MAJOR RESEARCH PROJECT

LITERATURE REVIEW: A Review of Yogic type Interventions during Pregnancy and their Effects on Maternal Well-being

EMPIRICAL PAPER: Physiological Regulation, Responses and Reactivity towards Infant Related Stimuli, during Pregnancy, and their Relationship with Affective Disorder Symptoms

Submitted by Hannah Curtis, to the University of Exeter as a thesis for the degree of Doctor of Clinical Psychology, May 2015

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I certify that all material in this thesis which is not my own work has been identified and that no material has previously been submitted and approved for the award of a degree by this or any other University.

Signature: .................................................................
Author’s Declaration

The literature review was completed independently by the author.

In terms of the empirical work, participants were recruited by Dr Rebecca Pearson between June 2007 and February 2008 for the project “Psycho-physiological Preparations for Motherhood and the Relationship with Affective Disorder Symptoms.” All other aspects of the study were completed by the author including data entry, analysis, and write up.
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TITLE: A Review of Yogic type Interventions during Pregnancy and their Effects on Maternal Well-being

Trainee Name: Hannah Curtis

Primary Research Supervisor: Dr Heather O’Mahen.
Senior Lecturer in Clinical Psychology, Mood Disorders Centre, University of Exeter.

Secondary Research Supervisor: Dr Anke Karl.
Senior Lecturer, University of Exeter.

Target Journal: Journal of Developmental Psychology

Word Count: 4000 words (excluding abstract, all headings, figures, tables, footnotes, references, and appendices).

Submitted in partial fulfilment of requirements for the Doctorate Degree in Clinical Psychology, University of Exeter
A Review of Yogic Type Interventions, During Pregnancy, and their Effects on Maternal Well-being

Abstract

Background. A pregnant women’s health and well-being can impact on the developing baby’s health. It is, therefore, important to find acceptable interventions that can maintain and, if necessary, help improve maternal health and well-being. Yoga is an ancient holistic Indian spiritual discipline that is used for health and well-being promotion and stress reduction. Objectives: This review aimed to consider the relationship between yogic type interventions and maternal health and well-being, during pregnancy, and to critically evaluate the studies in this area.

Method. Databases were searched using combinations of key words.

Results. A total of 11 papers were included in the review. Although yoga type interventions appear to be beneficial to maternal health and well-being during pregnancy such findings have to be interpreted with caution because studies are vulnerable to design limitations and biases.

Conclusions. More large scale research, utilising diverse samples, is needed in order to draw conclusions for clinical practice.

Keywords. Pregnancy, health, well-being, yoga, adults.
Introduction

The World Health Organisation defines health as a state of physical, mental, social and spiritual well-being\(^1\) (Larson, 2006). Pregnancy can affect each of these domains, and, importantly, the mother’s health and well-being has a direct and indirect impact on the developing baby’s health (Glover, 1999). It is therefore important to examine interventions that seek to improve and/or uphold a mother’s health and well-being during pregnancy.

A growing body of recent research has focused on the effects of yogic type interventions on pregnant women’s health and well-being. These interventions may be particularly suitable during pregnancy because of their potential benefits on a number of health and well-being characteristics. This review therefore focuses on systematically evaluating the evidence for yogic type interventions on maternal health and well-being during pregnancy.

The impact of pregnancy. The biology and psychology of becoming a mother is complex (Baistow 2007): It has the potential to cause physical, emotional and psychological stress (Da Costa, Larouche, Dritsa, & Brender, 1999), even amongst healthy pregnant women, which may impact on a mother’s quality of life in different areas. Preserving and, if possible, therefore, enhancing health and well-being during pregnancy is beneficial particularly as pregnancy characterised by difficulties with antenatal mood is associated with poorer outcomes including lower

\(^1\) Spiritual well being: This has been described as the ability to stand outside of ourselves and to consider the meaning of our actions, the complexity of our motives and the impact we have on the world. It is also the capacity to experience passion for a cause, compassion for others and forgiveness of self (Prezioso, 1987).

Social well being: This has been described as achieving a dynamic balance between opportunities and limitations and the capacity to move through life in spite of social and environmental challenges (Huber et al., 2011).
birth weight and length of gestation (Federenko & Wadhwa, 2004) and adolescent mental health (Pearson et al., 2013).

**Physical health and well-being.** Physically, a mother’s body changes during pregnancy; in part to support the growing and developing baby, but also in preparation for impending motherhood (Baistow, 2007). Whilst this is a normal process of pregnancy, it can place the body under stress and strain. For example, increased physical discomfort is common. This not only has a direct impact on a mothers’ functioning in terms of activities which she is perhaps unable to engage in as a result of physical discomfort, but it can also, negatively influence sleep patterns. Disrupted sleep and increasing levels of fatigue are common (Lee & Zaffke, 1999) with research demonstrating 72% of healthy pregnant women to report moderate to high fatigue (Lee & DeJoseph, 1992) which may have negative implications for other areas of physical health.

**Mental health and well-being.** Such physical well-being challenges during pregnancy have the potential to contribute to a mother’s experiences of distress (Noor, 2002), and although concerns and worries are a normal experience during pregnancy they may be enhanced by usual resilience levels being depleted. This may mean that pregnant women are more vulnerable to experiencing worry and stress during pregnancy. It is important, therefore, that pregnant women’s experience of stress is monitored and managed. This seems particularly relevant for

\[2\] It is not uncommon for pregnant women to experience worry about their ability to cope with, and fulfil, their expected role, and also experience concerns about potential role conflict, future childcare arrangements, and economic pressures (Gjerdingen, Froberg, & Fontaine, 1991). Additionally, although a postnatal problem, financial necessity often sees mothers worrying about having to return to work sooner that they may desire (Baistow, 2007).
two reasons: (a) both animal and human studies have displayed prenatal maternal stress to not only be associated with increased negative pregnancy outcomes, such as increased risk of spontaneous abortion and preterm labour (Mulder, Robles de Medina, Huizink, Van den Bergh, Buitelaar, & Visser, 2002), but to also be a significant risk factor in predicting adverse perinatal outcomes (Beddoe, Yang, Kennedy, Weiss, & Lee, 2009); and (b) depressive and anxiety symptoms are common responses to stress which have the potential to negatively impact upon the healthy progression of pregnancy (Beddoe, Yang, Kennedy, Weiss, & Lee, 2009). Moreover, ‘mental health difficulties’ do not just imply serious disorders; but include moderate to relatively minor stressful experiences. Although the latter may be milder in experience, it nevertheless has the potential to have negative impact and be distressing (Baistow, 2007), which, if not managed has the potential to grow in severity causing negative implications for the health and well-being of the mother and developing baby (Lundy et al., 1999).

*Impact of maternal anxiety.* Around 13% of pregnant women experience clinical anxiety states at some point in pregnancy (NICE, 2014). This is concerning because blood flow through uterine arteries of anxious pregnant women has been found to be impaired by the 32\(^{nd}\) week of pregnancy which has been strongly correlated with increased cortisol levels,\(^3\) in both mother and foetus (Weinstock, 2005; Glover, 1999). Of concern here is that impaired blood supply, paired with increased cortisol, contributes to reduced levels of oxygenated blood which is negatively associated with the development of the foetal brain (Weinstock, 2008).

\(^3\) Increased cortisol levels are an indicator of the activation of the biological stress axis that is chronically over activated in persistent anxiety or depression.
Impact of maternal depression. There are a high proportion (12%) of pregnant women who experience a depressive episode during pregnancy (NICE, 2014) and an even greater amount experiencing clinically significant depressive symptom elevations (Gavin, Gaynes, Lohr, Meltzer-Brody, Gartlehner, Swinson, 2005). This is concerning because infants of depressed mothers are at greater risk of preterm delivery and a lower birth weight which are associated with higher maternal basal cortisol levels (Field, Diego, Hernandez-Reif, Figueiredo, & Schanberg, 2006). Additionally, antenatal depression frequently precedes postpartum depression which has been found to have negative implications for the child’s cognitive and emotional development; often the result of impaired or problematic attachment with their primary caregiver (Beebe et al., 2010).

Social and spiritual health and well-being. Although less is known about the impact of pregnancy on this domain of health and well-being it is still none-the-less important to consider. For example, the above health and well-being challenges during pregnancy all have the potential to negatively impact upon social and spiritual health and well-being by potentially disrupting a mother’s experience of relationships, employment and, if relevant, parental competence (Gay, Lee, & Lee, 2004).

Not only, therefore, does the pregnancy process elicit potential challenges for child-bearing women, which may negatively impact on the different domains of their health and well-being, but those pregnant women experiencing more severe symptoms of poor health and well-being have been found to under report symptoms to professionals (Battle, Uebelacker, Magee, Sutton, Miller, 2015). This may be due to stigma associated with accessing support for mental health difficulties, and concerns about treatment: Medication is often viewed as unacceptable during pregnancy by pregnant women (Battle, Uebelacker, Magee, Sutton, Miller, 2015). It
is therefore, important that there are accessible interventions which can preserve and, if necessary help to boost, pregnant women's health and well-being.

**Yogic type interventions.** Yoga is an ancient holistic Indian spiritual discipline that has been used for centuries for health and well-being promotion and stress reduction (Collins, 1998). The history and the mechanisms of change associated with yoga are beyond the scope of the review, but briefly, the deep guided relaxation techniques based on yoga have been linked to reduced sympathetic activity\(^4\) and a shift towards vagal dominance\(^5\) (Satyapriya, Nagendra, Nagarathna, Padmalatha, 2009) associated with adaptive and flexible physiological regulation (Geisler, Kubiak, Siewet & Weber, 2013): Yogic relaxation techniques reduce sympathetic tone in normal volunteers and enhances the plasticity of the autonomic nervous system (ANS); thereby improving the body’s ability to quickly restore its basal state of relaxation after it has responded to a stressor (Satyapriya, Nagendra, Nagarathna, Padmalatha, 2009). Furthermore, cortisol levels have been found to significantly reduce after yoga interventions (Thirthalli, Naveen, Rao, Varambally, Christopher & Gangadhar, 2013).

Recent studies indicate that yoga can improve quality of life in physical conditions such as cancer (Smith & Pukall, 2009) and menopause (Cramer, Lauche, Langhorst, Dobos, 2012). Additionally, yoga has been found to prevent feelings of sadness (Telles, Singh, Joshi, & Balkrishna, 2010) and depression and anxiety disorders (Taso, Lin, Lin, Chen, Huang, Chen, 2014). Prenatal yoga differs from yoga that is geared for the general population because pregnant women have

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\(^4\) The branch of the body’s autonomic nervous system (ANS) responsible for the stimulation of the fight or flight response.

\(^5\) The parasympathetic branch of the body’s ANS responsible for maintenance of the body at rest.
unique physiological needs (Sulochana Gunasheela & Samsthana, 2005). It is, therefore, important to examine yoga specifically during the prenatal period.

With regard to enhancing and preserving the health and wellbeing of child-bearing women, and also supporting those who are experiencing some form of distress, one way yogic type interventions can help is by increasing mindfulness, or non-judgemental attention, which may reduce negative self-judgement, and/or increase focus on the present moment rather than ruminating about the past or future (Battle, Uebelacker, Magee, Sutton, Miller, 2015).

Although reviews do exist about yoga during pregnancy, they have tended to be disorder specific; for example focusing on perinatal depression specifically (Gong, Ni, Shen, Wu, & Jiang, 2015). This review will, therefore, integrate the literature that has investigated yogic type interventions during pregnancy in an effort to better understand, more broadly, the effects of yogic type interventions, during pregnancy, on maternal health and well-being.

The research questions for this review are, therefore, as follows: (1) What methods have been used, during pregnancy, to assess the potential benefits of yogic type interventions on maternal health and well-being? (2) What is the relationship between yogic type interventions and maternal health and well-being during pregnancy?

Method

Protocol and registration. An electronic search was conducted between February and March 2015 and the review was conducted according to the ‘PRISMA’
statement (Moher, Liberati, Tetzlaff, & Altman, 2009) as this allows for a
standardised non-biased approach to the review.

**Eligibility criteria and study selection.** To be included in the review, studies
needed to include: (a) a distinct pregnant sample; (b) an outcome variable related to
well-being; (c) an adult sample (≥18 years); (d) a specific yogic type intervention
(e.g., antenatal yoga); and (e) quantitative.

Studies were excluded if: (a) not in English; (b) were not original research
(e.g., review papers); (c) the health and well-being intervention was for a specific
physical condition (e.g., headache\(^6\)); (d) studies that did not reveal a specific
treatment outcome (e.g., perceived stress and anxiety symptoms); (e) the study was
not specifically exploring yoga as a independent intervention (e.g., massage and
yoga); and (f) qualitative. There were no exclusion criteria surrounding study design,
and there were no parameters set for data to reflect the fact that yoga is an ancient
practice.

**Information sources and searches.** The search strategy involved the
systematic review of published peer-reviewed articles. Databases searched
included: PsychInfo; PubMed; and SCOPUS. The following search terms were used
to search titles, abstracts and keywords: “preg*,” “antenatal,” “prenatal,” “mind-body,”
“complementary,” “yoga,” “well-being,” “benefit,” and “health.” The two terms “yoga”
and “preg*” were linked together using the Boolean operator “AND” in order to
search articles containing both terms. Additionally, terms were searched in
combinations using “AND,” and “OR” with terms within each category (e.g., “yoga”
[OR “mind-body” OR “complementary”] AND “preg*” [OR “antenatal” OR “prenatal”]).

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\(^6\) Anxiety and depressive symptoms were not excluded because they have been described as directly
linked to stress and poor well-being (Beddoe, Yang, Kennedy, Weiss, & Lee, 2009)
No limits were set and “remove related items” was selected. These search terms allowed for multiple spellings, plurals and combinations. In addition to this, there are a number of different types of yoga being practiced today: Some only include physical exercise such as stretching or other specific postures and others, in addition to the physical exercise, are more integrated including specific breathing exercise, meditation and deep relaxation (Gong, Ni, Shen, Wu, & Jiang, 2015). Both were, therefore, accepted. Similarly, there are many different domains of well-being that may be negatively associated with the process of pregnancy; many of which have been previously described in this review and include, for example, relationships, sleep, and mood. Studies were, therefore, evaluated on a case-by-case basis and where there was a measure of ‘well-being’ they were accepted. For example, Rakhshani, Maharana, Raghuram, Nagendra & Venkatram (2010) was included because it explored well-being during pregnancy by assessing the effect of yoga on improving quality of life, dissatisfaction and inter-personal relationships by utilising the World Health Organisation Quality of Life Scale (WHOQOL-100) and Fundamental Interpersonal Relations Orientation (FIRO). Additionally, Satyapriya, Nagarathna, Padmalatha & Nagendra (2013) was included because it explored well-being during pregnancy by studying the effect of yoga on anxiety, depression and well-being by assessing mood and pregnancy experience by utilising the Hospital Anxiety Depression Scale (HADS) and the Pregnancy Experience Scale (PES).

**Data collection process.** A total of 2093 citations resulted from these combinations of search terms across the databases. Removal of duplicates, screening of titles and abstracts, and references screened and added led to 18 full-

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7 Initial searches also returned results about complementary medicine (e.g., herbal medicine) and specific interventions (e.g., managing pain of labour and breast feeding). These were not included.
text papers being read. A further seven were excluded based on inclusion/exclusion
criteria resulting in 11 papers for review (Figure 1).

**Databases Searched:** PsychInfo, PubMed and SCOPUS

**Number of records identified through searches:** 2093

**Titles screened. Number of records deemed to be appropriate:** 107

**Number of records deemed appropriate once duplicates removed and abstracts read:** 70

**Number of records deemed appropriate after exclusion:** 15

**After references screened and added:** 21

**Number of full texts read:** 18

**Papers to be included in review:** 11

**Number or records excluded due to title and/or abstract being misleading:** 55

**Number excluded as unable to obtain full text:** 3

**Number excluded for violating exclusion/inclusion:** 7
Figure 1. Search strategy and process of identification, screening, eligibility and inclusion for the review.

**Data collection/extraction.** To aid data extraction, questions developed by Woolliams, Williams, Butcher & Pye (2009) were, in the first instance, drawn from to focus the review author’s thinking about the value of the literature. Additionally, the EBL critical appraisal checklist (Glynn, 2006) was used alongside the Critical Appraisal Skills Programme (CASP) tools (e.g., CASP cohort study checklist; CASP, 2014) for critical appraisal to ensure all avenues were appropriately considered. Where appropriate, the CONSORT statement (2010) was held in mind when critically appraising RCTs. The Cochrane Collaboration’s tool was used to assist with assessing risk of bias (Higgins, Altman & Sterne, 2011). Strengths and limitations, appropriateness of methodology and measures, statistical issues, quality of reporting and generalizability of the findings were all considered (Table 1).
Table 1

Review: A review of yogic type interventions, during pregnancy, and their effects on maternal well-being.

<table>
<thead>
<tr>
<th>Study</th>
<th>Aims</th>
<th>Population</th>
<th>Intervention</th>
<th>Comparison</th>
<th>Study design</th>
<th>Measures</th>
<th>Main results</th>
<th>Evaluation and risk of bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Battle, Uebelacker, Magee, &amp; Sutton, Miller, 2015</td>
<td>To examine the acceptability and feasibility of a gentle prenatal yoga intervention, as a strategy for treating depression during pregnancy.</td>
<td>Place of study: America</td>
<td>Yoga group (N=34): Yoga intervention: Weekly classes of 75 minutes for 10 weeks. Also provided with a DVD and mat to practice at home. Detailed structure/detail provided. Registered instructors.</td>
<td>No control group</td>
<td>A pilot case series treatment development study with a pre-post intervention design.</td>
<td>Pre-post-comparisons. Baseline (pre-intervention): SCID QIDS EPDS Treatment response antidepressant questionnaire Expectations and satisfaction with treatment: Credibility expectancy questionnaire Exercise/prenatal yoga: International physical activity questionnaire Mindfulness: FFMQ Post-intervention: As above (minus SCID)</td>
<td>Expectancy, credibility, and participant satisfaction: Post-intervention participants, on average, rated their satisfaction as high. Change in Depression Severity: Significant decreases in symptoms over time on both QIDS and EPDS Estimated ESs: Unknown. Minutes practicing: Significantly lower levels of depression were found to be associated with length of time practicing yoga. Estimated ES: Unknown. Correlations: Baseline mindfulness and baseline depression negatively correlated. Pre- and post-analysis: All domains of mindfulness changed in expected direction (increasing) two domains (increased awareness and increased non-judgement) reached significance. Estimated ES: Moderate.</td>
<td>Strengths: Good assessment strategy. Provides information about participant severity. Limitations: Does not present ES for initial analysis. Only includes the mean of the QIDS. Does not have the design to evaluate definitively the efficacy of prenatal yoga in reducing depression. Possible sources of bias: Possible selection bias because of the need for reliable transportation and participants had to have QIDS score of 7 or above. Risk of bias: Low</td>
</tr>
</tbody>
</table>
To evaluate the immediate effects of a prenatal yoga session on cortisol and affect at two gestational ages.

**Place of study:** California, America.  
**Yoga group:** Early pregnancy (time one N=51); mid-pregnancy (time two N=34).  
**Post-delivery (time three N=34).**  
**Inclusion:** 18+ English-speaking Nulliparous 12–19 weeks gestation  
**Exclusion:** Self-reported current depressive/anxiety disorder diagnosis.  
**Control group:** Early pregnancy (time one N=13); mid-pregnancy (time two N=11).  
**Post-delivery (time three N=5).**  
**Recruited via:** Yoga studios.

**Yoga group:** Took part in a 90 minute prenatal Hatha yoga session instructed by a qualified instructor.  
Hatha yoga emphasises physical, mental and breathing techniques to condition the body, focus the mind and connect the body and mind.  
**Control group:** No yoga intervention. Instead, they completed assessments identical to those described for the yoga group only on days of usual activity at each gestational stage (early, mid and post-partum).  
Timing of assessments with regard to gestational/postpartum week and time of day was matched to that of the yoga group assessments.

**A prospective cohort study with a mixed with between subjects design.**  
**Within-subjects:** Stage of pregnancy (early, mid, post-partum).  
**Between-subjects:** Yoga Vs Control group.

**Yoga group early pregnancy (time one):**  
**Pre-intervention:** DABS before 90 minute yoga intervention.  
**Saliva sample provided before and after the intervention.**  
**DABS used to assess affect.**  
**Saliva used to measure cortisol level.**  
**Post-intervention:** 2 days later participants, at the same time as their yoga intervention, again completed the DABS and provided two saliva samples.  
The spare 90 minutes that they had been partaking in the yoga intervention was used to complete the following: CES-D (measure of depressive symptoms); and researcher created questions to assess sociodemographic and health information; and behavioural characteristics.

**Effects of prenatal yoga on cortisol and affect.**  
**Yoga group (yoga) Vs yoga group (usual activity).**  
**Cortisol:** Significant decrease over the yoga session.  
No significant effect of group.  
**Estimates of ES:** Small

**Positive affect:** Significant increase over time.  
No significant effect of group.  
**Estimates of ES:** Medium

**Yoga group (yoga) Vs control group (usual activity).**  
**Cortisol:** Significantly lower in yoga group in early pregnancy.  
**Estimates of ES:** Unknown.

**Strengths:**  
Both within and between subject analyses.  
Subjective outcome measures complemented with physiological outcome measures.  
**Limitations:**  
No power analysis.  
No effect sizes.  
87% of the yoga group had previous experience of yoga.  
Very small N for control group making meaningful comparisons difficult.  
No control over activity on usual activity days.  
Couldn’t look at mid pregnancy as N too low

**Possible sources of bias:**  
Possible selection bias as recruited from yoga classes; so already partaking in yoga.  
Allocation to groups based on clinician.  
Insufficient details about missing data.  
**Risk of bias:** Unclear

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To investigate the effects of antenatal yoga on maternal anxiety and

**Place of study:** Manchester  
**Yoga group (N=29):** Primiparous women 18+ second or early third  
**TAU:** 8 week antenatal, Hatha, yoga course designed and taught by a trained antenatal  
**RCT:** Participants who were randomised into TAU were not allowed to partake  
**Consent (time one):** Both groups given a self-report questionnaire pack  
**Time one and time two mean comparisons.**  
**Within subjects repeated measures.**  
**STAI-S:** Significantly

**Strengths:**  
Comparable groups.  
Subjective & psycho-physiological measures.  
Group/partner massage
To explore the effects of a brief yoga routine on prenatal depression, anxiety and sleep disturbance.

Yoga group (N=46)
Inclusion: Clinically depressed (SCID). Younger than 40 years.
Exclusion: Multiple pregnancy. Complicated pregnancy. Use of drugs (prescribed or illicit).
Control group (N=46)
Inclusion & exclusion:
As above.
Recruited via: Perinatal clinics.

Yoga group:
Women participated in a 20 minute session per week for 12 weeks. Facilitated by a trained instructor.

Control group:
Waitlist control group.

Screening for eligibility:
SCID
Pre- and post-intervention:
CES-D
STAI
Sleep disturbance questionnaire.

Prospective cohort, between subjects, study.

Pre- post-intervention comparisons:
Significant group by treatment session interactions for yoga for CES-D summary score.
Estimated ES: Large.
Significant difference in CES-D subscale scores for affect and somatic/vegetative.
Estimated ES: Large.
Significant differences in STAI scores.
Estimated ES: Large.
Significant differences in sleep disturbances.

Strengths:
Considers anxiety and sleep disturbance as well as depression. Reliable and valid measures used.

Limitations:
No power analysis. No information re: severity. ES not presented.

Possible sources of bias:
Incomparable baseline information between the two samples.

Risk of bias:
Unclear.

TAU group (N=22):
As above.

Overall exclusion:
Multiparous Medical illnesses Taking prescribed medication Already participating in antenatal yoga.

Recruited via:
Medical appointments/perinatal clinics

Inclusion & exclusion:
Younger than 40 years.

Exclusion:
Clinically depressed (SCID).

Inclusion:
Yoga group (N=46)
As above.

Yoga group:
The STAI S was completed pre- and post-session for session one and session eight to explore immediate effects of yoga.

Similarly they provided pre- and post-session saliva samples for session one and session eight to explore immediate physiological effects of yoga.

Between groups post intervention subgroup analysis (excluding those in TAU group who had attended other yoga classes): WDEQ significantly lower in the yoga group compared to TAU. Estimates of ES: Medium.

Cortisol:
Estimates of ES: Large.

TAU could attend external yoga classes. Intervention’s educational element may have been a confounding factor.

Possible sources of bias:
Supplement sequence clearly stated with appropriate random methods but limited information about blindness.

Adequate sample size but generalisability restricted due to the homogeneity of the sample.

Risk of bias:
Unclear.

To study the effect of integrated yoga on anxiety, depression and well-being in normal pregnancy.

Place of study: Bengalum, India.

Yoga group (N=51)
Control group (N=45)

Overall inclusion: 18-20 weeks gestation Prime gravidae or multi gravidae.

Overall exclusion: Associated medical problems Multiple pregnancy IVF Previous history of Complicated pregnancy Maternal physical abnormalities Previous yoga exposure.

Both groups:
Learned the practices from trained instructors in sessions of 2 h/day (3days/week) for one month. Subsequently, they continued the practices at home using a pre recorded instruction cassette for one hour each day.

Both groups had refresher classes of 2 h each time they came for their antenatal obstetric assessment. (Once in 3 weeks up to 28 weeks and every two weeks up to 36 weeks).

Compliance ensured by phone calls and activity diary.

Yoga group:
Practiced an Integrated approach of yoga therapy (IAYT).
Details provided.

Control group:
Practiced standard antenatal exercises.

A prospective randomised two-armed control design with supervised practices for both groups from time of recruitment until time of delivery.

Participants were randomly placed into yoga or control group by a computer generated random number.

Recruitment (time one):
All participants were given the following measures:
- PES
- STAI
- HADS

36 weeks gestation (time two):
As above.

STAI-State:
Reduced in the yoga group.
Increased in the control group.
Significant differences between groups.
Estimated ES: Large.

STAI-Trait:
Reduced in the yoga group.
Increased in the control group.
Significant differences between groups.
Estimated ES: Moderate.

HADS Anxiety:
Reduced in the yoga group.
Significant differences between groups.
Estimated ES: Large.

HADS Depression:
Reduced in the yoga group.
Significant differences between groups.
Estimated ES: Moderate.

PES:
Reduction in the yoga group.
Significant group difference.
Estimated ES: Moderate.

Strengths:
Groups matched on baseline maternal characteristics. Power analysis completed. Sufficient N.

Limitations:
Unexpected number of dropouts from control group due to popularity of yoga.

Possible sources of bias:
Full blinding not possible due to nature of intervention but accounted for and masking used where possible.

Risk of bias:
Low.

Estimated ES: Small.

Risk of bias:
Low.

Estimated ES: Moderate.
To assess the effects of yoga on prenatal depression symptoms.

Yoga group: 20 minute sessions 2 times a week for 12 weeks.
Trained instructor.
Details about 20 minute routine provided.

Parenting education attention (control) group: Participated in parenting education sessions to control for the effects of attention and social support received by the women in the yoga group.

Prospective cohort study. Between subjects factor of group (yoga vs parenting education attention control group)

Completed pre- and post-intervention (20 weeks and 32 weeks gestation)
CES-D

Pre- post-intervention comparisons:
CES-D:
Significant decrease in CES-D summary score. No significant effect of group.

Estimates of ES:
Large (yoga)
A significant group by time interaction.
Estimated effect size: Modest.

Post hoc:
The group by time interaction effects were significant for depressed affect (modest ES) and somatic/vegetative subscales (modest ES).

Strengths:

To explore the feasibility, acceptability and efficacy of M-Yoga in reducing symptoms of depression among pregnant women with current and lifetime psychiatric diagnoses.

Yoga group: 10 week prenatal M-Yoga class facilitated by trained instructors. Classes met once a week for 90 minutes that focused on a variety of poses. M-Yoga differs from typical Hatha yoga classes by highlighting mindfulness practice with targeted instructions, reminders and readings.

Details provided about

Women completed the following at consent (time one):
SCID
EPDS
If eligible they completed:
BDI-II
FFMQ-R
MFAS
Post-intervention:
BDI-II
FFMQ-R
MFAS
A brief feedback survey regarding acceptability.

Qualitative:
Women felt yoga was helpful and perceived the social support positively. Pre-post intervention analysis:

Strengths:
Consideration of potential confounding variables. Use of multiple validated and reliable outcome measures. Limitations:
No severity information. Detailed yoga procedure limited and varied depending on participant need. No control group. Group Support not included as a confounding factor. Self-report measures.

Strengths:

To assess the effects of yoga on prenatal depression symptoms.

Parenting education attention (control) group: Participated in parenting education sessions to control for the effects of attention and social support received by the women in the yoga group.

Prospective cohort study. Between subjects factor of group (yoga vs parenting education attention control group)

Completed pre- and post-intervention (20 weeks and 32 weeks gestation)
CES-D

Pre- post-intervention comparisons:
CES-D:
Significant decrease in CES-D summary score. No significant effect of group.

Estimates of ES:
Large (yoga)
A significant group by time interaction.
Estimated effect size: Modest.

Post hoc:
The group by time interaction effects were significant for depressed affect (modest ES) and somatic/vegetative subscales (modest ES).

Strengths:

To assess the effects of yoga on prenatal depression symptoms.

Parenting education attention (control) group: Participated in parenting education sessions to control for the effects of attention and social support received by the women in the yoga group.

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Pre- post-intervention comparisons:
CES-D:
Significant decrease in CES-D summary score. No significant effect of group.

Estimates of ES:
Large (yoga)
A significant group by time interaction.
Estimated effect size: Modest.

Post hoc:
The group by time interaction effects were significant for depressed affect (modest ES) and somatic/vegetative subscales (modest ES).

Strengths:

To assess the effect of selected yoga exercises on anxiety symptoms in pregnant women during the second and third trimester.

**Recruited via:**
Perinatal clinics intervention.

**Pregnant participants (N=24).**
- **Second trimester**
  - Yoga group (N=7)
  - Control group (N=5)
- **Third Trimester**
  - Yoga group (N=6)
  - Control group (N=6)

**Inclusion & exclusion:**
Apart from 'any diseases that would prevent them from doing the exercises were not participated in the study' this was unclear.

**Yoga group**
An 8 week course of selected yoga exercises taught two days a week for 60 minutes by a qualified instructor.

**Control group**
No information provided

**POQ**
In both the second and third trimester, mean anxiety decreases between pre- and post-intervention for the yoga group.

A repeated measures ANOVA presented a significant main effect of time (pre and post) Estimated ES: Unknown

**Strengths:**
- Parametric assumptions considered.
- Appropriately randomised.
- Sufficiently large enough sample to reduce chance of type 1 & 2 errors.

**Limitations:**
- The reliability and the


To assess the effect of integrated yoga on improving quality of life as well as the sources of tension, incompatibility, Place of Study:
Bangalore, India.

**Yoga group (N=51):**
- 18+ Between 18 and 20 weeks gestation
- Normal pregnancy
- Control group (N=51):
  - As above.

**Overall exclusion:**
- Yoga group: Taught for 1 hr sessions three times a week for one month. Sessions led by a trained instructor.
- Control group: Standard antenatal exercises taught to control group for 1 hr sessions three times a week for one month. Sessions led by a trained instructor.

**Baseline (time one):**
- Both groups given WHOQOL-100 and FIRO.
- 36 weeks gestation (time two):
  - As above.

**WHOQOL-100:**
Significant differences between groups with higher improvements in the yoga group Vs controls in the physical,

**Strengths:**
- Presents ES.
- Appropriately randomised.
- Sufficiently large enough sample to reduce chance of type 1 & 2 errors.

**Limitations:**
- The reliability and the
and dissatisfaction in women during their normal pregnancy that could potentially affect interpersonal relationships.

Any high risk pregnancy conditions that would heighten the stress adaptation including: Medical conditions; multiple pregnancies; IVF; history of severe pregnancy complications; and foetal abnormalities. Previous yoga exposure.

**Both groups:**
After being taught for a month they continued their respective practices at home with a pre-recorded cassette until delivery.

One hour refreshers were given when they attended routine check-ups.

Completed a ‘practice diary’ so practice at home could be monitored.

**Recruited via:**
Antenatal clinics.

**Place of study:**
San Francisco, America.

**Yoga group (N=16)**
Inclusion:
18+
Able to read and write in English
Expecting 1st baby
Planning hospital birth
12 – 32 weeks gestation.

Exclusion:
Multiple pregnancy
Current psychiatric

**Yoga group**
7 week mindful yoga intervention. Sessions lasted 75 minutes.
Combined elements of yoga methods of Lyengar and the curriculum of mindfulness-based stress reduction, relaxation and stress management.

**N/A**
No control group

A pilot case series feasibility study with a pre-post intervention design.
Within subjects factor of intervention (pre-post).

**Pre- post-intervention assessments.**

**Pre-intervention:**
PSS
PPP
STAI (trait & state)
BPI
Saliva sample

**Post-intervention**
As above with addition of psychological, social relationships and general health domains.

**Estimates of ES:**
Medium.

**FIRO between subjects:**
Significant difference between expressed inclusion and wanted control domains; near significance for wanted affection.

**Estimates of ES:**
Small

**FIRO within subjects:**
Significant improvements in all FIRO domains (expressed inclusion, wanted inclusion, expressed control, wanted control, expressed affection, and wanted affection). There were no significant improvements in any domains for the control group.

**Estimates of ES:**
Large

**Validity of the measures used are unknown amongst the Indian population.**

**Possible sources of bias:**
Although full blinding was not possible appropriate steps were taken to mask staff/researchers wherever possible. Sufficient information provided about sequence procedure. Generalizability possibly restricted due to the characteristics of the.

**Risk of bias:**
Low.

**10. Beddoe, Yang, Kennedy, Weiss, & Lee, 2009.**

To examine the feasibility and acceptability of a mindful yoga intervention during pregnancy.

**Strengths:**
Good description of the yoga intervention. Combination of both self-report measures and physiological outcome measures.

**Limitations:**
No ES. Alpha level of .10: Difficult to interpret how meaningful significant differences are.

Pre-post comparisons. Perceived stress:
Significant decrease in perceived stress for the third trimester group.

**Estimates of ES:**
Moderate.

 Trait anxiety:
Significant decrease in third trimester.

**Estimates of ES:**
Moderate.
illness
Current medication for pain, sleep, depression or anxiety
Night shifts
Diabetes, hyper-tension, HIV.
History of back surgery.

Recruited via:
Perinatal clinics.

Qualified instructor
Details of Lyengar yoga provided.

subjects factor of group
(second Vs third trimester).

acceptance questionnaire.

State anxiety:
No significant changes for either group.

Pain: No significant changes over time and no significant differences between trimester groups.

There was a significant time by group effect for overall BPI scale: Second trimester women had significantly lower BPI scores post-intervention compared to the third trimester women.

Significant group differences in pain intensity: Pain intensity was significantly higher post intervention for third trimester women Vs second trimester women.

Cortisol:
No significant differences in cortisol by trimester.

Acceptibility:
63% reported feeling more hopeful and confident; having a greater knowledge of what is stressful in their lives and knowing how to better take care of themselves, having greater awareness of a stressful situation at the time it occurs and having the ability to appropriately handle stressful situations.

Validity threatened by no control group.
Small N.
Possible sources of bias:
Main researcher was the intervention facilitator. Possible selection bias as influenced by working hours and transport availability.
Risk of bias:
Low.


To assess levels of perceived and objective measures of

Place of study:
Bangalore, India

Yoga group (N=45):
Inclusion:
18th – 20th weeks

Yoga:
Practiced 2 modules of integrated yoga, specifically designed for the 2nd and 3rd trimester

Control:
Practiced standard prenatal exercises which included simple stretching

Prospective, randomised 2-arm study in which all pts engaged in

Pre- and post-intervention analysis.

PSS:
Given pre, mid, and post intervention.

Pre- post-intervention analysis.

Strengths:
Presents effects sizes. Randomised. Good sample size. Objective physiological
stress in response to yoga modules integrating a yogic-guided deep relaxation technique. 

gestation
Primigravidity, or multigravidity when the participant had at least one living child.


Control group (N=45)
As above

Both groups: In 1st month learned movements from trained instructors in 2 hr sessions 3 days per week.

After 1 month the pts continued their practice at home for 1 hr using a pre-recorded tape.

Both groups had refresher classes each time they came for their prenatal visits, once every 4 weeks up to 28th week and every 2 weeks up to 36th week. Compliance for at home practice ensured by telephone calls and activity diary.

Recruited via:
Obstetric units.

The modules used in the yoga group were based on concepts from yoga scriptures. All procedures described in detail.

Mean score increased in the control group. Significant group difference.

Estimated effect size: Small.

HRV during yoga and control interventions: 20 and 36 weeks:
Measures of sympathetic tone decreased in both groups. Significant group difference with a greater reduction in the yoga group.

Estimates of ES: Large.

Measures of parasympathetic tone increased in both groups. Significant group difference with greater increase in yoga group.

Estimated effect size: Large.

HRV post -yoga and control interventions. 36 weeks:
The low frequency band was significantly reduced post-yoga intervention but not post-control intervention.

Estimates of ES: Moderate.

The low frequency/high frequency was significantly reduced post-intervention in both groups (yoga and control)

Estimates of ES: Moderate - Large.

The high frequency band was significantly increased outcomes as well as subjective outcomes.

Limitations: Interaction between two groups could not be avoided. Possible sources of bias:
Full blinding not possible due to nature of intervention. Possible selection bias toward those who are 'open' to alternative treatment and those who are compliant with prenatal healthcare.
Risk of bias:
Low.
Estimate of effect size was calculated based on reported means and standard deviations in the study.
Results

Review question 1: What methods have been used to assess the potential benefits of yoga, during pregnancy, on maternal well-being?

**Design.** A total of 11 papers were reviewed. Four were RCTs (3, 5, 9, & 11), four were prospective cohort studies (2, 4, 6, & 8) and three were prospective case-series studies (1, 7, & 10). Where design incorporated a control group these varied from wait-list control (4) and TAU (3), to a specially designed parenting education control group (6).

Although causal inferences are suggested from the RCTs it is important to consider their limitations and possible sources of bias as listed within the review table and later discussed. The other studies are observational in nature and so, although some included a control group, no causal inferences can be made.

**Participants.** Total sample sizes ranged from 16 (10) to 102 participants (9). For the comparative studies total control group size ranged from 12 (6) to 51 participants (9) with yoga groups ranging from 12 (6) to 51 participants (2 & 5).

The studies’ inclusion and exclusion criteria varied depending on whether the sample was required to have clinically significant affective disorder symptoms (clinical sample) or not: Seven studies included a healthy sample (2, 3, 5, 8, 9, 10, & 11), and four included a clinical sample (1, 4, 6, & 7). All studies included the exclusion criteria of a complicated pregnancy. For those studies including a clinical sample, only one out of the four provided information about the severity of their sample which included mild – severe depressive symptoms (1).

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1 RCTs were defined as studies where the participants had been clearly randomised into different groups. Prospective cohort studies were defined as studies where there was a clear control group but allocation was not based on randomisation. Prospective case studies were defined as studies where there was no control group.
Nine of the studies recruited women from obstetric and perinatal settings (e.g., perinatal clinics; 1, 3, 4, 5, 6, 7, 9, 10, & 11). One study recruited from a yoga studio (2) and another did not include this information (8).

**Interventions.** Four studies utilised antenatal yoga (1, 2, 3 & 6), three studies utilised integrated yoga (5, 9 & 11), two studies utilised mindfulness-yoga (7 & 10) and two studies were not clear about what yoga modality they were drawing from (4 & 8). The studies varied on the amount of detail provided about their interventions.

**Measures.** The studies used a variety of measures to explore maternal well-being, dependent on their aims. However, there was overlap on some of their measures of wellbeing: Seven studies included symptoms of depression (1, 2, 3, 4, 5, 6, & 7) five included symptoms of anxiety (3, 4, 5, 8, & 10), two included perceived stress (10 & 11), one included quality of life (9), one included general well-being (5), and one included sleep disturbance (4). Additionally, five studies utilised psychophysiological measurements to assess well-being including cortisol levels (3, 2, 10, & 6) and heart rate variability (11).

The following measures were, therefore, used to measure and assess well-being: The Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden, & Sagovsky, 1987); the Beck Depression Inventory (BDI; Beck, Ward & Mendelson, 1961); Quick Inventory of Depressive Symptomatology (QIDS; Rush et al., 2003); Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983); Centre for Epidemiologic Studies Depression Scale (CES-D; Santor & Coyne, 1997); Perceived Stress Scale (PSS; Cohen, Kamarck & Merzelstein, 1983); Pregnancy Outcome Questionnaire (POQ; Theut, Pedersen, Zaslow, & Rabinovich, 1988); Five Facet Mindfulness Questionnaire (FFMQ; Baer, Smith, Hopkins, Krietemeyer, & Toney,
2006); Prenatal Psychosocial Profile (PPP; Curry, Burton, & Fields, 1998); State-Trait Anxiety Inventory (STAI-T, STAI-S; Spielberger, Gorsuch, & Lushene, 1970; Spielberger, 1983); Brief Pain Inventory (BPI; Daut, Cleeland, & Flanery, 1983); Pregnancy Related Experience Questionnaire (PES; DiPietro, Ghera, Costigan, & Hawkins, 2004); Fundamental Interpersonal Relations Orientation (FIRO-B; Schutz, 1958); Wijma Delivery Expectancy Questionnaire (WDEQ; Wijma, Wijma & Zar, 1998); Maternal Foetal Attachment Scale (MFAS; Cranley, 1981); World Health Organisation Quality of Life (WHOQOL-100; WHOQOL Group, 1995); Derogatis Affect Balance Scale (DABS; Derogatis, 1975); and a Sleep Disturbance Questionnaire (Snyder-Halpern & Verra, 1987).

As well as well-being outcome measures, three studies included results about acceptability and feasibility of the interventions (1, 7, & 10), and two studies generated qualitative results from author created satisfaction questionnaires (7 & 10) and one from the credibility expectancy questionnaire (1).

The structured clinical interview (SCID; First, Spitzer, Gibbon, & Williams, 2002) was used by four studies (1, 4, 6 & 7) at consent to check for eligibility (if requiring a clinical sample) and the maternal social support scale (MSSS) was used by one study to gather additional baseline information (3).

Method of analysis. Five studies employed parametric statistics to examine within and between group differences (e.g., repeated measures ANOVA; 6, 7, 8, 10, 11). Some of these also employed bivariate correlations to examine associations. Four studies employed a mixture of non-parametric (Mann Whitney U, Wilcoxon Signed Rank and Spearman Rank) and parametric tests (independent and dependent t tests and Pearson) to account for some data being normally distributed.
and some not (1, 3, 5, & 9). One study employed generalised estimating equations to compare a yoga intervention to other conditions (2), and another employed a multi-level linear modelling approach to examine change in depression over time (3).

**Review question 2: What is the relationship between yogic type interventions and maternal well-being during pregnancy?**

**RCTs.** Three out of the four RCTs found significant group differences with participants in the yoga interventions displaying well-being improvements in stress, quality of life, interpersonal relations, state and trait anxiety, pregnancy specific anxiety, and depression (5, 9 & 11) as reported from self-report measures (i.e., PSS, WHOQOL-100, FIRO-B, STAI-S, STAI-T, PES & HADS) and measured by the psycho-physiological marker HRV (11). These three studies calculated their effects sizes: Cohen’s d ranged from small to large, with small effects observed for perceived stress (11) and interpersonal relations (9); moderate effects observed for trait anxiety (STAI-T; 5), depression (HADS; 5), pregnancy specific anxiety (PES; 5) and quality of life (WHOQOL-100; 9); and large effects observed for state anxiety (STAI-S; 5), anxiety (HADS; 5), and HRV (11).

However, one out of the four RCTs (3) failed to find group differences for anxiety and depression as reported from self-report measures (STAI-S, STAI-T & EPDS) and measured by the psycho-physiological marker cortisol. Despite this a significant group difference was found for pregnancy specific anxiety as reported from the self-report measure (WDEQ), and within subject’s improvements, for those in the yoga intervention, were found for anxiety as reported from the self-report measure (STAI-S) and measured by the psycho-physiological marker cortisol. The reviewing author had to calculate effects sizes: Cohen’s d ranged from moderate to large, with moderate effects observed for pregnancy specific anxiety (WDEQ), and
large effects observed for state anxiety (STAI-S) and cortisol. However, with regard to pregnancy specific anxiety, caution needs to be taken because this significant group difference was a result of sub-group analysis which may increase the risk of bias (3).

**Controlled studies.** No main effect of group was found in any of the controlled studies, however, two out of the four comparative studies (4 & 6) found a group by time interaction whereby those in the yoga interventions showed improvements in overall depression, and in depressed affect and somatic subscale scores as reported from self-report measures (CES-D; 4 & 6). Additionally, anxiety and sleep disturbances were found to improve over time amongst those in the yoga groups as reported from self-report measures (STAI & sleep disturbance questionnaire; 4). The review author had to calculate effect sizes: Cohen’s d ranged from small to large with small effects observed for sleep (4); moderate and large effects observed for depressed affect and somatic subscales (6 & 4); and large effects observed for overall depression (CES-D; 4 & 6) and anxiety (STAI; 4).

Similarly, one out of the four comparative studies (8) reported an improvement in anxiety over time for those within a yoga intervention as reported from the self-report measure (POQ; 8). However, the reviewing author could not calculate effect sizes as means and standard deviations were not provided.

The final one out of the four comparative studies (2) reported a significant decrease in depression, and increase in positive affect, over the course of a yoga session as reported from self-report measures (DABS & CES-D) and measured by the psycho-physiological marker cortisol. The review author had to calculate the effect sizes: Cohen’s d ranged from small to moderate with small effects observed for cortisol changes and moderate effects observed for affect changes.
**Non-comparative studies.** The three non-comparative studies demonstrated a variety of findings. Stress and anxiety were found to significantly decrease pre-post-yoga intervention as reported by self-report measures (PSS & STAI-T; 10). However, there were no significant differences found for pain or state anxiety as reported by self-report measures (BDI & STAI-S) or the psycho-physiological marker cortisol (10). Additionally, improvements in depression were found as reported by self-report measures (QIDS, EPDS & BDI; 1 & 7) and these improvements were also found to be associated with the amount of time spent practicing yoga (1). Moreover, significant improvements were observed in mindfulness skills as reported by the self-report measure (FFMQ, 7). Furthermore, correlations revealed negative relationships between baseline depression as reported by the self-report measure (BDI) and post-intervention mindfulness as reported by the self-report measure (FFMQ; 1 & 7). Similarly, a negative relationship was revealed between baseline depression and foetal attachment (7). Additionally, all domains of mindfulness improved pre-post-intervention (1) with increased awareness and non-judgement reaching significance as reported by the self-report measure (FFMQ; 1).

The review author had to calculate all effect sizes: Cohen’s d ranged from small to large with small effects observed for the negative correlation between baseline depression and post-intervention foetal attachment (7); moderate effects observed for the significant improvement in mindfulness skills (1), and improvement in stress and trait anxiety (10); and large effects were observed for the negative correlation between baseline depression and post-intervention mindfulness skills (7). It was not possible to calculate effect sizes for reduction in depression as reported by the QIDS and EPDS (1) because there were no means or standard deviations presented.
Discussion

The studies included within this review consider a broad range of factors related to health and well-being during pregnancy including: Depression and anxiety symptoms; perceived stress; quality of life; general well-being; sleep quality; perceived pain; cortisol and cardiovascular markers. This broad range included within studies reflects the many different domains to health and well-being. Moreover, the majority of studies included a measure of anxiety and/or depressive symptoms, which are in-line with literature suggesting that depressive and anxiety symptomatology often occur, at least in part, as a consequence of stressful life experiences (Beddoe, Yang, Kennedy, Weiss, & Lee, 2009). Few studies included spiritual well-being outcomes.

The majority of studies found statistically significant benefits, or observed improvements, to health and well-being from partaking in yogic type interventions during pregnancy. However, only four of these were RCTs and, despite their more rigorous design nature, they still included design limitations and concerns such as generalizability to the wider population, due to homogenous samples, and queries about the blinding procedures. Additionally, the other study designs, by their nature, cannot infer causality because they were either not controlled enough or did not include a comparison group. Moreover, it is tricky to disentangle potential confounding factors from the effects of the intervention (e.g., social support from the group). This is further complicated by there being different types of yogic interventions included within the studies; so although the majority of studies do find some benefit to the many domains of health and well-being by engaging in yogic type interventions during pregnancy, the question still remains about what is it from the intervention that helps: What are the effective components (e.g., physical
exercises/postures, relaxation technique and/or mindfulness skills). Such challenges are further complicated by there being a broad range of well-being domains explored amongst the studies, and the majority of studies not providing adequate detail about their yogic interventions; both of which make drawing specific conclusions about how yoga may benefit particular areas of well-being during pregnancy challenging.

Specifically, although there were some RCTs that utilised the same yogic type intervention (integrated yoga; 5, 9 & 11) each RCT was interested in different well-being domains. It is, therefore, only possible to generally conclude from these RCTs, that integrated yoga is beneficial for many different areas of well-being during pregnancy. It is challenging, from these studies alone, to be more specific. For this to happen further RCTs would need to be conducted that replicate the areas of interest presented by these RCTs. At this stage, it can only be generally concluded that the areas of well-being that have been explored across the RCTs are broad-ranging and that yoga does appear to have benefits during pregnancy by showing greater improvements to areas of well-being compared to control groups. For example, stress (as a measure of well-being) was found to reduce in the yoga group and increase in the control group with a significant group difference (Satyapriya, Wagendra, Nagarathna & Padmalatha, 2009).

However, there was overlap amongst two of the RCTs in their area of interest (3 and 5): Both explored the effect of yoga on anxiety and depression but revealed inconstant results. They both utilised the same outcome measures for anxiety (STAI-S & STAI-T) but did not use the same outcome measure for depression. This makes the inconsistent results for depression more challenging to disentangle. Additionally, these inconsistent findings for anxiety and depression are further complicated because the two RCTs did not use the same yogic intervention (one used integrated
yoga and the other antenatal yoga). The different interventions, and the overall
general lack of detail about both interventions provided by these RCTs, make
drawing conclusions about these inconsistent results difficult. However, like the
majority of studies included within this review, the sample that failed to show any
difference in anxiety and depression was healthy (3) which may suggest that
although there was no observed improvement for this particular sample, that the
participation in the yoga intervention may have helped participants to preserve and
maintain their already adequate mental well-being. Additionally, the RCT that found
improvements had a larger sample size.

When discussing the results from the RCTs, there are some important study
design limitations to consider which may even suggest that the general conclusion
that yoga is beneficial for many different areas of well-being during pregnancy,
needs to be considered with caution. Although the majority of the RCTs had good
sample sizes of over 95 participants and utilised outcome measures that were
reliable and valid (5, 9 &11) there are some concerns. For example, for three of the
RCTs the population used were Indian (5, 9 and 11); within which, the validity and
reliability of the measures used is unknown. Additionally, it was not possible to
prevent interaction between the different groups (5, 9 and 11). Moreover, in terms of
risk of bias amongst these RCTs, one study recruited women from a yoga studio
resulting in the sample consisting of pregnant women already practicing yoga; some
of whom had previous life-time experiences of yoga as much as 10 years.
Furthermore, in one of the RCTs women who were originally randomised into the
control condition requested to be placed into the yoga arm of the study because of
its popularity and were allowed to do so (5). It is, therefore, challenging to
disentangle any apparent positive effects of short term yoga during pregnancy from
the life-time experience of engaging with yogic type practice and, arguably, any randomisation procedure has potentially been contaminated. Finally, due to the nature of the RCTs, it was not possible for there to be a full blinding procedure and, in addition to this, there was generally insufficient information available about participant sequencing and allocation. For example, they lacked detail about whether or not appropriate safeguards were taken to minimise bias.

Amongst the comparative studies, there was similarly little overlap in their areas of interest and so it is, again, difficult to draw conclusions about specific areas of well-being across pregnancy because the areas of interest explored are broad ranging. However, despite this, the four comparative studies provided some consistent findings with some of the RCTs by showing improvements to the following areas of physical and mental well-being: Anxiety and depressive symptoms; cortisol levels; and positive affect. Additionally, there were also positive findings from these comparative studies for other areas of well-being that had not been explored by RCTs (e.g., sleep disturbance). However, in order for such a positive finding to be concluded, it would need to be replicated within a study with greater rigour so, therefore, needs to be interpreted with caution. Moreover, even though some of the observed improvements to anxiety and depression, amongst the comparative studies (2 & 4), are consistent with the findings from a more rigorous RCT (5), this consistency needs to be interpreted with caution: The RCT utilised integrative yoga whereas the comparative studies used antenatal yoga (2) or did not provide adequate information about the type of yoga (4). Moreover, one of the RCTs (previously discussed) that utilised antenatal yoga (3) found no improvements for anxiety and depression. This further demonstrates that the positive findings from the
comparative studies that appear to be consistent with some of the RCT findings need to be interpreted with caution.

Furthermore, and similar to the RCTs, there are some important study design limitations amongst these comparative studies, which may suggest that the general conclusion that yoga seems beneficial for many different areas of well-being across pregnancy needs to be considered with caution. Although there was strength including good inclusion of a more ethnic diverse sample (6), and good consideration of parametric assumptions within the results section (8), there were some concerns. For example, many of the comparative studies did not provide adequate detail about their choice of yoga interventions (if at all), and some studies did not exclude participants participating in (for example) psychotherapy alongside the yoga intervention (6). This reiterates the challenges associated with disentangling potential mechanisms of change. Moreover, there were limited power calculations provided and there was also incomparable baseline information between groups. Such design limitations make it challenging to draw meaningful interpretations from any of the findings (2, 4, 6 & 8) and also result in any analysis being vulnerable to confounding factors. Moreover, in terms of risk of bias amongst these comparative studies, there was little information about how the participants were allocated to groups (2, 4, 6 & 8), and there was also a risk of selection bias because some studies recruited participants directly from a yoga classes (2 & 4).

When discussing the findings from the non-comparative studies, it becomes clear that it is difficult for them to add anything further due to the nature of their design. Although there are consistent findings with previous comparative studies and RCTs for the well-being domains of depression, anxiety and stress, it is not possible to infer meaning and suggest that yoga improves these areas of well-being, from
these studies alone, due to the lack of controls. Moreover, two of the non-comparative studies (7 & 10) used a type of yoga that had not been used in the previously discussed comparative and RCT studies; mindfulness based yoga, and the other utilised antenatal yoga (1). This is an important caveat because mindfulness based yoga has not been explored by any of the more rigorous study designs in this review, and one of the RCTs in this review that used antenatal yoga did not find any significant improvements for depression and anxiety. These positive findings, therefore, from the non-comparative studies need to be interpreted with extreme caution and to be able to draw conclusions they would need to be replicated by more rigorous study design.

Additionally, and similar to the previously discussed RCTs and comparative studies, there are some important study design limitations amongst these non-comparative studies which further demonstrate that the findings need to be interpreted with caution. Although many of the non-comparative studies have a good assessment strategy including consideration of confounding variables (1, 7 & 10), their overall sample sizes are small and also validity is threatened due to the lack of a control group: Their designs cannot definitively evaluate the efficacy of yoga in improving well-being. Moreover, in terms of risk of bias amongst these non-comparative studies, they included women who were ‘open’ to partaking in ‘alternative’ interventions. The participants, therefore, may well have had prior beliefs about yogic interventions which may have affected their engagement and subsequent findings. Additionally, within many of these non-comparative studies it was emphasised that it was important to be able to attend the intervention on a regular basis so having access to reliable transport was encouraged. This may have
biased against women who perhaps do not have access to transport which may be indicative of their financial situation.

Overall, when considering all study designs, there are study design limitations that need to be considered. For example, all yogic interventions were different across all studies even if they were utilising the same ‘type’ (e.g., integrated or antenatal yoga). For example, they ranged from 20 minute sessions twice weekly to 75 minute sessions for 10 weeks. Additionally, in terms of overall bias, the location of recruitment was a source of potential bias for all studies regardless of design. Women were mainly recruited from antenatal clinics when they attended regular check-ups and appointments. This raises questions about compliance with health care; it seems that the samples mainly consisted of compliant pregnant women who attended regular health checks, This is perhaps biased against women who are not compliant and perhaps, as a result, have a more challenging/distressing experience of pregnancy.

The study design limitations and potential sources of bias highlighted amongst the different study designs, and the overall study design limitations and potential sources of bias across studies lead to the generalization of results being challenging.

**Strengths and weaknesses of this review.** This review acknowledges that well-being during pregnancy is a broad concept: It integrates different aspects of well-being that can be impacted upon during pregnancy and allows the author to better understand, the potential benefits of yogic type interventions during pregnancy, more broadly than has been presented elsewhere.

The search for papers was systematic with appropriate search terms and the quality of the papers, alongside consideration of potential bias, has been presented and discussed. This review, however, had inclusion and exclusion criteria that may
be viewed as weakness: It included both clinical and non-clinical samples which may be considered as too broad. However, inclusion of both has enabled the author to critically appraise the design of a broad range of studies and it supports the existing line of argument that ‘mental health problems’ range from serious disorders to moderate and relatively minor conditions and it is important to manage both ends of the spectrum effectively (Baistow, 2007). Additionally, it is in-line with the important concept of preserving healthy pregnant women’s well-being.

**Conclusions and Implications and Future Research.** Yoga has been used for centuries as an intervention to improve both physical and mental health. This review highlights a body of evidence that suggests, at an observational level, that practicing yogic type interventions, during pregnancy, are beneficial for pregnant adult’s maternal well-being (in uncomplicated and healthy pregnancies) by either preserving or improving it.

Initial evidence suggests self-report and physiological markers of well-being show greater improvements compared to control groups and where control groups were not available, the yogic type intervention seemed promising. However, the design limitations and potential biases that have been identified, alongside the broad range of well-being domains included within the studies means that it is difficult to draw conclusions about specific areas of well-being, and that the general conclusion that yoga is beneficial for many different areas of well-being during pregnancy, needs to be interpreted with caution. Furthermore, although there is some overlap of interest (for example, anxiety and depression) there are some inconsistent findings amongst the studies.

In terms of clinical practice implications, given the variety of yogic type interventions used, this it is challenging: There is a continued lack of understanding
regarding the mechanisms that underlie any seemingly positive impact that yoga has on maternal well-being. Additionally, any observed improvements in the variety of well-being domains need to be interpreted with caution because they are vulnerable to multiple study design limitations and some level of bias. Larger, more diverse samples should be sought to include factors such as being unmarried and having a low income: Both of which can increase risk of depressive symptoms and stress amongst women (Mitchell, Field, Diego, Bendell, Newton & Pelaez, 2012). There is also an argument to suggest that care and attention should be directed towards ensuring that well-being questionnaires are validated amongst a pregnant sample. Future studies should also include a more comprehensive battery of variables to allow more insight into potential mechanisms of change and ensure that the same type of yogic intervention is used.
References


SCHOOL OF PSYCHOLOGY
DOCTORATE IN CLINICAL PSYCHOLOGY

EMPIRICAL PAPER
Physiological Regulation, Responses and Reactivity towards Infant Related Stimuli, during Pregnancy, and their Relationship with Affective Disorder Symptoms

Trainee Name: Hannah Curtis
Primary Research Supervisor: Dr Heather O'Mahen
Senior Lecturer in Clinical Psychology, Mood Disorders Centre, University of Exeter.

Secondary Research Supervisor: Dr Anke Karl
Senior Lecturer, University of Exeter.

Target Journal: Journal of Developmental Psychology
Word Count: 8000 words (excluding abstract, all headings, footnotes, references and appendices).

Submitted in partial fulfilment of requirements for the Doctorate Degree in Clinical Psychology, University of Exeter
Abstract

Objective: Pregnancy requires thorough monitoring and management because not only is it a time where normal physiological and psychological changes put a mother under stress and strain, but maternal sensitivity begins to develop, and the developing foetus needs a well regulated intrauterine environment. Such important processes can be compromised by abnormal or inconsistent physiological and emotional regulation. The study aimed to explore pregnant women’s regulation capacity at rest and their physiological reactivity, and return to physiological baseline, in response to infant related stimuli. Methods: Extended analyses of previously acquired psycho-physiological data at baseline, and pre- and post-presentation of relevant audio-visual stimuli. Results: Baseline physiological activity was significantly different between pregnant participants and controls. There were, however, no other differences in reactivity. Conclusion: Findings were inconsistent with previous research which indicates infant stimuli to become increasingly salient throughout pregnancy.
Introduction

Pregnancy serves to protect the developing infant by striving to nurture it within a well regulated; consistent, maternal environment. It is vital that this period is monitored and managed because, overall, pregnancy is an important life transition involving multi-level adjustment. More specifically, it is a period of vulnerability (Baistow, 2007) with a marked incidence and prevalence for stress (Patrick & O'Keane, 2007) and psychiatric symptoms and disorders (Seneviratne & Conroy, 2004).

Stress, anxiety and depressive symptoms are common during pregnancy and early identification and intervention are important (NICE, 2014). Research demonstrates the substantial association between poor maternal well-being, during pregnancy, on long-term child outcomes. For example, antenatal depression is an independent risk factor for offspring depression (Pearson et al., 2013), and offspring of mothers with poor maternal well-being are at elevated risk of developing an affective disorder with both genetic and environmental determinants being attributed as causal factors (Dean, Stevens, Mortensen, Murray, Walsh & Pedersen, 2010; Saudino, & Eaton, 1991).

Pregnancy is also accompanied by physiological and psychological changes and maternal sensitivity develops throughout pregnancy (Pearson, 2010); preparing the mother to attend appropriately to her infant post-delivery. These processes further highlight the importance for successful adaptation during this transition, particularly as these important processes may be compromised by stress, anxiety or depressive symptoms.
To date, these processes are not yet well understood but it is proposed that effective adaptation and regulation during pregnancy, and developing maternal sensitivity, can be understood within recent frameworks of physiological and emotional regulation and social functioning, such as Porges’s social engagement system (Porges, 1997; 2001).

A summary, therefore, of evidence surrounding inappropriate physiological responses/activity during pregnancy will be provided. The evidence for developing maternal sensitivity, during pregnancy, will then be described, followed by briefly considering how Porges’s theoretical frameworks link physiological states, emotion regulation and social functioning. This will then provide opportunity to consider how these concepts may help understanding of adaptive and non-adaptive responses during pregnancy.

**Pre-natal Programming**

Stress responses are designed to enable necessary hormone and neurotransmitter activity to prepare individuals for action in response to stressors (actual or perceived) and are adaptive for human survival. However, although stress related changes in autonomic and neuroendocrine function are necessary for energy and mobilization, if prolonged, they have negative implications for physical and mental health (Taylor & Stanton, 2007). It is, therefore, vital for mothers, during pregnancy, to have as regulated and flexible physiological systems as possible because (1) their physiological systems are already under strain¹ and (2)

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¹ Pregnancy itself puts the female body under stress and strain. During pregnancy blood volume increases by 45% above non-pregnant values accompanied by an increase in cardiac output (De
inappropriate physiological responses/activity, during pregnancy, can have negative effects on maternal health and on the behavioural and physiological development of the offspring (De Weerth, & Buitelaar, 2005) known as programming (Gluckman & Hanson, 2004): Because of the foetus’s rapid growth, it is vulnerable to programming insults and the attendant changes in its hormonal milieu (Weinstock, 2005).

Animal studies highlight the importance of regulated maternal stress responses to stressors during pregnancy whereby inappropriate response variations are negatively correlated with infant gene expression and brain development (Ahern & Young, 2009). Additionally, studies with rodents and non-human primates suggest that maternal distress during gestation can alter the development of limbic structures including the amygdala (Weinstock, 2008).

Similar negative implications have been replicated in human pregnancy studies. Adverse life situations, and the mother’s reactions to them, have demonstrated subsequent alterations in the foetal environment with deleterious effects on the rate of later development, and mental and physical health of the child for example, increased anxiety in novel situations (Weinstock, 2001). Additionally, the number and severity of potentially stressful events during pregnancy is associated with adverse birth outcomes (Lederman, Rauh, Weiss, Stein, Hoepner, Becker & Perera, 2004) including preterm birth, low birth weight and adverse health and behavioural outcomes in offspring (Weinstock, 2005; Bilbo & Schwarz, 2009). Moreover, mothers reacting to stressors with high reactivity, accompanied by too

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Weerth, & Buitelaar, 2005). Moreover, the increasing levels of fatigue (Lee & Zaffke, 1999) during pregnancy have implications for a mother’s physical and mental well-being (Noor, 2002).
slow recovery are more at risk of detrimental programming effects on their foetus (De Weerth, & Buitelaar, 2005).

In summary, inadequate maternal responses, during pregnancy, can negatively interfere with programming which can impair infants’ emotional, cognitive and physical development (Bigelow, MacLean, Proctor, Myatt, Gillis, & Power, 2010; Mäntymaa, Puura, Luoma, Salmelin, Davis, Tsiantis, & Tamminen, 2003; Murray, Fiori-Cowley, Hooper, & Cooper, 1996). From a motherhood perspective, therefore, this may also mean that mothers experiencing emotion regulation difficulties, for example stress and/or anxiety and depressive symptoms, may find it challenging to accurately interpret and respond to their infant’s signals because their physiological and emotional regulation systems may be less flexible.

**Maternal Sensitivity**

Not only are physiological flexibility and emotional regulation capability, therefore, vital to consider during pregnancy because of the negative implications for a foetus exposed to prolonged abnormal physiological reactivity, and the already compromised physiology system due to pregnancy, but, maternal sensitivity also develops throughout pregnancy via maternal mental representations of the baby (Levendosky, Huth-Bocks & Bogat, 2011). Pregnancy is therefore, arguably, a period of time aiming to keep the baby safe, beginning the process of developing relationships between mother and baby, and preparing women for impending motherhood.

There is emerging evidence from both animal and human studies to suggest that infant related stimuli are becoming increasing salient throughout pregnancy. Rats and mice, by late pregnancy, show increased aggressive behaviour towards
nest intruders (Mayer & Rosenblatt, 1993) and an attenuated response to irrelevant stress (Russell & Brunton, 2006). Similarly, during late pregnancy rat dams show a preference for bedding containing infant odour (Bauer, 1983). Additionally, similar research has been extended to non-human primates which found increased maternal responsiveness during late pregnancy demonstrated by an increased interest and interaction with other females’ infants (Maestripieri and Zehr, 1998). Additionally, in humans, self-reported feelings of nurturance develop across pregnancy (Fleming, Ruble, Krieger & Wong, 1997). However, self reports could reflect social expectations of and conscious preparations for motherhood. As such, Pearson (2010) found objective evidence to suggest that there are automatic attentional biases towards infant related stimuli by utilising a dot-probe task to measure attentional engagement: Pregnant women in late pregnancy were found to have an attentional bias towards infant related distress which was also reflected physiologically via systolic blood pressure and pulse rate. Such findings are valuable because there is a lack of human data in this field and so Pearson’s data

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2 Pearson explored the following:

1. Perception: Exploration of whether pregnant women can accurately encode threat emotions and general emotions, and whether this changes across pregnancy and, if so, whether this is effected by mood disorder symptoms.
2. Attention: Exploration of whether pregnant women have a fear bias and infant distress bias, and whether this changes across pregnancy and, if so, whether this is effected by mood disorder symptoms.
3. Autonomic: Exploration of whether pregnant women have a change in blood pressure in response to threat stimuli and infant distress and crying, and whether this changes across pregnancy and, if so, whether this is effected by mood disorder symptoms.
contributes to knowledge in this area. Pearson (2010) concluded this is an important component of motherhood preparation: To ensure infant survival a mother has to be physically and mentally ready to respond to her infant and their surrounding environment. Mothers are expected to meet their infant’s needs reliably and responsively the moment they are born (Davenport, Flynn & Shaw, 2007); survival depends on the mother’s ability to appropriately protect and nurture (Pearson, Lightman & Evans, 2009). Such important processes, however, can be compromised during pregnancy by poor maternal mental health (O’Conner, Heron, & Glover, 2002) and, arguably, an accompanying poorly regulated physiological system.

Both infant, and perceived threats to infant safety, stimuli should, therefore, be salient: Causing larger physiological changes and a possible slower return to baseline because it is advantageous for a mother to stay alert to their infant. This pattern is seen in motherhood whereby physiological responses are biased towards stimuli of greater salience and meaning, evoking larger physiological changes compared to non-salient stimuli (Sander, Grafman & Zalla, 2003). For example, parents compared to non-parents show greater neural activity in the limbic emotion processing regions of the brain to infant distress compared to infant laughter (Seifritz et al., 2003). Similarly, mothers demonstrate preferential physiological responses to infant crying compared to non-mothers including blood pressure increase (Frodi, Lamb & Willie, 1981) and accelerative pulse rate (Stallings, Fleming, Corter, Worthman, & Steiner, 2001). Such physiological responses reflect sympathetic arousal which is required when the body needs to actively respond. This is in contrast to parasympathetic responses (e.g., decelerative pulse rate) which reflects an organism paying attention to a stimulus but not actively responding to it;
commonly seen in non-mothers in response to infant related stimuli (Bradely, Codispoti, Cuthbert & Lang, 2001).

There is, therefore, a physiological challenge during pregnancy, particularly in the last trimester when infant stimuli are salient, because whilst, from an evolutionary perspective, rapid increases in sympathetic arousal is adaptive; enabling physical responses to ensure infant survival, it is also advantageous to stay-attuned to infant non-verbal signs (by not rapidly disengaging attention). This helps to ensure that the infant’s needs are continuously monitored and interpreted and, therefore, responded to appropriately. However, infant related stimuli (e.g., crying) are designed to evoke a stress response, and place immediate demands on parents (Parpal & Maccoby, 1985), to ensure that appropriate action is taken and, postnatally, mothers will experience daily and repeated exposure to such stressors. These demands, however, may impede a mother’s ability to regulate her own emotions (Scaramella & Leve, 2004) at a time when there is arguably more demand for good emotional and physiological regulation systems; enabling balance between staying flexibly attuned to relevant stressors, whilst regulating to ensure the stressor is not causing too much potentially detrimental physiological arousal.

**Physiological States and Emotion Regulation**

Emotional flexibility and regulation affects a person’s ability to adjust physiological arousal on a momentary basis (Gross, 1998). The ability to regulate emotion is vital to social functioning (Eisenberg, 2001); emotions guide decisions and facilitate responses to challenges (Tooby & Cosmides, 1990). Given the numerous challenges associated with impending motherhood and motherhood,
therefore, it is important that mothers have flexible and well regulated physiological systems.

The detrimental effects of unregulated and inflexible systems have already been summarised: During pregnancy, the intrauterine environment is sensitive and the developing foetus is vulnerable; and postnatally, a good developing relationship and attachment style, requires the mother to appropriately and sensitively respond to her infant’s needs. What will now follow is a description of the physiological underpinnings of adaptive and maladaptive emotional-social regulation that are relevant for understanding programming and maternal sensitivity. Of particular relevance are approaches by Porges (1997; 2001) and Gilbert (1993) which make links between autonomic nervous system (ANS) activation and emotional functioning in social contexts.

The autonomic nervous system (ANS) is the key system involved in physiological arousal (Appelhans & Luecken, 2006), thus contributing to flexibility and regulation capabilities in response to the surrounding environment. The ANS has two parts, the excitatory sympathetic nervous system (SNS) and the inhibitory parasympathetic nervous system (PNS). In states of stress and anxiety, the SNS is dominant to secure survival (“fight or flight”). Physiologically, this is characterised, for example, by increased heart rate (HR) and, often, the activation of the biological stress axis (the hypothalamus-pituitary axis) which regulates cortisol release in response to perceived stress. PNS activation, however, regulates bodily recovery functions (“rest and digest”) and responds to inescapable danger by enabling the body to “freeze” by down-regulating energy-consuming processes. Physiologically, for example, this is characterised by increased heart rate variability (HRV).
HRV represents the degree of parasympathetic and sympathetic influences on HR (Kemp & Quintana, 2013). Specifically, stressors are associated with an increase in sympathetic cardiac dominance, a decrease in parasympathetic dominance, and subsequent increased HR and reduced HRV (Berntson & Cacioppo, 2004). Reduced HRV at rest is associated with impaired cardiovascular recovery following acute stress (Weber et al., 2010), cognitive and affective dysregulation and psychological inflexibility (Kashdan & Rottenberg, 2010). Individuals with higher resting HRV, however, display more adaptive regulation, social engagement, context appropriate responses and recovery after stressors, and effective emotion regulation (Geisler, Kubiak, Siewet & Weber, 2013; Thayer, Åhs, Fredrickson, Sollers & Wager, 2012). Furthermore, HRV is negatively correlated with stress, anxiety and depressive symptoms (Berntson & Cacioppo, 2004): Resting HRV is described as a “marker for flexible dynamic regulation of autonomic activity” (Thayer, Åhs, Fredrikson, Sollers & Wager, 2012, p. 751). Moreover, according to Porges (2001), PNS dominance also denotes the activation of a ‘Social Engagement System.’ When activated this indicates an individual feeling safe and secure and, therefore, able to engage in healthy interpersonal interactions guided by a flexible and well-regulated physiology system. Gilbert (1993) describes such systems as the contentment system (i.e., an individual feels calm and content).

From an evolutionary perspective, this supports humans in managing complex and demanding environments by facilitating an appropriate increase in physiological arousal, in response to a stressor, followed by an appropriate return to baseline (De Weerth, & Buitelaar, 2005). From a motherhood perspective, this supports mothers in managing their infant’s changing communication and emotional cues by enabling quick and appropriate responses. However, for mothers, it is also important to
sustain awareness and a sensitive stance towards their infant (Ainsworth, 1979) because a successful mother-infant relationship seems based upon a mother’s ability to accurately interpret and respond to infant distress (McElwain & Booth-LaForce, 2006).

In summary, flexible and regulated physiological systems are important for accurate and appropriate responding and, ultimately, the long-term survival of infants; they are also, however, important for good physical and mental health because they facilitate limited duration stress responses with an appropriate return to pre-stress levels.

**Understanding Adaptive and Non-adaptive Responses During Pregnancy**

Given that: Different stimuli, emotional states and regulation abilities, are associated with varying levels of physiological arousal (Levenson, 2003); not all pregnant women experience adverse stress outcomes (Christian, 2012); and any ambiguous or aversive infant stimuli may transiently lead to increased emotional and physiological arousal due to increased salience (Pearson, 2010), it seems appropriate to gain greater understanding about the physiological processes involved in emotion regulation during pregnancy and what are adaptive and non-adaptive responses. Furthermore, it is important to understand if individuals with more flexible and well regulated physiological and emotional systems are better able to cope with these transient arousal states (e.g., down-regulate appropriately even under mild distress). Moreover, the consequences of reduced ability to accurately interpret infant emotions may be that anxiety and physiological arousal is increased which may, in turn, perpetuate a vicious cycle of poor emotion regulation and coping which may negatively interfere with essential bonding and attachment process.
Being able to assess, therefore, stress reactivity during pregnancy in response to infant related stimuli is important: Helping to delineate the relationship between stress and prenatal health and potentially lead towards identifying individuals at greatest risk for adverse outcomes upon stress exposure (Christian, 2012). Specifically, drawing from cardiovascular activity such as sympathetic and parasympathetic activity, and markers of regulation capability such as HRV, has been described as important for future research within the field of stress responses during pregnancy (Christian, 2012). Moreover, research within this area has only focused on irrelevant motherhood stressors, for example, cold pressor tests, thermal stress tests, stroop tests, mental arithmetic (Saisto, Kaaja, Helske, Ylikorkala & Halmesmaki, 2004; Pirhonen, Vaha-Eskeli, Seppanen, Vuorinen & Erkkola, 1994; DiPietro, Costigan, & Gurewitsch, 2003; McCubbin, Lawson, Cox, Sherman, Norton & Read, 1996), the Trier Social Stress Test (Klinkenberg, Nater, Nierop, Bratsikas, Zimmermann & Ehlert, 2009), and recent research that has used relevant stimuli relevant (Pearson, 2010) only focused orientation.

**Research Aims and Hypotheses**

This study aims to reanalyse Pearson’s (2010) data to explore pregnant women’s baseline regulation capacity, and their physiological reactivity and return to physiological baseline after exposure to salient infant stimuli in healthy pregnant woman compared to age-matched non-pregnant controls. It also aims to consider the influence of affective disorder symptoms.

To achieve this, the following will be analysed: HR and HRV at rest; HR activity during stimulus presentation relative to the pre-stimulus baseline; and HR
activity post-stimulus presentation relative to the pre-stimulus baseline. The hypotheses are, therefore, as follows:

1. Pregnant women will display stronger physiological activity (e.g., higher HR) and lower HRV at rest in comparison to non-pregnant women.

2. During stimulus presentation pregnant women will display distinctive physiological reactivity (e.g., HR), from pre-stimulus baseline, in response to the different stimuli, and compared to non-pregnant women.

3. During the post-stimulus presentation phase pregnant women will display distinctive HR change, from pre-stimulus baseline, in response to the different stimuli, and compared to non-pregnant women.

4. Pregnant women with affective disorder symptoms will display stronger physiological activity (e.g., higher HR) and lower HRV at rest compared to pregnant women without affective disorder symptoms.

5. During stimulus presentation pregnant women with affective disorder symptoms will display distinctive physiological reactivity (e.g., HR), from pre-stimulus baseline, in response to the different stimuli, and compared to pregnant women without affective disorder symptoms.

6. During the post-stimulus presentation phase pregnant women with affective disorder symptoms will display distinctive HR change, from pre-stimulus baseline, in response to the different stimuli, and compared to pregnant women without affective disorder symptoms.

**Method**

**Design**

This psycho-physiological study used a mixed design. The first three hypotheses had a between subjects factor of pregnancy (pregnant/not-pregnant),
and hypotheses four to six had a between subjects factor of affective disorder symptoms (yes/no). All hypotheses (except one and four) had a within subjects factor of stimulus including pictures of a fearful adult face accompanied with a computer tone (FNoise), fearful adult face accompanied with a baby crying (FCry), distressed baby face accompanied with a baby crying (BabCry), and a flashing screen accompanied with a computer tone (INoise) (Pearson, 2010). The dependent variables (DV) are described in Table one.
Table 1.

*Description of the Dependent Variables During the Different Phases of the Study*

<table>
<thead>
<tr>
<th>Phase</th>
<th>Dependent variables: Physiological reactivity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Three minute baseline period.</td>
<td>Average resting HR (bpm).</td>
</tr>
<tr>
<td></td>
<td>Average resting HRV (ms^2).</td>
</tr>
<tr>
<td>During six second stimulus-presentation phase:</td>
<td>Average HR reactivity (Δ bpm) compared to the average HR pre-stimulus presentation.</td>
</tr>
<tr>
<td></td>
<td>Average minimum HR reactivity (Δ bpm).</td>
</tr>
<tr>
<td></td>
<td>Average maximum HR reactivity (Δ bpm).</td>
</tr>
<tr>
<td>During 12 second post-stimulus presentation phase:</td>
<td>Average HR reactivity (Δ bpm) compared to the average HR pre-stimulus presentation.</td>
</tr>
<tr>
<td></td>
<td>Average minimum HR reactivity.</td>
</tr>
<tr>
<td></td>
<td>Average maximum HR reactivity.</td>
</tr>
</tbody>
</table>
Participants

The data utilized were part of a larger study investigating changes in women’s perception, attention and autonomic reactivity towards threat and infant distress across early and late pregnancy.

Sample. The sample was comprised of healthy pregnant women and age matched non-pregnant controls. They were recruited and tested between June 2007 and February 2008. See Table two for available demographic information about the sample.

Table 2.

<table>
<thead>
<tr>
<th>Available Demographic Information</th>
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</thead>
<tbody>
<tr>
<td>Stage of pregnancy</td>
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<tr>
<td>Early</td>
</tr>
<tr>
<td>Late</td>
</tr>
<tr>
<td>Controls</td>
</tr>
</tbody>
</table>

Inclusion criteria. Less than 14 weeks pregnant and able to speak English at a level necessary to understand the information sheet.

Exclusion criteria. History of severe mental illness, substance abuse or epilepsy. The control group was required to not be taking the contraceptive pill as changes in hormones may have altered perceptions of infants.

Recruitment. Eligible pregnant women had been recruited by midwives and details of women who met the criteria were passed on to the research group. The control sample had been recruited via the pregnant participants (e.g., friends), and a University research volunteer database.

Number. See Appendix A.
**Power Analyses**

Sample size determination was informed by power calculations (see Appendix B).

**Measures**

**Clinical interview schedule-revised (CIS-R).** The CIS-R is widely used in epidemiological community samples to detect symptoms and diagnosis of common mental health disorders. It comprises a computerised, self-administered interview, which generates scores on a scale of 0 – 4 according to severity for 14 classified symptoms including both anxiety and depression. The interview is standardised, reliable and valid (Lewis, Pelosi, Araya & Dunn, 1992).

Cronbach’s alpha could not be calculated because the individual items were not available to the author.

**Symptoms of depression.** Anhedonic symptoms of depression are required for a major depressive episode to be considered in both the ICD-10 and the DSM-V. However, other symptoms are also required. At least two of the following are required for a diagnosis: Disturbed appetite; sleep; motor responses; diminished concentration; fatigue; poor self-esteem; and suicidality. However, care has to be taken considering depressive symptoms during pregnancy because some of these associated symptoms may be confounded by pregnancy (Kammerer et al., 2009). A further complicating factor is that, at the time of this original study, there were no diagnostic interviews validated of depression during pregnancy. To overcome this, the original research categorised pregnant women into those with and without at least one of the anhedonic depressive symptoms (a low mood and/or loss of pleasure) by utilising the Whooley screening questions (NICE, 2007).
**Symptoms of anxiety.** Similar to symptoms of depression, the original study categorised women into those who were and were not experiencing at least one symptom of anxiety at the time of testing. To score one or more for an anxiety disorder symptom, symptoms were required to be of a significant frequency (more than four days in the past week), duration (more than three hours a day in the past week), or impact (if the participant reports that the symptom is unpleasant, unbearable or has led to avoidance of a situation) as in line with the ICD-10.

**Autonomic response paradigm.** This task was designed to measure the blood pressure and pulse rate responses to threat and infant salient signals; enabling autonomic responses towards stimuli relevant to motherhood to be determined. It also has the capability to explore baseline HR and HRV, and return to baseline post-stimulus presentation.

Four different stimuli conditions (as described earlier) were presented in a counterbalanced, block-wise design. Each stimulus was presented for six seconds (used for determining HR reactivity to stimulus) and was followed by a 12 – 25 second inter-stimulus interval (used for determining post-stimulus HR reactivity as a measure of return to baseline) where participants were presented with a blank screen and instructed to remain still. This presentation was repeated four times: Each participant would see each of the four different stimuli four times so would, in total, see 16 stimuli presentations. Stimuli were presented in blocks and stimulus presentation within the blocks was randomised; the inter-stimulus interval times and the block order were also randomised. There was an 8 minute baseline period at the beginning of the task\(^3\) (used to determine resting physiological activity). All stimuli were presented on a Toshiba laptop with a screen size of 33cm x 20cm; viewing

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\(^3\) This varied; for this current study the author used 3 minutes of baseline as all participants had this amount as a minimum.
distance was 30cm. These presentations and inter stimulus interval times were in line with previous task procedures using similar stimuli and autonomic measurements (Sarlo, Palomba, Buodo, Minghetti & Stegagno, 2005).

Adult faces were taken from the Ekman set (Ekman & Friesen, 1976), and infant faces were taken from the internet. Specifically, 60 infant faces were shown to a convenience sample who reported the emotion in the image. The faces that were consistently rated as displaying a distressed emotion were used. Similarly, 11 buzzing computer noises and 16 baby cries (from babies under 5 months) were taken from sound effect internet sites and rated by a convenience sample: The top four rated as the most negative were used.

To ensure this task measured responses specific to the emotional nature of the stimulus, as opposed to a startle response, Pearson (2010) used strategies to minimise such responses for example by adding a short buzz noise at the beginning of the task to remove startle to the novelty of the first stimuli.

**Physiological data acquisition and pre-processing**

**Data acquisition.** Inter-beat intervals for the determination of HR and HRV were measured using non-invasive, ambulatory equipment; a portable portapres® (Finapress Medical Systems), which measured pulse rate for every heartbeat in real time. Measurements were downloaded onto a PC using Beatscope software. This software allowed the measurements to be exported into a beat to beat format in an Excel spreadsheet.

**Physiological data pre-processing.** All data obtained in the excel spreadsheet from the original author underwent pre-analysis pre-processing adopting a visual case-by-case strategy to check for physiological artefacts. The
parameters used were below 40 bpm and above 220 bpm. These values were deemed physiologically impossible, suggesting mechanical error. Additionally, data was checked for irregular readings.

To determine baseline HR, three minutes of artefact-free HR readings during the rest period were averaged (Appendix C). Similarly, to determine baseline HRV, three minutes of artefact-free inter beat intervals recorded at rest were processed using Kubios HRV analysis software (Tarvainen, Niskanen, Lipponen, Ranta-Aho, Karjalainen, 2009). Specifically, the time series was submitted to a fast Fourier transformation enabling the power spectrum of the inter-beat interval variation to be given in the 3 minute time window (Berntson et al., 1997; Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology, 1996). Of particular interest was the frequency range between 0.15 Hz and 0.4 Hz (high frequency; HF) that is generally considered a marker of parasympathetic input. It was not possible to compute HRV during the stimulus presentation and post-stimulus presentation phase because, unfortunately, after data scrutiny it was apparent that there was not enough of a time window for HRV: HRV analyses require a minimum of 60 seconds of HR data which was not available for this data.

Additionally, the participant’s HR reactivity (and minimum and maximum readings, as reported in supplementary results) was determined during the presentation and return to baseline phases following standard procedures (Orr, Lasko, Metzger & Pitman, 1997). Specifically, this involved a case-by-case calculation (Appendix D). To explore the participant’s reactivity to the stimulus, their HR responses during stimulus-presentation were subtracted from each subsequent HR response over the six seconds of stimulus-presentation. This gave an indication
of the potential relationship between the stimulus and HR: Whether there was an increase (as indicated by positive HR reactivity values; i.e., acceleration) or decrease (as indicated by negative HR reactivity values; i.e., deceleration). Minimum and maximum reactivity readings were also determined. Similarly, in order to explore a person’s capability to return to baseline their HR reactivity was explored during the first 12 seconds\(^4\) of the post-stimulus period (i.e., the inter-stimulus interval). This was done by comparing their HR reactivity, during the 12 seconds, to their average pre-stimulus HR; enabling exploration of what happened to their HR after the stimulus was presented in relation to their average HR pre-stimulus presentation.

**Data analysis strategy**

Less than 5 % of any data was affected by artefacts and/or irregular readings; there was, therefore, greater flexibility in deciding how to manage these readings (Tabachnick & Fidell, 2014). The method chosen was mean substitution and, in an attempt to replace the identified values with the next most appropriate physiological reading, for that particular time point of the experiment, the value before the perceived error and the value after it, were used to calculate a replacement value.

After the initial data cleaning process each DV was calculated by hand.\(^5\) After the DVs had been calculated an average value, across all participants, was obtained for the DVs by creating new variables within SPSS.

The next phase required checking for univariate and multivariate outliers by following standard procedures (Tabachnick & Fidell, 2014), checking for parametric

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\(^4\) Because the time period between stimulus presentation was variable (12 – 25 seconds), it was better to have the same interval for everybody: Every participant had a minimum rest period of 12 seconds.

\(^5\) It was not possible to create a macro to do this due to different timings for each participant.
assumptions, and determining differences between B/L HR and HRV between groups.

**Univariate outliers.** Univariate outliers are cases that have an unusual value for a single variable. Z scores were calculated and interpreted for each DV. Scores above +3.29 or below -3.29 were deemed a univariate outlier, and procedures were followed to reduce their impact. This involved multiplying the standard deviation by three, and then adding this value to the mean value and using this to replace the univariate outlier. Where this procedure identified negative Z scores the standard deviation was multiplied by three, and *subtracted* from the mean to create a new value.

**Multivariate outliers.** Mahalanobis distances were calculated to identify multivariate outliers. These outliers are cases that have an unusual combination of values for a number or variables. Identified multivariate outliers were subsequently removed from further analysis.

**Parametric assumptions.** Parametric tests were conducted to determine whether parametric assumptions could be accepted. This involved:

- Calculating and interpreting the Z scores for both kurtosis and skewness;
- visually examining histograms, QQ and box plots; and
- checking the Shapiro Wilk significance value.

Where appropriate (between groups) a Levene’s test was calculated to check for homogeneity of variance (HOV). Where this was not appropriate (within subjects) Mauchly’s test of sphericity was checked.
Some data met parametric assumptions and other data did not: Variables that did not meet assumptions were assessed on a case-by-case basis. Where there were mild violations, but homogeneity of variance could be accepted, repeated measures ANOVA was still deemed appropriate given its robust nature towards some parametric violations (Tabachnick & Fidell, 2014). Where the majority of parametric assumptions were violated the Friedman ANOVA and Mann Whitney U test were utilised. The rationale for utilising these tests in place of the repeated measures ANOVA is that it provides an indirect alternative for checking for indications of interactions. The Friedman ANOVA highlights whether there is a main effect of stimulus type in the overall sample and within each group. The Mann Whitney U tests if there is a group difference at any one stimulus type. Although this approach can not directly test interactions and does not provide an omnibus test for a main effect of group, a significant main effect of stimulus type in only one group, and a significant group difference for only a subset of stimulus types, may suggest an interaction between stimulus type and group. However caution is necessary when there are small unequal samples sizes.

**Baseline HR and HRV.** Independent samples t-tests were used to determine if there were statistically significant differences between groups (pregnancy Vs controls) (pregnancy with affective disorder symptoms Vs pregnancy without affective disorder symptoms) on baseline HR and HRV. Statistically significant differences were found between pregnant participants and controls for baseline HR and HRV (see results). These were, therefore, controlled for in subsequent analysis by entering them as covariates which also enabled exploration of any interaction.

Where non-parametric tests were required it was not possible to control for B/L HR and HRV as covariates or to explore possible interactions.
Results

Hypothesis One

Heart rate (HR). An independent samples t-test revealed significant differences between pregnant and non-pregnant females, $t(58) = 3.85$, $p = .001$, Cohen’s $d = 1.09$, indicating that pregnant participants have a higher resting HR ($M = 85.55$, $SD = 10.71$) compared to controls ($M = 75.02$, $SD = 8.34$).

Heart rate variability (HRV). Prior tests of normality indicated that the HRV data did not meet the assumptions of normality. A non-parametric Mann Whitney U test revealed that the control group ($Mdn = 832.99$, Range $= 169.05 – 19977.65$) had statistically significant higher resting HRV compared to pregnant women ($Mdn = 455.75$, Range $= 41.86 – 4726.50$), $U = 244.00$, $Z = -2.4$, $p = 0.014$, Kraemer’s $r = -0.32$.

Hypothesis Two

Average HR reactivity during stimulus presentation phase. The assumptions of normality were violated; therefore, a Friedman’s ANOVA test was conducted. There were no differences of stimulus, on average HR reactivity, during the stimulus presentation phase, $\chi^2(3) = 1.15$, $p = .764$. A Mann Whitney U test, however, revealed a statistically significant group difference for the fearful adult face accompanied with a computer tone (FNoise) stimulus with non-pregnant women showing greater deceleration in their average HR reactivity compared to pregnant women, $U = 311.00$, $Z = -2.01$, $p = .04$, Kraemer’s $r = -.25$. No other stimulus demonstrated significant group differences (see Table 3 for Mdn and Range).
Table 3.

Medians and ranges for average HR reactivity (baseline-to-stimulus change in bpm) in response to the different stimuli for both pregnancy and non-pregnancy samples.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy</th>
<th></th>
<th></th>
<th>Non-Pregnancy</th>
<th></th>
<th></th>
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<td>Mdn</td>
<td>Min</td>
<td>Max</td>
<td>N</td>
<td>Mdn</td>
</tr>
<tr>
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<td>-1.42</td>
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<td>-1.52</td>
</tr>
<tr>
<td>FNoise</td>
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<td>6.25</td>
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<td>-1.45</td>
</tr>
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</table>

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone.

Note. A positive value indicates heart rate acceleration and a negative value indicates a deceleration as compared to pre-stimulus baseline.

Hypothesis Three

Average HR reactivity, during the post-stimulus phase, in relation to average HR pre-stimulus presentation. Non-parametric tests were required. A Friedman ANOVA revealed no differences in average HR reactivity between the stimuli, $\chi^2(3) = 1.54$, $p = .673$. A Mann Whitney U test found no differences between groups for any of the different stimuli types (see Table 4 for Mdn and Range).
Table 4.

*Medians and ranges for average HR reactivity, during the post-stimulus phase, in relation to average HR pre-stimulus presentation, for both pregnancy and non-pregnancy samples.*

<table>
<thead>
<tr>
<th>Stimulus Type</th>
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<th></th>
<th></th>
<th>Non-Pregnancy</th>
<th></th>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td></td>
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<td>Mdn</td>
<td>Min</td>
<td>Max</td>
<td>N</td>
<td>Mdn</td>
<td>Min</td>
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<td>-.33</td>
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*Note.* BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone.

*Note.* A positive value indicates an increase in HR as compared to pre-stimulus baseline, and a value closer to zero indicates a return towards the to pre-stimulus average HR; a negative value indicates a deceleration and no return towards the pre-stimulus average HR/baseline.

**Hypothesis Four**

**Baseline heart rate.** An independent samples t-test revealed no differences between pregnant females with depressive symptoms and pregnant females without, \( t(38) = .690, p = .494 \), Cohens’s \( d = .21 \), indicating that pregnant participants with depressive symptoms (\( M = 86.85, SD = 12.67 \)) and pregnant participants without (\( M = 84.49, SD = 8.97 \)) do not significantly differ on their B/L HR.

**Baseline HRV.** Prior tests of normality indicated that the HRV data did not meet the assumptions of normality. The Mann Whitney U test was, therefore, conducted to examine differences between pregnant participants’ (with depressive symptoms) and pregnant participants’ (without depressive symptom) HRV at rest. This revealed no significant differences, \( U = 147.00, Z = -1.13, p = .257 \), Kraemer’s \( r \)
=.18, indicating that pregnant participants with depressive symptoms (Mdn = 347.46, Range = 41.86 – 4435.80) and pregnant participants without (Mdn = 593.54, Range = 94.58 – 4726.50), do not significantly differ on their B/L HRV.

Due to no statistically significant differences between groups, neither B/L HR nor B/L HRV was entered as covariates within subsequent analysis.

**Hypothesis Five**

*Average HR reactivity during stimulus presentation phase.* The assumptions of normality were violated; therefore, a Friedman’s ANOVA was conducted. There were no differences of stimulus, on average HR reactivity during the stimulus presentation phase between pregnant participants with depressive symptoms and pregnant participants without depressive symptoms, \( \chi^2(3) = 1.154, p = .764 \). A Mann Whitney U test revealed no differences between pregnancy with depressive symptoms and pregnancy without depressive symptoms (see Table 5 for Mdn and Range).
Table 5.

Medians and ranges for average HR reactivity (baseline-to-stimulus change in bpm) in response to the different stimuli for both pregnancy with depressive symptoms and pregnancy without depressive symptoms.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
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<th>Pregnancy without depressive symptoms</th>
</tr>
</thead>
<tbody>
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<td>Mdn</td>
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</tr>
<tr>
<td>FNoise</td>
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<td>.07</td>
</tr>
<tr>
<td>INoise</td>
<td>17</td>
<td>-.06</td>
</tr>
</tbody>
</table>

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone.

Note. A positive value indicates heart rate acceleration and a negative value indicates a deceleration as compared to pre-stimulus baseline.

**Hypothesis Six**

**Average HR reactivity, post-stimulus presentation, compared to average HR pre-stimulus presentation.** A repeated measures 2x4 ANOVA was conducted to examine the main effects of the within subjects variable of stimulus (the four stimuli), the between subjects variable of group (pregnancy with depressive symptoms Vs pregnancy without depressive symptoms), and a stimulus x group interaction on average HR reactivity, post-stimulus phase, in relation to the average HR pre-stimulus presentation phase.

There was no main effect of stimulus, $F(3,34) = 1.36$, $p = .409$, $\eta^2_p = .080$, nor did depressive symptoms moderate the relationship of stimulus type and HR reactivity, $F(3, 34) = 1.267$, $p = .301$, $\eta^2_p = .101$. Tests of between-subjects effects...
revealed no statistically significant effect of group, $F(1,36) = .48, p = .492, \eta^2_p = .013$, (see Table 6 for Ms and SDs).

Table 6.

Means and standard deviations for average HR reactivity during the post-stimulus presentation phase, compared to average HR pre-stimulus presentation, for both pregnancy with depressive symptoms and pregnancy without depressive symptoms.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td>Mean</td>
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<td>BabCry</td>
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<td>1.29</td>
</tr>
<tr>
<td>FCry</td>
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<td>-.80</td>
</tr>
<tr>
<td>FNoise</td>
<td>17</td>
<td>.17</td>
</tr>
<tr>
<td>INoise</td>
<td>17</td>
<td>-.26</td>
</tr>
</tbody>
</table>

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone.

Analyses were also conducted with pregnant women with anxiety symptoms compared to pregnant women without anxiety symptoms (Appendix E). However, these results also revealed no statistically significant findings and were similar to that of the presented depressive symptoms.

Achieved Power

Although efforts were made to sustain the large pre-determined sample size for the study based on a priori power calculations, the study was underpowered, for
some hypotheses, to detect significant differences. For example, the t tests for hypothesis one had sufficient statistical power (.98) to detect a large Cohen’s d effect size of 1.09. For hypothesis two, the achieved power ranged from not being acceptable to detect significant differences (.4), to achieving power (.99) to detect a medium (.25) Cohen’s f effect size. The repeated measures ANOVA for hypothesis three found no significant differences but was adequately powered (.78) to detect medium effect sizes (.23). Furthermore, the t tests for hypothesis four did not have sufficient statistical power (.16) to detect large effects. Similarly, for hypothesis five, there was inadequate power ranging from .05 to .14 to detect large effects. Finally, the repeated measures ANOVA, for hypothesis six, found no significant differences but had power (.92); although only to detect large effect sizes (0.35).

Discussion

The study aimed to investigate pregnant women’s baseline physiological regulation capacity, and physiological reactivity and return to physiological baseline, in response to infant related stressors. Additionally, it aimed to explore how affective disorder symptoms, during pregnancy, are associated with these physiological markers of emotion processing and regulation.

To satisfy these aims, the study extended analyses of previously acquired psycho-physiological data (Pearson, 2010) at baseline, and pre- and post-presentation of emotional audio-visual stimuli. This was done in pregnant woman with and without depressive symptoms compared to age-matched non-pregnant healthy controls.

Baseline physiology. The study found support for the hypothesis that pregnant women would display higher physiological activity (e.g., HR) and lower
HRV, at rest, compared to non-pregnant women. This is in-line with existing literature about the normal physiological changes during pregnancy including reduced HRV and increased HR (Stein, Hagley, Cole, Domitrovich, Kleiger, & Rottman, 1999), thought to occur due to an increase in blood volume and reduction in systemic vascular resistance (De Weerth, & Buitelaar, 2005). Moreover, the reduced parasympathetic activity during pregnancy, found in this study, is consistent with previous research (Yang, Chao, Kuo, Yin, & Chen, 2000) demonstrating a difference between the pregnant participants’ and controls’ high frequency (HF), baseline, HRV (HF is a known marker of predominantly parasympathetic input; Thayer, Ahs, Fredrikson, Sollers & Wager, 2012). Furthermore, such findings are consistent with literature demonstrating that a pregnant person’s physiological system is in more demand during pregnancy; systems have to adapt to meet the metabolic demands of the mother and the foetus (Carlin & Alfirevic, 2008).

It could be argued, however, that whilst these physiological changes are consistent with normal pregnancy; that they could also symbolise further preparation for motherhood and an ability to be able to respond appropriately to the needs of the infant with the balance of also being able to stay attuned to infant cues. It is, therefore, theoretically possible that reduced HRV, during pregnancy, is a physiological attempt to maintain greater physiological homeostasis during a time when abnormal or inconsistent physiology reactions have the potential to negatively interfere with developmental programming of the foetus. This is consistent with evidence that inadequate maternal responses, during pregnancy, are associated with programming insults and impair infants’ emotional, cognitive and physical development (Bigelow, MacLean, Proctor, Myatt, Gillis, & Power, 2010; Mäntymaa, Puura, Luoma, Salmelin, Davis, Tsiantis, & Tamminen, 2003; Murray, Fiori-Cowley,
Hooper, & Cooper, 1996). However, of concern is that HRV described as too low is indicative of an individual experiencing lower resiliency and greater stress (Thayer, Ahs, Fredrikson, Sollers & Wager, 2012). This concern reinforces the physiological challenge for pregnant women, whereby there is a need to have as regulated and flexible a physiological system as possible, but they also need to stay attuned to infant related stimuli; designed to place immediate physiological demands on parents (Parpal & Maccoby, 1985), in order to ensure long term survival and adequate attachment.

The study, however, did not find support for the hypothesis that pregnant women with affective disorder symptoms would display larger physiological activity (i.e., higher HR) and lower HRV at rest in comparison to pregnant women without affective disorder symptoms. This is against what was expected because HRV is negatively correlated with stress, anxiety and depressive symptoms (Pagani et al., 1991; Berntson & Cacioppo, 2004), specifically, resting HRV is associated with cognitive and affective dysregulation and psychological inflexibility (Kashdan & Rottenberg, 2010).

**Reactivity during stimulus presentation.** The study did not find support for the hypothesis that pregnant women would display distinctive physiological reactivity, from pre-stimulus baseline, in response to the different stimuli compared to non-pregnant women. This goes against previous findings that suggest infant related stimuli become increasingly salient and meaningful during pregnancy (Bauer, 1983; Mayer & Rosenblatt, 1993; Maestripieri & Zehr, 1998; Russell & Brunton, 2006) and generate greater physiological reactivity and attentional biases (Pearson, 2010). It could be argued, therefore, that autonomic reactivity to infant cues is not substantially altered during pregnancy. However, although no main effect of group
was found the results demonstrated a difference in average HR reactivity, between groups, for the audio-visual stimulus comprising of an adult fearful face accompanied by an computer tone (FNoise): Controls displayed greater deceleration in HR when presented with the FNoise stimulus. This is similar to existing findings where parasympathetic responses (decelerative patterns of activity) are commonly seen in non-mothers, particularly in response to infant related stimuli (Bradley, Codispoti, Cuthbert & Lang, 2001): Reflecting paying attention to a stimulus but not actively responding to it. Although the FNoise stimulus type is not infant related, the general pattern of greater negative reactivity amongst controls (deceleration), compared to pregnancy, is interesting and could suggest controls are paying more attention to the stimuli; perhaps generated by more parasympathetic input and less sympathetic input in reactivity to the stimulus. It is also of interest to note that controls have a significantly higher resting HRV which is indicative of a more flexible physiological system; it is possible, therefore, that they are able to pay more attention to the stimuli and engage more flexibly. Moreover, the overall direction of average reactivity during stimulus-presentation was negative (indicative of greater parasympathetic input) indicating that stimuli, in particular infant related stimuli, may not be as associated with ‘threat’ or ‘action’ responses as has been previously found.

Similarly, there was no support for the hypothesised distinctive HR reactivity, in response to the different stimuli, amongst pregnant women with affective disorder symptoms and pregnant women without. This goes against previous findings because individuals with an inflexible autonomic system (as identified by lower level HRV at rest) are more likely to have difficulty regulating their emotions (Porges, 1997; 2001) and, as a result, are susceptible to larger physiological responses driven by the sympathetic system. As this notion did not seem to be supported by these
current findings, it could be suggested that infant cues are not becoming as salient across pregnancy as previously thought. However, it has to be noted that no statistically significant differences were found in resting HRV (as discussed above): There were differences in the expected direction, but they were not significant.

**Reactivity post-stimulus presentation.** This study did not find support for the hypothesis that pregnant women would display distinctive HR change, from the pre-stimulus baseline, in response to the different stimuli and compared to non-pregnant women. This is not in-line with previous findings demonstrating that reduced HRV is associated with impaired cardiovascular recovery following acute stress (Weber et al., 2010); neither the notion that, from a motherhood perspective, it is advantageous to stay both physically and mentally attuned to the infant as has been previously suggested (Pearson, 2010).

However, it needs to be noted that the initial reactivity (as previously discussed), overall, was not governed by a ‘threat’ or ‘action’ response (dominant sympathetic input) as would perhaps be expected based on previous findings (Pearson, 2010). This pattern of seemingly little stress in response to the stimuli and, therefore, smaller alterations required to be able to return to baseline, for pregnant women, is consistent with literature that suggests, overall, there is a dampened cardiovascular stress reactivity in pregnancy (De Weerth & Buitelaar, 2005), but goes against the notion that human processing systems prioritise stimuli on the basis of relevance (Sander, Grafman & Zalla, 2003) because expectant mothers seem not as reactive as was expected. However, it could be argued that, amongst pregnant women, the little cardiovascular activity required to be able to return to baseline, enables a calmer physiological state which is beneficial for mother and baby. In addition to this, however, it could also be suggested that there is just less variability
in pregnant women, due to normal pregnancy physiology changes, which makes it harder to observe any possible differences.

Similarly, the study did not find support for the hypothesis that pregnant women with affective disorder symptoms would display distinctive HR change, from pre-stimulus baseline, in response to the different stimuli, and compared to pregnant women without affective disorder symptoms. This goes against previous findings that suggest different stimuli, emotional states and regulation abilities are associated with varying levels of physiological arousal (Levenson, 2003). Moreover, affective disorder symptoms are associated with abnormal physiological arousal which is often characterised by high reactivity to stimuli followed by slow recovery (De Weerth & Buitelaar, 2005).

**Rejection of the null hypotheses.** It is possible that the majority of null hypotheses failed to be rejected for a number of reasons. One possibility is that calculating mean reactivity across the stimulus-presentation and post-stimulus phase did not allow for any variations in reactivity; possible defensive responses, to be highlighted. Additionally, the stimuli utilised within the study may not have been intense enough; although it is difficult to make comment on intensity in the absence of subjective information about how the participants perceived the stimuli.

However, in an attempt to overcome these possible shortcomings minimum and maximum HR reactivity was also calculated (Appendix F). These results revealed very little, however, there was a difference during the post-stimulus phase between pregnant participants’ and controls’ maximum HR reactivity, post-presentation of the audio-visual stimulus comprising the adult distressed face and baby cry (FCry). Both the pregnant and control participants’ maximum average HR
reactivity were positive, indicating an increase in HR, as compared to the pre-stimulus baseline, however, the pregnant participant’s reactivity was significantly closer to zero reflecting a smaller return towards the pre-stimulus average. This pattern also supports the dampened down stress response during pregnancy (as discussed earlier) and is indicative of pregnant women not getting as distressed/physiologically aroused by their experiences, even in response to an infant related stimulus. Of interest here is the concept that hypo-responsivity during pregnancy may be preparing women for the demands of early infant care (Sennaroglu & Belgin, 2001). Moreover, dampening down of stress responses may serve a protective function, preventing the mother and foetus from excessive exposure to stress hormones and dramatic alterations in cardiovascular parameters (Christian, 2012).

Despite this however, it needs to be considered that the majority of null hypotheses failed to be rejected due to the possibility that autonomic reactivity to infant cues is not as substantially altered during pregnancy as much as previously thought. This is not in-line with previous findings which suggest that pregnancy is a time where maternal sensitivity develops (Pearson, 2010) because it is beneficial for a mother to be ready to immediately respond to relevant infant stimuli the moment they are born (Davenport, Flynn & Shaw, 2007).

Limitations.

Statistical power. The study’s sample size only allowed for the detection of medium (hypotheses two and three) to large effects (hypotheses one and six) with some being underpowered to detect clinically relevant differences (hypotheses four and five). The original study planning and consideration of statistical power was based on an overall available sample of 141 participants (100 pregnant and 41
controls), of which there was an available sample of 46 participants with affective disorder symptoms. However, psychophysiological data scrutinising and pre-processing resulted in a substantially smaller sample size than anticipated. Consequently, the results of the study should be interpreted with caution and it cannot be reliably concluded that physiological responses to infant stimuli does not differ in pregnant and non-pregnant women, and in pregnant women with affective disorder symptoms and pregnant women without. The study would have, therefore, benefitted from an increased sample size.

**Methodological issues.** This study could have benefitted from addressing a number of methodological issues. First, individuals could have been asked to rate the stimuli in terms of level of threat, relevance, valence and arousal; this would have complemented concrete physiological data with subjective data. Second, guidelines on the analyses of HF-HRV recommend the concomitant recording of the respiratory function (Society for psychophysiological research; Berntson et al., 1997). However, as there was no access to this parameter, the role of breathing on the high frequency band of HRV could not be controlled for. This could have been an important confounding factor because respiratory function during pregnancy also changes (Carlin & Alfirevic, 2008), which could have explained the baseline group differences in HRV. Furthermore, it was originally planned to analyse HRV during the return to baseline sections; however data scrutiny revealed that the inter-stimulus interval was not 60 seconds as originally assumed which was not an adequate length of time for this measurement. The ability to restore baseline HRV levels post-stimulus would have been an important factor to investigate for the understanding of effective emotion regulation after potentially stressful infant stimuli. Alongside this, again, individual differences in the participants’ subjective experience may have helped
elucidate conclusions around maternal sensitivity during pregnancy. Finally, HR was obtained directly by an external devise to accommodate collecting data within the participants’ homes. It was, therefore, not possible to use a more accurate device such as an ECG. Although considerable time and attention was spent in ensuring that the data pre-processing aspect of this research was thorough; there was no objective measure (e.g., an ECG reading print out) to support the author in determining if any artefacts of unusual patterns had been missed.

**Sample.** This study looked at the relationship between HR reactivity and affective disorder symptoms within a non-clinical sample. This, therefore, has negative implications for the generalizability of the findings to the wider population and to pregnant individuals with a diagnosis of an affective disorder.

**Ecological validity.** It is possible that the design of this study lacks ecological validity: The stimuli are computer generated, and although well designed, they are not real and the mother knows she is partaking in a research experiment with no consequences as a result of her actions. It may be, therefore, that the study design was not sensitive enough to detect the hypothesised differences. If the mother was placed in an actual ‘real life’ scenario where their actions would impact on an infant’s survival, their physiological reactivity and ability to regulate may have been different as the infant ‘stimuli’ would have had more meaning and may have generated an actual action/threat response from which they would then need to recover.

**Strengths.** This study offered something unique to the field of research within pregnancy because the majority of studies only assess the pregnant woman’s peak physiological reactivity as a response to a stress, and do not monitor or assess the participant when the stressor has been removed to see how long it takes to recover.
from the stressful situation (DeWeerth & Buitelaar, 2005). This study incorporated such exploration. It was unfortunate, however, that the stimuli did not seem to evoke a ‘threat’ or ‘action’ reactivity in the participant which meant that they theoretically, during the ‘recovery’ period, had nothing to ‘recover’ from. To be able to understand how pregnant women recover from infant related stimuli, future studies will have to ensure that the infant related stimuli evoke a sympathetically driven response which the individual will need to recover.

**Conclusions and future directions.** The results from this study are not in-line with previous research demonstrating infant related cues to become more salient across pregnancy; with all but one of the null hypotheses failing to be rejected based on statistical insignificance. However, pregnancy remains a vital period for research because not only is it a process where the developing baby requires a well regulated environment in order to protect against programming insults but also, maternal representations of the baby begin to develop. Both of these processes are important factors to consider and preserve because they can be negatively compromised as a result of abnormal physiological and emotional regulation. Additionally, it is important for mothers to be able to respond sensitively and effectively towards their infant the moment they are born to ensure long-term survival and successful attachment.

Being able, therefore, to consider ways to identify those (via non-invasive procedures), during pregnancy, who may be at risk of unregulated responding, therefore, remains paramount. This is particularly important given that in the presence of clinical and sub-clinical pathology, the normal physiological changes of pregnancy can place significant strain on already demanded upon and compromised systems (Carlin & Alfirevic, 2008) potentially reducing flexibility and regulation capacity.
Future directions. It was not within the scope of this research to explore the habituation process to repeated stressors. However, this would be of interest because it would enable better understanding as to whether pregnant women are able to habituate over time (e.g., showing decreases in responsiveness to the stressor each time it is presented). This may have implications for clinical practice: Helping to identify women who find it challenging to habituate to a stressor, or who may even experience sensitization. Such understanding would enable support of mother and baby during pregnancy, and would also provide beneficial preparation for motherhood in terms of the mother accessing interventions to improve her physiological and emotional regulation capability which, in turn, would better her ability to interpret and, therefore, respond appropriately to the baby’s cues.
References


interface between the female body and mental health (pp. 132-135). London: Routledge.


outcomes among term deliveries at three lower Manhattan hospitals.

*Environmental Health Perspectives, 112, 1772–1778.*


Appendices

Appendix A

Table 1.

<table>
<thead>
<tr>
<th>Details of Available Data from Original Study and Actual Data Available</th>
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Experimental data

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</table>

Depressive symptoms*  

<table>
<thead>
<tr>
<th></th>
<th>Early</th>
<th>Late</th>
<th>Controls</th>
<th>Early</th>
<th>Late</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31</td>
<td>23</td>
<td>N/A</td>
<td>16</td>
<td>12</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Anxiety symptoms*  

<table>
<thead>
<tr>
<th></th>
<th>Early</th>
<th>Late</th>
<th>Controls</th>
<th>Early</th>
<th>Late</th>
<th>Controls</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>49</td>
<td>23</td>
<td>N/A</td>
<td>21</td>
<td>11</td>
<td>N/A</td>
</tr>
</tbody>
</table>

Note. This table does not take into consideration multivariate outliers excluded from subsequent analysis nor does it take into consideration participants that were later found to have incomplete data.

¹ Data was lost for reasons including: The original author no longer having a hard copy of the participant’s data.

*To enhance N within the analyses, historical affective disorder symptoms were also included.
Appendix B

Sample size/power calculations were performed separately for each hypothesis using G*Power (Faul, Erdfelder, Lang, Buchner, 2007).

**Hypotheses one and four.** For the independent samples t-test an a priori power calculation was conducted: Assuming a medium effect size (ES; Cohen’s $d = .05$), a statistical power of .8 and $\alpha = .05$, and an unequal number of participants per group (resulting in an allocation ratio of .41), a sample of 122 would be required to detect statistically significant group differences. Given the predefined total sample size of 141 participants (late pregnancy and controls), the statistical power I will be able to obtain for the medium ES is .79, which is acceptable.

**Hypotheses two and three.** For the 2 (groups; pregnancy status) x 4 (stimulus) repeated measures ANOVA an a priori power calculation was conducted: Assuming a medium ES ($f = .25$), a statistical power of .8 and $\alpha = .05$, and assuming a low correlation ($r = .1$) between repeated measures, a total sample size of 48-86 would be required to detect a significant Group by Stimulus interaction (depending on the necessity to apply the nonsphericity correction). This indicates that the available sample of 141 participants (late pregnancy and controls) would be sufficient to detect a significant interaction.

**Hypotheses five and six.** For the 2 (groups; affective disorder status) x 4 (stimulus) repeated measures ANOVA an a priori power calculation was conducted: Assuming a medium effect size ($f = .25$), a statistical power of .8 and $\alpha = .05$, and assuming a low correlation ($r = .1$) between repeated measures, a total sample of 42 would be required to detect a significant Group by Stimulus interaction (depending on the necessity to apply the nonsphericity correction). This indicates that with the available
sample of 46 (late pregnancy) participants with affective disorder symptoms would be sufficient power to detect a significant interaction.
Appendix C

To calculate an individual’s average HR and HRV during the 3 minute baseline/rest period the artefact-clean, individual readings, were averaged over the time period.

It is not possible to demonstrate a full example here as the baseline period was 3 minutes which includes multiple readings; too long to present here. As an example, the following HR readings over the time course were averaged:

72
80
85
80
81
81
82
90
89
88

\[
\frac{72+80+85+80+81+81+82+90+89+88}{10} = 82.8
\]

This procedure was also used to calculate the average HRV over the resting time course.
Appendix D

To calculate an individual’s average HR, pre-stimulus presentation, the following was calculated (for example):

Pre-stimulus presentation HR reading 1  90
Pre-stimulus presentation HR reading 2  92
Pre-stimulus presentation HR reading 3  90

Average of the three HR readings pre-stimulus presentation

\[(90 + 92 + 90) / 3 = 90.66\]

To calculate an individual’s average HR reactivity, during the six second stimulus presentation, compared to the average HR pre-stimulus presentation, the following was calculated (for example):

HR during presentation 1 second  95  \[95 - 90.66 = 4.34\]
HR during presentation 2 second  96  \[96 - 90.66 = 3.34\]
HR during presentation 3 second  100  \[100 - 90.66 = 9.34\]
HR during presentation 4 second  100  \[100 - 90.66 = 9.34\]
HR during presentation 5 second  100  \[100 - 90.66 = 9.34\]
HR during presentation 6 second  99  \[99 - 90.66 = 8.34\]

Average HR reactivity over six seconds

\[(4.34 + 3.34 + 9.34 + 9.34 + 9.34 + 8.34) / 6 = 7.34\]

Minimum HR reactivity  3.34
Maximum HR reactivity  9.34
To calculate an individual’s average HR reactivity, during the 12 second post-stimulus phase, compared to the average HR pre-stimulus presentation, the following was calculated (for example):

<table>
<thead>
<tr>
<th>HR post-stimulus 1 second</th>
<th>99</th>
<th>99 – 90.66 = 8.34</th>
</tr>
</thead>
<tbody>
<tr>
<td>HR post-stimulus 2 second</td>
<td>99</td>
<td>99 – 90.66 = 8.34</td>
</tr>
<tr>
<td>HR post-stimulus 3 second</td>
<td>101</td>
<td>101 – 90.66 = 10.34</td>
</tr>
<tr>
<td>HR post-stimulus 4 second</td>
<td>102</td>
<td>102 – 90.66 = 11.34</td>
</tr>
<tr>
<td>HR post-stimulus 5 second</td>
<td>98</td>
<td>98 – 90.66 = 7.34</td>
</tr>
<tr>
<td>HR post-stimulus 6 second</td>
<td>97</td>
<td>97 – 90.66 = 6.34</td>
</tr>
<tr>
<td>HR post-stimulus 7 second</td>
<td>96</td>
<td>96 – 90.66 = 5.34</td>
</tr>
<tr>
<td>HR post-stimulus 8 second</td>
<td>95</td>
<td>95 – 90.66 = 4.34</td>
</tr>
<tr>
<td>HR post-stimulus 9 second</td>
<td>95</td>
<td>95 – 90.66 = 4.34</td>
</tr>
<tr>
<td>HR post-stimulus 10 second</td>
<td>94</td>
<td>94 – 90.66 = 3.34</td>
</tr>
<tr>
<td>HR post-stimulus 11 second</td>
<td>94</td>
<td>94 – 90.66 = 3.34</td>
</tr>
<tr>
<td>HR post-stimulus 12 second</td>
<td>89</td>
<td>89 – 90.66 = 1.66</td>
</tr>
</tbody>
</table>

**Average HR reactivity over 12 seconds**

\[ \frac{8.34+8.34+10.34+11.34+7.34+6.34+5.34+4.34+4.34+3.34+3.34+1.66}{12} = 6.2 \]

**Minimum HR reactivity**

- 1.66

**Maximum HR reactivity**

11.34
Appendix E (anxiety symptoms)\(^6\)

**Hypothesis four**

**Baseline heart rate.** An independent samples t-test revealed no differences between pregnant females with anxiety symptoms and pregnant females without, \(t(38) = -.812, p = .442\), Cohen’s \(d = -.25\), indicating that pregnant participants with anxiety symptoms \((M = 84.48, SD = 9.54)\) and pregnant participants without \((M = 87.33, SD = 12.57)\) do not significantly differ on their B/L HR.

**Baseline HRV.** Prior tests of normality indicated that the HRV data did not meet the assumptions of normality. The Mann Whitney U test was, therefore, conducted to examine differences between pregnant participants’ (with anxiety symptoms) and pregnant participants’ (without anxiety symptoms) HRV at rest. This revealed no differences, \(U = 142.00, Z = -1.097, p = .273\), Kraemer’s \(r = -.18\), indicating that pregnant participants with anxiety symptoms \((Mdn = 476.44, Range = 92.50 – 4435.80)\) and pregnant participants without \((Mdn = 347.46, Range = 41.86 – 4726.50)\), do not significantly differ on their B/L HRV.

Due to no statistically significant differences between groups, neither B/L HR nor B/L HRV was entered as covariates within subsequent analysis.

**Hypothesis five**

**Average HR reactivity during stimulus presentation phase.** The assumptions of normality were violated; therefore, a Friedman’s ANOVA was conducted. There were no differences of stimulus on average HR reactivity during

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\(^6\) The state anxiety scale was used to gather data about current state of anxiety amongst the early pregnancy participants. This measure has been found to be reliable and valid (Spielberger, 1983). Cronbach’s alpha could not be calculated because the individual items were not available to the author.
the stimulus presentation phase between pregnant participants with anxiety symptoms and pregnant participants without, $\chi^2(3) = 1.154, p = .764$. A Mann Whitney U test found no differences between pregnancy with anxiety symptoms and pregnancy without (see Table 2 for Mdn and Range).

Table 2.

Medians and ranges for average HR reactivity (baseline-to-stimulus change in bpm) in response to the different stimuli for both pregnancy with anxiety symptoms and pregnancy without anxiety symptoms.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy with anxiety symptoms</th>
<th>Pregnancy without anxiety symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mdn</td>
</tr>
<tr>
<td>BabCry</td>
<td>24</td>
<td>-.01</td>
</tr>
<tr>
<td>FCry</td>
<td>24</td>
<td>-.43</td>
</tr>
<tr>
<td>FNoise</td>
<td>24</td>
<td>.33</td>
</tr>
<tr>
<td>INoise</td>
<td>24</td>
<td>.23</td>
</tr>
</tbody>
</table>

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone.

Note. A positive value indicates heart rate acceleration and a negative value indicates a deceleration as compared to pre-stimulus baseline.

**Average Minimum HR reactivity during the stimulus presentation.** The assumptions of normality were violated; therefore, a Friedman’s ANOVA test was conducted. There was no difference of stimulus, on average minimum HR reactivity, during the stimulus presentation phase, $\chi^2(3) = 2.169, p = .538$. A Mann Whitney U test revealed no differences between pregnancy with anxiety symptoms and
pregnancy without anxiety symptoms, across any of the stimuli, for average minimum HR reactivity (see Table 3 for Mdn and Range).

Table 3.

*Medians and ranges for average minimum HR reactivity (baseline-to-stimulus change in bpm) in response to the different stimuli for both pregnancy with anxiety symptoms and pregnancy without anxiety symptoms.*

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy with anxiety symptoms</th>
<th>Pregnancy without anxiety symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mdn</td>
</tr>
<tr>
<td>BabCry</td>
<td>24</td>
<td>-4.42</td>
</tr>
<tr>
<td>FCry</td>
<td>24</td>
<td>-6.44</td>
</tr>
<tr>
<td>FNoise</td>
<td>24</td>
<td>-5.67</td>
</tr>
<tr>
<td>INoise</td>
<td>24</td>
<td>-4.67</td>
</tr>
</tbody>
</table>

*Note.* BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone. *Note.* A positive value indicates heart rate acceleration and a negative value indicates a deceleration as compared to pre-stimulus baseline.

**Average Maximum HR reactivity during the stimulus presentation.** The assumptions of normality were violated; therefore, a Friedman's ANOVA test was conducted. There was no difference of stimulus, on average maximum HR reactivity, during the stimulus presentation phase, $\chi^2(3) = 2.260, p = .520$. A Mann Whitney U test revealed no differences between pregnancy with anxiety symptoms and pregnancy without across any of the stimuli for average maximum HR reactivity (see Table 4 for Mdn and Range).
Table 4.

Medians and ranges for average maximum HR reactivity (baseline-to-stimulus change in bpm) in response to the different stimuli for both pregnancy with anxiety symptoms and pregnancy without anxiety symptoms.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy</th>
<th></th>
<th></th>
<th>Non-Pregnancy</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mdn</td>
<td>Min</td>
<td>Max</td>
<td>N</td>
<td>Mdn</td>
</tr>
<tr>
<td>BabCry</td>
<td>24</td>
<td>4.71</td>
<td>.92</td>
<td>11.17</td>
<td>15</td>
<td>3.67</td>
</tr>
<tr>
<td>FCry</td>
<td>24</td>
<td>4.71</td>
<td>-2.25</td>
<td>17.42</td>
<td>15</td>
<td>4.46</td>
</tr>
<tr>
<td>FNoise</td>
<td>24</td>
<td>5.12</td>
<td>-.50</td>
<td>12.67</td>
<td>15</td>
<td>3.83</td>
</tr>
<tr>
<td>INoise</td>
<td>24</td>
<td>4.46</td>
<td>1.83</td>
<td>14.41</td>
<td>15</td>
<td>4.33</td>
</tr>
</tbody>
</table>

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone. Note. A positive value indicates heart rate acceleration and a negative value indicates a deceleration as compared to pre-stimulus baseline.

Hypothesis six

Average HR reactivity, post-stimulus presentation, compared to average HR pre-stimulus presentation. A repeated measures 2x4 ANOVA was conducted to examine the main effects of the within subjects variable of stimulus (the four stimuli), the between subjects variable of group (pregnancy with anxiety symptoms Vs pregnancy without anxiety symptoms), and a stimulus x group interaction on average HR reactivity, post-stimulus phase, in relation to the average HR pre-stimulus presentation phase.

There was no main effect of stimulus, $F(3,34) = .857, p = .473, \eta^2_p = .070$, nor did anxiety symptoms moderate the relationship of stimulus type and HR reactivity, $F(3, 34) = .593, p = .624, \eta^2_p = .050$. Tests of between-subjects effects revealed no
statistically significant effect of group, $F(1,36) = .033$, $p = .857$, $\eta_p^2 = .001$, (see Table 5 for M and SD).

Table 5.
Means and standard deviations for average HR reactivity during the post-stimulus presentation phase, compared to average HR pre-stimulus presentation, for both pregnancy with anxiety symptoms and pregnancy without anxiety symptoms.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy with anxiety symptoms</th>
<th>Pregnancy without anxiety symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>BabCry</td>
<td>24</td>
<td>.57</td>
</tr>
<tr>
<td>FCry</td>
<td>24</td>
<td>-.70</td>
</tr>
<tr>
<td>FNoise</td>
<td>24</td>
<td>-.21</td>
</tr>
<tr>
<td>INoise</td>
<td>24</td>
<td>-.09</td>
</tr>
</tbody>
</table>

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone. Note. A positive value indicates an increase in HR as compared to pre-stimulus baseline, and a value closer to zero indicate a return towards the pre-stimulus average HR; a negative value indicate a deceleration and no return towards the pre-stimulus average HR baseline.

Average minimum HR reactivity, post-stimulus presentation, compared to average HR pre-stimulus presentation. A repeated measures 2x4 ANOVA was conducted to examine the main effects of the within subjects variable of stimulus (the four stimuli), the between subjects variable of group (pregnancy with anxiety symptoms Vs pregnancy without anxiety symptoms), and a stimulus x group interaction on average minimum HR reactivity, post-stimulus presentation, in relation to the pre-stimulus presentation HR.

There was no statistically significant main effect of stimulus, $F(3,34) = 1.65$, $p = .197$, $\eta_p^2 = .127$, or interaction with anxiety symptoms, $F(3,34) = .187$, $p = .905$, $\eta_p^2$.
Tests of between-subjects effects revealed no statistically significant effect of group, $F(1,36) = .823, p = .370, \eta_p^2 = .022$, (see Table 6 for Ms and SDs).

Table 6.

Means and standard deviations for average minimum HR reactivity, during post-stimulus phase, in relation to pre-stimulus presentation average HR for both pregnancy with anxiety symptoms and pregnancy without anxiety symptoms.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy with anxiety symptoms</th>
<th>Pregnancy without symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>BabCry</td>
<td>24</td>
<td>-7.12</td>
</tr>
<tr>
<td>FCry</td>
<td>24</td>
<td>-8.21</td>
</tr>
<tr>
<td>FNoise</td>
<td>24</td>
<td>-7.07</td>
</tr>
<tr>
<td>INoise</td>
<td>24</td>
<td>-7.67</td>
</tr>
</tbody>
</table>

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone. Note. A positive value indicates an increase in HR as compared to pre-stimulus baseline, and a value closer to zero indicates a return towards the pre-stimulus average HR/baseline; a negative value indicates a deceleration and no return towards the pre-stimulus average HR/baseline.

Average maximum HR reactivity, post-stimulus presentation, compared to average HR before stimulus presentation. The assumptions of normality were violated; therefore, a Friedman’s ANOVA test was conducted. There was no difference of stimulus on average maximum HR reactivity, $\chi^2(3) = 2.58, p = .460$. A Mann Whitney U test revealed no differences between pregnancy with anxiety symptoms and pregnancy without anxiety symptoms (see Table 7 for Mdn and Range).
Table 7.

Medians and ranges for average maximum HR reactivity, during the post-stimulus phase, in relation to the average HR, pre-stimulus presentation, for both pregnancy with anxiety symptoms and pregnancy without anxiety symptoms.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy with anxiety symptoms</th>
<th>Pregnancy without anxiety symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mdn</td>
</tr>
<tr>
<td>BabCry</td>
<td>24</td>
<td>7.75</td>
</tr>
<tr>
<td>FCry</td>
<td>24</td>
<td>6.15</td>
</tr>
<tr>
<td>FNoise</td>
<td>24</td>
<td>6.42</td>
</tr>
<tr>
<td>INoise</td>
<td>24</td>
<td>5.62</td>
</tr>
</tbody>
</table>

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone. Note. A positive value indicates an increase in HR as compared to pre-stimulus baseline, and a value closer to zero indicates a return towards the pre-stimulus average HR/baseline; a negative value indicates a deceleration and no return towards the pre-stimulus average HR/baseline.
Appendix F: Supplementary minimum and maximum analyses

Hypothesis two.

**Average Minimum HR reactivity during the stimulus presentation.** The assumptions of normality were violated; therefore, a Friedman’s ANOVA test was conducted. There was no difference of stimulus, on average minimum HR reactivity, during the stimulus presentation phase, $\chi^2(3) = 5.479, p = .140$. A Mann Whitney U test revealed no differences between pregnancy and controls, across any of the stimuli, for average minimum HR reactivity (see Table 8 for Mdn and Range).

Table 8.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy</th>
<th></th>
<th></th>
<th>Non-Pregnancy</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mdn</td>
<td>Min</td>
<td>Max</td>
<td>N</td>
<td>Mdn</td>
</tr>
<tr>
<td>BabCry</td>
<td>39</td>
<td>-4.92</td>
<td>-17.48</td>
<td>-.33</td>
<td>22</td>
<td>-5.46</td>
</tr>
<tr>
<td>FCry</td>
<td>39</td>
<td>-5.50</td>
<td>-14.50</td>
<td>-2.08</td>
<td>22</td>
<td>-6.96</td>
</tr>
<tr>
<td>FNoise</td>
<td>39</td>
<td>-5.08</td>
<td>-14.89</td>
<td>-1.17</td>
<td>22</td>
<td>-5.58</td>
</tr>
<tr>
<td>INoise</td>
<td>39</td>
<td>-4.67</td>
<td>-21.69</td>
<td>-.08</td>
<td>22</td>
<td>-6.50</td>
</tr>
</tbody>
</table>

Note. A positive value indicates heart rate acceleration and a negative value indicates a deceleration as compared to pre-stimulus baseline.

**Average Maximum HR reactivity during the stimulus presentation.** The assumptions of normality were violated; therefore, a Friedman’s ANOVA test was conducted. There was no difference of stimulus type, on average maximum HR reactivity, during the stimulus presentation phase, $\chi^2(3) = 6.671, p = .083$. A Mann Whitney U test revealed no differences between pregnancy and controls, across any of the stimuli, for average maximum HR reactivity (see Table 9 for Mdn and Range).
Table 9.

Medians and ranges for average maximum HR reactivity (baseline-to-stimulus change in bpm) in response to the different stimuli for both pregnancy and non-pregnancy samples.

| Stimulus Type | Pregnancy | | Non-Pregnancy | | |
|---------------|-----------|---|---|---|---|---|---|
|               | N         | Mdn | Min | Max | N | Mdn | Min | Max |
| BabCry        | 39        | 4.50 | .42  | 13.92 | 22 | 4.13 | -.50 | 13.33 |
| FCry          | 39        | 4.33 | -2.25 | 17.42 | 22 | 4.15 | -15.50 | -2.17 |
| FNoise        | 39        | 4.58 | -.50 | 12.67 | 22 | 4.17 | .25  | 39.25 |
| INoise        | 39        | 4.42 | -.08 | 14.41 | 22 | 4.46 | 1.17  | 17.33 |

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone.

Note. A positive value indicates heart rate acceleration and a negative value indicates a deceleration as compared to pre-stimulus baseline.

Hypothesis three.

Average minimum HR reactivity, during the post-stimulus phase, compared to average HR pre-stimulus presentation. Non-parametric tests were required. A Friedman ANOVA revealed no statistically significant differences in average minimum HR reactivity, during the recovery phase, amongst the stimuli types, $\chi^2(3) = 3.90, \ p = .272$. Similarly, the Mann-Whitney U test found no statistically significant differences between groups for any of the different stimuli types (see Table 10 for Ms and SDs).
Table 10.

Medians and ranges for average minimum HR reactivity, during post-stimulus phase, in relation to average HR pre-stimulus presentation for both pregnancy and non-pregnancy samples.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy</th>
<th></th>
<th></th>
<th></th>
<th>Non-Pregnancy</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mdn</td>
<td>Min</td>
<td>Max</td>
<td>N</td>
<td>Mdn</td>
<td>Min</td>
</tr>
<tr>
<td>BabCry</td>
<td>38</td>
<td>-7.21</td>
<td>-15.08</td>
<td>1.42</td>
<td>22</td>
<td>-5.29</td>
<td>-13.67</td>
</tr>
<tr>
<td>FCry</td>
<td>38</td>
<td>-6.96</td>
<td>-17.33</td>
<td>-2.92</td>
<td>22</td>
<td>-7.37</td>
<td>-16.28</td>
</tr>
<tr>
<td>FNoise</td>
<td>38</td>
<td>-5.87</td>
<td>-11.17</td>
<td>-1.42</td>
<td>22</td>
<td>-6.12</td>
<td>-24.09</td>
</tr>
<tr>
<td>INoise</td>
<td>38</td>
<td>-6.92</td>
<td>-21.33</td>
<td>-.08</td>
<td>22</td>
<td>-6.87</td>
<td>-33.50</td>
</tr>
</tbody>
</table>

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone.

Note. A positive value indicates an increase in HR as compared to pre-stimulus baseline, and a value closer to zero indicates a return towards the pre-stimulus average HR/baseline; a negative value indicates a deceleration and no return towards the pre-stimulus average HR/baseline.

Average maximum HR reactivity, post-stimulus phase, compared to average HR pre-stimulus presentation. Non-parametric tests were required. A Friedman ANOVA revealed no statistically significant differences in average maximum HR reactivity, post-stimulus presentation, amongst the stimuli types, $\chi^2(3) = 2.985, p = .394$. The Mann Whitney U test, however, found a statistically significant difference between pregnant participants and controls for average maximum HR reactivity, post-stimulus presentation, for FCry, $U = 262.000$, $Z = -2.39$, $p = 0.017$, Kraemer's $r = -.31$, (see Table 11 for Ms and SDs).
Table 11.

*Medians and ranges for average maximum HR reactivity, during post-stimulus phase, in relation to average HR pre-stimulus presentation for both pregnancy and non-pregnancy samples.*

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy</th>
<th>Non-Pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mdn</td>
</tr>
<tr>
<td>BabCry</td>
<td>38</td>
<td>7.54</td>
</tr>
<tr>
<td>FCry</td>
<td>38</td>
<td>5.92</td>
</tr>
<tr>
<td>FNoise</td>
<td>38</td>
<td>6.44</td>
</tr>
<tr>
<td>INoise</td>
<td>38</td>
<td>5.62</td>
</tr>
</tbody>
</table>

*Note.* BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone.

*Note.* A positive value indicates an increase in HR as compared to pre-stimulus baseline, and a value closer to zero indicates a return towards the pre-stimulus average HR/baseline; a negative value indicates a deceleration and no return towards the pre-stimulus average HR/baseline.

**Hypothesis five.**

*Average Minimum HR reactivity during stimulus presentation.* The assumptions of normality were violated; therefore, a Friedman’s ANOVA test was conducted. There was no difference of stimulus, on average minimum HR reactivity, during the stimulus presentation phase, \( \chi^2(3) = 2.169, p = .538 \). A Mann Whitey U test revealed no differences between pregnancy with depressive symptoms and pregnancy without depressive symptoms, across any of the stimuli, for average minimum HR reactivity (see Table 12 for Mdn and Range).
Table 12.

*Medians and ranges for average minimum HR reactivity (baseline-to-stimulus change in bpm) in response to the different stimuli for both pregnancy with depressive symptoms and pregnancy without depressive symptoms.*

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy</th>
<th>Non-Pregnancy</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mdn</td>
</tr>
<tr>
<td>BabCry</td>
<td>17</td>
<td>-3.50</td>
</tr>
<tr>
<td>FCry</td>
<td>17</td>
<td>-6.25</td>
</tr>
<tr>
<td>FNoise</td>
<td>18</td>
<td>-4.96</td>
</tr>
<tr>
<td>lNoise</td>
<td>17</td>
<td>-4.67</td>
</tr>
</tbody>
</table>

*Note.* BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; lNoise, flashing screen accompanied by a computer tone.

*Note.* A positive value indicates heart rate acceleration and a negative value indicates a deceleration as compared to pre-stimulus baseline.

**Average Maximum HR reactivity during stimulus presentation.** The assumptions of normality were violated; therefore, a Friedman’s ANOVA test was conducted. There was no difference of stimulus, on average maximum HR reactivity, during the stimulus presentation phase, $\chi^2(3) = 2.260, p = .520$. A Mann Whitney U test revealed no differences between pregnancy with depressive symptoms and pregnancy without depressive symptoms, across any of the stimuli, for average maximum HR reactivity (see Table 13 for Mdn and Range).
Table 13.

Medians and ranges for average maximum HR reactivity (baseline-to-stimulus change in bpm) in response to the different stimuli for both pregnancy with depressive symptoms and pregnancy without depressive symptoms.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy</th>
<th></th>
<th></th>
<th>Non-Pregnancy</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mdn</td>
<td>Min</td>
<td>Max</td>
<td>N</td>
<td>Mdn</td>
</tr>
<tr>
<td>BabCry</td>
<td>17</td>
<td>4.75</td>
<td>2.08</td>
<td>11.17</td>
<td>22</td>
<td>4.04</td>
</tr>
<tr>
<td>FCry</td>
<td>17</td>
<td>3.42</td>
<td>1.00</td>
<td>17.42</td>
<td>22</td>
<td>4.46</td>
</tr>
<tr>
<td>FNoise</td>
<td>18</td>
<td>4.79</td>
<td>-.50</td>
<td>12.67</td>
<td>23</td>
<td>4.50</td>
</tr>
<tr>
<td>INoise</td>
<td>17</td>
<td>4.42</td>
<td>1.83</td>
<td>9.92</td>
<td>22</td>
<td>4.29</td>
</tr>
</tbody>
</table>

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone.

Note. A positive value indicates heart rate acceleration and a negative value indicates a deceleration as compared to pre-stimulus baseline.

Hypothesis six.

Average minimum HR reactivity, post-stimulus presentation, compared to average HR pre-stimulus presentation. A repeated measures 2x4 ANOVA was conducted to examine the main effects of the within subjects variable of stimulus (the four stimuli), the between subjects variable of group (pregnancy with depressive symptoms Vs pregnancy without depressive symptoms), and a stimulus x group interaction on average minimum HR reactivity, post-stimulus presentation, in relation to the pre-stimulus presentation HR.

There was no statistically significant main effect of stimulus, $F(3,34) = 1.606$, $p = .206$, $\eta^2_p = .124$, or interaction with depressive symptoms, $F(3,34) = .104$, $p = .957$, $\eta^2_p = .009$. Tests of between-subjects effects revealed no statistically
significant effect of group, $F(1,36) = 1.48$, $p = .231$, $\eta^2_p = .040$, (see Table 14 for M and SD).

Table 14.

*Means and standard deviations for average minimum HR reactivity, during post-stimulus phase, in relation to pre-stimulus presentation average HR for both pregnancy with depressive symptoms and pregnancy without depressive symptoms.*

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy with depressive symptoms</th>
<th>Pregnancy without depressive symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mean</td>
</tr>
<tr>
<td>BabCry</td>
<td>17</td>
<td>-6.61</td>
</tr>
<tr>
<td>FCry</td>
<td>17</td>
<td>-7.76</td>
</tr>
<tr>
<td>FNoise</td>
<td>17</td>
<td>-5.79</td>
</tr>
<tr>
<td>INoise</td>
<td>17</td>
<td>-6.49</td>
</tr>
</tbody>
</table>

*Note.* BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone.

*Note.* A positive value indicates an increase in HR as compared to pre-stimulus baseline, and a value closer to zero indicates a return towards the to pre-stimulus average HR/baseline; a negative value indicates a deceleration and no return towards the pre-stimulus average HR/baseline.

*Average maximum HR reactivity, post-stimulus presentation, in relation to average HR pre-stimulus presentation.* The assumptions of normality were violated; therefore, a Friedman’s ANOVA test was conducted. There was no difference of stimulus on average maximum HR reactivity, $\chi^2(3) = 2.58$, $p = .460$. A Mann Whitney U test revealed no differences between pregnancy with depressive symptoms and pregnancy without depressive symptoms (see Table 15 for Mdn and Range).
Table 15.  
Medians and ranges for average maximum HR reactivity, during the post-stimulus phase, in relation to the average HR, pre-stimulus presentation, for both pregnancy with depressive symptoms and pregnancy without depressive symptoms.

<table>
<thead>
<tr>
<th>Stimulus Type</th>
<th>Pregnancy with depressive symptoms</th>
<th>Pregnancy without depressive symptoms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td>Mdn</td>
</tr>
<tr>
<td>BabCry</td>
<td>17</td>
<td>7.75</td>
</tr>
<tr>
<td>FCry</td>
<td>17</td>
<td>5.42</td>
</tr>
<tr>
<td>FNoise</td>
<td>18</td>
<td>5.83</td>
</tr>
<tr>
<td>INoise</td>
<td>17</td>
<td>5.42</td>
</tr>
</tbody>
</table>

Note. BabCry, distressed baby face accompanied with a baby cry; FCry, fearful adult face accompanied by baby cry; FNoise, fearful adult face accompanied by a computer tone; INoise, flashing screen accompanied by a computer tone.

Note. A positive value indicates an increase in HR as compared to pre-stimulus baseline, and a value closer to zero indicates a return towards the to pre-stimulus average HR/baseline; a negative value indicates a deceleration and no return towards the pre-stimulus average HR/baseline.
Appendix G: Ethical approval

To: Curtis, Hannah;

Ethical Approval system

Your application (2014/554) entitled Psycho-physiological responses and regulation during pregnancy, and the relationship with affective disorders, has been accepted.

Please visit http://www.exeter.ac.uk/staff/ethicalapproval/
Please click on the link above and select the relevant application from the list.
Appendix H: Dissemination statement

I will use the following dissemination strategy to ensure that the findings of this research are shared with interested parties.

**University of Exeter Doctorate in Clinical Psychology.** This thesis will be submitted as part of the requirements of the doctorate programme.

**Wider academic and clinical community.** In June 2015, my research findings will be presented to an academic audience, for peer review, as part of the Doctorate in Clinical Psychology at the University of Exeter.

**Journal Publication.** It is expected that a reduced research paper will be submitted for publication with a peer-reviewed journal.
Appendix I: Instructions to authors (Journal of Developmental Psychology)

Length

Manuscripts should be the appropriate length for the material being presented. Manuscripts can vary from 2500–4500 words for a brief report to 10,500 words for a larger research report to 15,000 words for a report containing multiple studies or comprehensive longitudinal studies. Editors will decide on the appropriate length and may return a manuscript for revision before reviews if they think the paper is too long. Please make manuscripts as brief as possible. We have a strong preference for shorter papers.

Facilitating Manuscript Review

In addition to email addresses, please supply mailing addresses, phone numbers, and fax numbers. Most correspondence will be handled by email. Keep a copy of the manuscript to guard against loss.

Masked Review Policy

This journal uses masked review for all submissions. Make every effort to see that the manuscript itself contains no clues to the authors’ identity. The submission letter should indicate the title of the manuscript, the authors’ names and institutional affiliations, and the date the manuscript is submitted.

The first page of the manuscript should omit the authors’ names and affiliations but should include the title of the manuscript and the date it is submitted. Author notes, acknowledgments, and footnotes containing information pertaining to the authors’ identity or affiliations may be added on acceptance.

Methodology

Description of Sample

Authors should be sure to report the procedures for sample selection and recruitment. Major demographic characteristics should be reported, such as sex, age, socioeconomic status, race/ethnicity, and, when possible and appropriate, disability status and sexual orientation. Even when such demographic characteristics are not analytic variables, they provide a more complete understanding of the sample and of the generalizability of the findings and are useful in future meta-analytic studies.

Significance

For all study results, measures of both practical and statistical significance should be reported. The latter can involve either a standard error or an appropriate confidence interval. Practical significance can be reported using an effect size, a standardized regression coefficient, a factor loading, or an odds ratio.

Reliability
Manuscripts should include information regarding the establishment of interrater reliability when relevant, including the mechanisms used to establish reliability and the statistical verification of rater agreement and excluding the names of the trainers and the amount of personal contact with such individuals.

**Manuscript Preparation**

Prepare manuscripts according to the *Publication Manual of the American Psychological Association (6th edition)*. Manuscripts may be copyedited for bias-free language (see Chapter 3 of the *Publication Manual*).

Review APA’s [Checklist for Manuscript Submission](#) before submitting your article.

Double-space all copy. Other formatting instructions, as well as instructions on preparing tables, figures, references, metrics, and abstracts, appear in the *Manual*.

Below are additional instructions regarding the preparation of display equations, computer code, and tables.

**Display Equations**

We strongly encourage you to use MathType (third-party software) or Equation Editor 3.0 (built into pre-2007 versions of Word) to construct your equations, rather than the equation support that is built into Word 2007 and Word 2010. Equations composed with the built-in Word 2007/Word 2010 equation support are converted to low-resolution graphics when they enter the production process and must be rekeyed by the typesetter, which may introduce errors.

To construct your equations with MathType or Equation Editor 3.0:

- Go to the Text section of the Insert tab and select Object.
- Select MathType or Equation Editor 3.0 in the drop-down menu.

If you have an equation that has already been produced using Microsoft Word 2007 or 2010 and you have access to the full version of MathType 6.5 or later, you can convert this equation to MathType by clicking on MathType Insert Equation. Copy the equation from Microsoft Word and paste it into the MathType box. Verify that your equation is correct, click File, and then click Update. Your equation has now been inserted into your Word file as a MathType Equation.

Use Equation Editor 3.0 or MathType only for equations or for formulas that cannot be produced as Word text using the Times or Symbol font.

**Computer Code**

Because altering computer code in any way (e.g., indents, line spacing, line breaks, page breaks) during the typesetting process could alter its meaning, we treat computer code differently from the rest of your article in our production process. To that end, we request separate files for computer code.
In Online Supplemental Material
We request that runnable source code be included as supplemental material to the article. For more information, visit Supplementing Your Article With Online Material.

In the Text of the Article
If you would like to include code in the text of your published manuscript, please submit a separate file with your code exactly as you want it to appear, using Courier New font with a type size of 8 points. We will make an image of each segment of code in your article that exceeds 40 characters in length. (Shorter snippets of code that appear in text will be typeset in Courier New and run in with the rest of the text.) If an appendix contains a mix of code and explanatory text, please submit a file that contains the entire appendix, with the code keyed in 8-point Courier New.

Tables
Use Word's Insert Table function when you create tables. Using spaces or tabs in your table will create problems when the table is typeset and may result in errors.

Submitting Supplemental Materials
APA can place supplemental materials online, available via the published article in the PsycARTICLES® database. Please see Supplementing Your Article With Online Material for more details.

Abstract and Keywords
All manuscripts must include an abstract containing a maximum of 250 words typed on a separate page. After the abstract, please supply up to five keywords or brief phrases.