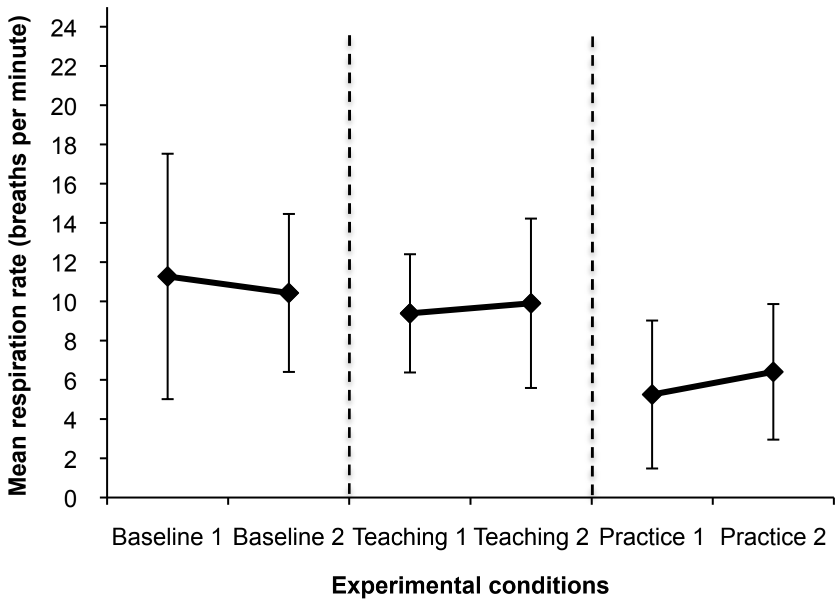

Figure 14. Participant 3 mean and standard deviation of RR over three conditions.

The RR ranged between 6 and 11 breaths per minute. The mean RR was highest during the baseline condition and trended down over the teaching and practice conditions. The greatest variation in the data occurred in the first segment of the baseline condition and the least in the first segment of the teaching condition.

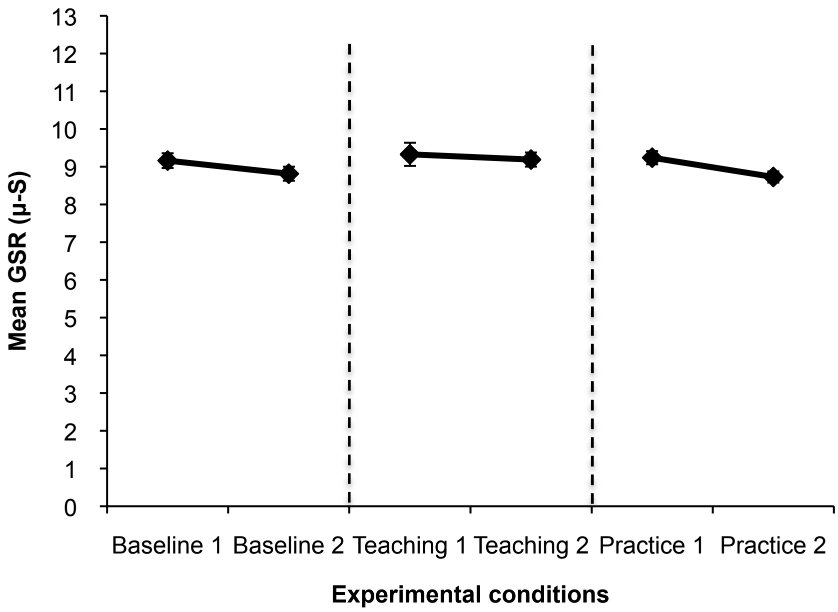

Figure 15. Participant 3 mean and standard deviation of GSR over three conditions.

The mean GRS ranged between 8.7 and 9.3 over the three conditions. Very little variation occurred in the data across the three conditions. A slight downward trend occurred in the second baseline segment and the second practice segment.

3.5 Participant 4

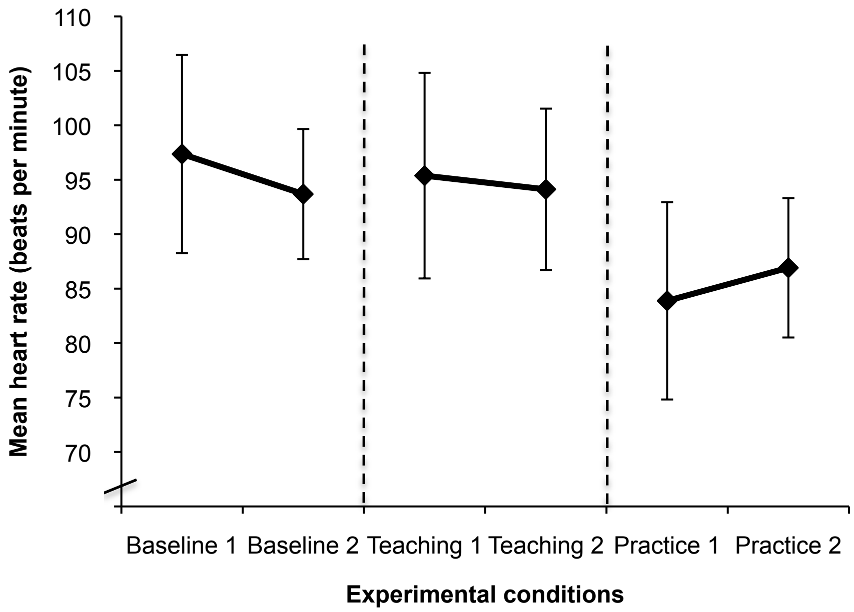

Figure 16. Participant 4 mean and standard deviation of maternal HR over three conditions.

The mean HR for participant 4 ranged between 83 and 94 beats per minute over the three conditions. There was a trending down of the mean rate from the first to the second segment for both the baseline and the teaching conditions. There was a drop in the mean rate from the last segment of the teaching segment to the first segment of the practice segment, with a tending up in mean rate from the first to the last segment of the practice condition. The mean rate at the end of the practice condition was 11 beats lower than the first segment of the baseline. The greatest variation in the data occurred during the first segment of each condition.

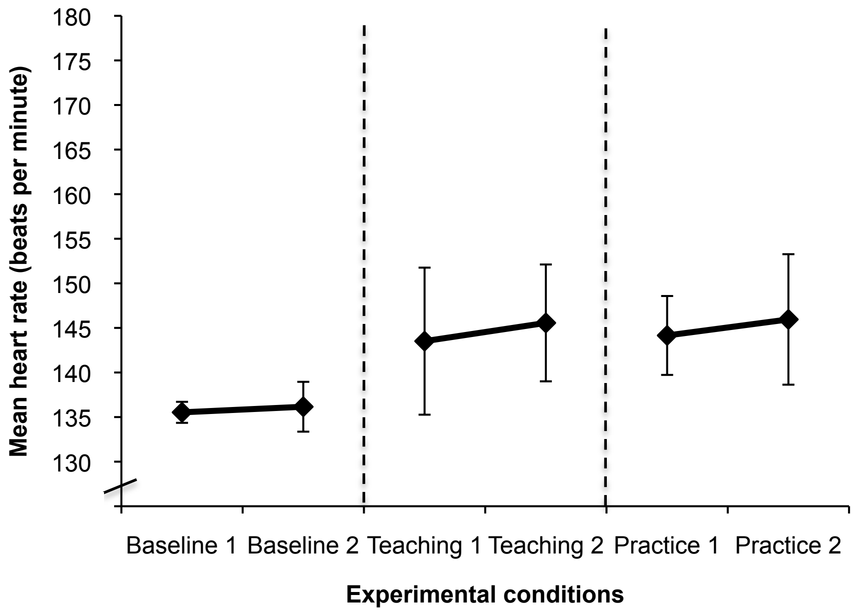

Figure 17. Participant 4 mean and standard deviation of fetal HR over three conditions.

The mean fetal HR for participant 4 ranged between 135 and 145 beats per minute. The mean HR was lowest within the baseline condition increasing during the teaching condition and levelling out in the practice condition.

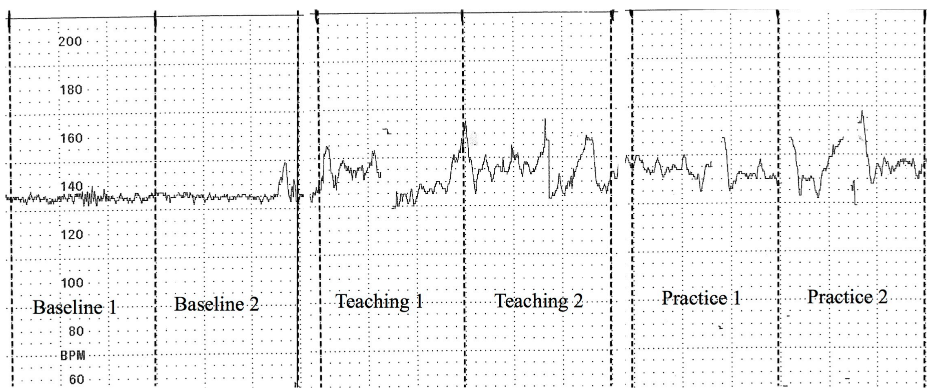

Figure 18. Participant 4 CTG display of fetal HR.

There is significantly less short- and long-term variability in the baseline condition for this participant. Both short- and long-term variability increased in the teaching and practice conditions with multiple accelerations in HR occurring in both these conditions.

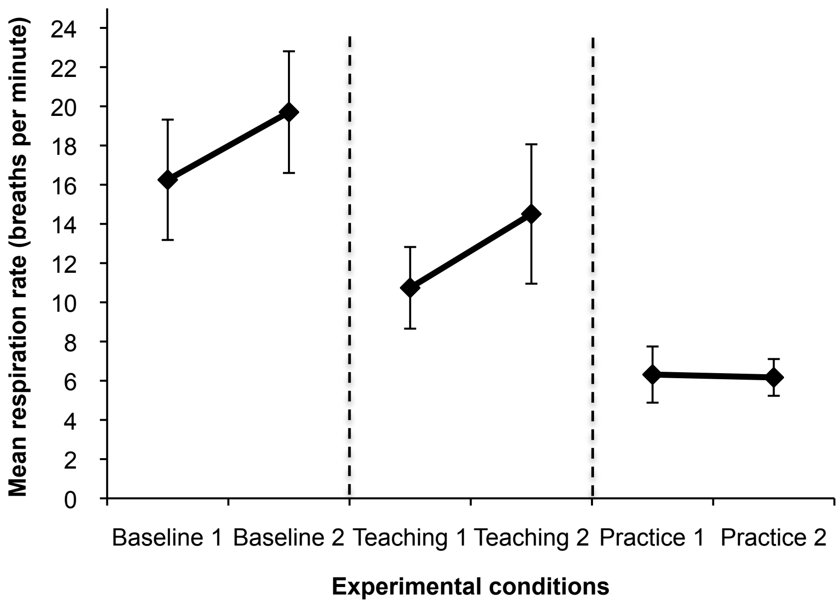

Figure 19. Participant 4 mean and standard deviation of RR over three conditions.

The mean RR ranged between 19 and 6 breaths per minute. Overall, the mean RR fell over the three conditions; however, in the baseline and teaching conditions the RR increased in the last segment of each of these conditions. The rate in the practice condition was the least variable and was consistent at 6 breaths per minute in both segments.

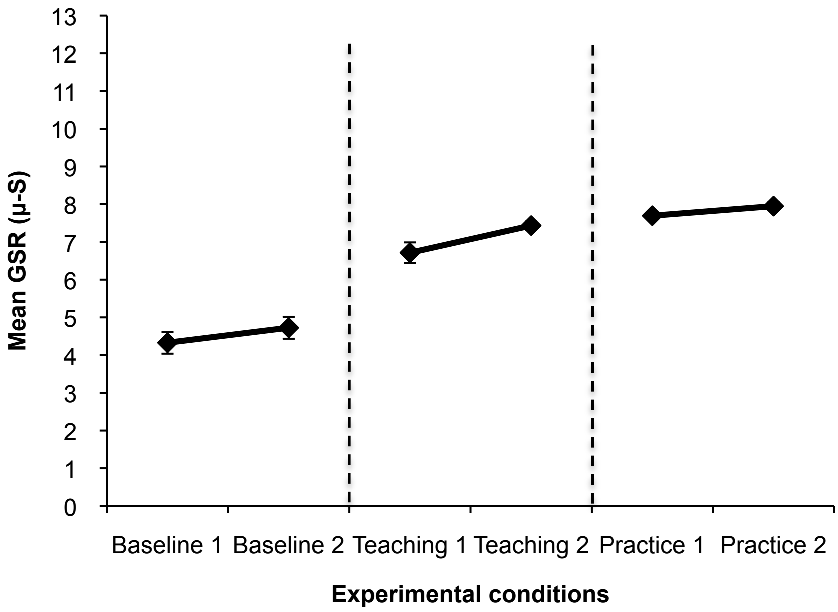

Figure 20. Participant 4 mean and standard deviation of GSR over three conditions.

The GSR for participant ranged between 4.3 and 7.9 MS and trended up, with very little variation in the data, over the three conditions.

3.6 Participant 5

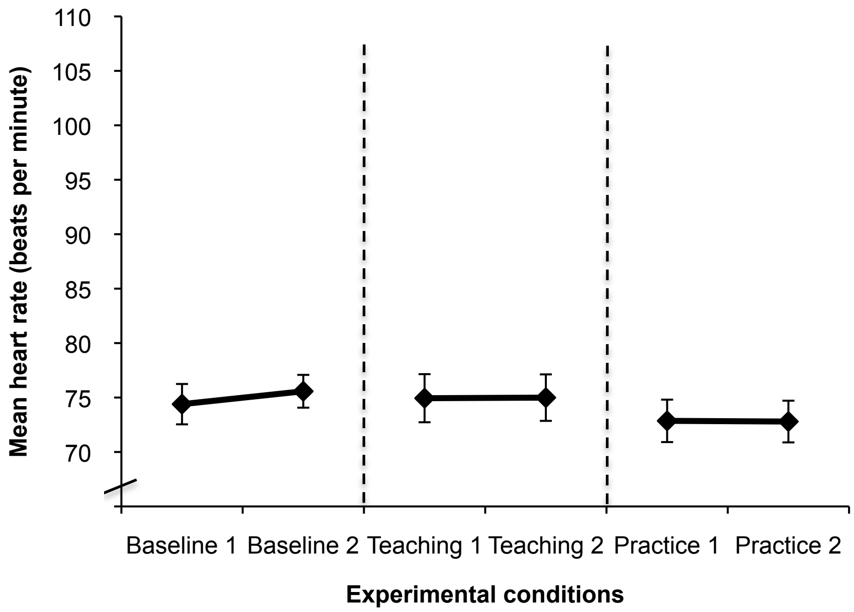

Figure 21. Participant 5 mean and standard deviation of maternal HR over three conditions.

Participant 5 completed the procedure twice. Data from the first trial was not retrievable. The results shown in figure 20 relate to the second trial conducted in her home 3 weeks after the first trial. The mean HR over the three conditions ranged between 72 and 75 beats per minute. During the baseline condition the mean rate trended up slightly in the last segment of this condition. During the teaching condition the mean rate dropped slightly remaining stable over the two segments and trended down in the teaching condition. There was minimal variability in the data over the three conditions, with slightly more variation in the teaching condition.

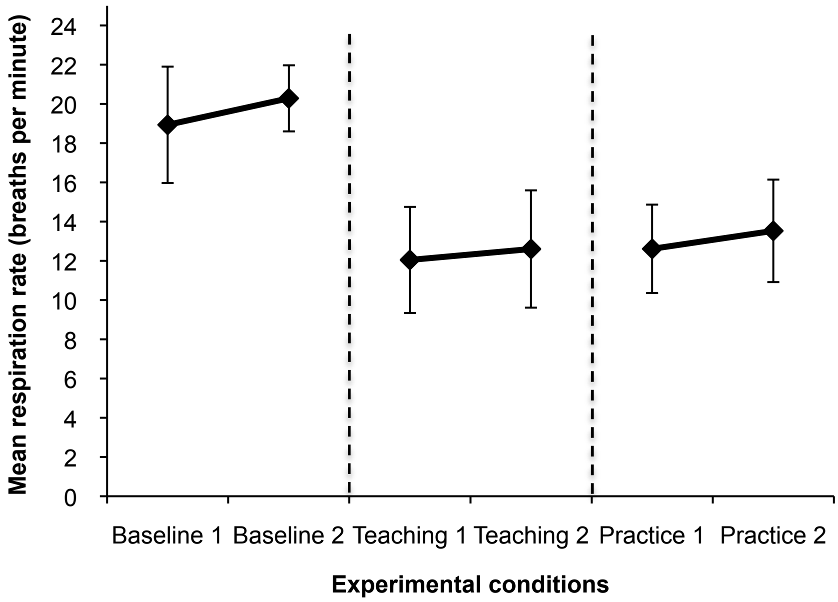

Figure 22. Participant 5 mean and standard deviation of RR over three conditions.

The mean RR for participant 5 ranged between 12 and 20 breaths per minute over the three conditions. The mean rate was highest in the baseline condition, trending up in the last baseline segment. The mean RR dropped in the teaching condition and remained at this lower rate in the first segment of the practice condition, with a slight increase in the last segment of the practice condition. The greatest variability in the data was seen in the last segment of the baseline condition and in last segment of the teaching condition.

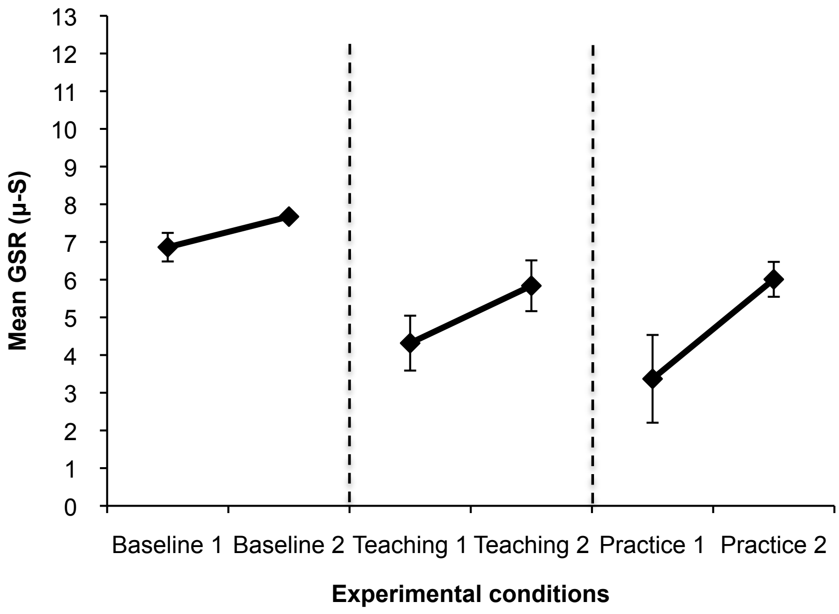

Figure 23. Participant 5 mean and standard deviation of GSR over three conditions.

The mean GSR for Participant 5 ranged between 7.6 and 3.3 MS across the three conditions. The highest mean GSR was recorded in the baseline condition with the lowest occurring in the first segment of the practice condition. The mean GSR rate trended up in the last segment of each condition. The greatest variability in the data occurred in the first segment of the practice condition.

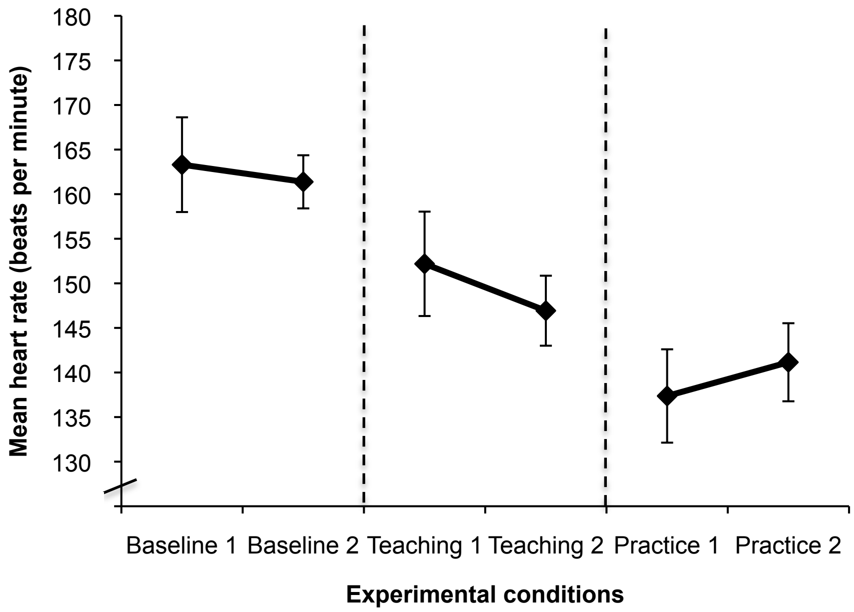

Figure 24. Participant 5 mean and standard deviation of fetal HR over three conditions.

The mean fetal HR for participant 5 ranged between 163 and 137 beats per minute. The mean rate trended down over the three conditions. There was a downward trend of the mean in both the baseline and teaching conditions. In the practice condition there was a trending up of the mean HR, while remaining lower than the teaching condition. This data pattern cannot be considered in conjunction with the maternal data pattern as it was recorded during the first procedure for participant 5.

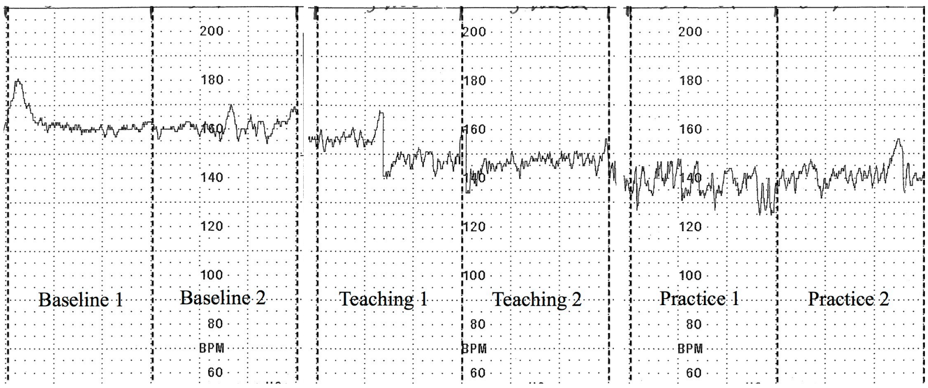

Figure 25. Participant 5 CTG display of fetal HR.

There is similar short- and long-term variability in the HR across the three conditions for this participant. There was slightly less variability in the last segment of each of the three conditions. A more consistent pattern of variability was evident across the practice condition as a whole, than in the two previous conditions.

3.7 Participant 6

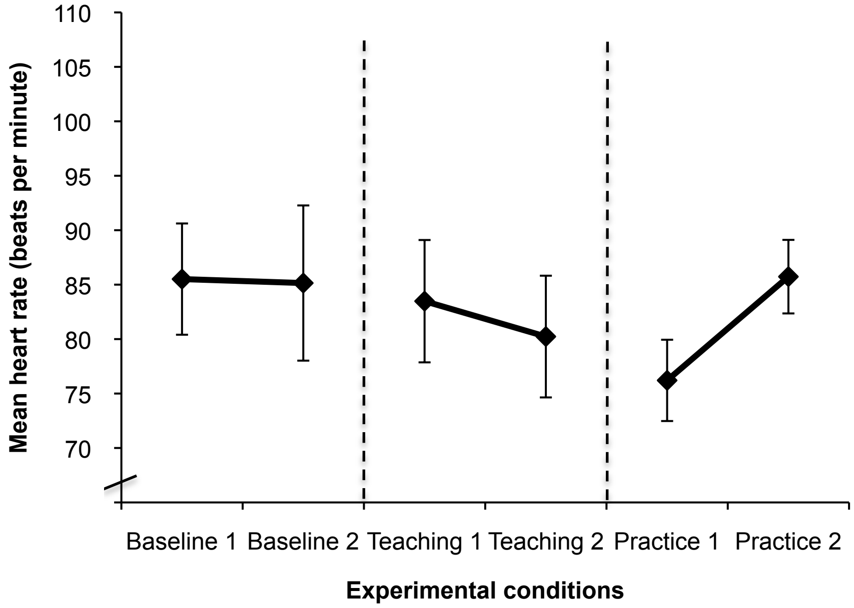

Figure 26. Participant 6 mean and standard deviation of maternal HR over three conditions.

The mean HR for participant 6 ranged between 76 and 85 beats per minute over the three conditions. During the baseline condition, the mean rate was stable at 85 beats per minute, trending down in the teaching condition and for the first segment of the practice condition. In the last segment of the practice condition the mean rate trended back up to the mean baseline rate. The greatest variation in the data occurred in the last segment of the baseline condition, and the least variation occurred in the teaching condition.

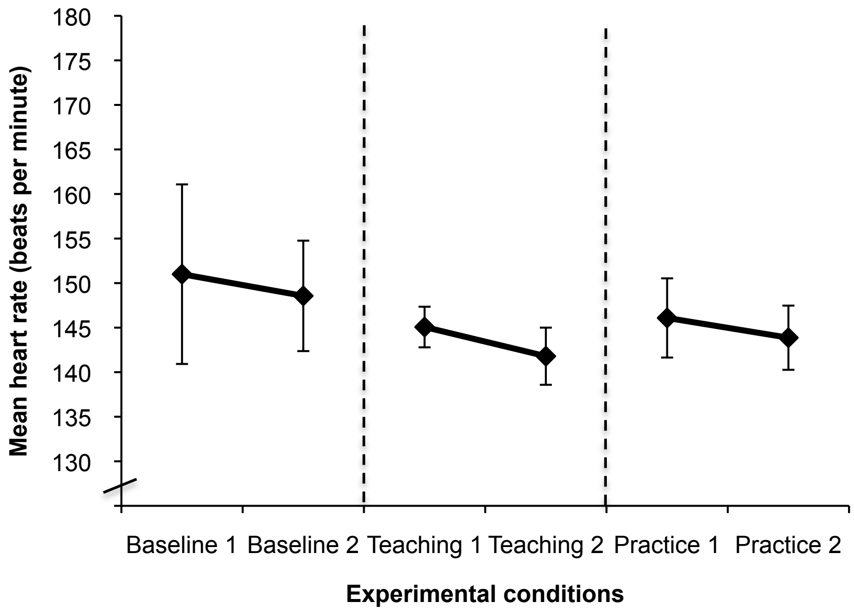

Figure 27. Participant 6 mean and standard deviation of fetal HR over three conditions.

The mean HR over the three conditions varied between 151 and 141 beats per minute. The highest mean HR occurred during the baseline condition. The mean HR trended down over the baseline and teaching conditions. In the first segment of the practice condition, the mean rate was 5 beats per minute higher than in the first segment of the practice condition, trending down slightly in the last segment of the practice condition.

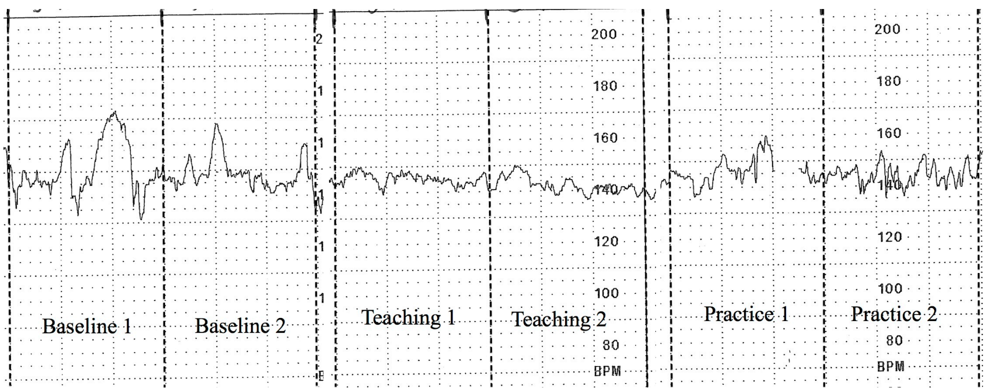

Figure 28. Participant 6 CTG display of fetal HR.

The greatest HR variability across the three conditions was seen in the baseline. During this condition there was increased short-and long-term variability with evidence of frequent HR acceleration when compared to the teaching or practice conditions. The least variability was seen in the first segment of the teaching condition where there is less long-term variability when compared to the baseline or practice conditions; however, short-term variability appeared to be relatively constant over the three conditions.

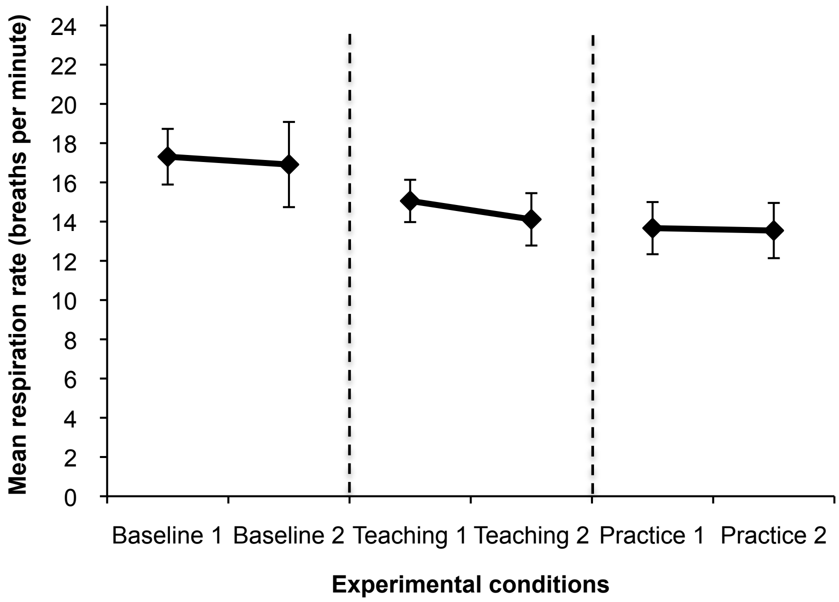

Figure 29. Participant 6 mean and standard deviation of RR over three conditions.

The mean RR for participant 6 ranged between 17 and 13 breaths per minute. The RR trended down over the three conditions to stabilise in the practice condition at 13 breaths per minute. The greatest variation in the breathing rate occurred in the last segment of the baseline condition.

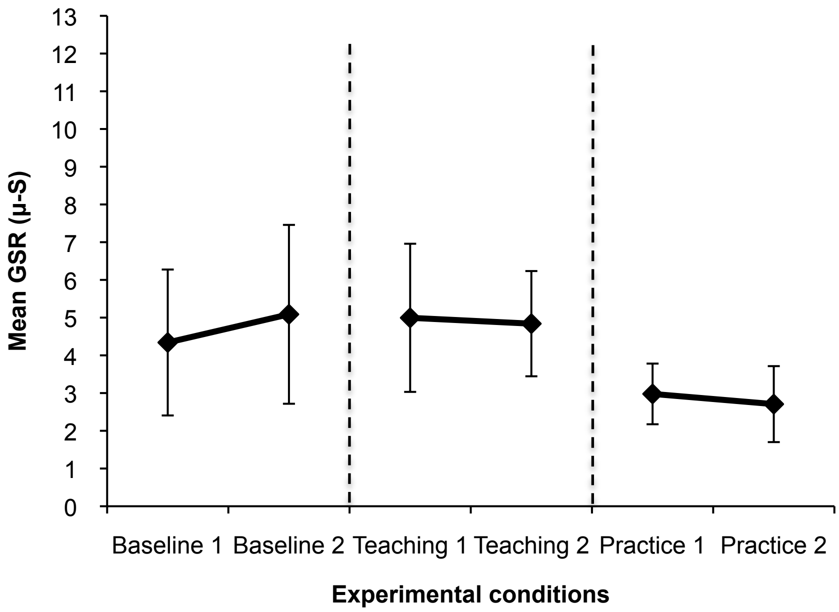

Figure 30. Participant 6 mean and standard deviation of GSR over three conditions.

The mean GSR rate over the three conditions ranged between 2.7 and 5.0 MS. The mean GSR rate trended up in the last segment of the baseline condition, trending down in the teaching and practice conditions. The greatest variability in the data occurred in the last segment of the baseline condition and in the first segment of the teaching condition.

Chapter 4: Discussion

This chapter will provide a summary of the general findings for both the mothers and their babies. Where possible any specific findings related to the individual pairs will be discussed. The challenges related to discussing this study in relation to previous research will be outlined. The limitations of the current project and suggested directions for future research will conclude the chapter.

This project had two main aims. The first was to explore how pregnant women's physiological responses change when exposed to a brief mindfulness meditation teaching and practice session. The second was to determine, if the pregnant woman's physiology does change, how this might impact her baby's physiological response.

The programme employed to teach and guide the practice aspect of the procedure used an element of biofeedback. Although the effectiveness of the biofeedback element was not directly tested, it was anticipated that some information regarding its effectiveness might be gained through the results obtained following exposure to the procedure.

During this project, the measurement of the maternal physiological response was limited to heart and respiration rates and GSR. The measurement of fetal responses was limited to HR and HR variability. The measurement of maternal HR variability was limited to the calculation of standard deviations in each condition, therefore providing only a rough indication of HR variation. For the fetal HR, the standard deviations were calculated for the data in each condition, in addition a visual inspection of the CTG trace was conducted.

4.1 Overall maternal findings

Physiological changes were recorded from baseline to teaching and practice conditions for all the participants. None of the participants demonstrated all of the expected changes (a reduced heart and respiration rate and a decrease in the GSR over the three conditions). Rather, each participant demonstrated a decrease in one or two of the variables.

The variable that appeared to be most effectively impacted by the procedure was RR. The mean RR in the final segment of the practice condition was lower than in the baseline condition for all of the participants. This finding may be related to the content of the instruction in the teaching segment: the narrator asks the participant to observe and focus attention on the breath cycle without any attempt to alter it. The practice condition also had a focus on RR. In the practice condition a visual cue (a butterfly moving its wings in a slow constant rhythm) appeared on the screen. The participant was told that she could follow this cue (if it felt comfortable or helpful to do so) as a guide for assisting her to maintain her focus on the breath cycle. The biofeedback element of the practice condition may also have also impacted RR in an indirect way, as a slower RR would facilitate the participant achieving more feedback on her performance. The animation in this segment shows birds dropping flowers in a pool, and the more the participant's physiology changes to be consistent with a relaxed state, the more flowers are dropped. If the participant were able to reduce RR (this is the only variable under voluntary control), this could facilitate reductions in heart and GSR rate, she would receive reinforcement for her physiological changes. Exposure to, and awareness of, changes in physiology as a result of the teaching and practice could potentially increase her ability to detect and positively influence her physiology through focussed attention.

4.2 Specific maternal findings

In all but two of the participants, the mean HR was lower at the end of the practice condition when compared to the baseline condition. As for variability, only Participant 1's HR data indicated a clear pattern of increased variability in the data from baseline to the end of the practice condition. A pattern of increased HR variability is suggestive of an increase in RSA (see section 1.3 above), however accurate measurement and analysis of RSA was beyond the scope of this study.

Participant 3's mean HR rose over the three conditions, even though her mean RR dropped and she showed little change in GSR. There was little change in the variability in the HR data for this participant over the three conditions. These findings indicate that the procedure for this participant was only moderately effective in assisting her positively to influence her physiology, in that she was able to slow her breathing, but this was not associated with decreasing HR and GSR as would be expected.

The mean HR for Participant 6 did trend downwards in the teaching condition from the stable mean rate observed in the baseline condition. In the first segment of the practice condition the downward trend continued, but returned to the mean rate of the baseline condition in the last segment of the practice condition. The variability of the HR data was greater in the last segment of the baseline and in the teaching condition and mean respiration and GSR trended downwards, suggesting that the teaching condition and practice were effective in assisting physiological changes. However, it is possible that during the practice condition the biofeedback was not as effective as the direct instruction of the teaching condition in assisting this participant to initiate and maintain physiological change across all the variables.

The results for Participant 5 may be subject to a practice effect as she repeated the procedure at a later date and in a different setting. It is possible that being in her own home and repeating the procedure enhanced this participant's performance. Her overall results would fit with a suggested practice effect as they showed a slight rise of the mean HR in the second segment of the baseline condition followed by a trending down over the teaching and practice conditions. Her RR and GSR also slowed a general downward trend from the mean rates observed in the baseline condition. A common theme in much of the literature concerning the effectiveness of mindfulness is the need for practice. It has been demonstrated that ability to affect physiology through mindfulness meditation is enhanced with repeated practice (Kabat-Zinn et al., 1992; Kleen & Retsma, 2011). It is possible the opportunity for repeated practice would have enhanced the participants' ability to positively affect their physiology and in turn that of their babies.

The variable that was least affected by the exposure to experimental conditions was GSR. For Participants 1 and 4, the GSR went up during the teaching and practice conditions. This finding is unexpected given the trending down of the HR and RR for these two participants, and could be related to a malfunction in the GSR recording. For Participant 5, the GSR trended downwards in the teaching condition and for the first segment of the practice condition before returning to the baseline rate in the last segment of the practice condition. For

Participant 3, little change in GSR was observed across the three conditions and for Participant 2 there was a modest trending downwards of the GSR over the three conditions. Participant 6 demonstrated the most convincing change in GSR and GSR variability over the three conditions, suggesting a positive sympathetic nervous system response and subsequent decrease in sweat gland activity. Somewhat surprisingly, however, this participant's mean HR did not stay below the baseline level throughout the entire experimental condition, as would have been expected in relation to a lowered GSR and mean RR.

The finding of an unclear pattern of suppression of sympathetic activation as measured by skin conductance was also noted by DiPietro et al. (2008). They noted that in the group who experienced a longer baseline period before commencing the relaxation procedure there was a rise in GSR from baseline level and a higher level throughout the relaxation procedure than the group that had shorter baseline period. They concluded that this group had more time to think and possibly worry about what was to come next. This finding demonstrates the complexity of examining multiple measures of differing aspects of maternal physiology in addition to the difficulty of determining the most effective and appropriate baseline time to use to determine stable responding.

4.3 Fetal findings

For four of the six participants, the mean fetal HR was lower in the last segment of the practice condition than in the baseline condition. The mean fetal HR for Participant 4 was alone in demonstrating a clear upward trend across the three conditions; however, there was a distinct increase in the variability of the HR in the teaching and practice conditions for this participant.

Generally, high short- and long-term variability in the fetal HR is indicative of good immediate fetal condition and wellbeing (Fink et al., 2011). The lack of variability in fetal HR in the baseline condition for Participant 4 could indicate that her baby was in a quiet sleep state during this period, and may have moved to an active sleep state or wakefulness state in the teaching condition. The current study did not control for fetal behavioural states. This could have been achieved by waiting for the CTG trace to indicate that the baby was in an active sleep state, as suggested by Fink et al. (2011). However, to ascertain that this was the case was beyond the recourses of this study. As suggested by Fink et al. (2011) it is possible to interpret changes in fetal sleep/wake states as a positive effect of an intervention.

The mean fetal HR for Participant 2 did not show a clear pattern of trending down over the three conditions; however, there was a consistent pattern of increased variability during the last segment of each condition when compared to the first segment of each condition. This pattern of variability change within each condition was associated with a pattern of a lower mean fetal HR in the first segment of each of the conditions when compared to the last segment of each condition. When this response pattern is compared to the maternal pattern, it is evident that the maternal mean HR is lower in the last segment of each condition when compared to the first segment of each condition. Thus for Participant 2 there is the unexpected finding of a fetal HR pattern that is essentially the opposite of the maternal pattern. This finding could be similar to some of the reported data contributing to the findings by Fink et al. (2011), who found no association between fetal HR and maternal HR during maternal exposure to a relaxation procedure.

Of the four participants that demonstrated a pattern of decreased mean fetal HR in the practice condition when compared to the baseline condition, only one (Participant 1) demonstrated a clear pattern of increased fetal HR variability associated with the lower mean HR. When this fetal HR pattern is compared to the maternal pattern for Participant 1, it is similar, in that the maternal HR trends down over the three conditions and the maternal HR variability is greater in the practice condition when compared to the baseline and teaching conditions. The findings for this maternal fetal dyad are consistent with DiPietro et al.'s (2008) finding that a reduction of fetal HR and increased fetal variability are associated with maternal reductions in HR when exposed to a brief relaxation procedure. The other three participants that demonstrated a reduction in fetal HR means in the practice condition when compared to the baseline condition (being Participants 3, 5, and 6), did not demonstrate a corresponding increase in fetal HR variability as was found in DiPietro et al.'s (2008) study.

The mean fetal HR for Participant 5 showed a distinct decrease in both segments of the teaching condition and the first segment of the practice condition. There was a slight increase the mean HR in the last segment of practice for this participant with little change in the HR variability. In Participant 5's case the fetal HR pattern cannot be compared to the maternal HR data as they occurred at different times. However, it would seem reasonable to assume that the maternal findings for Participant 5 on completing the procedure for a second time may have been similar to the first time she completed the procedure. If this were to be the case (and this would be conjecture only) the fetal pattern would appear to be similar to the maternal pattern.

The fetal HR for Participant 6 did not show an increase in variability over the three conditions (the greatest variability was seen in the first segment of the baseline condition). The fetal HR pattern for this participant was similar to the maternal pattern in part (lower in the teaching condition than in the baseline); however, the maternal HR trended up over the practice condition while the fetal HR trended down in this condition.

Although the mean fetal HR for Participant 3 trended down over the three conditions, there was no associated increase in variability with the decease in the baseline rate (the greatest variability for this participant occurred in the baseline condition). When compared to the maternal HR pattern, the fetal pattern trends in the opposite direction (the mean maternal HR trends up over the three conditions with little change in HR variability).

It was expected that maternal exposure to a brief mindfulness procedure would induce not only a decrease in fetal HR but also an increase in fetal HR variability. Overall this increase in variability was not found. It is possible that the increased fetal HR variability expected but not seen over the three conditions may have been observed if the study had employed a period of post-procedure observation similar to that used by Fink et al. (2011). These authors found that an increase in long term-fetal HR variability was particularly noticeable in the 10-minute post relaxation period for the group of babies exposed to a guided imagery or progressive relaxation procedure rather than during the relaxation procedure.

The fetal findings in the current study do not appear to align consistently with the findings of the previous research conducted into fetal physiological changes in response to brief maternal stress reduction procedures. Research in the area of fetal responses to various forms of maternal relaxation is relatively new and the small amount of research that has been conducted has yet to demonstrate any pattern of constant findings. In addition to the lack of consistent findings, the proposed mechanisms underlying maternal/fetal interactions are a long way from being fully understood. The differences between the findings of this study and previous research could be due to the differences in the type of procedure the mothers were exposed to, or the differences in study design undertaken. These factors of the current study are commented on below.

4.4 Differing methodologies

The rational for using a single-subject design for this study was to provide information about how individual pregnant women and their babies respond to a brief mindfulness meditation procedure. This approach would seem to be particularly relevant when attempting to understand the interaction between individual maternal fetal dyads. Comparisons between the findings of this study and those of Fink et al. (2011) and DiPietro et al. (2008) are difficult to draw as data presented in the previous studies represents averaged fetal group and maternal group performance data, as opposed to data relating to individual mother and baby pairs. Those studies do, however, have the benefit examining the data from larger groups.

There are, however, significant challenges in applying single-subject methodology to behavioural change linked to changes in physiology. As physiological responses are sensitive to a wide range of factors, it is difficult to control for all possible confounding variables. It is also difficult to determine a stable state of responding across all the variables within a baseline period upon which to assess behavioural change.

The previously identified small amount of published research on the effects of mindfulness-based interventions using pregnant women, such as that by Astin (2008) and Beddoe et al. (2009), have used validated self-report measures to assess outcomes. The current study attempts to extend enquiry beyond what the mother is able to report, to what may be happening for the baby while the mother participates in a brief mindfulness procedure. As the baby is only able to communicate well-being through observable behaviour, such as movement and physiological markers, physiological measures become central to assessing fetal behavioural change in response to any procedure.

Research undertaken to date to assess the impact of brief maternal stress procedures has used targeted relaxation, such as progressive muscle relaxation (Fink et al., 2011) and or guided imagery (DiPietro et al., 2008). Mindfulness meditation procedures do not attempt to elicit a state of relaxation per se; biophysical changes such as relaxation are considered to be by-product of mindfulness procedures rather than an intended outcome (Vieten & Astin, 2008). It is therefore possible that the type of physiological change that could be expected as a consequence of a targeted relaxation procedure may be different from that expected as a consequence of a mindfulness-based procedure.

There is a developing body of research concerned with the potential long-lasting physical changes related to the practice of mindfulness, such as the work of Holzel et al. (2011), which found changes in brain structure following exposure to an eight-week mindfulness stress reduction programme similar to that developed by Kabat-Zinn et al. (1992). The possible effect of mindfulness practice on short-term physiological measures is less evident in the literature. With the development of more extensive computer-assisted technology, the possibility of examining outcomes and enhancing the acquisition of mindfulness through biofeedback is becoming more accessible (Kleen et al., 2011).

The current study attempted to use a biofeedback element as way of assisting participants to focus attention on their breath and private moment-by-moment experience, without interacting with these experiences. This ability to focus attention is central to mindfulness, and generally acknowledged to be a skill that needs to be learned over time. This study attempted to assess the effect of having participants initiate and facilitate a brief mindfulness procedure without the benefit of repeated practice but with the assistance of biofeedback. Although the biofeedback component of the intervention not directly tested, the change that was observed in the participants' respiration rates in the practice condition would suggest that the biofeedback was helpful in assisting focus on the breathing cycle. To date there has been no identified previous attempt to facilitate mindfulness meditation in pregnant women using biofeedback or to measure any effects of such a procedure on unborn babies.

4.5 Limitations of the research

This study was limited by the lack of technical equipment and skill required to examine fetal behaviour and physiology beyond basic HR data. First, it is recognised that fetal behavioural states vary between quiet sleep and active wake states. These states are reflected in the fetal HR and variability pattern. It is possible, as suggested by Fink et al., (2010), to misinterpret a change in fetal wake/sleep state as a positive reaction to any maternal physiological state. The ability to control for fetal wake/sleep states relies first on access to personnel trained to make such an assessment, and secondly on the capacity for a participant to extend the potential time that any procedure may take so as to ensure that the baby is in the desired quiet wake state prior to commencing any intervention.

Assessment of fetal behaviour and biophysiology is complex and the recording of the fetal HR and pattern via CTG provides only limited information. If the ability to assess fetal movement and HR coupling via ultrasound, could also be employed then a more complete picture of the fetal response would be available.

Secondly, these limitations also extend to the ability to access maternal physiological measures by techniques or mechanisms such as hormonal assays, uterine activity, uterine arterial measures and blood pressure measurement. The ability to access data related to these variables would potentially provide a more accurate and complete picture of maternal physiological change in relation to any intervention.

Related to this study's limited ability to collect maternal and fetal measures was a limited ability to analyse that data in detail. The interpretation of the fetal pattern of CTG variability for this study was obtained by calculating the standard deviations for the fetal HR over the three conditions in addition to visual interpretation of the raw CTG data. Visual interpretation is the method most usually used in the clinical settings by midwives to assess fetal wellbeing (Murray, Huelsmann & Romo, 2007). Equipment and software is available in some settings that can both collect maternal and fetal data in tandem and analyse it (as used by, for example, Fink et al., 2010). This would potentially provide more accurate measures of performance. However, this equipment is not currently available or in use in New Zealand.

It is possible that technological limitations also affected the delivery of the teaching programme in the most effective way. Physiological responses are very sensitive to distraction, and as the programme delivery method required the researcher to manipulate the Healing Rhythms programme to provide the participant with the correct segment for each part of the procedure, this intrusion could have distorted the participants' responses. This possibility could account for the higher mean HR in the first segment as compared to the second segment for each condition for Participant 2. The ability to deliver the sequential programme segments without the need for human intrusion would limit the possibility of this form of distraction.

The current study is limited in that it is a study with a small number of participants. Although demographic data was not collected, the self-selection recruitment method used would suggest that the participants might represent a narrow demographic of the possible pregnant population (for example, limited to those able to attend antenatal classes or massage therapists).

The need to limit the time any unborn baby is exposed to observational procedures, such as ultrasound, is a limitation of this type of research in general. Fetal exposure to CTG recording via ultrasound is considered to be safe and is a commonly used technology to record fetal HR measures (Visser, 1984). While ultrasound is considered safe for the fetus, many midwifery and obstetric professionals recognize that exposing healthy, well women and their unborn babies to a CTG recording has the potential to lead to unnecessary intervention. This is due to the ability of the CTG to pick up transient and sporadic changes in

HR, which are not of clinical significance or pathological. However, these changes can be easily misinterpreted as a pathological sign, thus initiating intervention. Any unborn baby should therefore only be exposed to external recording devices at any time in pregnancy or labour when there is a well-considered indication for such recording, so as to minimise the potential for unnecessary intervention (Goddard, 2001). This potential difficulty was observed in Participant 7. In this case, the participant required follow-up assessment by her midwife to ensure the deceleration in HR that was observed was a benign event. It is for this reason that this form of research must take place in an appropriate setting where trained midwifery or obstetric professionals are in attendance to oversee any fetal observation procedures used. Concern about over-monitoring, and the possible implications of this (as outlined above), by both women and midwives may make recruitment of participants for this type of research challenging.

4.6 Overall conclusions and future directions

The results obtained during this study indicate that exposure to a brief mindfulness meditation procedure in the last four weeks of pregnancy has the potential to effect physiological responses associated with a state of relaxation. The finding of a change in a positive direction in at least one of the variables in question for all of the participants, and a reduction in the fetal HR baseline in four of the six participants, is suggestive that this form of intervention may have the potential to have a positive impact on both mothers and their babies.

Intervention strategies that use mindfulness-based procedures are particularly attractive for the pregnant population as there is a need to provide non-pharmacological options for pregnant women who require assistance with coping with distress (in a range of forms) during this time. This study had an immediate focus in that it provided essentially a 'snapshot' of how a brief mindfulness-based intervention may affect maternal and fetal physiology at one small moment in time. A pregnancy is, by its nature, time limited; however, as this study demonstrated that physiological change may be elicited in the short term, there could be the potential for this type of study to be extended to examine the possible effects and benefits of mindfulness-based interventions in pregnancy over a longer timeframe. This might be achieved through multiple measures of physiological change. This approach could be combined with self-reports using validated mindfulness measures over the course of a woman's pregnancy. This approach may be particularly appropriate for women with 'high risk' pregnancies where elevated levels of stress and concern are probable.

This study did not attempt to examine if this form of intervention would be considered to be acceptable by pregnant women, or if they would rate the experience of mindfulness meditation to be beneficial. It is possible that a combination of self-report and physiological measures, like that used by Teiexira et al. (2005), may provide the widest range of information to lead ultimately to the development of an effective and acceptable mindfulness-based intervention package for use in the wider pregnant population. This form of enquiry could also usefully be extended to pregnant women who have been diagnosed with identifiable psychological conditions such as depression or anxiety.

During a pregnancy there are many things that may happen that are potentially distressing and outside of the control of the woman. Animal research would suggest that distress in pregnancy, of a kind where the mother has no ability to attempt to mediate her condition, has the potential to be the most damaging to the fetus (Charil, 2010). If this were to be found to be the case for human mothers, a mindfulness-based approach may be effective as it emphasizes acceptance of experience (both private and environmental), whilst at the same time giving the participant a sense of doing something active to help themselves.

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Appendix A: Recruitment Flyer

Below is a reproduction of the recruitment flyer that was supplied antenatal classes and pregnancy massage therapists in the local community.

Appendix B: Birthing Room Setup

Below is a photograph of the birthing room used for the procedure, with the apparatus set up.

Appendix C: Apparatus in Use

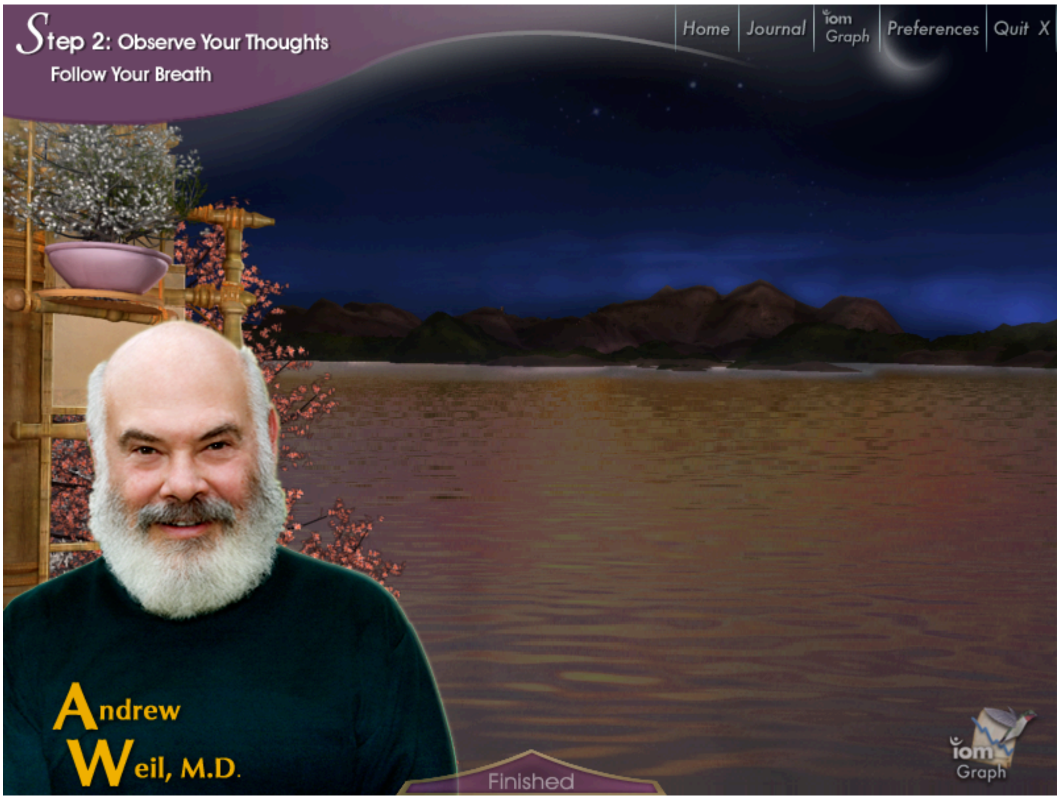
Below is a photograph of the apparatus in use.

Appendix D: Laptop and Finger Sensors

Below is a photograph of the laptop and finger sensors used in conjunction with the biofeedback programme.

Appendix E: Biofeedback Programme Screenshots

This appendix contains screenshots of what the participants were exposed to during the procedure. The top screenshot shows Healing Rhythms, Step 2: Observe Your Thoughts- Mind/Body Practice#2: Mindfulness, Breathing- *Learn to follow your Breath*, used in the teaching condition. The bottom screenshot shows Healing Rhythms Step 13: Take A Daily Supplement, Biofeedback event- *Lotus Blossoms*, used in the practice condition.


Step 2: Observe Your Thoughts
Follow Your Breath
Home
Journal
iom Graph
Preferences
Quit X
Andrew Weil, M.D.
Finished
iom Graph


Step 13: Take A Daily Supplement
Lotus Blossoms
Home
Journal
iom Graph
Preferences
Quit X
I'm finished here.
Finished

Appendix F: Information Sheet

This appendix contains the information sheet provided to participants prior to signing the consent form.

Information sheet for research participants

My name is Mary Clark and I am a psychology masters student at the University of Waikato. I have a particular interest in the experiences of pregnant women and early parenting. I have a background in nursing and midwifery, and I have three children of my own.

I am undertaking a research project as part of my masters degree and I am interested in looking at how the mother's physiology (her heart rate etc) correlates to her unborn baby's heart rate and variability. In particular I wish to find out how relaxation may affect the baby.

The research procedure would take about one hour and would take place at River Ridge Birthing centre. It would involve being connected to some sensors on three fingers of one hand and one on the other hand as well as having sensors attached to measure heart rate and breathing. A CTG (cardiotocograph) monitor would be put in place on your abdomen to measure the baby's heart rate. It is anticipated that this should not be uncomfortable. The procedure has three parts. Part 1 is to simply sit and have the recordings taken for approximately 15 minutes. The second part requires looking at an animation on a computer screen while listening to a short information session. This takes approximately 15 minutes. The third part involves a computer guided practice session using the relaxation technique that you have been taught.

All participants will be able to see their results at the end of the session and are welcome to see a copy of the completed research.

Any participant will be free to withdraw from the study at any time for any reason. I am happy to provide any additional information or explanation at any time.

It is hoped that this research will aid us in developing methods to help pregnant women cope with stress and anxiety in pregnancy.

My details are:
Mary Clark
marymrc14@gmail.com
Ph: 021932166 or (07) 8593256

My supervisor's details are:
Dr Carrie Barber
ccbarber@waikato.ac.nz
Ph: (07) 838 4466 extn 6685

Appendix G: Consent Form

This appendix contains the consent form given to participants prior to participation in the procedure.

Consent Form

Research Project Title: The role of mindfulness instruction and practice in changing biophysical indicators in pregnant women and their babies.

____

1. I have read the Information Sheet for this study and have had details of the study explained to me.

2. My questions about the study have been answered to my satisfaction, and I understand that I may ask further questions at any time.

3. I also understand that I am free to withdraw from the study at any time, or to decline to answer any particular questions in the study.

4. I agree to provide information to the researchers under the conditions of confidentiality set out on the information sheet.

5. I wish to participate in this study under the conditions set out in the Information Sheet.

6. I would like my information: (circle your option)
   a) returned to me
   b) returned to my family
   c) other (please specify)………………………………………………

7. I consent/do not consent to the information collected for the purposes of this research study to be used for any other research purposes. (Delete what does not apply)

Participant's Name: ________________________________

Participant's Signature: ________________________________

Date: / /

Contact details: ________________________________

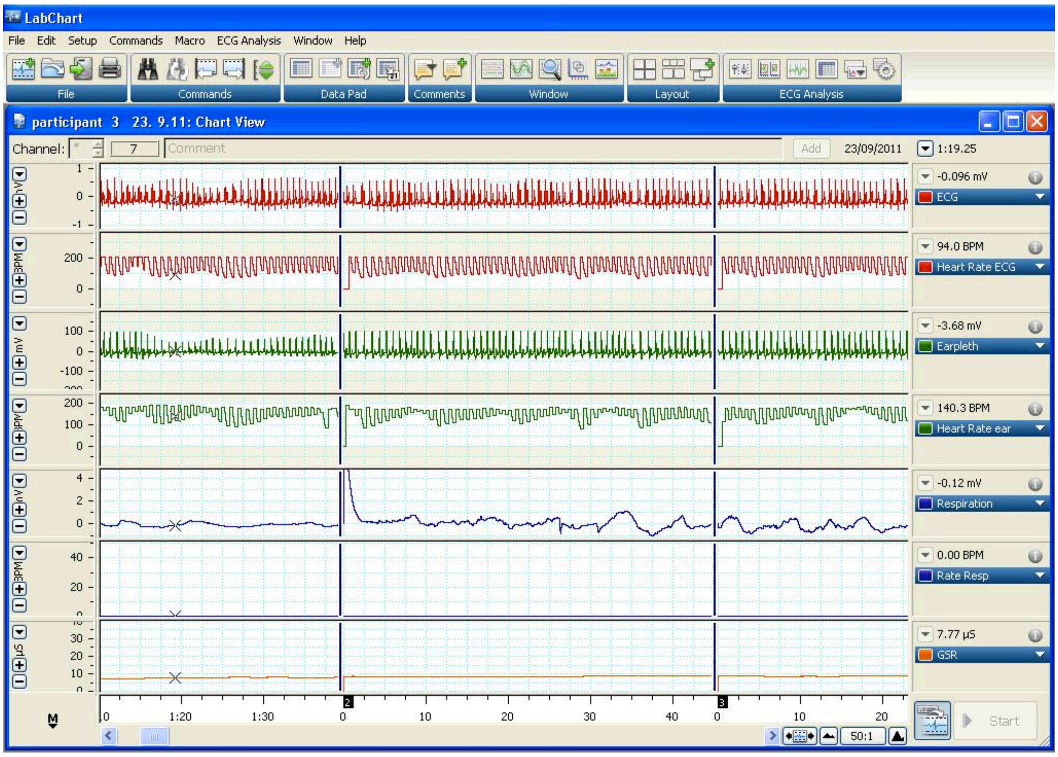
____

Researcher's Name: ________________________________

Researcher's Signature: ________________________________

Appendix H: Raw Maternal Data

Below is a screenshot of a sample of raw maternal data.



Appendix I: CTG Trace for Participant 7

Below is the CTG trace for participant 7, who did not complete the procedure.