Maternal Bonding and Negative Affect:
Association with Infant Social-Emotional Development

by

Genevieve Le Bas, BA (Hons)

Submitted in partial fulfilment of the requirements for the degree of

Doctor of Psychology (Clinical)

Deakin University

June 2019
DEAKIN UNIVERSITY
CANDIDATE DECLARATION

I certify the following about the thesis entitled:
Maternal Bonding and Negative Affect: Association with Infant Social-Emotional Development

submitted for the degree of:
Doctor of Psychology (Clinical)

a. I am the creator of all or part of the whole work(s) (including content and layout) and that where reference is made to the work of others, due acknowledgment is given.

b. The work(s) are not in any way a violation or infringement of any copyright, trademark, patent, or other rights whatsoever of any person.

c. That if the work(s) have been commissioned, sponsored or supported by any organisation, I have fulfilled all of the obligations required by such contract or agreement.

d. That any material in the thesis which has been accepted for a degree or diploma by any university or institution is identified in the text.

e. All research integrity requirements have been complied with.

'I certify that I am the student named below and that the information provided in the form is correct'.

Full Name: Genevieve Le Bas

Signed: [Signature Redacted by Library]

Date: 06/06/2019
I am the author of the thesis entitled:
Maternal Bonding and Negative Affect: Association with Infant Social-Emotional Development

submitted for the degree of:
Doctor of Psychology (Clinical)

The thesis may be made available for consultation, loan and limited copying in accordance with the Copyright Act 1968.

'I certify that I am the student named below and that the information provided in the form is correct'.

Full Name: Genevieve Le Bas

Signed: Signature Redacted by Library

Date: 06/06/2019
Acknowledgements

First and foremost, I would like to thank Delyse Hutchinson. You have guided me through these past few years with wisdom, care, and encouragement. You truly are one of a kind, and I am so grateful to have shared this experience with you.

George Youssef. You and me, just a couple of kids living the dream, crunching numbers on a weekly basis. I value your generosity, humour, and good sense. Thank you for keeping me grounded.

Thank you also to Craig Olsson, Jacqui Macdonald, and Jennifer McIntosh, for providing guidance on my papers.

My friends in the Masters and Doctorate, in particular my ABCDEs. Gaining you as friends has made everything about this degree worthwhile. I will forever cherish the memories we have made together, and I celebrate our success.

Thank you also to my friends outside of this course.

Your love and care underlie everything that I do.

And of course, thank you to my most treasured support team, my family.

Mum, thank you for all of the little things you have done that equate to large gestures of support. The “brain food”, the (beautiful) cakes, the pep talks. You picked me up when I stumbled.

Dad, I have no doubt that I chose this pathway because I see myself as similar to you. You are gentle and kind in your work, and with me. Thank you for your continued support.

Liz and Cin, my original study buddies and lifelong partners. I could not have endured the marathon study sessions without you! Thank you for always being there for me.

Darcy, for all of the cuddles along the way.
List of Publications

The current thesis has been submitted as a conventional thesis. Study I (Chapter 7; Appendix A for authorship statement) was published by Social Development in July 2019. Study II (Chapter 8; Appendix B for authorship statement) was submitted to Child Development in May 2019. Study III (Chapter 9) was submitted to Child Development in September 2019.

Table 1

List of Publications

<table>
<thead>
<tr>
<th>Study</th>
<th>Chapter</th>
<th>Publication</th>
</tr>
</thead>
</table>
Table of Contents

1. List of Tables ........................................................................................................................................ 12
2. List of Figures ......................................................................................................................................... 13
3. Thesis Abstract ....................................................................................................................................... 14
4. List of Abbreviations and Definitions ................................................................................................. 17

5. Introduction ......................................................................................................................................... 19
   5.1. Importance of the Perinatal Period ................................................................................................. 19
   5.2. Social, Emotional, and Behavioural Development During Infancy ............................................. 20
       5.2.1. Social-emotional development ............................................................................................... 20
       5.2.2. Adaptive behaviour development ......................................................................................... 22
       5.2.3. Temperament ......................................................................................................................... 22
       5.2.4. Prevalence and continuity of infant social-emotional problems .......................................... 22
   5.3. Cognitive, Language, and Motor Development During Infancy ................................................... 24
       5.3.1. Cognitive development ........................................................................................................... 25
       5.3.2. Language development ......................................................................................................... 25
       5.3.3. Motor development ............................................................................................................... 25
   5.4. Prediction of Infant Development ................................................................................................ 26
   5.5. Maternal Bonding in the Perinatal Period ...................................................................................... 28
       5.5.1. Maternal bonding disorders ................................................................................................... 30
       5.5.2. Bonding and attachment ....................................................................................................... 31
       5.5.3. Maternal bonding and infant development ............................................................................ 32
   5.6. Maternal Negative Affect in the Perinatal Period ........................................................................... 35
       5.6.1. Clinical presentation of maternal negative affect ................................................................. 38
       5.6.2. Maternal negative affect and infant development ............................................................... 39
   5.7. Interrelations Between Maternal Bonding and Negative Affect ................................................ 40
5.8. Contribution of Maternal Bonding and Negative Affect to Infant Social-Emotional Development ................................................................. 44
5.9. Key Gaps in the Literature .................................................................... 46
5.10. The Current Thesis ................................................................................. 47
5.11. References ................................................................................................. 49

6. General Method .............................................................................................. 68
   6.1. Design ........................................................................................................ 68
       6.1.1. Ethics .................................................................................................. 69
       6.1.2. Funding ............................................................................................... 70
   6.2. Participants .................................................................................................. 70
   6.3. Procedures ................................................................................................... 71
   6.4. Measures ..................................................................................................... 72
       6.4.1. Maternal and infant demographics ....................................................... 73
       6.4.2. Maternal bonding ................................................................................ 75
       6.4.3. Maternal negative affect ................................................................. 76
       6.4.4. Infant developmental outcomes .................................................. 77
   6.5. References ................................................................................................... 83

7. Study I: The Role of Antenatal and Postnatal Maternal Bonding in Infant Development: A Systematic Review and Meta-Analysis ......................... 85
8. **Study II: The Role of Antenatal and Postnatal Maternal Bonding in Infant Development** ................................................................. 105

8.1. Abstract ......................................................................................................................................................... 108

8.2. Introduction ................................................................................................................................................ 109

8.2.1. The current study ........................................................................................................................................ 112

8.3. Method ........................................................................................................................................................ 112

8.3.1. Participants and procedures .................................................................................................................. 112

8.3.2. Measures ................................................................................................................................................ 113

8.3.3. Data analysis ........................................................................................................................................... 119

8.4. Results ......................................................................................................................................................... 120

8.4.1. Cognitive, language, and motor development ...................................................................................... 126

8.4.2. Social-emotional and adaptive behaviour development ......................................................................... 126

8.4.3. Infant temperament .............................................................................................................................. 126

8.5. Discussion .................................................................................................................................................. 127

8.5.1. Social, emotional, and behavioural development ................................................................................ 127

8.5.2. Cognitive, language, and motor development .................................................................................... 128

8.5.3. Limitations of the current study ......................................................................................................... 129

8.5.4. Conclusion ............................................................................................................................................. 130

8.6. References ................................................................................................................................................ 131
9. Study III: Maternal Bonding, Negative Affect, and Infant Social-Emotional Development: A Prospective Cohort Study

9.1. Abstract

9.2. Introduction

9.2.1. Maternal bonding and infant social-emotional development

9.2.2. Maternal negative affect and infant social-emotional development

9.2.3. Interrelations between maternal bonding and negative affect

9.2.4. The current study

9.3. Method

9.3.1. Participants and procedures

9.3.2. Measures

9.3.3. Data analysis

9.4. Results

9.4.1. Descriptive statistics

9.4.2. Autoregressive pathways

9.4.3. Transactional pathways

9.4.4. Prediction of infant social-emotional development

9.5. Discussion

9.5.1. Summary of evidence

9.5.2. Continuity of maternal bonding and negative affect

9.5.3. Transactional associations between maternal bonding and negative affect

9.5.4. Prediction of infant social-emotional development

9.5.5. Limitations and recommendations

9.5.6. Conclusion

9.6. References
10. Discussion

10.1. Summary of Findings

10.1.1. Study I findings.

10.1.2. Study II findings.

10.1.3. Study III findings.

10.2. Maternal Bonding Predicts Infant Social, Emotional, and Behavioural Development

10.2.1. Importance of effect sizes in the interpretation of findings.

10.2.2. Theorised mechanisms between maternal bonding and infant social, emotional, and behavioural development.

10.2.3. Prediction did not extend to cognitive, language, and motor developmental outcomes.

10.3. Maternal Bonding Difficulties are Distinct from Negative Affect.

10.4. Screening, Prevention and Early Intervention, and Treatment

10.4.1. Screening.

10.4.2. Prevention and early intervention.

10.4.3. Treatment.

10.5. Methodological Strengths and Limitations

10.5.1. Study I: Systematic review and meta-analysis.

10.5.2. Studies II and III: Empirical studies.

10.6. Recommendations for Future Research

10.7. Conclusion

10.8. References
11. Appendices ......................................................................................................................... 199

11.1. Appendix A. Authorship Statement for Study I................................................. 199

11.2. Appendix B. Authorship Statement for Study II............................................ 202

11.3. Appendix C. Ethics........................................................................................................ 206


11.5. Appendix E. Supplementary Materials for Study I................................. 218

11.6. Appendix F. Supplementary Materials for Study II................................. 225
1. List of Tables

Table 1. List of Publications ........................................................................................................ v
Table 2. Assessment Schedule for Measures Relevant to Current Thesis. .................. 71
Table 3. Summary of Measures Relevant to Current Thesis .............................................. 72
Table 4. Study II: Sample Antenatal Demographic and Postnatal Characteristics . 114
Table 5. Study II: Descriptive Statistics for MAAS and MPAS .............................. 115
Table 6. Study II: Descriptive Statistics for Outcome Variables .............................. 116
Table 7. Study II: Regression Results for MAAS and Infant Outcomes .............. 121
Table 8. Study II: Regression Results for MPAS and Infant Outcomes .............. 124
Table 9. Study III: Sample Demographic Characteristics ...................................... 147
Table 10. Study III: Descriptive Statistics and Intercorrelations for Measures ...... 154
Table 11. Theorised Mechanisms between Pregnant Women's Distress and
Fetal and Infant Brain-Behaviour Development ......................................................... 180
2. List of Figures

Figure 1. Bioecological model of health and development.................................27

Figure 2. The relationship between maternal negative affect and poor bonding. ......42

Figure 3. Study III: Cross-lagged model for MAAS, MPAS, EPDS,

and Bayley-III: SE........................................................................................................157

Figure 4. Study III: Cross-lagged model for MAAS, MPAS, DASS-21:Anxiety,

and Bayley-III: SE........................................................................................................158

Figure 5. Study III: Cross-lagged model for MAAS, MPAS, DASS-21:Stress,

and Bayley-III: SE........................................................................................................159
3. Thesis Abstract

Background

Theory and empirical research suggest that there are important associations between the constructs of mother-to-fetus/infant bonding, maternal negative affect, and infant social-emotional development; yet critical gaps remain in knowledge on these associations. Notably, few studies have examined the interrelationships between bonding and negative affect during the antenatal and perinatal periods, nor the extent to which these factors independently predict social-emotional development in early infancy.

Aims

Across three studies, the current thesis sought to examine the contribution of a mother’s affective experience during the perinatal period, indicated by maternal bonding and negative affect, to infant social-emotional development. Study I is a systematic and meta-analytic review on the role of mother-to-fetus/infant bonding in infant development. Study II examines the extent to which mother-to-fetus/infant bonding predicts offspring outcomes, including temperament and five key domains of development: cognitive, language, motor, social-emotional, and adaptive behaviour. Finally, Study III utilises a cross-lagged model to examine the transactional relationships between bonding and negative affect across the antenatal and postnatal periods, while controlling for earlier bonding and negative affect. Study III also includes a specific focus on social-affective outcomes, examining the independent contribution of maternal bonding and negative affect to infant social-emotional development.
Method

Study I adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines. Nineteen articles met inclusion criteria and were included in a qualitative synthesis (79 effect sizes); fifteen articles were suitable for aggregation in a series of 14 meta-analyses (51 effect sizes). Studies II and III examined perinatal data collected as part of an Australian longitudinal pregnancy cohort study. Pregnant women were recruited from four major public hospitals (three in New South Wales, one in Western Australia) between 2009 and 2013 ($N = 1,623$). Mothers completed a comprehensive perinatal assessment, which included self-report measures of maternal bonding and negative affect at each trimester of pregnancy, and at 8 weeks and 12 months postpartum. Infant developmental (cognitive, language, motor, social-emotional, and general adaptive behaviour) outcomes were assessed observationally at 12 months using the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III).

Results

Across all three studies, we found evidence of maternal bonding predicting infant social-affective outcomes. Specifically, in Study I, higher maternal bonding predicted higher infant attachment quality and mood, and lower infant temperament difficulty and colic rating. In Study II, higher maternal bonding predicted infant social-emotional development, general adaptive behaviour, emotional stability, and approach behaviour. Further, elevated maternal negative affect during pregnancy was found to predict postnatal bonding difficulties, and in turn, less optimal social-emotional development in infancy (Study III).
Conclusion

The current thesis examined the contributions of maternal bonding and negative affect to infant social-emotional development. Consistent with theoretical perspectives and prior empirical research, results supported the hypothesis that maternal bonding and negative affect play a role in shaping social-affective development in infancy. Across the three studies, it is notable that effect sizes were generally small; this fits with the theoretical perspective that infant mental health is multiply informed via a complex interplay of genetic, biological, and environmental factors. Maternal bonding and negative affect are two potentially modifiable factors within the domain of infant mental health. Together, results suggest that during the perinatal period, prevention and intervention initiatives that support a mother’s affective experience and foster a healthy mother-to-fetus/infant bond, may promote a healthy start to offspring emotional life.
4. List of Abbreviations and Definitions

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Antenatal maternal bonding</td>
<td>A mother’s internalised representation of her unborn child accompanied by an affectional tie to her fetus.</td>
</tr>
<tr>
<td>Antenatal period</td>
<td>The time from conception to the onset of labour.</td>
</tr>
<tr>
<td>Attachment quality</td>
<td>The patterning of the infant’s expectations of caregiving responses from the mother.</td>
</tr>
<tr>
<td>Depression Anxiety and Stress Scales</td>
<td>A 21-item self-report measure that assesses clinical symptoms of depression, anxiety, and stress over the past week.</td>
</tr>
<tr>
<td>Developmental Origins of Health and Disease (DOHaD)</td>
<td>A developmental framework that suggests early life events interact with genetics to influence the organism’s capacity to cope with its environment in later life.</td>
</tr>
<tr>
<td>Early infancy</td>
<td>The first 12 months postpartum.</td>
</tr>
<tr>
<td>Edinburgh Antenatal and Postnatal Depression Scale (EPDS)</td>
<td>A 10-item self-report measure that assesses clinical symptoms of antenatal and postnatal depression over the past week.</td>
</tr>
<tr>
<td>Infancy</td>
<td>The first 24 months postpartum.</td>
</tr>
<tr>
<td>Infant adaptive behaviour</td>
<td>An indicator of social-affective development, which relates specifically to the display of skills needed to adequately respond to environmental demands and manage needs.</td>
</tr>
<tr>
<td>Infant cognitive development</td>
<td>Aspects of cognitive processing, including the acquisition, processing, storage, and manipulation of information.</td>
</tr>
<tr>
<td>Infant language development</td>
<td>The ability to communicate receptively and expressively.</td>
</tr>
<tr>
<td>Infant motor development</td>
<td>The ability to use muscles to complete actions, including fine and gross motor skills.</td>
</tr>
<tr>
<td>Infant social-emotional development</td>
<td>An infant’s capacity to express and co-regulate emotional states, form close and trusting relationships, explore the environment, and learn from experience.</td>
</tr>
</tbody>
</table>

1 References for definitions provided in Introduction.
| **Maternal Antenatal Attachment Scale (MAAS)** | A 19-item self-report measure that assesses the mother’s felt bond to her unborn child. It has two dimensions measuring: the quality of bonding (affective experiences) and intensity of preoccupation with the unborn child. |
| **Maternal bonding** | A mother’s perceived emotional connection to her child. |
| **Maternal bonding disorder** | A disorder that occurs when a mother experiences persistent feelings of aversion, hatred, or anger towards her child. |
| **Maternal Postnatal Attachment Scale (MPAS)** | A 19-item self-report measure that assesses the mother’s felt bond to her infant. It has three dimensions measuring: the quality of bonding (affective experiences), absence of hostility, and pleasure in interaction. |
| **Negative affect** | A general dimension of subjective distress and unpleasurable engagement that may include a variety of aversive mood states, such as depression, anxiety, and stress. Depressive symptoms include dysphoria, hopelessness, devaluation of life, and anhedonia. Anxiety is specific, situational arousal. Stress is chronic, non-specific arousal, including nervous tension, difficulty relaxing, and irritability. |
| **Perinatal period** | The period of time around childbirth, including the antenatal and postnatal periods. |
| **Postnatal maternal bonding** | A mother’s emotional connection to her infant following birth. |
| **Postnatal period** | The first 12 months following childbirth. |
| **Postpartum** | The time following childbirth. |
| **Temperament** | Differences between individuals, present from birth, in behaviour and response to social surroundings. |
5. Introduction

5.1. Importance of the Perinatal Period

The Developmental Origins of Health and Disease (DOHaD) theory posits that early in life the environment interacts with genetics to influence an organism’s health and disease risk in later life. The theory describes development as a continuum across the life course but suggests that the earliest period of life (first 1,000 days), spanning the period in utero, around birth and through infancy, is particularly critical to later health and disease risk (Gluckman, Hanson, & Mitchell, 2010). This period of time around childbirth is known as the perinatal period, and it includes both the antenatal and postnatal periods. The antenatal period spans the time from conception to the onset of labour (Wilcox, 2010); and the postnatal period spans the first 12 months following childbirth (Newman et al., 2016). The DOHaD theory suggests that the interaction between the developing fetus/infant and its environment during this critical early phase has considerable influence on later health-related outcomes (Bornstein, 1989).

The antenatal and postnatal periods are considered to be times of both vulnerability and opportunity for health and development. The fetus or infant may be placed at permanent risk of deficit or delay if the conditions necessary for healthy development are not met (i.e., this can be a vulnerable period for development). When such conditions are met, these periods are typically characterised by rapid, healthy development (i.e., this can also be an optimal period for development). The antenatal period spans three trimesters and each is associated with significant changes in physiological functioning. These periods are pregnancy trimester one (T1; first 14 weeks); trimester two (T2; second 14 weeks); trimester three (T3; final 12 weeks; Carlin & Alfirevic, 2008; Da Costa, Larouche, Dritsa, & Brender, 1999). The post-birth period of infancy is also characterised by marked physical, physiological
and psychological changes (Bornstein, 2014). The infant rapidly acquires new information to enhance the probability of survival and achieve competence (Bornstein, 1989). In fact, during infancy, the brain grows more extensively and more rapidly than during any other stage of life; its size more than doubles by 12 months, with 40,000 synapses formed every second (Schore & McIntosh, 2011).

Definitions of infancy vary somewhat between theorists and researchers. Bornstein, Arterberry, and Lamb (2013) define infancy as the period of life between birth and the emergence of language, at approximately 18-24 months of age (the Latinate root of infant, in + fans, translates to non-speaker). This definition of infancy is consistent with another seminal review by Rosenblith (1992). In the current thesis, infancy is defined as the first 24 months postpartum, with early infancy referring to the first 12 months postpartum.

5.2. Social, Emotional, and Behavioural Development During Infancy

5.2.1. Social-emotional development.

Social-emotional development is a multifaceted and complex process that relies on both social and emotional competence (Blair et al., 2014; Hubbard & Coie, 1994; Saarni, 1988). Social competence is the ability to achieve personal goals in social interactions, whilst maintaining positive relationships (Eisenberg et al., 1998). Emotional competence involves understanding the emotions of self and others, expressing emotions in a situationally and culturally appropriate manner, and regulating emotional behaviour to facilitate social interactions – processes that are also critical to social development (Blair et al., 2014; Eisenberg, Cumberland, & Spinrad, 1998; Hubbard & Coie, 1994; Saarni, 1988).

During infancy, social-emotional development refers to an infant’s capacity to express and co-regulate emotional states, form close and trusting relationships, explore the environment, and learn from experience (Clinton, Feller, & Williams,
There are a wide range of social and emotional phenomena that emerge during early infancy, including: smiling, fearful reactions to strangers and heights, distressed reactions to separation from parents, the formation of discriminating social attachments, and recognition of emotions (Bornstein & Lamb, 1999). Although newborns may produce facial expressions that resemble smiling, research suggests that voluntary smiling does not occur until the infant is aged 4-6 weeks (Bornstein & Lamb, 1999; Jones, 2008; Messinger et al., 2002). Most infants experience stranger wariness at age 6-15 months, with behaviours including distress and avoidance. Although depth perception emerges at age 2-4 months, fear of depth does not emerge until 8 months of age. Most infants show signs of separation anxiety (distress, agitation, and anger) at age 6-8 months, with long-term separation sometimes resulting in despair and detachment. The emergence of separation anxiety indicates the formation of social attachments, with the infant remembering and missing the parent or primary attachment figure when separated (Bornstein & Lamb, 1999). Recognition of emotions also emerges during early infancy. Most infants are able to discriminate between facial expressions at 1-2 months, however, understanding the meaning of emotions does not occur until aged 4-9 months. At age 4-9 months, infants are able to use emotions in an interactive and purposeful way (for example, pointing at a toy and making a distinct sound), and at age 8-9 months, infants begin to make connections between the emotional displays of others and specific objects or events (Bornstein & Lamb, 1999; Weiss, Oakland, & Aylward, 2010).
5.2.2. **Adaptive behaviour development.**

*Aadaptive behaviour* is another indicator of social-affective development, which relates specifically to the display of skills needed to adequately respond to environmental demands and manage needs (Bayley, 2006; Weiss et al., 2010). This includes conceptual, social, and practical skills. Conceptual skills developed during infancy include the ability to listen and comprehend language and communicate; for example, crying when hungry. Social skills related to adaptability include smiling, imitating facial expressions, and reaching for a caregiver. Practical skills relate to self-care behaviours such as eating, bathing, and toileting. During infancy, this would be indicated by behaviours such as opening the mouth when offered food and alerting a caregiver to a wet or soiled nappy (Bayley, 2006; Tassé et al., 2012).

5.2.3. **Temperament.**

Temperament is also relevant to emotions and social interactions during infancy (Bornstein, 2014). *Temperament* is defined as differences between individuals, present from birth, in behaviour and response to social surroundings (Edwards et al., 2013). Aspects of infant temperament include: *sociability*, the tendency to be shy or outgoing; *reactivity*, response to frustration; and *persistence*, ability to maintain attention. Research indicates that whilst temperament is fairly stable from infancy to childhood, it can also be shaped by environmental factors such as the caregiving context (Pedlow, Sanson, Prior, & Oberklaid, 1993).

5.2.4. **Prevalence and continuity of infant social-emotional problems.**

There are a number of social-emotional problems that can emerge during early infancy. These can be categorised as: (1) delays in the acquisition of developmentally appropriate competence; (2) age-appropriate behaviours that are exhibited with heightened or reduced frequency, intensity, and/or duration; and, (3) unusual behaviours that are not typical at any age (Carter, Briggs-Gowan, &
Problems are commonly classed into two categories in the literature. These are externalising problems, which relate to attention, self-regulation, aggression, and non-compliance; and internalising problems, which relate to depression, withdrawal, and anxiety (Carter et al., 2004; Mathiesen & Sanson, 2000; Radke-Yarrow, Nottelmann, Martinez, Fox, & Belmont, 1992).

The Copenhagen Child Birth Cohort conducted an epidemiological profile of infant social-emotional development at 18 months. Of 6,090 children born in 2000, 16-18% expressed significant and non-transitory emotional and/or behavioural problems that met criteria for ICD-10 Axis 1 (World Health Organization, 1992) or DC: 0-3 Axis 1 diagnosis (Skovgaard et al., 2007; Skovgaard et al., 2008; Zero to Three, 2005). A seminal review by Brauner and Stephens (2006) reported the prevalence of infant social-emotional problems in the range of 5-26% in developing countries, with estimates varying relative to study focus and methods (e.g., selected populations and diagnostic classification systems).

A considerable body of research indicates that early social-emotional problems are likely to persist over time, with links to later psychopathology (Andersson, Bohlin, & Hagekull, 1999; Briggs-Gowan, Carter, Bosson-Heenan, Guyer, & Horwitz, 2006; Erickson, Sroufe, & Egeland, 1985; Frost et al., 2019; Hudson, Murayama, Meteyard, Morris, & Dodd, 2018; Keenan, Shaw, DelliQuadri, Giovannelli, & Walsh, 1998; Mathiesen & Sanson, 2000; Rothbart, Derryberry, & Hershey, 2000). Mathiesen and Sanson (2000) found that 27% of children with extreme social-emotional problems at 18 months continued to have extreme difficulties at 2 years of age. Briggs-Gowan et al. (2006) highlighted the persistence of social-emotional problems in a large sample of infants ($N = 1,082$). The authors found that 50% of infants with social-emotional and behavioural problems at 1 year of age had continuing problems at 2 years of age.
Social-emotional problems have been shown to persist into childhood, with He et al. (2010) linking low approach behaviours at 9 months to internalising behaviours at 4 years of age. Another study by Keenan et al. (1998) found that aggression at 18 months predicted externalising problems at 3 years of age, and difficult temperament at 18 months predicted internalising problems at 5 years of age. Taken together, the extant research suggests that early social-emotional problems are key indicators for the development of later psychopathology. Early identification of infant social-emotional problems may thus help guide preventive strategies to reduce such difficulties and promote a healthy developmental trajectory (Barlow, Bennett, Midgley, Larkin, & Wei, 2015; Jenkins, Bax, & Hart, 1980).

5.3. Cognitive, Language, and Motor Development During Infancy

The current thesis is primarily focused on infant social, emotional, and behavioural outcomes given: (1) the links to later psychopathology described above; and, (2) maternal bonding and negative affect are both affective constructs likely to be more strongly associated with these outcome domains (i.e., relative to other areas of development such as cognition, language, and motor development). Howsoever, there is evidence to suggest that associations do exist between differing domains of infant development (i.e., affective signalling by an infant, shared problem-solving, and the emergence of language; Bayley, 2006; Greenspan & Shanker, 2009), and that a mother’s affective state may also influence offspring cognitive, language, and motor outcomes during infancy. As such, whilst the major focus of this thesis is on infant social and emotional development, Studies I and II include a broader range of developmental outcomes defined below. As Study III is focused on the transactional associations between maternal bonding and negative affect specifically, the outcome of interest is limited to infant social-emotional development.
5.3.1. Cognitive development.

*Cognitive development* refers to aspects of cognitive processing, including the acquisition, processing, storage, and manipulation of information (Bayley, 2006; Bjorklund & Causey, 2017). Cognitive development during infancy includes interpreting sensory information and responding accordingly, and exploring, manipulating, and memorising information. For example, cognitive development includes recognising and responding to the return of a caregiver (Bayley, 2006).

5.3.2. Language development.

*Language development* relates to the ability to communicate receptively and expressively (Weiss et al., 2010). *Receptive development* refers to preverbal behaviours, vocabulary development, social referencing, and verbal comprehension. For example, during infancy, receptive development may be indicated by a child reaching for an object and stopping or hesitating when a caregiver says “no” firmly. *Expressive development* includes preverbal communication, vocabulary development, and morpho-syntactic development. For example, infant expressive development may include “jabbering” expressively, with alterations in pitch or tone that resemble conversational inflections (Bayley, 2006).

5.3.3. Motor development.

*Motor development* refers to the ability to use muscles to complete actions, and includes fine and gross motor skills (Piek, 2006; Weiss et al., 2010). *Fine motor development* refers to prehension, perceptual-motor integration, motor planning, and motor speed. Fine motor skills during infancy include the ability to reach for, and hold a crayon, and to scribble spontaneously. *Gross motor development* refers to movement of the limbs and torso, including sitting, standing, coordination, balance, and motor planning. For example, gross motor development during infancy includes the ability to stand alone (Bayley, 2006).
5.4. Prediction of Infant Development

*Infants come into being differently according to whether the conditions are favourable or unfavourable..... the inherited potential of an infant cannot become an infant unless linked to maternal care.*

(Winnicott, 1960, p. 589)

The “inherited potential” described in this statement by Winnicott (1960) incorporates an inherent drive toward growth and optimal, healthy development. Winnicott (1960) also emphasises the vulnerability of infancy through its inextricable links to maternal care. This perspective aligns with transactional and bioecological models, which can be applied to infant development, including social-emotional development. Sameroff’s (1975) transactional development framework suggests that maternal behaviours elicit concordant infant behaviours, which in turn reinforce maternal beliefs and set the stage for maternal and infant expectations.

The mother plays a key role in supporting infant social-emotional development:

*The movements of expression in the face and body ... serve as the first means of communication between the mother and her infant; she smiles approval, and this encourages her child on the right path, or frowns disapproval.*

(Darwin, 1872, p. 385)

The bioecological model of health and development further extends the transactional model, suggesting that infant health and development are influenced by a range of macro- and micro-environmental factors (see Figure 1). Macro-environmental factors encompass laws and social or cultural ideologies, and
micro-environmental factors (or proximal social environments) encompass relationships and direct interactions with family and peers (Bronfenbrenner & Ceci, 1994; Lynch, 2000; Nicholson & Sanson, 2003). The bioecological model emphasises that infant development is multiply informed, with a mother’s affective state being one factor likely to contribute to a healthy start to emotional life.

Figure 1. Bioecological model of health and development.

The current thesis will focus on the specific contributions of two micro-environmental factors to infant development: (1) a mother’s felt bond to her developing fetus/infant; and, (2) her experience of negative affectivity. Understanding the links between these factors and early development has the potential to inform preventative and treatment interventions that foster healthy maternal and infant affective experiences and optimal infant developmental outcomes. Maternal bonding and negative affect are described in sections 5.5 to 5.8, including definitions, theoretical perspectives and current evidence for the role these factors may play in infant development.

5.5. Maternal Bonding in the Perinatal Period

As noted above, one factor likely to contribute to infant social-emotional development is maternal bonding, defined as a mother’s self-reported emotional connection to her child. During pregnancy, a mother develops an internalised representation of her unborn child accompanied by an affectional tie to her fetus, often referred to as antenatal maternal bonding (Condon, 1993). A positive bond during pregnancy is associated with engagement in behaviours of affiliation and affection, such as talking to the unborn child, and positive health practices, such as abstaining from drugs (Condon, 1993; Cranley, 1981; Van der Zalm, 1995). Postnatal maternal bonding refers to a mother’s emotional connection to her infant following birth. A positive postnatal bond would be indicated if a mother reported pleasure in interacting with her infant, a developing competence in her own capacity to understand and meet her infant’s needs, and acceptance and tolerance of the demands of the maternal role (Condon & Corkindale, 1998). Higher postnatal affectional bonding is typically associated with more nurturing maternal-infant interactions (Feldman, Weller, Leckman, Kuint, & Eidelman, 1999; Korja et al., 2010), including behaviours such as sensitivity to infant cues and emotional
These maternal behaviours invite interaction and support affective signalling (e.g., interest, touch, smiles, play, adaptivity, approach, emotional regulation; Bornstein & Lamb, 1999; Grant, McMahon, Reilly, & Austin, 2010).

Condon (1993) suggests that a mother’s internalised representation of her child is increasingly elaborated upon during pregnancy, with antenatal bonding providing structure for the subsequent development of postnatal bonding (Condon & Corkindale, 1998). In a sample of 372 mothers, Rossen et al. (2016) found that higher antenatal bonding predicted higher postnatal bonding at all pregnancy time-points, after controlling for a range of demographic and postnatal covariates. Although antenatal bonding provides structure for later postnatal bonding, birth marks the introduction of additional complexities. The mother is required to integrate perceptions of motherhood and her child with new realities, including the characteristics of her infant (Condon, 1993; Solomon & George, 1996). Given the complexities unique to the antenatal and postnatal periods, it is important to examine how the maternal bond in each of these phases may shape development in infancy.

Maternal bonding is underpinned by the integration of oxytocin and dopamine in striatum. Oxytocin and dopamine systems support multiple motivational behaviours, including social orienting, social seeking, and maintaining contact. Activation and tighter crosstalk among these systems during bond formation enables plasticity of the brain reward system and reorganisation of neural networks around the new bond (Feldman, 2017). This process of the mother forming a selective and enduring bond with her child is accompanied by mental, emotional, and behavioural changes that facilitate physical and psychological proximity (Feldman et al., 1999; Insel & Young, 2001; Kendrick, 2000). Research evidence shows that bio-behavioural synchrony is a key feature of maternal-infant relationships, with
evidence for synchronised: nonverbal behaviour (gaze, affect, vocal, touch); heart
rate during interactions; oxytocin response following contact; cortisol response to
stress; and brain oscillations in alpha and gamma rhythms (Feldman, 2017).

Individual differences related to the timing and intensity of bonding remain
unclear, though an amalgam of psychological, interpersonal, and biological
mechanisms is likely. Of these potential factors, perinatal depression and anxiety
have been linked to bonding difficulties (Righetti-Veltema et al., 2002), including
clinical bonding disorders, described below.

5.5.1. Maternal bonding disorders.

Maternal bonding disorders are characterised by a mother experiencing
persistent feelings of aversion, hatred, or anger towards her child (Brockington &
Guedeney, 1999; Klier, 2006; Kumar, 1997). Maternal bonding disorders often
develop immediately or very shortly after birth (Kumar, 1997). In a sample of 200
women referred to psychiatrists after childbirth, 11% reported feelings of rejection
towards their child, with predictors including unwanted pregnancy and poor
antenatal bonding (Brockington, Aucamp, & Fraser, 2006).

Bonding disorders are not formally recognised in the Diagnostic and
Statistical Manual of Mental Disorders (American Psychiatric Association, 2013),
and are often considered equivalent to postnatal depression. This is because they
commonly co-occur, and the symptom profiles overlap in some affective
components. For example, depressed mood is often accompanied by social
withdrawal, which may result in the mother experiencing difficulties establishing an
emotional connection with her child. Yet these disorders are not synonymous and
they can occur in isolation (Brockington, 2004; Brockington et al., 2006; Klier, 2006;
Kumar, 1997; Righetti-Veltema, Conne-Perréard, Bousquet, & Manzano, 2002). The
difference is in the affective focus; namely, the affective focus of bonding disorders
lies in a mother’s feelings towards her child; whereas postnatal depression involves non-specific feelings of low mood and anhedonia (Brockington et al., 2006). Righetti-Veltema et al. (2002) compared mothers suffering depression to controls ($N = 570$) and found that 45% of the depressed group and 9% of the non-depressed group experienced bonding difficulties. Findings highlight the interrelated nature of maternal bonding disorders and postnatal depression, whilst also emphasising the need for screening and intervention to be tailored to the distinct symptom profiles of these separate profiles.

**5.5.2. Bonding and attachment.**

The constructs of bonding and attachment are often confused or conflated. This is compounded by the fact that many widely-used measures of bonding, for example, the *Maternal Antenatal Attachment Scale* (Condon, 1993), are specifically referred to as “attachment” measures. Indeed, many researchers refer to maternal-offspring relational quality under the umbrella term of attachment, as the relationship encompasses the development of feelings of love and protection and a strong emotional tie (Walsh, 2010). Bowlby (1969, p. 377), however, argued, “There is a strong case... for restricting the term ‘attachment’ to the behaviour typical of the child to parent and the behavioural system responsible for it, and to avoid using it to describe the complementary behaviour and behavioural system of the parent.”

Attachment quality represents the patterning of the infant’s expectations of caregiving responses from the mother, whereas bonding refers to the mother’s felt emotional connection to her infant (Ainsworth, 1989; Cassidy & Shaver, 2016; Walsh, 2010). Although bonding and attachment are interrelated constructs, they are motivated by different goals and governed by different behavioural systems. Bonding is a function of the caregiving behavioural system and serves to protect and comfort the infant in times of distress or threat. The attachment behavioural system is
activated when an individual feels threat or distress and seeks to elicit care and protection. The systems operate reciprocally but are distinct. The mother’s emotional tie to her infant should not be considered an attachment relationship because it is not about eliciting care from her infant (rather, the mother elicits care from other adult attachment relationships).

Numerous studies have established associations between infant attachment and development (Ainsworth, 1989; Bowlby, 1969; Cassidy & Shaver, 2016; Groh, Fearon, van Ijzendoorn, Bakermans-Kranenburg, & Roisman, 2017), and between maternal adult attachment and infant development (Benoit, Zeanah, & Barton, 1989; Benoit, Zeanah, Boucher, & Minde, 1992; Van Ijzendoorn, 1995). In contrast to the attachment literature, a relatively smaller body of work has explored the role that a mother’s felt bond to her infant may have on early social-emotional development.

5.5.3. Maternal bonding and infant development.

Branjerdporn, Meredith, Strong, and Garcia (2017) recently synthesised the available longitudinal research on a mother’s felt emotional connection to her infant during pregnancy and infant developmental outcomes. While the authors termed this construct maternal-infant “attachment”, the conceptual content within this measure closely approximates the definition of antenatal bonding in this thesis. Data were qualitatively synthesised according to developmental domain: infant temperament ($k = 5$), adaptive behaviour ($k = 2$), and milestone attainment ($k = 1$). The review found evidence that higher antenatal bonding was associated with more optimal infant development (across infants aged 0-26 months), with outcomes including: normal levels of activity (i.e., not overactive; Davoudi, 2012); regular physiologic functions, such as sleep and hunger (Priel & Besser, 2000); approach to new stimuli (Davoudi, 2012; Priel & Besser, 2000); adaptable temperament (Davoudi, 2012; Priel & Besser, 2000); less intense temperament (i.e., less high energy responses;
Davoudi, 2012; Priel & Besser, 2000); positive overall mood (Davoudi, 2012; White, Wilson, Elander, & Persson, 1999); attentive temperament (Davoudi, 2012); higher sensory threshold (i.e., more stimulation required to evoke a response; Davoudi, 2012); lower colic rating (Escallier, 1995); and increased developmental milestone attainment (Alhusen, Hayat, & Gross, 2013). Only one association was identified that linked higher maternal bonding with a less optimal outcome – lower (total) sleep time in infancy (Speltzer, O’Beirne, & Bishop, 2008). The authors found evidence to suggest that higher maternal bonding was generally linked to more optimal infant developmental outcomes, but concluded that results should be interpreted with caution due to the limited number and low quality of many of the available studies.

The review by Branjerdporn et al. (2017) highlights the paucity of research on bonding and infant development. In particular, few studies have investigated the relationship between maternal bonding and specific domains of development within the one study, such as cognition, language, motor, social-emotional, and behavioural development. One study by Alhusen et al. (2013) found an association between higher antenatal bonding and overall infant development ($r = .59$, $N = 81$); however, more specific domains of development were not explored. This limits capacity to understand how the mother-infant bond relates to key facets of infant development, which is important to guide preventative interventions, early in the life course.

Only one known study has investigated the relationship between bonding and the specific domains of cognitive, language, and motor development (unpublished data from Sierau et al., 2016). The study investigated the associations between bonding and infant development across a number of antenatal and postnatal time-points ($N$ ranged from 235 to 499). The study used the Bayley Scales of Infant and Toddler Development, Second Edition to assess cognitive and motor development. There was limited evidence to support associations between antenatal
or postnatal bonding and infant cognitive or motor development; though some
isolated findings indicated higher antenatal bonding predicted less optimal cognitive
development \( (r = -.15) \), and more optimal motor development \( (r = .12) \). Findings
linking bonding and infant language development were inconsistent across time-
points; higher antenatal bonding predicted more optimal language development at 24
months, and higher postnatal bonding at 6 and 12 months predicted less optimal
language development at 24 months \( (r = -.13) \). Moreover, the majority of
associations between bonding and infant cognitive, language, and motor
development were not statistically significant.

Few studies have linked bonding to social-emotional and adaptive behaviour
development. One study by Mason, Briggs, and Silver (2011) linked higher bonding
at 2 months postpartum and infant social-emotional competence at 6 months
\( (r = .24, N = 219) \). Sierau et al. (2016) also explored associations between bonding
and infant internalising and externalising behaviours, and bonding and the child’s
behaviour during assessment (including attention, social engagement, and affect).
Higher bonding was consistently linked to less internalising and externalising
behaviour at 24 months, across a number of antenatal and postnatal time-points
\( (r = .12-.27, \) with effect sizes increasing across the perinatal period). Findings on the
association between maternal bonding and infant behaviour during assessment were
inconsistent; most findings were not statistically significant, though some isolated
findings linked higher bonding and less optimal behaviour during assessment
(e.g., less able to attend and engage with researcher; Sierau et al., 2016). Taken
together, it is difficult to make any firm inferences on the basis of this one study with
somewhat mixed results (Sierau et al., 2016).
In summary, there remains a paucity of empirical work on the associations between maternal bonding and infant development, and a lack of high-quality longitudinal research, making it difficult to draw conclusions about aetiological relationships. The Branjerdporn et al. (2017) review provides a much needed synthesis of research linking antenatal bonding and infant development; however, three specific limitations are noted here. First, the review was confined to associations between antenatal bonding and infant development. Examination of both the antenatal and postnatal periods remains important, given the complexities unique to each period (Condon, 1993; Rossen et al., 2017; Solomon & George, 1996). Second, the review only reported on statistical significance and direction of effects, rather than reporting specific correlation values (i.e., no information was provided on the magnitude of associations) nor meta-analytic estimates of the population effect. Third, the review restricted the search to a limited number of developmental outcome domains, and within these, did not have a sufficient number of studies for meta-analysis. Addressing these limitations may allow more studies to be retrieved and for the results to be examined via meta-analysis. Better understanding of the links between the mother-to-infant bond and early development has the potential to inform preventative and treatment interventions that promote a healthy start to emotional life.

5.6. Maternal Negative Affect in the Perinatal Period

As noted in section 5.5.1, bonding and mood disorders have been shown to share some overlap in the extent of associated negative affect (Brockington et al., 2006). Given this overlap, it is important to examine the contribution of bonding to infant social-emotional development alongside the contribution of negative affect. 

Negative affect refers to a general dimension of subjective distress and unpleasurable engagement that may include a variety of aversive mood states, such
as depression, anxiety, and stress (Watson, Clark, & Tellegen, 1988). Depressive symptoms include dysphoria, hopelessness, devaluation of life, and anhedonia. The current thesis defines anxiety as specific, situational arousal; and stress as chronic, non-specific arousal, including nervous tension, difficulty relaxing, and irritability (Lovibond & Lovibond, 1996).

The antenatal and postnatal periods are commonly characterised by heightened negative affect in mothers linked to a significant transition from a familiar reality to a novel and uncertain one (Agius, Xuereb, Carrick-Sen, Sultana, & Rankin, 2016; Riecher-Rössler & Steiner, 2005). This transition to motherhood (including new phases of motherhood with the addition of children) is considered a major developmental life event; requiring complex cognitive, affective, and behavioural changes to establish maternal identity. A mother’s identity continues to evolve as she develops competence in her own capacity to understand and meet her child’s needs, and acceptance and tolerance of the demands of the maternal role (Mercer & Ferkehch, 1990). This major transition period can be accompanied by feelings of guilt and inadequacy about being an incompetent parent, which may lead to elevated negative affect (Fowles, 1998). It has also been suggested that increased negative affect in the perinatal period may have a biological underpinning. During pregnancy, the brain is exposed to a 100-fold increase in oestradiol levels, which abruptly decrease in the first few days following birth. This marked steroid withdrawal has been linked to increased maternal negative affect in the period just after birth (O'Hara & Wisner, 2014).

A 20-year prospective, Australian cohort study by Patton et al. (2015) revealed that symptoms of depression were reported in 19% of pregnancies (109/564), with 16% (93/564) of these pregnancies reporting mental health problems that preceded pregnancy. Another Australian cohort study (Woolhouse, Gartland,
Hegarty, Donath, & Brown, 2012) found that 16% of women experienced depressive symptoms in the 12 months after childbirth, with depression during pregnancy a predictive factor. Similar prevalence rates are reported for postnatal anxiety, and their comorbidity with depression is high (Dennis, Falah-Hassani, & Shiri, 2017; Wisner et al., 2013). For example, findings from a recent review by Dennis et al. (2017) revealed prevalence rates of approximately 15% for symptoms of postnatal anxiety, and 10% for a diagnosable anxiety disorder. Importantly, these rates are likely to underestimate true prevalence; Coates, Schaefer, and Alexander (2004) estimate that up to two thirds of cases of mothers with substantial postnatal depressive or anxious symptoms remain undetected.

Elevated negative affect can, for some pregnant women, result in clinical symptoms of depression and anxiety, as well as more elevated stress. Research in this field has demonstrated relative stability (or continuity) of negative affect across the antenatal and postnatal periods (Fairbrother, Janssen, Antony, Tucker, & Young, 2016; Fairbrother, Young, Janssen, Antony, & Tucker, 2015; Grant et al., 2010; Heron et al., 2004; Howard, Flach, Mehay, Sharp, & Tylee, 2011; Patton et al., 2015; Rossen et al., 2016; Woolhouse et al., 2012). For example, Heron et al. (2004) investigated the course of maternal negative affect in a large cohort sample of 8,323 women, across four antenatal and postnatal time-points. Results revealed stability of anxiety and depression across this period ($r$ (range) = .49-.63 for symptoms of depression; $r$ (range) = .52-.66 for symptoms of anxiety). Further to this, antenatal anxiety predicted depression at both postnatal time-points, independent of antenatal depression (Heron et al., 2004). Taken together, the results of these studies emphasise the high prevalence, comorbidity, and stability of depression, anxiety, and stress across the perinatal period, and the likely implications for maternal mental health and wellbeing.
5.6.1. Clinical presentation of maternal negative affect.

Non-clinical symptoms of negative affect can be transient and adaptive in nature, but they may also contribute to the onset or relapse of psychiatric disorders (Agius et al., 2016). These disorders are wide ranging and can include mood and anxiety disorders, such as major depressive disorder (MDD) with peripartum onset, persistent depressive disorder with peripartum onset, and generalised anxiety disorder (American Psychiatric Association, 2013; Bybee, 1989). Fairbrother et al. (2016) used the Structured Clinical Interview for DSM-IV to assess the prevalence of MDD and anxiety disorders in a community sample of 310 pregnant women. During pregnancy, 4% of women had symptoms consistent with a diagnosis of MDD, and 16% had symptoms consistent with diagnosis of an anxiety disorder (for example, generalised anxiety disorder, obsessive compulsive disorder, and posttraumatic stress disorder). Symptoms of perinatal psychiatric disorders are consistent with classical diagnoses; however, associated cognitions may be specific to pregnancy and motherhood. Cognitions may include: fear of childbirth (Paschetta et al., 2014), fear about not being able to cope with a helpless infant (Brockington & Guedeney, 1999; De Armond, 1954; Riecher-Rössler & Steiner, 2005), guilt about not being a good enough mother (Riecher-Rössler & Steiner, 2005), and anxiety about an infant not thriving (Riecher-Rössler & Steiner, 2005).

It is postulated that the development of perinatal psychiatric disorders is multiply determined by genetic, biological, cognitive, interpersonal, and contextual pathways (Grant, McMahon, & Austin, 2008). Specific risk factors include adverse events (e.g., illness in the baby), poor parental relationship quality, inadequate social support, burden of child care, birth complications, recent stressful life events and past psychiatric illness (Agius et al., 2016; Brockington & Guedeney, 1999; De Armond, 1954; Riecher-Rössler & Steiner, 2005). The distress and impairment
associated with perinatal psychiatric disorders is likely to have implications for maternal health and wellbeing, birth outcomes, maternal-infant relational formation, and infant affective experience and social-emotional development (Brockington, 2004; Fairbrother et al., 2015; Kingston, Tough, & Whitfield, 2012).

5.6.2. Maternal negative affect and infant development.

Maternal expression of negative affect plays an important role in healthy infant development: the mother teaches the infant (who has limited capacity to regulate emotions) that negative affect can be felt, expressed, held, processed, and integrated (Fox & Calkins, 2003). Elevated maternal negative affect can, however, block the mother’s accessibility and emotional availability to her baby. For example, a meta-analysis by Bernard, Nissim, Vaccaro, Harris, and Lindhiem (2018; k = 48 studies, N = 4,934) found that mothers with higher depression levels were less sensitive to infants’ cues than mothers with lower depression levels. This can in turn negatively impact birth outcomes and infant cognitive, behavioural, psychomotor, and social-emotional development (Feldman et al., 2009; Gentile, 2017; Grigoriadis et al., 2013; Kingston et al., 2012; Littleton, Breitkopf, & Berenson, 2007; Stein et al., 2014; Waters, Hay, Simmonds, & van Goozen, 2014).

Extensive research has demonstrated associations between elevated symptoms of negative affect during pregnancy and difficulties in infant emotional regulation and social behaviour (Blair et al., 2014; Davis & Sandman, 2012; Gerardin et al., 2011; Leis, Heron, Stuart, & Mendelson, 2014; Talge et al., 2007; Velders et al., 2011). A systematic review by Talge et al. (2007), for example, reported significant associations between antenatal maternal stress and child emotional and cognitive problems, including attentional deficit/hyperactivity, anxiety, and language delay, with effects independent of depressive symptoms. Further, postnatal experience of negative affect also has associations with child emotional difficulties (Field, 2010;
Glasheen, Richardson, & Fabio, 2010; Kingston et al., 2012; Trapolini, McMahon, & Ungerer, 2007; Tronick & Reck, 2009). A systematic review by Kingston et al. (2012) included four studies (N = 44-223) that linked postnatal maternal negative affect and infant social-emotional development. Prevalence rates of infant social-emotional problems ranged from 6-15% in offspring born to mothers with low negative affect, to 27-55% in offspring born to mothers with high negative affect; highlighting the link between high maternal negative affect and infant social-emotional problems. Importantly, these studies emphasise that maternal negative affect is likely to influence, but does not wholly determine, maternal-infant relational formation and infant mental health. Rather, these outcomes are multiply determined by a range of macro- and micro-environmental factors (see Figure 1), with maternal affective experience being one potentially modifiable factor (Stein et al., 2014).

5.7. Interrelations Between Maternal Bonding and Negative Affect

Given the affective underpinning of both bonding and negative affect, it makes theoretical sense that these constructs interrelate during the perinatal period. As noted earlier in section 5.5.1, both clinical symptom profiles (i.e., bonding and mood disorders) are characterised by emotion regulation problems (Brockington, 2004). For example, depressed mood commonly dampens a person’s emotional responsivity, which may result in a mother experiencing difficulty interacting sensitively and establishing an emotional connection with her child (Trapolini, Ungerer, & McMahon, 2008). Howsoever, these disorders are also characterised by distinct affective foci and can occur independently (Brockington, 2004; Brockington et al., 2006; Klier, 2006; Righetti-Veltema et al., 2002). Specifically, the affective focus of bonding impairment is a mother’s feelings towards her child; be it a lack of emotion or feelings of estrangement, aversion, hatred, and/or anger. In contrast, postnatal depression is typically characterised by non-specific feelings of low mood
and anhedonia (Brockington et al., 2006). Similarly, there is some overlap in the affective components of bonding impairments and postnatal anxiety. Poor bonding may include symptoms of infant-focused anxiety, where the mother fears being alone with her infant, often resulting in the mother distancing herself from her infant. In contrast, postnatal anxiety is typically characterised by a mother experiencing excessive worry about her infant; for example, intrusive thoughts about her infant dying or being ill, which may result in difficulties separating from the infant in an age-appropriate manner (Brockington, 2004; Brockington et al., 2006).

Theoretical and empirical perspectives from Bansil et al. (2010), Grant et al. (2008), and Riecher-Rössler and Steiner (2005) have been integrated into a proposed framework for the relationship between maternal bonding and negative affect (see Figure 2). This framework suggests that poor bonding and symptoms of negative affect share common triggers and trajectories of development and resolution. One potential pathway is that symptoms of depression and anxiety reinforce negative self-schema, which may affect a mother’s felt bond with her baby (Dobson & Dozois, 2011). Alternatively, poor bonding may lead to guilt and other negative feelings, in turn triggering symptoms of negative affect. Another factor that may contribute is personality; for example, research has linked low extraversion and low conscientiousness with symptoms of negative affect (Kotov, Gamez, Schmidt, & Watson, 2010), and with bonding difficulties (de Cock et al., 2016).

Biological mechanisms also appear common to both symptom profiles. During pregnancy, women experience a substantial reduction in grey matter in brain regions linked to social cognition; this adaptive restructuring has been shown to facilitate the transition to motherhood. Smaller grey-matter volumes than average have, however, also been linked to poorer bonding (Hoekzema et al., 2017) and to major depression (Wise et al., 2017). In summary, it is likely that complex pathways
exist between maternal bonding and negative affect, which may be explained by a combination of psychological, interpersonal, and biological mechanisms.

Figure 2. The relationship between maternal negative affect and poor bonding.

A number of cross-sectional studies have examined the associations between bonding and negative affect, revealing moderate correlations ($r$ (range) = .31-.49; Condon & Corkindale, 1998; Scopesi, Viterbori, Sponza, & Zucchinetti, 2004; Tietz, Zietlow, & Reck, 2014). Tietz, Zietlow, and Reck (2014), for example, found that mothers diagnosed with postpartum anxiety disorders ($n = 30$) reported poorer
bonding when compared to a healthy control group \((n = 48)\). Ohara et al. (2017) extended this research by examining bonding and depressed mood across the perinatal period (25 weeks’ gestation, 35 weeks’ gestation, and 5 days postpartum; \(N = 751\)). Results revealed stability of bonding and negative affect across time, however, transactional relations were not examined. Rather, the model examined concurrent relations between maternal bonding and negative affect. At each time-point, poorer bonding predicted depressed mood; however, depressed mood did not predict bonding at any of the examined time-points (Ohara et al., 2017). Taken together, there is evidence for a cross-sectional association between maternal bonding and negative affect.

Very few studies have examined prospective relations between maternal bonding and negative affect. Notably, Rossen et al. (2016) investigated these constructs in a sample of 372 women across the antenatal and postnatal periods (trimesters one, two, and three of pregnancy and 8 weeks postnatal). The study utilised multiple linear regression models to investigate predictors of postnatal bonding at 8 weeks. In contrast to findings from Ohara et al. (2017), higher levels of depressive symptoms in trimesters two and three, and stress in trimester two were found to predict higher bonding (Rossen et al., 2016). Taken together, findings from these studies (Condon & Corkindale, 1998; Ohara et al., 2017; Rossen et al., 2016; Scopesi et al., 2004; Tietz et al., 2014) suggest associations between maternal bonding and negative affect. However, questions remain regarding the direction and magnitude of transactional effects across the perinatal period, and their independence after controlling for earlier bonding and negative affect. Isolating these transactional (and potentially bi-directional) relations would inform intervention targeted to critical risk-points and specific affective difficulties.
5.8. Contribution of Maternal Bonding and Negative Affect to Infant Social-Emotional Development

Only two known studies have explored prospective associations between maternal bonding, negative affect, and infant development (Alhusen et al., 2013; Mason et al., 2011). These studies focused specifically on depressive symptomology, rather than examining negative affect as a general dimension. Both Alhusen et al. (2013) and Mason et al. (2011) examined American samples of mother-infant dyads across two time-points (N = 81 and 232, respectively). Alhusen et al. (2013) utilised a series of regression analyses to examine predictors of early childhood development, assessed using the Ages and Stages Questionnaire. Poor antenatal bonding at 24-28 weeks’ gestation and depressive symptomology at 14-26 weeks postpartum were found to predict infant developmental delays at 14-26 months postpartum. However, specific developmental domains (e.g., social-emotional development) were not examined.

Similar to Alhusen et al. (2013), Mason et al. (2011) utilised a series of regression analyses to examine predictors of infant social-emotional development. The study found that maternal depressive symptoms at 8 weeks postpartum predicted infant social-emotional developmental delays at 6 months, with this relationship mediated by postnatal bonding at 8 weeks postpartum. Findings from Alhusen et al. (2013) and Mason et al. (2011) suggest that pathways exist between maternal affective experience (bonding and depressive symptomatology) and later infant developmental outcomes. Knowledge of these pathways would be enhanced by prospective, longitudinal research with larger samples (to increase the generalisability of findings), in addition to assessment of the association of these constructs across multiple antenatal and postnatal waves.
It is important to consider why maternal bonding and negative affect might contribute to infant social-emotional development from a theoretical perspective. A number of potential pathways are possible, although it is likely that time-varying interrelationships exist. Studies have consistently demonstrated the stability of these constructs across the perinatal period, with early experience of bonding and negative affect identified as strong predictors of later affective experience (Condon & Corkindale, 1998; Heron et al., 2004; Patton et al., 2015; Rossen et al., 2016; Woolhouse et al., 2012). These constructs may shape maternal expectations of pregnancy, motherhood and maternal behaviour. For example, poor bonding and elevated negative affect during pregnancy may lead to negative health behaviours, such as alcohol and nicotine use (Lindgren, 2001; Van den Bergh & Simons, 2009), which can adversely impact child development (Barker, 1990). Further, maternal affect is likely to influence maternal-infant interactions, shaping infant expectations, affective experience, and development (Ainsworth, 1989; Belsky & Fearon, 2002; Winnicott, 1960). Given maternal-infant interactions are reciprocal, a child’s display of positive social and emotional attributes is also likely to influence maternal affective experience (Fogel, 1982; Kuzava & Bernard, 2018). Further, biological mechanisms are known to exist, with associations identified between pregnant women’s distress (perceived stress, life events, depression, and anxiety) and fetal and infant brain-behaviour development (Monk, Lugo-Candelas, & Trumpff, 2019). These mechanisms and pathways will be further considered in the Discussion (section 10.2.2) in light of findings from the current thesis.
5.9. **Key Gaps in the Literature**

In sum, critical gaps remain in knowledge on the associations between maternal bonding and negative affect, and their independent contributions to infant social-emotional development. The Branjerdporn et al. (2017) review highlights the paucity of research on bonding and infant development. However, this review has three key limitations: (1) the review was confined to associations between *antenatal* bonding and infant development, rather than also examining the contribution of *postnatal* bonding; (2) no information was provided on the magnitude of associations; and, (3) a limited number of developmental domains were examined. Addressing these limitations may allow more studies to be retrieved and for the results to be examined via meta-analysis. Further, there is a clear need for longitudinal studies that include multiple antenatal and postnatal waves assessing bonding and a range of infant developmental outcomes. Including multiple waves would enable isolation of the timing of potential effects to guide key intervention points for prevention and treatment of bonding-related difficulties.

Further, theoretical perspectives and empirical evidence indicate that maternal bonding and negative affect play an important role in supporting infant social-emotional development (Branjerdporn et al., 2017; Kingston et al., 2012); however, the temporal and potentially bi-directional associations between these constructs are not yet understood (Goebel, Stuhrmann, Harder, Schulte-Markwort, & Mudra, 2018). Examining longitudinal data in a cross-lagged model would allow for the estimation of cross-lagged effects (*transactional* relations), while controlling for correlations within time-points and autoregressive effects (*stability* of bonding and negative affect across time; Kearney, 2017). This model could also be used to examine the independent contributions of maternal bonding and negative affect to infant social-emotional development. Disentangling these interactive processes may
inform optimised timing of interventions offered by health services, and in turn, improve outcomes for both mothers and their babies.

5.10. The Current Thesis

The overarching aim of the current thesis is to address the key gaps identified in the literature by examining the interrelations between maternal bonding and negative affect, and their independent contributions to infant development. Studies I and II will examine a broad range of developmental outcomes including social-emotional development. Study III will focus on infant social-emotional development specifically, given theoretical perspectives and empirical evidence indicate that this domain is most strongly associated with maternal bonding and negative affect (Branjerdporn et al., 2017; Kingston et al., 2012). These studies are described below.

Study I aims to systematically and meta-analytically review research on the role of antenatal and postnatal bonding in infant development. This study will address the limitations of the Branjerdporn et al. (2017) by including studies on both antenatal and postnatal bonding and by reporting on the magnitude of associations. Further, this study aims to employ a systematic and extensive search strategy to identify a larger number of relevant studies and allow for quantitative synthesis.

Study II will contribute to the gap in knowledge on bonding and infant development. The Branjerdporn et al. (2017) review highlighted a marked paucity of empirical work in this area (k = 8 studies), and a lack of high quality longitudinal research. Study II will therefore examine the extent to which antenatal and postnatal maternal self-reported bonding predict infant development at 12 months of age in a large sample of Australian mother-infant dyads (N = 1,347). Outcome domains will include infant temperament as well as social-emotional, behavioural, cognitive, language and motor development, as assessed by the Bayley-III Social-Emotional Scales and Scales of Infant and Toddler Development. This study will investigate
whether bonding differentially predicts these developmental outcomes, and examine
associations across multiple (three antenatal, two postnatal) time-points.

Study III will similarly examine data from this large Australian cohort. A cross-lagged model will be utilised to examine the interrelationships between maternal bonding and negative affect, and their independent contributions to infant social-emotional development. Study III has two main aims: (1) to determine the direction and magnitude of transactional paths between maternal bonding and negative affect across three antenatal and two postnatal time-points; and then, after accounting for the antenatal pathways; (2) to examine the independent contributions of bonding and negative affect from 8 weeks postnatal to infant social-emotional development at 12 months. Analysing data in a cross-lagged model will advance existing research by allowing isolation of effects across the perinatal period.

Together these three studies will contribute to knowledge on the associations between maternal bonding and negative affect in the perinatal period, as well as the extent to which these factors are related to infant development. Findings will be considered within the context of theory, research and clinical practice.
5.11. References


doi:10.1093/med:psych/9780190271381.001.0001


6. General Method

6.1. Design

Study I was a systematic review and meta-analysis, with data collected and extracted by the candidate. Study II and Study III used pre-existing data from the Triple B Pregnancy Cohort Study (“Bumps, Babies and Beyond”), collected between 2009 and 2013. Triple B is a longitudinal pregnancy study conducted by the National Drug and Alcohol Research Centre at the University of New South Wales (UNSW) and by the National Drug Research Institute at Curtin University, in collaboration with the Universities of Sydney and Queensland, and Deakin University. The data collected include demographic, parental, familial and infant factors, with a focus on parental substance use and mental health, parenting practices, familial functioning, and infant development. Pregnant women (N = 1,623) were recruited from four major public hospitals: three hospitals in New South Wales (the Royal Prince Alfred Hospital, Royal Hospital for Women, and Liverpool Hospital); and one in Western Australia (the King Edward Memorial Hospital). The study used a prospective cohort design with multiple waves of data collection including: pregnancy trimester one (T1); pregnancy trimester two (T2); pregnancy trimester three (T3); hospital statistics at birth; postnatal 8 weeks; and postnatal 12 months. More detailed information on the Triple B Cohort is provided in (Hutchinson et al., 2017).

In place of data collection for Study II and Study III, the candidate completed 50 days of data collection for the “Triple B: Life at 8” pilot study. The Life at 8 study is the next wave of the Triple B study. The candidate completed all data collection for mothers and partners involved in the pilot study (N = 69 mothers and their partners). Data collection for mothers and partners involved re-engaging participants, preparing and sending out web surveys, tracking participant progress, reimbursing participants, and issuing child reports on completed measures. Further, the candidate
completed Computer Assisted Telephone Interviews with all mothers (approximately 1.5 hours required per interview). Further, the candidate was involved in data cleaning and preparation for Study II and Study III (approximately 10 days in addition to the 50 days already completed).

6.1.1. Ethics.

The Triple B Study was designed in accordance with the National Health and Medical Research Council’s (NHMRC) national statement on ethical conduct in human research (National Health and Medical Research Council, 2007). Approval to conduct this research was received from the UNSW Human Research Ethics Committee (HREC reference number: 08224, 14 August 2008). This approval was ratified by the following Australian institutions: Prince Alfred Hospital (SSA reference number: 08/RPAH/412, 1 September 2008), Royal Women’s Hospital (SSA reference number: 09/G/097, 1 September 2009), Liverpool Hospital (SSA reference number: SSA/11/LPOOL/80, 10 June 2011), and the King Edward Memorial Hospital (SSA reference number: 1811/EW, 1 February 2011). After approval from area health services was obtained, women (and partners) were invited into the study at each of the participating hospitals. Deakin University is a partnering institution on the original grant and ethical agreements, with two project Chief Investigators (CIs) based at Deakin University (CIs Hutchinson and Olsson). In regard to the Triple B: Life at 8 follow-up study, ethics approval was received from Deakin University Human Research Ethics Committee, see Appendix C (DUHREC reference number: 2016-347, 16 February 2017). Data are securely stored at UNSW and Deakin University.

The candidate was included in an ethics amendment as a student on the project. The candidate has completed the research integrity and human research ethics training online, see Appendix C for certificates of completion.
6.1.2. Funding.

The Triple B Cohort was established through the NHMRC Project Grant Scheme (APP630517: Funded $2.2M, 2010-14). The candidate was funded by a Deakin University postgraduate research scholarship, with some funding requested for the Triple B: Life at 8 pilot study.

6.2. Participants

Pregnant women were recruited from four major public hospitals (three in New South Wales, one in Western Australia) between 2009 and 2013 ($N = 1,623$). The study recruited two sub-samples: (1) a general antenatal clinic sample of pregnant women ($N = 1,534$: NSW = 1246, WA = 288); and (2) a smaller sample of pregnant women with a history of diagnosed substance abuse and/or dependence ($N = 89$: NSW = 59, WA = 30). Research assistants attended antenatal clinics at each hospital, across all days and months of the year, to ensure recruitment sites were proportionally represented. A standardised script was used to describe the study to pregnant women. Eligibility criteria included: being pregnant, being aged 16 years or over, having no major medical complications (mother or fetus), residence in New South Wales or Western Australia, intention of mother or both parents to be the primary caregiver(s), possessing sufficient literacy in English, and, informed consent.

Study II and Study III investigated a sub-sample of the Triple B cohort. Study II participants were a subsample of 1,347 mothers and their infant offspring with data on the requisite measures of interest. Study III participants were a subsample of 1,579 mothers and their offspring with the measures of interest assessed in trimester three. The main assessment measures across these studies are described below.
6.3. Procedures

The study used a prospective cohort design with multiple waves of data collection including: pregnancy trimester one (T1); pregnancy trimester two (T2); pregnancy trimester three (T3); hospital statistics at birth; postnatal 8 weeks; and postnatal 12 months. Structured interviews and self-complete questionnaires were administered to mothers at all time-points (see Appendix D for the maternal report measures included in the current thesis). Partner data was also collected at T3, and at 8 weeks and 12 months postpartum, however the current thesis focused on maternal and infant data only. Comprehensive developmental assessments were conducted with infants at 12 months, including cognitive, motor, and language skills, along with measures of social and emotional functioning. The assessment schedule for measures included in the current thesis is described in Table 2.

Table 2

*Assessment Schedule for Measures Relevant to Current Thesis*

<table>
<thead>
<tr>
<th></th>
<th>Pregnancy T1a</th>
<th>Pregnancy T2a</th>
<th>Pregnancy T3</th>
<th>Postnatal 8 weeks</th>
<th>Postnatal 12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mother</td>
<td>Interview</td>
<td>Interview</td>
<td>Interview</td>
<td>Interview</td>
<td>Interview</td>
</tr>
<tr>
<td></td>
<td>Questionnaire</td>
<td>Questionnaire</td>
<td>Questionnaire</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant</td>
<td></td>
<td></td>
<td></td>
<td>Hospital records</td>
<td>Developmental</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(Blue Book)</td>
<td>assessment</td>
</tr>
</tbody>
</table>

*In instances where women commenced participation after trimester one or two, pregnancy assessments were completed for earlier waves retrospectively.*

*The Blue Book is a record completed by hospital staff post-birth.*
6.4. Measures

The measures included in the current thesis are listed in Table 3 and described in detail below.

Table 3

*Summary of Measures Relevant to Current Thesis*

<table>
<thead>
<tr>
<th></th>
<th>Pregnancy T1*</th>
<th>Pregnancy T2*</th>
<th>Pregnancy T3</th>
<th>Postnatal 8 weeks</th>
<th>Postnatal 12 months</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Maternal and infant demographics</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>State of residence</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Country of birth</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Socioeconomic status</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Highest level of education</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Living arrangement</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Parity</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Maternal age at birth</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Infant sex</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Infant weight at birth</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td>Prematurity</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>-</td>
</tr>
<tr>
<td><strong>Maternal bonding</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bonding to the fetus</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Bonding to the infant</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Maternal negative affect</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depression, anxiety, stress</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td><strong>Infant developmental outcomes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Language</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Motor</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Social-emotional</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Adaptive behaviour</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
<tr>
<td>Temperament</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>✓</td>
</tr>
</tbody>
</table>

*In instances where women commenced participation after trimester one or two, pregnancy assessments were completed for earlier waves retrospectively.*
6.4.1. Maternal and infant demographics.

Maternal and infant demographic information was collected across all waves of data collection, with baseline data collected at pregnancy T3 and postnatal 8 weeks.

6.4.1.1. State of residence.

State of residence was indicated by recruitment hospital: (1) NSW, Australia, or (2) WA, Australia.

6.4.1.2. Country of birth.

Participants were asked, “In which country were you born?”. Responses were categorised as: (1) born in Australia, (2) other English-speaking country, or (3) non-English speaking country.

6.4.1.3. Socioeconomic status.

The ABS Socioeconomic Indexes for Areas (SEIFA) data package was used to determine socioeconomic status (SES) deciles based on residential postcode. SES was collapsed into three broad categories: (1) low SES (deciles 1-3), (2) medium SES (deciles 4-7), or (3) high SES (deciles 8-10).

6.4.1.4. Highest level of education.

Participants were asked “What is your highest level of education?”. Responses were categorised as: (1) Less than Year 12, (2) Completed Year 12, (3) Completed TAFE/technical, or (4) Completed university/college.

6.4.1.5. Living arrangement.

Participants were asked “Are you currently living with a partner?”. Responses were categorised as: (1) Yes, or (2) No.
6.4.1.6. **Parity.**

Parity is a measure of the total number of pregnancies carried to term prior to the current pregnancy (Creinin & Simhan, 2009). Responses were categorised as: (1) zero, (2) one or two, or (3) three or more.

6.4.1.7. **Maternal age at birth.**

Maternal age at birth was calculated based on mother and infant dates of birth (assessed at T3 and 8 weeks postpartum, respectively). Responses were categorised as: (1) ≤24 years, (2) 25-29 years, (3) 30-35 years, or (4) ≥36 years.

6.4.1.8. **Infant sex.**

Information on infant sex was extracted from hospital records (Blue Books), as recorded by hospital staff at birth. Responses were categorised as: (1) Female, or (2) Male.

6.4.1.9. **Infant weight at birth.**

Information on infant weight at birth was extracted from hospital records (Blue Books), as recorded by hospital staff. Responses were collapsed into two broad categories based on Australian norms (Dobbins, Sullivan, Roberts, & Simpson, 2012): (1) Normal (>10th percentile for gestational age), or (2) Small for gestational age (≤10th percentile for gestational age).

6.4.1.10. **Prematurity.**

Information on number of weeks’ gestation at birth was extracted from hospital records (Blue Books), as recorded by hospital staff. Responses were collapsed into two broad categories: (1) Not premature (≥37 weeks), or (2) Premature (≤36 weeks).
6.4.2. Maternal bonding.

6.4.2.1. Bonding to the fetus.

The Maternal Antenatal Attachment Scale (MAAS) is a 19-item self-report measure that asks a mother about her thoughts and feelings about her developing baby (Condon, 1993). Items focus on the past two weeks and are rated on a 5-point scale, with the scale options varying between items. The quality of bonding subscale (10 items) is based on a mother’s experienced closeness, tenderness, and positive feelings towards her unborn child; for example, “Over the past two weeks when I think about the baby inside me I get feelings which are”: 1 = Very sad to 5 = Very happy. The intensity of preoccupation subscale (8 items) measures the amount of time a mother spends thinking, talking, and dreaming about her unborn child; for example, “Over the past two weeks I have thought about, or been preoccupied with the baby inside me”: 1 = Almost all of the time to 5 = Not at all. Some items were reverse-scored, with items summed to provide three scores: quality of bonding (range 10-50), intensity of preoccupation (8-40), and a global total (19-95). Higher scores indicate higher, more adaptive bonding to the fetus. Reliability for the MAAS is 0.82, as measured in trimester three of pregnancy (Condon, 1993).

6.4.2.2. Bonding to the infant.

The Maternal Postnatal Attachment Scale (MPAS) is a 19-item self-report measure that asks a mother about her thoughts and feelings about her infant (Condon & Corkindale, 1998). The measure consists of three factors: (1) quality of bonding – a mother’s confidence and satisfaction in interactions with her infant (9 items); (2) absence of hostility towards her infant (5 items); and, (3) her desire for physical closeness and pleasure in interactions with her infant (5 items). The number of response options varies between items (2-, 4-, and 5-point scales); all response options are recoded to represent a score of one (poor bonding) to five (strong
bonding. Four scores are calculated: quality subscale (range 9-45), absence of hostility (5-25), pleasure in interaction (5-25), and a global total (19-95). Higher scores indicate stronger, more adaptive bonding to the infant. The MPAS has demonstrated high test-retest reliability ($r = .86$; Condon & Corkindale, 1998).

6.4.3. Maternal negative affect.

6.4.3.1. Depression.

The Edinburgh Antenatal and Postnatal Depression Scale (EPDS) is a 10-item self-report measure used to detect symptoms of antenatal and postnatal depression (Cox, Holden, & Sagovksy, 1987). Items tap symptoms of depression, including low mood, anhedonia, and sleep disturbance. Participants are required to rate their frequency of symptoms over the past week on a 4-point scale, with the scale options varying between items. Examples include, “I have looked forward with enjoyment to things” and “I have blamed myself unnecessarily when things go wrong”. Scores are summed to yield a total score (range 0-30), with higher scores indicating more depressive symptoms (0-9 classified as normal; 10-12 moderate symptoms; 13-30 severe). The EPDS has established sensitivity and specificity, and is sensitive to change in the severity of depressive symptoms over time (Cox et al., 1987).

6.4.3.2. Stress and anxiety.

The short-form of the Depression Anxiety and Stress Scales (DASS-21) is a 21-item self-report measure that assesses symptoms of depression, anxiety, and stress over the past week (seven items per subscale; Lovibond & Lovibond, 1996). The current thesis includes results from only the anxiety and stress subscales as depressive symptoms were assessed using the Edinburgh Postnatal Depression Scale (EPDS; gold-standard measurement for perinatal depression). The anxiety subscale (DASS: Anxiety) assesses autonomic arousal, skeletal muscle effects, situational
anxiety, and subjective experience of anxious affect; for example, “I worried about situations in which I might panic and make a fool of myself”. The stress subscale (DASS: Stress) assesses chronic non-specific arousal, including difficulty relaxing and nervous arousal; for example, “I found it hard to wind down”. Participants are asked to rate their frequency of symptoms on a 4-point scale (1 = *Never* to 5 = *Almost always*). Scores are summed and range between 0-28 for each subscale. For the anxiety subscale, scores of 0-3 are classified as normal; 4-5 mild; 6-7 moderate; 8-9 severe; 10-21 extremely severe symptoms of anxiety. For the stress subscale, scores of 0-7 are classified as normal; 8-9 mild; 10-12 moderate; 13-16 severe; 17-21 extremely severe symptoms of stress. The DASS-21 has demonstrated internal consistency across four perinatal time-points (r = 0.82-0.85; Rossen et al., 2016).

### 6.4.4. Infant developmental outcomes.

The current thesis focuses on infant outcomes at 12 months, as assessed using the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III; Bayley, 2006) and the Avon Longitudinal Study of Parents and Children measure of infant temperament (ALSPAC, 2001).


The Bayley-III scales assess the developmental functioning of infants and young children 1 month to 42 months of age (Bayley, 2006). The primary purpose of the Bayley-III is to identify children with developmental delay and to provide information for intervention planning. Infant and toddler development is assessed across five domains: cognitive, language, motor, social-emotional, and general adaptive behaviour. The Bayley-III scales have been shown to have strong internal consistency and test-retest reliability (Bayley, 2006). For the current study, Triple B
researchers achieved 98% interrater consistency for the assessment of cognitive, language, and motor domains (Hutchinson et al., 2017).

Assessment of the cognitive, language, and motor domains are conducted using items individually administered to the child by a trained research assistant or clinical psychologist. Caregivers are encouraged to remain present but not to influence administration. The administration time for these three scales is approximately 50 minutes in total. Within each scale and subtest, items are ordered according to level of difficulty. The basal and ceiling rules are consistent across the scales and subtests: the basal level is determined by obtaining a score of one on three consecutive items; the ceiling rule is applied when the child has received a score of zero on five consecutive items. Some items are timed and require stimulus materials (e.g., a bear, memory cards, a ball). Assessment of the social-emotional and general adaptive behaviour domains are conducted using maternal report questionnaires. The administration time for these two questionnaires is approximately 30-40 minutes in total.

Our analyses included the composite scores (cognitive, language, motor, social-emotional, general adaptive behaviour), and four subscale scores (receptive communication, expressive communication, fine motor, and gross motor). The composite scores each range from 40-160, with a mean of 100 and standard deviation of 10. The subscale scores range from 1-19, with a mean of 10 and standard deviation of three.

6.4.4.1.1. Cognitive scale.

The 91-item cognitive scale assesses sensorimotor development, exploration and manipulation, object relatedness, concept formation, memory, and other aspects of cognitive processing. Items on the cognitive scale do not require the child to respond verbally. An example item is: “Recognises Caregiver: During testing, gain
the child’s attention. Briefly interact with the child then move out of the child’s visual field. While observing the child’s face, ask the caregiver to move into the child’s visual field and get the child’s attention.” The child receives a point if they indicate recognition of their caregiver.

6.4.4.1.2. Language scale.

The language scale assesses receptive and expressive communication. The 49-item receptive communication subtest assesses: preverbal behaviours; vocabulary development (e.g., being able to identify objects and pictures that are referenced); vocabulary related to morphological development (pronouns, prepositions); understanding of morphological markers (plurals, tense markings); social referencing; and verbal comprehension. An example item on the receptive communication subtest is: “Responds to No-No: Place an object that the child appears interested in within the child’s reach. When the child reaches for it, say no-no in a firm voice.” The child receives a point if they stop reaching for the object in response to “no-no”.

The 48-item expressive communication subtest assesses: preverbal communication (babbling, gesturing, joint referencing, turn taking); vocabulary development (naming objects, pictures, and attributes); and morpho-syntactic development (two-word utterances, plurals, verb tense). An example item is: “Jabbers Expressively: During testing, listen if the child uses vocal inflections (alterations in pitch or tone) that are expressive and somewhat imitative of conversational inflections.” The child receives a point if they produce at least one vocalisation that contains inflections and is expressive.
6.4.4.1.3. Motor scale.

The motor scale assesses fine and gross motor skills. Fine motor skills relate to prehension, perceptual-motor integration, motor planning, and motor speed. The 66-item fine motor subtest assesses: visual tracking, reaching, object manipulation, grasping, functional hand skills, and responses to tactile information. An example item is: “Scribbles Spontaneously: Place the paper on the table, in front of the child. Place the crayon in the middle of the paper. Encourage the child to make marks on the paper such as to scribble, draw a picture, or write.” The child receives a point if they spontaneously and purposely scribble on the paper.

Gross motor skills relate to the movement of the limbs and torso. The 72-item gross motor subtest assesses: static positioning (sitting, standing); dyadic movement (locomotion, coordination); balance; and motor planning. An example item is: “Stands Alone: Stand the child on the floor and hold his or her hands so that the arms are extended at shoulder height. Slowly release your grasp on the child’s hands.” The child receives a point if they stand alone for at least three seconds after their hands are released.

6.4.4.1.4. Social-emotional scale.

The 35-item social-emotional scale (Bayley-III: SE) is a maternal report measure, which assesses the acquisition of age-related milestones that represent social-emotional patterns. The social-emotional scale includes items that assess: child’s mastery of functional emotional skills (for example, self-regulation and interest in the world); communicating needs; engaging others and establishing relationships; using emotions in an interactive, purposeful manner; and using emotional signals or gestures to solve problems. One example item is: “Likes to be swung around, danced with while in your arms, or quickly lifted up in the air.” The mother is asked to rate the frequency of each behaviour on a 6-point Likert scale.
(ranging from Can’t tell and None of the time to All of the time). These scores have associated qualitative descriptors that range from extremely low to very superior functioning. Scores from the Bayley-III: SE can also be used to determine possible sensory processing deficits, which may explain social-emotional problems.

6.4.4.1.5. General adaptive behaviour scale.

The 241-item general adaptive behaviour scale is a maternal report measure, which assesses the child’s independent display of skills needed in normal daily living. Areas assessed include: communication – speech, language, listening, and nonverbal communication; community use – interest in activities outside the home and recognition of different facilities; functional pre-academics – letter recognition, counting, and drawing simple shapes; home living – helping adults with household tasks and taking care of personal possessions; health and safety – showing caution and keeping out of physical danger; leisure – playing, following rules, and engaging in recreation at home; self-care – eating, toileting, bathing; self-direction – self-control, following directions, and making choices; social – getting along with other people, for example, using manners, assisting others, and recognising emotions; and motor – locomotion and manipulation of the environment. An example item is: “Recognises own home in his or her immediate neighbourhood.” The mother is asked to rate the frequency of each behaviour on a 4-point Likert scale (ranging from Not able to do it to Does it always or almost always when needed). These scores have associated qualitative descriptors that range from extremely low to very superior functioning.
6.4.4.2. **ALSPAC measure of infant temperament.**

Infant temperament was assessed using a questionnaire derived from the Avon Longitudinal Study of Parents And Children (ALSPAC, 2001). Mothers were asked to rate a list of 12 adjectives according to how accurately each item described her child, using a 4-point scale, with 1 = *Very like him/her* and 4 = *Very unlike him/her* (Braunstein, 2015; note that the current study reversed the scales used in the original study). A principal component factor analysis was used to identify correlated items and form temperamental dimensions. Component one contained six items, with one item ("placid") negatively related to the other items ("difficult", "unsettled", "grizzly", "demanding", and "angry"); this first component was labelled *emotional stability/reactivity*, with higher scores indicating more emotional stability (Cronbach’s α = .75). Component two contained five, positively related items ("smiley", "social", "happy", "alert", "cuddly"); this second component was labelled *social approach/withdrawal*, with higher scores indicating more social withdrawal (Cronbach’s α = .64). One item ("serious") did not load onto either component, and was excluded from analyses.
6.5. References


Hutchinson, D., Wilson, J., Allsop, S., Elliott, E., Najman, J., Burns, L., . . .


7. **Study I: The Role of Antenatal and Postnatal Maternal Bonding in Infant Development: A Systematic Review and Meta-Analysis**

Paper published in *Social Development* in July 2019.

Genevieve Le Bas¹, George Youssef¹²³, Jacqui Macdonald¹²³, Larissa Rossen⁴, Sam Teague¹, Emily Kothe¹, Jennifer McIntosh¹²³, Craig Olsson¹²³, and Delyse Hutchinson¹²³⁴.

¹Deakin University, Centre for Social and Early Emotional Development, School of Psychology, Faculty of Health, Geelong, Australia
²Murdoch Children’s Research Institute, Centre for Adolescent Health, Royal Children's Hospital, Melbourne, Australia
³University of Melbourne, Department of Paediatrics, Royal Children's Hospital, Melbourne, Australia
⁴National Drug and Alcohol Research Centre, University of New South Wales, Sydney, Australia

**Competing Interests**

The authors declare that they have no competing interests.
The Library has removed the following publication from the public version of this thesis due to copyright restrictions:


DOI: [10.1111/sode.12392](https://doi.org/10.1111/sode.12392)

©2019, John Wiley & Sons Ltd
8. Study II: The Role of Antenatal and Postnatal Maternal Bonding in Infant Development

Paper submitted to Child Development (under review).

Genevieve Le Bas¹, George Youssef²³, Jacqui Macdonald¹²³, Richard Mattick⁴, Sam Teague¹, Ingrid Honan⁴, Jennifer McIntosh¹²³, Sarah Khor⁴, Larissa Rossen⁴, Elizabeth Elliott⁵⁶, Steve Allsop⁷, Lucinda Burns⁴, Craig Olsson¹²³,

and Delyse Hutchinson¹²³⁴*.

¹Deakin University, Centre for Social and Early Emotional Development, School of Psychology, Faculty of Health, Geelong, Australia.
²Murdoch Children’s Research Institute, Centre for Adolescent Health, Royal Children's Hospital, Melbourne, Australia.
³University of Melbourne, Department of Paediatrics, Royal Children's Hospital, Melbourne, Australia.
⁴National Drug and Alcohol Research Centre, University of New South Wales, Sydney, Australia.
⁵Discipline of Child and Adolescent Health, University of Sydney, Sydney, Australia.
⁶The Children’s Hospital at Westmead, Sydney, Australia.
⁷National Drug Research Institute, Curtin University, Perth, Australia.
**Competing Interests**

The authors declare that they have no competing interests.

**Ethics Approval and Consent to Participate**

Ethics approval was granted by the Sydney South West Area Health Service Human Research Ethics Committee and the University of New South Wales Human Research Ethics Committee (Reference: HC08224; 29/08/2008). Written informed consent was obtained from all participants.

**Availability of Data and Materials**

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

**Funding**

The research was funded by an Australian National Health and Medical Research Council (NHMRC) Project Grant #GNT630517 for $2,196,179 to Richard P Mattick, Delyse Hutchinson, Steve Allsop, Jake Najman, Elizabeth Elliott, Lucy Burns, Sue Jacobs, Craig Olsson and Anne Bartu, and was financially supported by the National Drug and Alcohol Research Centre (NDARC), University of New South Wales (UNSW). The cohort is led by the National Drug and Alcohol Research Centre (NDARC) at UNSW Australia, the Drug Research Institute (NDRI) at Curtin University, and the School of Psychology at Deakin University, in collaboration with the University of Sydney, the University of Queensland, the University of Christchurch, and the Murdoch Children’s Research Institute. NDARC and the National Drug Research Institute (NDRI), Curtin University of Technology are funded by the Australian Government under the Substance Misuse Prevention and Service Improvements Grants Fund. The study has also been supported by Australian Rotary Health (ARH; 2012-2013; 2018-2020), the Foundation for Alcohol Research and Education (FARE; 2010-2011), and the Financial Markets Foundation for
Children (Australia) (2015-2016). Additionally, PhD candidates on the project have been funded through ARH; the NDARC Education Trust (NET) and the Australian Centre for Perinatal Science and NDARC, UNSW. EE is supported by NHMRC Practitioner Fellowship #1021480 and NHMRC Centre Research Excellence; CAO is financially supported by an Australian Research Council Principal Research Fellowship; and, RPM is financially supported by an NHMRC Principal Research Fellowship Award from the NHMRC.

Acknowledgements

We gratefully acknowledge the NDARC and NDRI research staff and students who assisted with collection of the data, study investigators not included as authors, the hospitals and antenatal clinics for their assistance with recruitment, and the study participants and their families. We also wish to acknowledge the Cannabis Cohorts Research Consortium (CCRC; NHMRC Project Grants: AAP1009381, AAP1064893; also referenced as the Longitudinal Cohorts Research Consortium (LCRC)).
8.1. Abstract

This study examined the extent to which mother-to-infant bonding predicted infant development in an Australian pregnancy cohort study ($N = 1,347$; maternal $M$ age = 32.71). Self-reported bonding was assessed at each trimester, and 8 weeks and 12 months postpartum. Infant development was assessed using Bayley-III at 12 months. Bonding predicted indicators of infant social-affective development, including social-emotional, behavioural, and temperamental outcomes. Effect sizes were small but increased over the perinatal period ($\beta = .07-.27$). Limited evidence was provided for associations between bonding and cognitive, language, and motor development ($\beta = .06-.07$). Findings suggest that a mother’s perceived emotional connection with her child plays a role in predicting social-affective outcomes; prediction may not extend to other domains of infant development.
8.2. Introduction

Pregnancy typically signifies the beginning of a powerful affectional bond between a mother and her infant (Bornstein, 1989; Condon, 1993; Korja et al., 2010; Lindgren, 2001; Sokolowski, Hans, Bernstein, & Cox, 2007). A positive affectional connection between a mother and her infant facilitates an environment of care in which the infant feels safe to explore, learn, and develop age-appropriate autonomy (Ainsworth, Blehar, & Waters, 2014; Belsky, Rovine, & Taylor, 1984; Winnicott, 1965). There has been widespread interest in perinatal maternal-infant bonding, yet few studies have investigated its associations with developmental outcomes (Branjerdporn, Meredith, Strong, & Garcia, 2017; Le Bas et al., in press, Study I). Understanding the links between mother-to-infant bonding and early development has the potential to inform preventative and treatment interventions that promote a healthy start to emotional life.

The constructs of “bonding” and “attachment” are often confused or conflated. Bonding specifically refers to the mother’s self-reported emotional connection with her infant. In contrast, attachment quality represents the patterning of the infant’s behaviour and expectations of the mother’s caregiving responses assessed observationally (Ainsworth, 1989; Cassidy & Shaver, 2016). During pregnancy a mother typically develops internalised representations of the unborn child accompanied by an affectional tie to her fetus, referred to as antenatal bonding (Condon, 1993; Walsh, 2010). Poor antenatal bonding has been linked to negative health behaviours during pregnancy, including alcohol and nicotine use (Lindgren, 2001; Rossen et al., 2016; Sedgmen, McMahon, Cairns, Benzie, & Woodfield, 2006), which can have detrimental effects on child development (Barker, Jaffee, Uher, & Maughan, 2011; Hutchinson, Mattick, Braunstein, Maloney, & Wilson,
Furthermore, antenatal bonding during each trimester has been shown to predict subsequent postnatal bonding (Rossen et al., 2017; Rossen et al., 2016).

Postnatally, maternal perceptions of a positive bond would be indicated if a mother reported pleasure in interacting with her infant, a developing competence in her own capacity to understand and meet her infant’s needs, and acceptance and tolerance of the demands of the maternal role (Condon & Corkindale, 1998). Maternal self-reported perceptions of postnatal affectional bonding indicate more nurturing maternal-infant interactions (Feldman, Weller, Leckman, Kuint, & Eidelman, 1999; Korja et al., 2010), which are essential for the infant’s development of complex affective signalling (Bornstein, 1989; Grant, McMahon, Reilly, & Austin, 2010). Higher bonding is expressed through behaviours such as maternal sensitivity and emotional availability (Feldman et al., 1999), which invite interaction and encourage social-emotional engagement (e.g., interest, touch, smiles, play, adaptivity, approach) and development (e.g., emotion regulation).

Two recent reviews synthesised the extant literature on maternal self-reported bonding and infant development (Branjerdporn et al., 2017; Le Bas et al., in press, Study I). Branjerdporn et al. (2017) provided a qualitative synthesis linking a mother’s felt emotional connection to her infant during pregnancy to infant development (N = 8 studies). While the authors termed this construct “maternal-infant attachment”, the measure’s content closely approximates the definition of “antenatal bonding”. The review found some evidence to suggest that higher antenatal bonding was linked to more optimal infant development, including “easier” infant temperament, lower colic rating, and developmental milestone attainment (Branjerdporn et al., 2017).

Le Bas et al. (in press, Study I) extended the findings of Branjerdporn et al. (2017), including studies on both the antenatal and postnatal mother-to-infant bond,
and completed a series of 14 quantitative meta-analyses \((k = 15\) studies, \(N\) effects = 51) investigating infant physical, psychological, and social development. All mean effects linking bonding and infant development were in a positive direction, albeit effects were generally small. Evidence was provided for meta-analytic associations between higher maternal self-reported bonding and higher infant attachment quality and mood, and lower infant temperament difficulty and colic rating \((r\) (range) = .19-.35). Cognitive, language, and motor outcomes were unable to be included in quantitative synthesis due to the small number of available effects. The review provided preliminary evidence that bonding plays a role in promoting social, emotional, and behavioural health in infancy, but noted that a paucity of high-quality longitudinal research prohibited firmer conclusions about the strength of these associations (Le Bas et al., in press, Study I).

Only a handful of studies have examined associations between maternal bonding and indicators of social-affective development. One study by Mason, Briggs, and Silver (2011) linked higher maternal self-reported bonding at two months postpartum and infant social-emotional competence at six months \((r = .24, n = 219)\). Sierau et al. (2016) also explored associations between maternal self-reported bonding and infant internalising and externalising behaviours, and the child’s behaviour at assessment (i.e., attention, social engagement, and affect). Higher bonding was consistently linked to lower internalising and externalising behaviours at 24 months, evidenced across a number of antenatal and postnatal time-points \((r = .12-.27)\). Results on the relations between maternal bonding and infant behaviour at assessment were inconsistent; most were not statistically significant, though some isolated findings linked higher bonding and less optimal behaviour (Sierau et al., 2016). This mixed picture on bonding and infant social-affective outcomes highlights the need for empirical clarification.
8.2.1. The current study.

The purpose of this study was to examine the extent to which antenatal and postnatal maternal self-reported bonding predicted infant development at 12 months of age. Outcome domains included infant temperament and social-emotional, behavioural, cognitive, language and motor development, as assessed by the Bayley III Social-Emotional Scales and Scales of Infant and Toddler Development. Importantly, this study included multiple assessment waves across the gestational period, to enable isolation of the timing of potential effects to guide key intervention points for prevention and treatment of bonding-related difficulties.

8.3. Method

8.3.1. Participants and procedures.

Data were obtained from the Triple B Pregnancy Cohort Study (also known as "Bumps, Babies and Beyond"; Hutchinson et al., 2017), a longitudinal pregnancy study conducted by the National Drug and Alcohol Research Centre at the University of New South Wales (UNSW) and the National Drug Research Institute at Curtin University, in collaboration with the Universities of Sydney and Queensland, and Deakin University. Ethics approval for this study was obtained from the Human Research Ethics Committees of each participating hospital, the Area Health Services where the hospitals were located, and the relevant collaborating institutions.

Pregnant women were recruited from four major public hospitals (three in New South Wales, one in Western Australia) between 2009 and 2013 ($N = 1,623$). Researchers attended antenatal clinics at each hospital, across all days and months of the year, to ensure recruitment sites were proportionally represented. Eligibility criteria included: being pregnant, being aged 16 years or over, having no major medical complications (mother or fetus), residence in New South Wales or Western Australia, intention of mother or both parents to be the primary caregiver(s),
possessing sufficient literacy in English, and, informed consent. Data were collected via structured interviews and self-complete questionnaires, and included demographic, parental, familial, and infant measures. The study used a prospective cohort design with multiple waves of data collection including: pregnancy trimester one (T1); trimester two (T2); trimester three (T3); hospital statistics at birth; postnatal 8 weeks; and postnatal 12 months. The assessment focused on parental substance use and mental health, parenting practices, familial functioning, and infant development and temperament. More detailed information on the cohort is provided in Hutchinson et al. (2017).

Participants of the current study were a subsample of 1,347 mothers and offspring, who had completed either of the relevant infant outcome measures (see Measures section). Maternal mean age at birth for this subsample was 32.71 years (SD = 4.95). The demographic characteristics of this sub-sample (n = 1,347) were compared with the mothers who were a part of the Triple B study but had not completed the requisite infant outcome measures for this analysis (n = 276), with no statistically significant differences noted. The demographic (antenatal) and obstetric (postnatal) characteristics of the study sample are described in Table 8.3.2. Measures

Maternal and infant demographic information was collected via structured interview and questionnaires administered in trimester three (28 weeks to birth) and hospital statistics at birth. The maternal and infant measures included in the current study, along with the assessment schedule, are described in Table and Table.
Table 4

*Sample Antenatal Demographic and Postnatal Obstetric Characteristics (N = 1,347)*

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>State of residence</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSW</td>
<td>1137</td>
<td>84%</td>
</tr>
<tr>
<td>WA</td>
<td>210</td>
<td>16%</td>
</tr>
<tr>
<td><strong>Country of birth</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>770</td>
<td>57%</td>
</tr>
<tr>
<td>Other English-speaking country</td>
<td>251</td>
<td>19%</td>
</tr>
<tr>
<td>Non-English-speaking country</td>
<td>326</td>
<td>24%</td>
</tr>
<tr>
<td><strong>Socioeconomic status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low SES</td>
<td>49</td>
<td>4%</td>
</tr>
<tr>
<td>Medium SES</td>
<td>397</td>
<td>29%</td>
</tr>
<tr>
<td>High SES</td>
<td>901</td>
<td>67%</td>
</tr>
<tr>
<td><strong>Highest level of education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than high school</td>
<td>81</td>
<td>6%</td>
</tr>
<tr>
<td>Completed high school</td>
<td>144</td>
<td>11%</td>
</tr>
<tr>
<td>Completed TAFE/technical</td>
<td>199</td>
<td>15%</td>
</tr>
<tr>
<td>Completed university/college</td>
<td>923</td>
<td>68%</td>
</tr>
<tr>
<td><strong>Living with partner</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1256</td>
<td>93%</td>
</tr>
<tr>
<td>No</td>
<td>91</td>
<td>7%</td>
</tr>
<tr>
<td><strong>Parity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>770</td>
<td>57%</td>
</tr>
<tr>
<td>1-2</td>
<td>518</td>
<td>39%</td>
</tr>
<tr>
<td>3+</td>
<td>59</td>
<td>4%</td>
</tr>
<tr>
<td><strong>Maternal age at birth (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤24 years</td>
<td>73</td>
<td>5%</td>
</tr>
<tr>
<td>25-29 years</td>
<td>280</td>
<td>21%</td>
</tr>
<tr>
<td>30-35 years</td>
<td>594</td>
<td>44%</td>
</tr>
<tr>
<td>≥36 years</td>
<td>400</td>
<td>30%</td>
</tr>
<tr>
<td><strong>Infant sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>643</td>
<td>48%</td>
</tr>
<tr>
<td>Male</td>
<td>704</td>
<td>52%</td>
</tr>
<tr>
<td><strong>Infant weight at birth</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>1204</td>
<td>89%</td>
</tr>
<tr>
<td>(&gt;10&lt;sup&gt;th&lt;/sup&gt; percentile for gestational age)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small for Gestational Age</td>
<td>143</td>
<td>11%</td>
</tr>
<tr>
<td>(≤10&lt;sup&gt;th&lt;/sup&gt; percentile for gestational age)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Prematurity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not premature (≥37 weeks)</td>
<td>1278</td>
<td>95%</td>
</tr>
<tr>
<td>Premature (≤36 weeks)</td>
<td>69</td>
<td>5%</td>
</tr>
</tbody>
</table>

*Note.*

<sup>a</sup> Information collected via structured interview and questionnaire assessments in trimester three (28 weeks to birth).

<sup>b</sup> Information collected via hospital statistics at birth.
Table 5
Descriptive Statistics for MAAS and MPAS (N = 1,347)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Pregnancy T1&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Pregnancy T2&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Pregnancy T3</th>
<th>Postnatal 8 weeks</th>
<th>Postnatal 12 months</th>
<th>Range of Possible Scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAS&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>73.9 (8.65)</td>
<td>78.07 (7.17)</td>
<td>79.94 (7.17)</td>
<td></td>
<td></td>
<td>19-95&lt;sup&gt;c&lt;/sup&gt;</td>
</tr>
<tr>
<td>Quality</td>
<td>43.67 (4.53)</td>
<td>45.82 (3.4)</td>
<td>46.47 (3.23)</td>
<td></td>
<td></td>
<td>10-50</td>
</tr>
<tr>
<td>Intensity</td>
<td>25.59 (5.25)</td>
<td>27.52 (4.77)</td>
<td>28.76 (4.74)</td>
<td></td>
<td></td>
<td>8-40</td>
</tr>
<tr>
<td>MPAS&lt;sup&gt;b&lt;/sup&gt;</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>82.18 (7.15)</td>
<td>81.96 (6.9)</td>
<td></td>
<td></td>
<td></td>
<td>19-95</td>
</tr>
<tr>
<td>Quality</td>
<td>39.59 (3.14)</td>
<td>39.77 (2.99)</td>
<td></td>
<td></td>
<td></td>
<td>9-45</td>
</tr>
<tr>
<td>Hostility (Low)</td>
<td>20.5 (3.2)</td>
<td>20.46 (3.2)</td>
<td></td>
<td></td>
<td></td>
<td>5-25</td>
</tr>
<tr>
<td>Pleasure</td>
<td>22.09 (2.78)</td>
<td>21.73 (2.78)</td>
<td></td>
<td></td>
<td></td>
<td>5-25</td>
</tr>
</tbody>
</table>

Note.
<sup>a</sup> In instances where women commenced participation after trimester one or two, pregnancy assessments were completed for earlier waves retrospectively.
<sup>b</sup> Higher scores indicate higher, more adaptive bonding, across all scales of the MAAS and MPAS.
<sup>c</sup> Item 7 of the MAAS loads onto total score only.
## Table 6

Descriptive Statistics for Outcome Variables ($N = 1,347$)

<table>
<thead>
<tr>
<th>Measure</th>
<th>Postnatal 12 months M (SD)</th>
<th>Range of Possible Scores</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Infant Bayley-III</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cognitive</td>
<td>106.99 ($11.57$)</td>
<td>40-160</td>
<td>Higher scores indicate more optimal development</td>
</tr>
<tr>
<td>Language</td>
<td>100.26 ($11.53$)</td>
<td>40-160</td>
<td>Aspects of cognitive processing, including concept formation and memory.</td>
</tr>
<tr>
<td>Receptive</td>
<td>9.92 ($2.63$)</td>
<td>1-19</td>
<td>Preverbal behaviours, vocabulary development, social referencing, verbal comprehension.</td>
</tr>
<tr>
<td>Expressive</td>
<td>10.11 ($1.94$)</td>
<td>1-19</td>
<td>Preverbal communication, vocabulary development, morpho-syntactic development.</td>
</tr>
<tr>
<td>Motor</td>
<td>99.56 ($12.67$)</td>
<td>40-160</td>
<td></td>
</tr>
<tr>
<td>Fine</td>
<td>10.61 ($2.51$)</td>
<td>1-19</td>
<td>Prehension, perceptual-motor integration, motor planning, motor speed.</td>
</tr>
<tr>
<td>Gross</td>
<td>9.19 ($2.72$)</td>
<td>1-19</td>
<td>Movement of the limbs and torso.</td>
</tr>
<tr>
<td>Social-Emotional</td>
<td>106.21 ($15.62$)</td>
<td>40-160</td>
<td>Functional emotional skills, communicating needs, engaging others and establishing relationships.</td>
</tr>
<tr>
<td>General Adaptive Behaviour</td>
<td>98.04 ($12.85$)</td>
<td>40-160</td>
<td>Independent display of skills needed in normal daily living.</td>
</tr>
<tr>
<td><strong>Infant Temperament</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emotional Reactivity/Stability</td>
<td>17.86 ($3.05$)</td>
<td>6-24</td>
<td>Higher scores indicate more emotional stability.</td>
</tr>
<tr>
<td>Approach/Withdrawal</td>
<td>6.51 ($1.63$)</td>
<td>5-20</td>
<td>Higher scores indicate more social withdrawal.</td>
</tr>
</tbody>
</table>
8.3.2.1. Maternal self-reported bonding to the fetus.

The Maternal Antenatal Attachment Scale (MAAS) is a 19-item self-report measure that asks a mother to report on her thoughts and feelings about her developing baby (Condon, 1993). Items focus on the past two weeks and are rated on a 5-point scale, with the scale options varying between items. The quality of bonding subscale (10 items) is based on a mother’s experienced closeness, tenderness, and positive feelings towards her unborn child; for example, “Over the past two weeks when I think about the baby inside me I get feelings which are”: 1 = *Very sad* to 5 = *Very happy*. The intensity of preoccupation subscale (8 items) measures the amount of time a mother spends thinking, talking, and dreaming about her unborn child; for example, “Over the past two weeks I have thought about, or been preoccupied with the baby inside me”: 1 = *Almost all of the time* to 5 = *Not at all*. Some items were reverse-scored, with items summed to provide three scores: quality of bonding (range 10-50), intensity of preoccupation (8-40), and a global total (19-95). Higher scores indicate stronger, more adaptive bonding to the fetus. Reliability for the MAAS is 0.82, as measured in trimester three of pregnancy (Condon, 1993).

8.3.2.2. Maternal self-reported bonding to the infant.

The Maternal Postnatal Attachment Scale (MPAS) is a 19-item self-report measure that asks a mother to report on her thoughts and feelings about her infant (Condon & Corkindale, 1998). The measure consists of three factors: (1) quality of bonding – a mother’s confidence and satisfaction in interactions with her infant (9 items); (2) absence of hostility towards her infant (5 items); and, (3) her desire for physical closeness and pleasure in interactions with her infant (5 items). The number of response options varies between items (2-, 4-, and 5-point scales); all response options are recoded to represent a score of one (poor bonding) to five (strong...
bonding). Four scores are calculated: quality subscale (range 9-45), absence of hostility (5-25), pleasure in interaction (5-25), and a global total (19-95). Higher scores indicate stronger, more adaptive bonding to the infant. The MPAS has demonstrated high test-retest reliability ($r = 0.86$; Condon & Corkindale, 1998).

8.3.2.3. Infant development.

The Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III) is an individually administered instrument that assesses the developmental functioning of infants and young children 1 month to 42 months of age (Bayley, 2006). The scales and subscales of Bayley-III are described in Table 8.3.3. The cognitive, language, and motor domains are assessed via observational measures; social-emotional and general adaptive domains are assessed via maternal report questionnaire. This study examined the composite scores (cognitive, language, motor, social-emotional, general adaptive behaviour), and four subscale scores (receptive communication, expressive communication, fine motor, and gross motor). The Bayley-III has been shown to be a reliable and valid measure (Bayley, 2006).

8.3.2.4. Maternal report of infant temperament.

Infant temperament was assessed using a questionnaire derived from the Avon Longitudinal Study of Parents And Children (ALSPAC, 2001). Mothers were asked to rate a list of 12 adjectives according to how accurately each item described her child, using a 4-point scale, with $1 = \text{Very like him/her}$ and $4 = \text{Very unlike him/her}$ (Braunstein, 2015; note that the current study reversed the scales used in the original study). A principal component factor analysis was used to identify correlated items and form temperamental dimensions. Component one contained six items, with one item (“placid”) negatively related to the other items (“difficult”, “unsettled”, “grizzly”, “demanding”, and “angry”); this first component was labelled emotional stability/reactivity, with higher scores indicating more emotional stability.
Component two contained five, positively related items (“smiley”, “social”, “happy”, “alert”, “cuddly”); this second component was labelled \textit{social approach/withdrawal}, with higher scores indicating more social withdrawal (Cronbach’s $\alpha = .64$). One item (“serious”) did not load onto either component, and was excluded from analyses.

8.3.3. Data analysis.

All analyses were conducted using Stata 15 (StataCorp, 2017). Missing data for any given variable was <10%. To address missing data, multiple imputation by chain equations was used. Specifically, 50 separate, fully imputed datasets were created based on all variables in the analysis, including exposures, outcomes and covariates. All descriptive statistics and inferential tests were based on pooled estimates over the 50 imputed datasets using Rubin’s rules (Rubin, 1987). A series of linear regression analyses were used to examine the relation between bonding and infant outcomes. Specifically, each of the Bayley-III composite scores (cognitive, language, motor, social-emotional, general adaptive behaviour), the Bayley-III subscale scores (receptive communication, expressive communication, fine motor, and gross motor), and the infant temperament scores (stability/reactivity, approach/withdrawal) were regressed onto the bonding measures (MAAS and MPAS), with separate analyses conducted for each time-point that bonding was assessed.

All analyses were adjusted for potential confounders including state of residence, country of birth, socioeconomic status, highest level of education, living arrangement, parity, maternal age at birth, infant sex, infant weight at birth, and prematurity. In the case of twins or triplets, only one child of each mother was randomly selected to be included in analyses, thus removing clustered data. Of note, the sample included 50 women with diagnosed substance use disorders. Sensitivity
analyses showed no influence on the magnitude, direction, nor the statistical significance of the results when these women were excluded. Consequently, all subsequent tables report on the full sub-sample of 1,347 women.

8.4. Results

The descriptive statistics for the current sample are described in Table 1, Table 2, and Table 3. Of note, means for the MAAS and MPAS were consistent with past findings from Condon (1993; antenatal: \( M = 75.7, SD = 8.1 \)) and Condon and Corkindale (1998; postnatal 4 weeks: \( M = 82.9, SD = 7.6 \); postnatal 8 months: \( M = 84.1, SD = 6.7 \)). Sample means for the MAAS and MPAS were relatively consistent, though there was a small increase in maternal self-reported bonding quality across time (pregnancy T1: \( M = 73.9, SD = 8.65 \); postnatal 12 months: \( M = 81.96, SD = 6.9 \)). Sample means for the Bayley-III cognitive \((M = 106.99, SD = 11.57)\) and social-emotional scales \((M = 106.21, SD = 15.62)\) were slightly higher than the normative means (100 for composite scores and 10 for subscale scores); whereas means for language, motor, and general adaptive behaviour were generally consistent with normative means.

Regression results for antenatal maternal self-reported bonding and infant temperament, and infant development outcomes measured by the Bayley III are provided in Table 1. Results for postnatal bonding are shown in Table 2. The findings for the Bayley-III language and motor subscales are provided as supplementary tables (see Appendix F). Interpretation of the results will focus on the total bonding scores as findings on the bonding subscales were generally consistent with the total scores.
Table 7

Regression Results for MAAS and Infant Bayley-III Scales and Temperament (N = 1,347)\(^a\)

<table>
<thead>
<tr>
<th></th>
<th>Cognitive</th>
<th>Language</th>
<th>Motor</th>
<th>Social-Emotional</th>
<th>General Adaptive Behaviour</th>
<th>Infant Temperament</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pregnancy T1: MAAS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Adjusted</strong></td>
<td>(\beta)</td>
<td>.01</td>
<td>.07</td>
<td>.07</td>
<td>.14</td>
<td>.10</td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>.02 (-.05, .09)</td>
<td>.1 (.03, .17)</td>
<td>.1 (.02, .18)</td>
<td>.25 (.15, .35)</td>
<td>.15 (.07, .23)</td>
<td></td>
</tr>
<tr>
<td><strong>Unadjusted</strong></td>
<td>(\beta)</td>
<td>-.01</td>
<td>.06</td>
<td>.05</td>
<td>.12</td>
<td>.10</td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>-.01 (-.09, .06)</td>
<td>.08 (.01, .15)</td>
<td>.07 (-.01, .15)</td>
<td>.22 (.12, .31)</td>
<td>.15 (.07, .23)</td>
<td></td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Adjusted</strong></td>
<td>(\beta)</td>
<td>.01</td>
<td>.03</td>
<td>.05</td>
<td>.11</td>
<td>.06</td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>.02 (-.12, .15)</td>
<td>.06 (-.07, .2)</td>
<td>.13 (.01, .28)</td>
<td>.37 (.18, .56)</td>
<td>.17 (.01, .32)</td>
<td></td>
</tr>
<tr>
<td><strong>Unadjusted</strong></td>
<td>(\beta)</td>
<td>0</td>
<td>.01</td>
<td>.04</td>
<td>.11</td>
<td>.05</td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>-.01 (-.15, .13)</td>
<td>.03 (-.11, .17)</td>
<td>.11 (-.04, .26)</td>
<td>.37 (.18, .55)</td>
<td>.14 (-.01, .3)</td>
<td></td>
</tr>
<tr>
<td>Intensity</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Adjusted</strong></td>
<td>(\beta)</td>
<td>.02</td>
<td>.10</td>
<td>.08</td>
<td>.14</td>
<td>.12</td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>.04 (-.09, .16)</td>
<td>.21 (.09, .33)</td>
<td>.19 (.06, .33)</td>
<td>.4 (.23, .58)</td>
<td>.29 (.14, .43)</td>
<td></td>
</tr>
<tr>
<td><strong>Unadjusted</strong></td>
<td>(\beta)</td>
<td>-.02</td>
<td>.08</td>
<td>.04</td>
<td>.11</td>
<td>.12</td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>-.03 (-.15, .09)</td>
<td>.18 (.07, .3)</td>
<td>.11 (-.02, .24)</td>
<td>.31 (.15, .47)</td>
<td>.29 (.15, .42)</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\) Emotional Reactivity/ Stability; Approach/ Withdrawal
<table>
<thead>
<tr>
<th></th>
<th>Cognitive</th>
<th>Language</th>
<th>Motor</th>
<th>Social-Emotional</th>
<th>General Adaptive Behaviour</th>
<th>Infant Temperament</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Infant Bayley-III Scales</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Infant Temperament</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pregnancy T2: MAAS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>Adjusted</td>
<td>.02</td>
<td>.06</td>
<td>.05</td>
<td>.15</td>
<td>.12</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>.03 (-.06, .12)</td>
<td>.1 (.01, .19)</td>
<td>.08 (-.02, .18)</td>
<td>.32 (.2, .45)</td>
<td>.21 (.11, .31)</td>
</tr>
<tr>
<td></td>
<td>Unadjusted</td>
<td>-.01</td>
<td>.05</td>
<td>.02</td>
<td>.13</td>
<td>.13</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>-.01 (-.1, .07)</td>
<td>.08 (.0, .17)</td>
<td>.04 (-.05, .14)</td>
<td>.27 (.15, .39)</td>
<td>.23 (.13, .32)</td>
</tr>
<tr>
<td>Quality</td>
<td>Adjusted</td>
<td>.02</td>
<td>.02</td>
<td>.03</td>
<td>.12</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>.07 (-.11, .25)</td>
<td>.08 (-.09, .26)</td>
<td>.1 (-.1, .3)</td>
<td>.54 (.3, .79)</td>
<td>.26 (.05, .46)</td>
</tr>
<tr>
<td></td>
<td>Unadjusted</td>
<td>.01</td>
<td>.02</td>
<td>.02</td>
<td>.12</td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>.05 (-.13, .23)</td>
<td>.06 (-.12, .24)</td>
<td>.08 (-.12, .28)</td>
<td>.52 (.27, .76)</td>
<td>.25 (.05, .46)</td>
</tr>
<tr>
<td>Intensity</td>
<td>Adjusted</td>
<td>.01</td>
<td>.07</td>
<td>.05</td>
<td>.15</td>
<td>.14</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>.02 (-.12, .16)</td>
<td>.18 (.04, .31)</td>
<td>.13 (-.02, .28)</td>
<td>.48 (.29, .67)</td>
<td>.35 (.2, .51)</td>
</tr>
<tr>
<td></td>
<td>Unadjusted</td>
<td>-.02</td>
<td>.06</td>
<td>.02</td>
<td>.11</td>
<td>.14</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>-.06 (-.19, .07)</td>
<td>.15 (.02, .28)</td>
<td>.05 (-.09, .2)</td>
<td>.35 (.17, .53)</td>
<td>.37 (.22, .52)</td>
</tr>
</tbody>
</table>

Notes: b = adjusted for maternal age and smoking. 95% CI = 95% confidence interval.
### Infant Bayley-III Scales

<table>
<thead>
<tr>
<th></th>
<th>Cognitive</th>
<th>Language</th>
<th>Motor</th>
<th>Social-Emotional</th>
<th>General Adaptive Behaviour</th>
<th>Infant Temperament</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Pregnancy T3: MAAS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted&lt;sup&gt;b&lt;/sup&gt;</td>
<td>β</td>
<td>.01</td>
<td>.05</td>
<td>.04</td>
<td>.16</td>
<td>.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.07</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.18</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Quality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted&lt;sup&gt;b&lt;/sup&gt;</td>
<td>β</td>
<td>-.01</td>
<td>.03</td>
<td>.02</td>
<td>.14</td>
<td>.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.04</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.16</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intensity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted&lt;sup&gt;b&lt;/sup&gt;</td>
<td>β</td>
<td>.02</td>
<td>.04</td>
<td>.03</td>
<td>.16</td>
<td>.05</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>.11</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-.17</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Note.

- Quality = Quality of Attachment subscale, Intensity = Intensity of Preoccupation subscale.
- Values in bold indicate \( p < .05 \).
- Higher scores indicate more optimal development across all infant outcomes excluding infant temperament approach/withdrawal, where higher scores indicate more withdrawal.
- Adjusted for state of residence, country of birth, socioeconomic status, highest level of education, living arrangement, parity, maternal age at birth, infant sex, infant weight at birth, prematurity.
Table 8

Regression Results for MPAS and Infant Bayley-III Scales and Temperament (N = 1,347)*

<table>
<thead>
<tr>
<th>Postnatal 8 weeks: MPAS</th>
<th>Infant Bayley-III Scales</th>
<th>Infant Temperament</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Adjusted b</td>
<td>β</td>
<td>.07</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td>.11 (.02,.2)</td>
<td>.05 (.03,.14)</td>
</tr>
<tr>
<td><strong>Unadjusted</strong></td>
<td>β</td>
<td>.05</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td>.08 (.01,.17)</td>
<td>.03 (.06,.11)</td>
</tr>
<tr>
<td><strong>Quality</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Adjusted b</td>
<td>β</td>
<td>.08</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td>.31 (.11,.52)</td>
<td>.19 (.01,.38)</td>
</tr>
<tr>
<td><strong>Unadjusted</strong></td>
<td>β</td>
<td>.08</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td>.29 (.09,.49)</td>
<td>.14 (.06,.34)</td>
</tr>
<tr>
<td><strong>Hostility (Low)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Adjusted b</td>
<td>β</td>
<td>.04</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td>.15 (.05,.35)</td>
<td>.0 (-.2,.19)</td>
</tr>
<tr>
<td><strong>Unadjusted</strong></td>
<td>β</td>
<td>.03</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td>.11 (.08,.31)</td>
<td>-.07 (-.27,.13)</td>
</tr>
<tr>
<td><strong>Pleasure</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>*Adjusted b</td>
<td>β</td>
<td>.03</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td>.11 (.12,.34)</td>
<td>.11 (.12,.34)</td>
</tr>
<tr>
<td><strong>Unadjusted</strong></td>
<td>β</td>
<td>0</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td>0 (-.23,.22)</td>
<td>.08 (.15,.31)</td>
</tr>
</tbody>
</table>
## Infant Bayley-III Scales

<table>
<thead>
<tr>
<th></th>
<th>Cognitive</th>
<th>Language</th>
<th>Motor</th>
<th>Social-Emotional</th>
<th>General Adaptive Behaviour</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postnatal 12 months: MPAS Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>β</td>
<td>.02</td>
<td>.01</td>
<td>0</td>
<td>.27</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td></td>
<td>.03 (-.07, .12)</td>
<td>.01 (-.08, .1)</td>
<td>-.01 (-.11, .1)</td>
<td>.6 (.47, .72)</td>
</tr>
<tr>
<td>Unadjusted</td>
<td>β</td>
<td>0</td>
<td>0</td>
<td>-.01</td>
<td>.27</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td></td>
<td>0 (-.1, .1)</td>
<td>0 (-.09, .1)</td>
<td>-.02 (-.12, .08)</td>
<td>.61 (.49, .74)</td>
</tr>
</tbody>
</table>

| Quality        |           |          |       |                  |                           |
| Adjusted       | β         | .05      | .03   | -.01             | .29                       |
| b (95% CI)     |           | .19 (-.03, .41) | .12 (-.09, .34) | -.02 (-.26, .21)   | 1.5 (1.22, 1.78)          |
| Unadjusted     | β         | .05      | .05   | 0                | .30                       |
| b (95% CI)     |           | .21 (-.01, .43) | .19 (-.03, .4) | .01 (-.23, .25)      | 1.55 (1.27, 1.83)         |

| Hostility (Low)|           |          |       |                  |                           |
| Adjusted       | β         | -.01     | .01   | 0                | .19                       |
| b (95% CI)     |           | -.02 (-.23, .18) | .02 (-.18, .22) | -.01 (-.24, .22) | .94 (.66, 1.22)         |
| Unadjusted     | β         | -.02     | -.01  | -.01             | .20                       |
| b (95% CI)     |           | -.08 (-.29, .13) | -.04 (-.25, .17) | -.03 (-.26, .19) | 1.01 (.73, 1.28)       |

| Pleasure       |           |          |       |                  |                           |
| Adjusted       | β         | -.01     | -.03  | 0                | .14                       |
| b (95% CI)     |           | -.03 (-.28, .22) | -.11 (-.35, .12) | 0 (-.26, .26)       | .77 (.44, 1.09)          |
| Unadjusted     | β         | -.04     | -.03  | -.02             | .13                       |
| b (95% CI)     |           | -.16 (-.4, .08) | -.14 (-.38, .1) | -.07 (-.36, .16) | .72 (.4, 1.04)          |

## Infant Temperament

<table>
<thead>
<tr>
<th></th>
<th>Emotional Reactivity/ Stability</th>
<th>Approach/ Withdrawal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postnatal 12 months: MPAS Total</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td>.27</td>
<td>-.19</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td>.12 (.1, .14)</td>
<td>-.05 (-.06, -.03)</td>
</tr>
<tr>
<td>Unadjusted</td>
<td>.26</td>
<td>-.19</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td>.11 (.09, .14)</td>
<td>-.04 (-.06, -.03)</td>
</tr>
</tbody>
</table>

Note. Quality = Quality of Attachment subscale, Hostility (Low) = Absence of Hostility subscale, Pleasure = Pleasure in Interaction subscale.

Values in bold indicate \( p < .05 \).

\( a \) Higher scores indicate more optimal development across all infant outcomes excluding infant temperament approach/withdrawal, where higher scores indicate more withdrawal.

\( b \) Adjusted for state of residence, country of birth, socioeconomic status, highest level of education, living arrangement, parity, maternal age at birth, infant sex, infant weight at birth, prematurity.
8.4.1. Cognitive, language, and motor development.

Limited evidence was provided for associations between antenatal or postnatal bonding and infant cognitive, language, and motor development. Effects sizes were inconsistent across time-points and negligible to small. Higher maternal bonding at 8 weeks postnatal was associated with higher cognitive development ($\beta = .07$). Higher antenatal maternal bonding during pregnancy T1 and T2 was associated with higher language scores on the Bayley-III (T1: $\beta = .07$; T2: $\beta = .06$). Higher antenatal bonding during pregnancy T1 was also associated with higher motor scores on the Bayley-III ($\beta = .07$).

8.4.2. Social-emotional and adaptive behaviour development.

Maternal-infant bonding quality was associated with higher social-emotional scores on the Bayley-III at all antenatal and postnatal time-points. Effect sizes were small, increasing over the perinatal period (T1: $\beta = .14$; postnatal 12 months: $\beta = .27$). A similar but attenuated pattern of results was evident for the adaptive behaviour scale of the Bayley-III. Namely, higher quality bonding predicted higher adaptive behaviour scores at all antenatal and postnatal time-points. Effect sizes were small ($\beta = .09$ to .13 across all five time-points).

8.4.3. Infant temperament.

Small effects were found between higher maternal bonding at pregnancy T3 ($\beta = .07$), postnatal 8 weeks ($\beta = .17$), and postnatal 12 months ($\beta = .27$) and infant emotional stability. Small associations existed between higher bonding and lower social withdrawal (i.e., more social behaviour, such as smiling and cuddling). These associations were evident across all bonding subscales at all antenatal and postnatal time-points ($\beta = -.17$ to -.19 across all five time-points).
8.5. Discussion

Results from this study provide evidence that a mother’s healthy bond to her child (antenatally and postnatally) plays a role in the prediction of her child’s social and emotional development, including social-emotional competence, general adaptive behaviour (independence), emotional stability, and social approach behaviour. Effects were generally small, increasing in strength across the antenatal to postnatal periods ($\beta$ (range) = .07-.27). Whilst associations between bonding and infant cognitive, language, and motor development were in a positive direction, the strength of associations were notably smaller and inconsistent across time-points ($\beta$ = .06-.07).

8.5.1. Social, emotional, and behavioural development.

Results indicate that a mother’s positive perception of her bond to her developing child, both during pregnancy and across the first year of life, is a marker of more optimal infant social, emotional, and behavioural development. This pattern extended to all bonding subscales including quality of “attachment”, intensity of preoccupation, absence of hostility, and pleasure in interaction. Effects were evident across the perinatal period, increasing in strength from pregnancy through postpartum. This finding is consistent with that of Mason et al. (2011) and Sierau et al. (2016), who linked higher self-reported bonding to infant social-emotional competence, and to lower internalising and externalising behaviours, with increasing effects across the perinatal period ($r = .12-.27$). Additionally, higher bonding was associated with the degree to which an infant functions independently, a less frequently examined outcome domain. Consistent with meta-analytic results from Le Bas et al. (in press, Study I), associations were demonstrated between higher bonding and the infant temperament domains of emotional stability and higher social
approach behaviour, with the effects strongest in the postnatal period ($\beta = .27$ for emotional stability; $\beta = .19$ for approach behaviour).

The strengthening association of maternal bonding with infant social, emotional, and behavioural outcomes over the perinatal period is suggestive of a cumulative influence. Namely, antenatal bonding may shape subsequent relational experiences via the early structuring of expectations linked to bonding (Condon & Corkindale, 1998; Rossen et al., 2016). This may in turn have a reciprocal relation with feelings about one’s self and the future. Taken together with the extant empirical base, results suggest that whilst infant social-emotional development is multiply informed, the quality of a mother’s felt bond to her child (fetus or infant) is likely to play some role in later social-affective developmental outcomes. Findings are also consistent with theoretical perspectives, which posit that social-emotional development, general adaptive behaviour, emotional stability, and approach behaviour are dependent on shared affective states, including joy in interaction (Greenspan & Shanker, 2009).

### 8.5.2. Cognitive, language, and motor development.

Whilst findings linking bonding and cognitive, language, and motor development were all in a positive direction, effects were negligible to small and inconsistent across the perinatal period. These results largely mirrored findings from a recent meta-analytic review (Le Bas et al., in press, Study I). Some isolated findings suggested links between: postnatal bonding at 8 weeks and cognitive development, antenatal bonding (T1 and T2) and language development, and antenatal bonding (T1) and motor development. The weak, isolated associations identified in this study suggest that factors other than maternal bonding are likely to influence these outcomes. It is likely that other factors play a more critical role than the bond in influencing these outcomes, such as parental IQ in relation to cognitive
and language development, and physical engagement in relation to motor
development.

8.5.3. **Limitations of the current study.**

The current study employed rigorous, multi-wave, prospective assessment of antenatal and postnatal maternal bonding and infant development in a large cohort. There are, however, several limitations to note. First, it is important to consider why effect sizes were generally small. The finding may reflect sampling and methodological limitations, and normative maturation. Notably, the current sample was drawn from a predominantly Anglo-Saxon, medium to high socioeconomic status cohort; thus results may represent a somewhat conservative estimate, particularly in contrast to clinical sub-populations (De Falco et al., 2014). Further to this, the bond was measured via self-report. A mother’s subjective experience may not impact developmental outcomes as strongly as the infant’s real and observable experience of her caregiving behaviours, particularly under stress. However, measures of maternal bonding require a focus on the mother’s self-reported affective bond to her child, rather than factors likely to mediate or indicate the presence of bonding (e.g. maternal attitudes, beliefs, or behaviours; Condon & Corkindale, 1998; Lamb, 1974). Current findings may reflect developmental consolidation of experience-dependent neural networks (Bornstein, 2014; Schore & McIntosh, 2011), with maternal bonding experiences having a cascading influence on later stages of development not assessed in this study. Finally, it is important to note that findings are likely influenced by shared method variance. Bonding, social-emotional development, general adaptive behaviour, and temperament were all assessed via maternal report, whereas cognitive, language, and motor development were assessed via clinician report (observational assessments). Taken together, future research could address these limitations by examining: concordance of the felt bond with
observable sensitivity, larger and more diverse samples to include variability in bonding presentations, and associations between bonding and social-emotional development over a longer developmental span.

8.5.4. Conclusion.

As one of only a handful of studies to date to examine bonding across multiple assessment waves, the results support the hypothesis that antenatal and postnatal maternal bonding play a role in early social-affective development. Specifically, this extends to social-emotional competence, general adaptive behaviour (independence), emotional stability, and social approach behaviour. Findings suggest that fostering an expectant mother’s expectation of her bond to her baby is likely to promote perinatal confidence, and associated advantage for infant emotional security. Replication of these results across more diverse samples, prospectively followed through to later periods of development, will further assist knowledge development in this field.
8.6. References


on maternal–fetal attachment and maternal health behavior in pregnancy.

*Ultrasound in Obstetrics & Gynecology, 27*(3), 245-251.
doi:10.1002/uog.2703


StataCorp. (2017). Stata statistical software: Release 15. College Station, TX: StataCorp LLC.


9. Study III: Maternal Bonding, Negative Affect, and Infant Social-Emotional Development: A Prospective Cohort Study

Paper submitted to Child Development (under review).

Genevieve Le Bas¹, George Youssef²³, Jacqui Macdonald¹²³, Richard Mattick⁴, Sam Teague¹, Ingrid Honan⁴, Jennifer McIntosh¹²³, Sarah Khor⁴, Larissa Rossen⁴, Elizabeth Elliott⁵⁶, Steve Allsop⁷, Lucinda Burns⁴, Craig Olsson¹²³, and Delyse Hutchinson¹²³⁴*.

¹Deakin University, Centre for Social and Early Emotional Development, School of Psychology, Faculty of Health, Geelong, Australia.
²Murdoch Children’s Research Institute, Centre for Adolescent Health, Royal Children's Hospital, Melbourne, Australia.
³University of Melbourne, Department of Paediatrics, Royal Children's Hospital, Melbourne, Australia.
⁴National Drug and Alcohol Research Centre, University of New South Wales, Sydney, Australia.
⁵Discipline of Child and Adolescent Health, University of Sydney, Sydney, Australia.
⁶The Children’s Hospital at Westmead, Sydney, Australia.
⁷National Drug Research Institute, Curtin University, Perth, Australia.
Competing Interests

The authors declare that they have no competing interests.

Ethics Approval and Consent to Participate

Ethics approval was granted by the Sydney South West Area Health Service Human Research Ethics Committee and the University of New South Wales Human Research Ethics Committee (Reference: HC08224; 29/08/2008). Written informed consent was obtained from all participants.

Availability of Data and Materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Funding

The research was funded by an Australian National Health and Medical Research Council (NHMRC) Project Grant #GNT630517 for $2,196,179 to Richard P Mattick, Delyse Hutchinson, Steve Allsop, Jake Najman, Elizabeth Elliott, Lucy Burns, Sue Jacobs, Craig Olsson and Anne Bartu, and was financially supported by the National Drug and Alcohol Research Centre (NDARC), University of New South Wales (UNSW). The cohort is led by the National Drug and Alcohol Research Centre (NDARC) at UNSW Australia, the Drug Research Institute (NDRI) at Curtin University, and the School of Psychology at Deakin University, in collaboration with the University of Sydney, the University of Queensland, the University of Christchurch, and the Murdoch Children’s Research Institute. NDARC and the National Drug Research Institute (NDRI), Curtin University of Technology are funded by the Australian Government under the Substance Misuse Prevention and Service Improvements Grants Fund. The study has also been supported by Australian Rotary Health (ARH; 2012-2013; 2018-2020), the Foundation for Alcohol Research and Education (FARE; 2010-2011), and the Financial Markets Foundation for
Children (Australia) (2015-2016). Additionally, PhD candidates on the project have been funded through ARH; the NDARC Education Trust (NET) and the Australian Centre for Perinatal Science and NDARC, UNSW. EE is supported by NHMRC Practitioner Fellowship #1021480 and NHMRC Centre Research Excellence; CAO is financially supported by an Australian Research Council Principal Research Fellowship; and, RPM is financially supported by an NHMRC Principal Research Fellowship Award from the NHMRC.

Acknowledgements

We gratefully acknowledge the NDARC and NDRI research staff and students who assisted with collection of the data, study investigators not included as authors, the hospitals and antenatal clinics for their assistance with recruitment, and the study participants and their families. We also wish to acknowledge the Cannabis Cohorts Research Consortium (CCRC; NHMRC Project Grants: AAP1009381, AAP1064893; also referenced as the Longitudinal Cohorts Research Consortium (LCRC)).
9.1. Abstract

The study used multi-wave perinatal data from an Australian pregnancy cohort study to examine the interrelationships between maternal bonding, negative affect, and infant social-emotional development in a cross-lagged model. 1,579 mothers completed a perinatal assessment which included the mother-infant affectional bond and indicators of negative affect (depression, anxiety, and stress) at each trimester in pregnancy, and at 8 weeks and 12 months postpartum. The social-emotional scale of the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III: SE) was administered at 12 months. Results revealed strong independent (autoregressive) associations of bonding and negative affect across pregnancy and postpartum. Small, cross-lagged associations (β (range) = -.10 to -.20) existed between symptoms of depression, anxiety, and stress in trimester three of pregnancy and poorer maternal bonding at 8 weeks postpartum (independent of earlier bonding and negative affect). Postnatal maternal bonding, but not postnatal negative affect, predicted infant social-emotional development at 12 months (β = .17). Further, there was an indirect effect of negative affect during trimester three on infant social-emotional development through early postnatal bonding. The associations between negative affect in the perinatal window and maternal bonding support theoretical perspectives that these are interrelated yet unique constructs. Results also suggest that a mother’s felt bond to her infant plays a role in infant social-affective development, supporting perinatal interventions that target improved bonding.
9.2. **Introduction**

Theory and empirical research suggest that there are important associations between the constructs of mother-to-fetus/infant bonding, maternal negative affect, and infant social-emotional development; yet critical gaps remain in knowledge on these associations. Independently, a mother’s infant-directed affect, marked by her emotional connection to her infant, and her general internalised negative affect, such as depression and anxiety, have both been associated with early social and emotional outcomes (Branjerdporn, Meredith, Strong, & Garcia, 2017; Feldman et al., 2009; Le Bas et al., in press, Study I; Stein et al., 2014). However, the temporal and potentially bi-directional associations between bonding and negative affect across the perinatal period are not yet understood (Goebel, Stuhrmann, Harder, Schulte-Markwort, & Mudra, 2018), nor the extent to which these factors independently predict social-emotional development in early infancy.

**9.2.1. Maternal bonding and infant social-emotional development.**

The affecional tie a mother has to her developing baby is referred to as *antenatal maternal bonding* (Condon, 1993; Walsh, 2010). The antenatal bond has been shown to predict health behaviours during pregnancy (e.g., alcohol and drug use) and subsequent postnatal bonding in the first year of life (Rossen et al., 2017; Rossen et al., 2016). Notably, birth marks the introduction of new complexities, including the mother transitioning to a new role (i.e., with a new baby or a growing family), adjusting her maternal identity, and navigating a complex and co-regulated relationship with her child (Condon, 1993; Solomon & George, 1996). *Postnatal maternal bonding* is characterised by a tri-fold of mutually informing features: a mother’s pleasure in interacting with her infant, her sense of developing competence and capacity to understand and meet her infant’s needs, and her acceptance and tolerance of the demands of the maternal role (Condon & Corkindale, 1998). Given
the complexities unique to each period, it is important to examine how the maternal bond in both phases shapes early social-affective development.

Two recent reviews (Branjerdporn et al., 2017; Le Bas et al., in press, Study I) support the hypothesis that a mother’s perception of her emotional connection with her child, during both the antenatal and postnatal periods, plays a role in early social-affective development. In a qualitative synthesis of eight studies, Branjerdporn et al. (2017) reported associations between stronger antenatal bonding and more optimal infant development, including “easier” infant temperament, lower colic rating, and developmental milestone attainment (Branjerdporn et al., 2017). Meta-analytic findings from Le Bas et al. (in press, Study I) found that stronger bonding predicted higher attachment quality ($r = .35$), positive infant mood ($r = .27$), lower colic rating (parent-report) ($r = .22$), and easier temperament ($r = .19$). Of note, both reviews identified a paucity of high-quality longitudinal, making it difficult to draw firm conclusions about aetiological relationships. Le Bas et al. (2019, Study II) commenced research to address this gap by investigating the associations of maternal bonding across multiple antenatal and postnatal assessment waves with a range of infant developmental outcomes ($N = 1,347$). Results revealed small yet significant associations between higher bonding and more optimal infant social-emotional competence, independence, emotional stability, and approach behaviour. These effects were evident antenatally, and increased in strength across the perinatal window ($\beta$ (range) = .07-.27). Results suggest that maternal bonding is one factor likely to contribute to infant emotional security and a healthy start to life.
9.2.2. Maternal negative affect and infant social-emotional development.

Maternal bonding difficulties have been found to overlap with the negative affective states that a mother may experience during the perinatal period (Brockington, Aucamp, & Fraser, 2006). Given this overlap, it is important to examine the contribution of bonding and infant social-emotional development alongside the contribution of negative affective states. Negative affect is a general dimension of subjective distress that encompasses a variety of aversive mood states, commonly including (but are not limited to) depression, anxiety, and stress (Watson, Clark, & Tellegen, 1988). The perinatal period is a vulnerable time for developing heightened symptoms of negative affect (Riecher-Rössler & Steiner, 2005), reflecting the complexities of adjustment to motherhood (Fowles, 1998; Mercer & Ferkehch, 1990). Symptoms of negative affect are commonly transient and adaptive in nature but can also contribute to the onset or relapse of psychiatric disorders (Agius, Xuereb, Carrick-Sen, Sultana, & Rankin, 2016; Heron et al., 2004). For example, a 20-year prospective cohort study by Patton et al. (2015) found that symptoms of depression were reported in 19% of pregnancies (109/564), with 16% (93/564) of these pregnancies reporting mental health problems preceding the pregnancy.

Maternal expression of negative affect plays an important role in healthy infant social-affective development. The first months of infancy are marked by heavy co-regulation of the infant’s affective states, informing the health of self-regulatory capacities (Schore & McIntosh, 2011). The infant’s limited capacity to regulate emotions requires a reliance on primary carers to model tolerance of a range of feeling states, and in turn to hold, regulate and integrate these same states in the infant (Fox & Calkins, 2003). However, elevated and chronic symptoms of negative
affect can block the mother’s accessibility and emotional availability to her baby, which may in turn negatively impact infant social-emotional development (Feldman et al., 2009; Gentile, 2017; Kingston, Tough, & Whitfield, 2012; Stein et al., 2014; Waters, Hay, Simmonds, & van Goozen, 2014). Elevated maternal negative affect in pregnancy has been linked to increased risk for child psychopathology, including anxiety, depression, attention deficit hyperactivity disorder, and schizophrenia (Monk, Lugo-Candelas, & Trumpff, 2019; O'Donnell, Glover, Barker, & O'Connor, 2014; Van den Bergh et al., 2017). The results of this review suggest both that maternal negative affect is one important factor related to infant social-affective outcomes, and that potential explanatory mechanisms for this association require further research.

9.2.3. Interrelations between maternal bonding and negative affect.

Theoretical perspectives and empirical evidence suggest that maternal bonding and negative affect play an important role in supporting infant social-emotional development (Branjerdporn et al., 2017; Kingston et al., 2012; Le Bas et al., in press, Study I), but that complex pathways are likely to exist between these constructs during the perinatal period (Goebel et al., 2018). The cross-sectional evidence to date reports moderate correlations ($r$ (range) = .31-.49) between poor maternal bonding and indicators of negative affect (Condon & Corkindale, 1998; Scopesi, Viterbori, Sponza, & Zucchinetti, 2004; Tietz, Zietlow, & Reck, 2014). A recent systematic review by Goebel et al. (2018) explored associations between maternal bonding and symptoms of anxiety during the antenatal period. Goebel et al. (2018) found that the quality of emotional proximity to the fetus was consistently impaired by symptoms of anxiety (reporting small to moderate effects), and concluded that additional impairment of maternal bonding by anxiety might intensify mother-infant relational formation and, in turn, infant development.
Few studies, however, have examined the prospective relations between maternal bonding and negative affect. Notably, Rossen et al. (2016) utilised multiple linear regression models to investigate predictors of postnatal bonding in 372 women (a subsample of the current study). Findings revealed elevated symptoms of depression in trimesters two and three, and stress in trimester two, predicted poorer maternal bonding at 8 weeks postpartum. No studies of which we are aware have investigated prospective associations between earlier bonding and later negative affect in the perinatal period, or the transactional relations between bonding and negative affect across this period. As such, the direction of associations between maternal bonding and negative affect remains unclear, particularly the independence of effects after accounting for earlier bonding and negative affect. To investigate this adequately, rare, prospective multi-wave data are required.

9.2.4. The current study.

The temporal and potentially bi-directional associations between maternal bonding and negative affect could be better understood through analysing longitudinal data in a cross-lagged model. This approach allows for the estimation of cross-lagged effects (transactional relations), while controlling for correlations within time-points and autoregressive effects (stability of bonding and negative affect across time; Kearney, 2017). Further, given that maternal bonding and negative affect are likely to interrelate across the perinatal period, a cross-lagged model would allow for examination of their independent contributions to infant social-emotional development. With data extending back into the antenatal period, an opportunity arises to explore targets for intervention prior to the birth of a child that may have profound and long-term benefits for development.
Utilising a cross-lagged model, the current study had two aims: (1) to determine the direction and magnitude of transactional paths between maternal bonding and negative affect across five time-points in the antenatal (trimesters one, two, and three) and postnatal periods (8 weeks and 12 months); and, after accounting for the antenatal pathways, (2) to examine the independent contributions of maternal bonding and negative affect at 8 weeks postnatal, to infant social-emotional development at 12 months.

9.3. Method

9.3.1. Participants and procedures.

Data were from the Triple B Pregnancy Cohort Study (also known as "Bumps, Babies and Beyond"; Hutchinson et al., 2017), a longitudinal pregnancy study conducted by the National Drug and Alcohol Research Centre at the University of New South Wales (UNSW) and by the National Drug Research Institute at Curtin University, in collaboration with the Universities of Sydney and Queensland, and Deakin University. Ethics approval for this study was obtained from the Human Research Ethics Committees of each participating hospital, the Area Health Services where the hospitals were located, and the relevant collaborating institutions.

Pregnant women were recruited from four major public hospitals (three in New South Wales, one in Western Australia) between 2009 and 2013 (N = 1,623). Eligibility criteria included: being pregnant, being aged 16 years or over, having no major medical complications (mother or fetus), residence in New South Wales or Western Australia, intention of mother or both parents to be the primary caregiver(s), possessing sufficient literacy in English, and, informed consent. Data were collected via structured interviews and self-complete questionnaires, and included demographic, parental, familial, and infant measures. The assessment focused on parental substance use and mental health, parenting practices, familial functioning,
and infant development. The study used a prospective cohort design with multiple waves of data collection including: pregnancy trimester one (T1), trimester two (T2) and trimester three (T3); birth (hospital record data); and 8 weeks and 12 months postpartum. More detailed information on the cohort is provided in Hutchinson et al. (2017).

Participants of the current study were a subsample of 1,579 mothers and their offspring, who had completed any of the relevant measures at T3. The antenatal demographic and postnatal obstetric characteristics for the study sample are described in Table 9.
Table 9.

*Antenatal Demographic and Postnatal Obstetric Characteristics (N = 1,579)*

<table>
<thead>
<tr>
<th></th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>State of residence</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NSW</td>
<td>1,275</td>
<td>81%</td>
</tr>
<tr>
<td>WA</td>
<td>304</td>
<td>19%</td>
</tr>
<tr>
<td><strong>Country of birth</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Australia</td>
<td>904</td>
<td>57%</td>
</tr>
<tr>
<td>Other English-speaking country</td>
<td>285</td>
<td>18%</td>
</tr>
<tr>
<td>Non-English-speaking country</td>
<td>385</td>
<td>24%</td>
</tr>
<tr>
<td><strong>Socioeconomic status</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low SES</td>
<td>70</td>
<td>4%</td>
</tr>
<tr>
<td>Medium SES</td>
<td>483</td>
<td>31%</td>
</tr>
<tr>
<td>High SES</td>
<td>1,022</td>
<td>65%</td>
</tr>
<tr>
<td><strong>Highest level of education</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Less than high school</td>
<td>139</td>
<td>9%</td>
</tr>
<tr>
<td>Completed high school</td>
<td>179</td>
<td>11%</td>
</tr>
<tr>
<td>Completed TAFE/technical</td>
<td>242</td>
<td>15%</td>
</tr>
<tr>
<td>Completed university/college</td>
<td>1,013</td>
<td>64%</td>
</tr>
<tr>
<td><strong>Living with partner</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>1,440</td>
<td>91%</td>
</tr>
<tr>
<td>No</td>
<td>134</td>
<td>8%</td>
</tr>
<tr>
<td><strong>Parity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>869</td>
<td>55%</td>
</tr>
<tr>
<td>1-2</td>
<td>628</td>
<td>40%</td>
</tr>
<tr>
<td>3+</td>
<td>73</td>
<td>5%</td>
</tr>
<tr>
<td><strong>Maternal age at birth (years)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>≤24 years</td>
<td>124</td>
<td>8%</td>
</tr>
<tr>
<td>25-29 years</td>
<td>336</td>
<td>21%</td>
</tr>
<tr>
<td>30-35 years</td>
<td>667</td>
<td>42%</td>
</tr>
<tr>
<td>≥36 years.</td>
<td>445</td>
<td>28%</td>
</tr>
<tr>
<td><strong>Infant sex</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>695</td>
<td>48%</td>
</tr>
<tr>
<td>Male</td>
<td>761</td>
<td>44%</td>
</tr>
<tr>
<td><strong>Infant weight at birth</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (&gt;</td>
<td>10th percentile for gestational age)</td>
<td>1,296</td>
</tr>
<tr>
<td>Small for Gestational Age (≤10th percentile for gestational age)</td>
<td>154</td>
<td>10%</td>
</tr>
<tr>
<td><strong>Prematurity</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Not premature (≥37 weeks)</td>
<td>1,377</td>
<td>87%</td>
</tr>
<tr>
<td>Premature (≤36 weeks)</td>
<td>80</td>
<td>5%</td>
</tr>
</tbody>
</table>

*Note.*

¹ Descriptive statistics based on unimputed data, consequently, totals will not equal 1,579 participants/100%.
² Information collected via structured interview and questionnaire assessments in trimester three (28 weeks to birth).
³ Information collected via structured interview and questionnaire assessments at 8 weeks postpartum.
9.3.2. Measures.

Maternal and infant demographic information used in this study were collected via structured interview and questionnaires administered in trimester three (28 weeks to birth) and hospital statistics at birth. Maternal bonding and negative affect were assessed across all five antenatal and postnatal time-points; infant social-emotional development was measured at 12 months postpartum.

9.3.2.1. Maternal self-reported bonding to the fetus.

The Maternal Antenatal Attachment Scale (MAAS) is a 19-item self-report measure that asks a mother to report on her thoughts and feelings about her developing baby (Condon, 1993). Items focus on the past two weeks and are rated on a 5-point scale, with the scale options varying between items. The quality of bonding subscale (10 items) is based on a mother’s experienced closeness, tenderness, and positive feelings toward her unborn child; for example, “Over the past two weeks when I think about the baby inside me I get feelings which are”: 1 = Very sad to 5 = Very happy. The intensity of preoccupation subscale (8 items) measures the amount of time a mother spends thinking, talking, and dreaming about her unborn child; for example, “Over the past two weeks I have thought about, or been preoccupied with the baby inside me”: 1 = Almost all of the time to 5 = Not at all. Some items were reverse-scored, with items summed to provide three scores: quality of bonding, intensity of preoccupation, and a global total (19-95). Higher scores indicate stronger, more adaptive bonding to the fetus. Reliability for the MAAS is 0.82, as measured in trimester three of pregnancy (Condon, 1993).
9.3.2.2. Maternal self-reported bonding to the infant.

The Maternal Postnatal Attachment Scale (MPAS) is a 19-item self-report measure that asks a mother to report on her thoughts and feelings about her infant (Condon & Corkindale, 1998). The measure consists of three factors: (1) quality of bonding – a mother’s confidence and satisfaction in interactions with her infant (9 items); (2) absence of hostility towards her infant (5 items); and, (3) her desire for physical closeness and pleasure in interactions with her infant (5 items). The number of response options varies between items (2-, 4-, and 5-point scales); all response options are recoded to represent a score of one (poor bonding) to five (strong bonding). Four scores are calculated: quality subscale (range 9-45), absence of hostility (5-25), pleasure in interaction (5-25), and a global total (19-95). Higher scores indicate stronger, more adaptive bonding to the infant. The MPAS has demonstrated high test-retest reliability ($r = 0.86$; Condon & Corkindale, 1998).

9.3.2.3. Maternal depression.

The Edinburgh Antenatal and Postnatal Depression Scale (EPDS) is a 10-item self-report measure used to detect symptoms of antenatal and postnatal depression (Cox, Holden, & Sagovsky, 1987). Items tap symptoms of depression, including low mood, anhedonia, and sleep disturbance. Participants are required to rate their frequency of symptoms over the past week on a 4-point scale, with the scale options varying between items. Examples items include, “I have looked forward with enjoyment to things” and “I have blamed myself unnecessarily when things go wrong”. Scores are summed to yield a total score (range 0-30), with higher scores indicating more depressive symptoms. The EPDS has established sensitivity and specificity, and is sensitive to change in the severity of depressive symptoms over time (Cox et al., 1987).
9.3.2.4. *Maternal anxiety and stress.*

The short-form of the Depression Anxiety and Stress Scales (DASS-21) is a self-report measure that assesses symptoms of anxiety and stress over the past week (Lovibond & Lovibond, 1996). The anxiety subscale (DASS: Anxiety) assesses autonomic arousal, skeletal muscle effects, situational anxiety, and subjective experience of anxious affect; for example, “I worried about situations in which I might panic and make a fool of myself”. The stress subscale (DASS: Stress) assesses chronic non-specific arousal, including difficulty relaxing and nervous arousal; for example, “I found it hard to wind down”. The DASS-21 subscales each consist of seven items, with participants asked to rate their frequency of symptoms on a 4-point scale (0 = Never to 3 = Almost always). Scores are summed to yield a score for each subscale (range 0-21), with higher scores indicating more symptoms of anxiety or stress. The DASS-21 has demonstrated internal consistency across four perinatal time-points ($r = 0.82$-$0.85$) in a subsample of 372 women included in the current study (Rossen et al., 2016).

9.3.2.5. *Infant social-emotional development.*

The social-emotional scale of the Bayley Scales of Infant and Toddler Development, Third Edition (Bayley-III: SE) is a 35-item maternal report measure used to assess social-emotional development of infants and young children 1 month to 42 months of age (Bayley, 2006). Items assess: child’s mastery of functional emotional skills (for example, self-regulation and interest in the world); communicating needs; engaging others and establishing relationships; using emotions in an interactive, purposeful manner; and using emotional signals or gestures to solve problems. An example item is: “Likes to be swung around, danced with while in your arms, or quickly lifted up in the air.” The mother is asked to rate the frequency of each behaviour on a 6-point Likert scale (ranging from Can’t tell...
and None of the time to All of the time). Analyses included composite scores. The Bayley-III: SE has been shown to be a reliable and valid measure (Bayley, 2006).

9.3.3. Data analysis.

All data cleaning, basic analyses, and missing data methods were conducted using Stata 15. Missing data for any given variable was less than 10%. To address missing data, we used multiple imputation by chained equations. Specifically, 50 separate fully imputed datasets were created based on all variables used in analysis including exposures, outcomes, and covariates. All descriptive statistics (Table, as well as the means and SDs included in Table ) were based on unimputed data; whereas, all other analyses were based on pooled estimates over the 50 imputed datasets using Rubin’s rules (Rubin, 1987).

To examine the primary research questions, a series of cross-lagged linear regression models were fitted in Mplus Version 7.2. Specifically, negative affect at pregnancy T1 was regressed on negative affect at pregnancy T2 (autoregressive path) and bonding at T1 (cross-lagged path). Similarly, bonding at T2 was regressed on to bonding at T1 (autoregressive path) and negative affect at T1 (cross-lagged path). This approach was used for all 5 time-points of data, using the appropriate measure of bonding for each time-point (i.e., MAAS in the antenatal and MPAS in postnatal periods). A separate cross-lagged model was fitted for each of the three negative affect variables under examination (i.e., depression, anxiety, and stress). The cross-lagged regression approach allowed for testing both stability (or continuity) of bonding and negative affect across waves, as well as transactional relationships between bonding and negative affect within and across waves.

In each model, 12-month Bayley-III: SE scores were also regressed in separate models onto 8 weeks bonding and negative affect (i.e., depression, anxiety, and stress scores). We chose to examine the contribution of bonding and negative
affect at the 8-week time-point for two reasons. First, to aid interpretation of an already complex model. Second, existing research has already established that, across the perinatal period, bonding and negative affect show stability (Heron et al., 2004; Rossen et al., 2016), and their associations with infant social-emotional development strengthen (Le Bas et al., 2019, Study II). Consequently, selecting the points of closest temporal proximity (8 weeks and 12 months) will allow for greater clarity on their independent contributions to infant social-emotional development.

All regression effects were adjusted for covariates (maternal state of residence, country of birth, socioeconomic status, highest level of education, living arrangement, parity, and age at birth; and infant sex, prematurity, and birth weight). Where relevant, mediational pathways were tested using the product of coefficients approach with 95% bias-corrected bootstrapped confidence intervals (CIs). Pooling of the CIs across the 50 multiply imputed datasets was not possible using Rubin’s rules (Rubin, 1987). Datasets were instead examined separately, and a significant mediation effect was indicated if the largest possible CI did not include zero.

In the case of twins or triplets, one infant born to each mother was randomly selected to be included in analyses, thus removing clustered data. Of note, the sample included 50 women with diagnosed substance use disorders. Sensitivity analyses showed no influence on the magnitude, direction, nor the statistical significance of the results when these women were excluded. Consequently, all tables report on the full sample ($N = 1,579$) with no clustered robust variance estimate.
9.4. Results

9.4.1. Descriptive statistics.

The descriptive statistics for the current sample are described in Table 9 and Table 10. Table 10 also details the intercorrelations for all study variables. Of note, means for the MAAS and MPAS were consistent with past findings from Condon (1993; antenatal: $M = 75.7$, $SD = 8.1$) and Condon and Corkindale (1998; postnatal 4 weeks: $M = 82.9$, $SD = 7.6$; postnatal 8 months: $M = 84.1$, $SD = 6.7$). Sample means for the MAAS and MPAS were relatively consistent, though we note an increase in bonding across time (pregnancy T1: $M = 74.01$, $SD = 8.64$; postnatal 12 months: $M = 81.99$, $SD = 6.69$). As expected, there was moderate to strong correlations between the same measures at different time-points.
Table 10

Descriptive Statistics and Intercorrelations for MAAS, MPAS, EPDS, DASS-21, and Bayley-III: SE (N = 1,579)\textsuperscript{a}

<table>
<thead>
<tr>
<th>Measure</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAAS\textsuperscript{c}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 T1\textsuperscript{b}</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2 T2\textsuperscript{b}</td>
<td>0.78***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 T3</td>
<td>0.65***</td>
<td>0.75***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPAS\textsuperscript{c}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4 8 weeks</td>
<td>0.3***</td>
<td>0.33***</td>
<td>0.41***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5 12 months</td>
<td>0.28***</td>
<td>0.3***</td>
<td>0.37***</td>
<td>0.62***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EPDS\textsuperscript{d}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6 T1\textsuperscript{b}</td>
<td>-0.22***</td>
<td>-0.1***</td>
<td>-0.1**</td>
<td>-0.16***</td>
<td>-0.24***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7 T2\textsuperscript{b}</td>
<td>-0.16***</td>
<td>-0.17***</td>
<td>-0.15***</td>
<td>-0.21***</td>
<td>-0.28***</td>
<td>0.67***</td>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8 T3</td>
<td>-0.14***</td>
<td>-0.14***</td>
<td>-0.22***</td>
<td>-0.25***</td>
<td>-0.28***</td>
<td>0.55***</td>
<td>0.68***</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 8 weeks</td>
<td>-0.1***</td>
<td>-0.1**</td>
<td>-0.16***</td>
<td>-0.44***</td>
<td>-0.31***</td>
<td>0.4***</td>
<td>0.5***</td>
<td>0.56***</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>10 12 months</td>
<td>-0.05</td>
<td>-0.07*</td>
<td>-0.12***</td>
<td>-0.23***</td>
<td>-0.42***</td>
<td>0.42***</td>
<td>0.46***</td>
<td>0.51***</td>
<td>0.51***</td>
<td>1</td>
</tr>
<tr>
<td>DASS: Anxiety\textsuperscript{d}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 T1\textsuperscript{b}</td>
<td>-0.06*</td>
<td>0.01</td>
<td>-0.01</td>
<td>-0.08***</td>
<td>-0.11***</td>
<td>0.55***</td>
<td>0.43***</td>
<td>0.4***</td>
<td>0.32***</td>
<td>0.33***</td>
</tr>
<tr>
<td>12 T2\textsuperscript{b}</td>
<td>-0.05</td>
<td>-0.01</td>
<td>-0.02</td>
<td>-0.11***</td>
<td>-0.14***</td>
<td>0.42***</td>
<td>0.53***</td>
<td>0.42***</td>
<td>0.39***</td>
<td>0.36***</td>
</tr>
<tr>
<td>13 T3</td>
<td>-0.07*</td>
<td>-0.05</td>
<td>-0.11**</td>
<td>-0.12***</td>
<td>-0.13***</td>
<td>0.31***</td>
<td>0.39***</td>
<td>0.52***</td>
<td>0.36***</td>
<td>0.36***</td>
</tr>
<tr>
<td>14 8 weeks</td>
<td>-0.05</td>
<td>-0.05</td>
<td>-0.08*</td>
<td>-0.23***</td>
<td>-0.17***</td>
<td>0.25***</td>
<td>0.33***</td>
<td>0.37***</td>
<td>0.51***</td>
<td>0.33***</td>
</tr>
<tr>
<td>15 12 months</td>
<td>0</td>
<td>-0.01</td>
<td>-0.07*</td>
<td>-0.11***</td>
<td>-0.26***</td>
<td>0.29***</td>
<td>0.38***</td>
<td>0.38***</td>
<td>0.37***</td>
<td>0.56***</td>
</tr>
<tr>
<td>DASS: Stress\textsuperscript{d}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>16 T1\textsuperscript{b}</td>
<td>-0.18***</td>
<td>-0.09**</td>
<td>-0.1**</td>
<td>-0.17***</td>
<td>-0.22***</td>
<td>0.67***</td>
<td>0.49***</td>
<td>0.44***</td>
<td>0.35***</td>
<td>0.37***</td>
</tr>
<tr>
<td>17 T2\textsuperscript{b}</td>
<td>-0.17***</td>
<td>-0.15***</td>
<td>-0.16***</td>
<td>-0.22***</td>
<td>-0.27***</td>
<td>0.49***</td>
<td>0.66***</td>
<td>0.53***</td>
<td>0.44***</td>
<td>0.42***</td>
</tr>
<tr>
<td>18 T3</td>
<td>-0.15***</td>
<td>-0.14***</td>
<td>-0.22***</td>
<td>-0.24***</td>
<td>-0.27***</td>
<td>0.41***</td>
<td>0.49***</td>
<td>0.66***</td>
<td>0.43***</td>
<td>0.45***</td>
</tr>
<tr>
<td>19 8 weeks</td>
<td>-0.16***</td>
<td>-0.16***</td>
<td>-0.2***</td>
<td>-0.48***</td>
<td>-0.35***</td>
<td>0.32***</td>
<td>0.38***</td>
<td>0.44***</td>
<td>0.66***</td>
<td>0.45***</td>
</tr>
<tr>
<td>20 12 months</td>
<td>-0.13***</td>
<td>-0.12***</td>
<td>-0.16***</td>
<td>-0.28***</td>
<td>-0.47***</td>
<td>0.37***</td>
<td>0.39***</td>
<td>0.43***</td>
<td>0.43***</td>
<td>0.69***</td>
</tr>
<tr>
<td>Bayley-III: SE\textsuperscript{e}</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21 12 months</td>
<td>0.12***</td>
<td>0.13***</td>
<td>0.14***</td>
<td>0.19***</td>
<td>0.27***</td>
<td>-0.06*</td>
<td>-0.07*</td>
<td>-0.11***</td>
<td>-0.09**</td>
<td>-0.13***</td>
</tr>
<tr>
<td>Measure</td>
<td>11</td>
<td>12</td>
<td>13</td>
<td>14</td>
<td>15</td>
<td>16</td>
<td>17</td>
<td>18</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>---------</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>M</td>
<td>1.84</td>
<td>2.03</td>
<td>2.19</td>
<td>.94</td>
<td>1.14</td>
<td>4.3</td>
<td>4.1</td>
<td>4.35</td>
<td>3.62</td>
<td>4.06</td>
</tr>
<tr>
<td>SD</td>
<td>2.43</td>
<td>2.3</td>
<td>2.51</td>
<td>1.68</td>
<td>2.14</td>
<td>4.02</td>
<td>3.7</td>
<td>3.67</td>
<td>3.26</td>
<td>3.56</td>
</tr>
</tbody>
</table>

**MAAS**
1. T1
2. T2
3. T3

**MPAS**
4. 8 weeks
5. 12 months

**EPDS**
6. T1
7. T2
8. T3
9. 8 weeks
10. 12 months

**DASS: Anxiety**
11. T1
12. T2
13. T3
14. 8 weeks
15. 12 months

**DASS: Stress**
16. T1
17. T2
18. T3
19. 8 weeks
20. 12 months

**Bayley-III: SE**
21. 12 months

Note. *p < .05, **p < .01, ***p < .001.

1. Descriptive statistics based on unimputed data; intercorrelations based on imputed data.
2. In instances where women commenced participation after trimester one or two, pregnancy assessments were completed for earlier waves retrospectively.
3. Higher scores indicate higher, more adaptive bonding, across all scales of the MAAS and MPAS.
5. Higher scores indicate more superior social-emotional functioning.
9.4.2. Autoregressive pathways.

The cross-lagged models for bonding and depression, bonding and anxiety, and bonding and stress are presented in Figure, Figure, and Figure, respectively. With respect to all models, there were strong, positive autoregressive paths across time. It is noted, however, that the effect size when using MAAS to predict MPAS (i.e., shifting from antenatal to postnatal), was weaker than when compared to relationships within the same bonding measure.

9.4.3. Transactional pathways.

When examining models for depression and anxiety, there was some evidence for small cross-lagged effects during the antenatal period (βs ranging from -0.06 to 0.07). There was evidence for somewhat stronger, negative cross-lagged paths between depression at T3 and bonding at postnatal 8 weeks (β = -0.20; independent of bonding at T3), and similarly for anxiety at T3 predicting bonding at postnatal 8 weeks (β = -0.10; independent of bonding at T3). Notably, this effect was smaller when examining the cross-lagged effects from 8 weeks to 12 months in both the depression and anxiety models. For stress, the cross lagged paths during the antenatal period were also weak (i.e., βs ranging from -0.06 to 0.04) with a relatively stronger, negative cross lagged path between stress at T3 and bonding at 8 weeks postpartum (β = -0.19; independent of bonding at T3) and between bonding at T3 and stress at postnatal 8 weeks (β = -0.09).
Figure 3. Cross-lagged model for MAAS, MPAS, EPDS, and Bayley-III: SE (N = 1,579).\textsuperscript{abc}

Note.
\textsuperscript{a} Model details $\beta$ (SE) for each cross-lagged and autoregressive pathway.
\textsuperscript{b} Pathways that are significant have been bolded; $p < .05$, $**p < .01$, $***p < .001$.
\textsuperscript{c} Adjusted for state of residence, country of birth, socioeconomic status, highest level of education, living arrangement, parity, maternal age at birth, infant sex, infant weight at birth, prematurity.
Figure 4. Cross-lagged model for MAAS, MPAS, DASS-21: Anxiety, and Bayley-III: SE (N = 1,579).abc

Note.

a Model details $\beta$ (SE) for each cross-lagged and autoregressive pathway.

b Pathways that are significant have been bolded; *$p < .05$, **$p < .01$, ***$p < .001$.

* Adjusted for state of residence, country of birth, socioeconomic status, highest level of education, living arrangement, parity, maternal age at birth, infant sex, infant weight at birth, prematurity.
Figure 5. Cross-lagged model for MAAS, MPAS, DASS-21:Stress, and Bayley-III: SE (N = 1,579).abc

Note.
- Model details β (SE) for each cross-lagged and autoregressive pathway.
- Pathways that are significant have been bolded; *p < .05, **p < .01, ***p < .001.
- Adjusted for state of residence, country of birth, socioeconomic status, highest level of education, living arrangement, parity, maternal age at birth, infant sex, infant weight at birth, prematurity.
9.4.4. Prediction of infant social-emotional development.

For all models, bonding at 8 weeks postpartum was an independent predictor of infant social-emotional development at 12 months ($\beta = .17$ in all three models). In contrast, depression, anxiety, and stress at 8 weeks did not predict infant social-emotional development (independent of bonding). In secondary analyses, we also examined whether there was an indirect path from negative affect at pregnancy trimester three to infant social-emotional development at 12 months, via bonding at 8 weeks postnatal. Early postnatal bonding was found to mediate the path between depression (pooled indirect effect = -0.12; 95% bias-corrected bootstrapped CIs = -0.21, -0.05), anxiety (pooled indirect effect = -0.10; 95% bias-corrected bootstrapped CIs = -0.21, -0.02), and stress (pooled indirect effect = -0.13; 95% bias-corrected bootstrapped CIs = -0.23, -0.06), and infant social-emotional development.

9.5. Discussion

9.5.1. Summary of evidence.

The current study makes three key contributions to the literature on maternal bonding, negative affect, and infant social-emotional development. First, this study confirms prior research showing strong continuity in maternal bonding and negative affect across the antenatal and postnatal periods. Second, results highlight the interrelated yet distinct nature of maternal bonding and negative affect, suggesting that these constructs need to be independently evaluated in screening and preventative intervention initiatives. The third key finding was that postnatal maternal bonding, but not postnatal negative affect, directly predicted infant social-emotional development at 12 months ($\beta = .17$ in all three models). An indirect effect of antenatal negative affect on infant social-emotional development was also
identified through postnatal bonding. Together, results underscore the importance of supporting a mother’s affective experience through the perinatal period.

9.5.2. **Continuity of maternal bonding and negative affect.**

Consistent with the extant literature, bonding and negative affect were relatively stable across the antenatal and postnatal periods (Heron et al., 2004; Patton et al., 2015; Rossen et al., 2016), with earlier bonding predicting later bonding, and earlier negative affect predicting later negative affect. Effects sizes for these independent pathways were relatively strong ($\beta = .37-.78$ for bonding; $\beta = .43-.71$ for negative affect), indicating that once established, both maternal bonding and negative affect tend to remain stable across the perinatal period. This underscores the importance of early screening and preventative intervention during the antenatal period to reduce potential risk to mothers and their infants as a result of elevated negative affect and bonding difficulties (Patton et al., 2015).

It is notable that the magnitude of effects reduced somewhat when using MAAS to predict MPAS (from pregnancy T3 to 8 weeks postnatal; $\beta = .37-.40$ across the three models). This is perhaps not surprising given the MAAS focuses on feelings towards the imagined baby, whereas the MPAS focuses on feelings towards the live infant. Despite this change in measurement, the pattern of findings remained largely unaltered, and inclusion of both measures enabled examination of bonding across the antenatal and postnatal periods, and the isolation of critical risk periods. Future research may benefit from including both self-reported and observer-rated indicators of the bond across the perinatal period.
9.5.3. **Transactional associations between maternal bonding and negative affect.**

Results from the current study indicate that the transactional pathways between maternal bonding and negative affect were isolated to the time-points surrounding birth (T3 and 8 weeks postpartum). Effects outside of this window, in the early antenatal (T1 to T3) and postnatal (8 weeks to 12 months) periods, were weak or non-existent (β ranged in magnitude from .01 to .07). Results also indicated that depression, anxiety, and stress in T3 of pregnancy independently predicted poorer bonding at 8 weeks postpartum (cross-lagged effects, which ranged from -.10 to -.20). There was limited evidence to suggest that bonding at T3 independently predicted negative affect at 8 weeks postpartum, though the pathway between bonding and stress was statistically significant (β = -.09). Rossen et al. (2016) similarly identified negative affect during pregnancy T3 as a predictor of postnatal bonding. The current study extends these findings by examining the transactional relations between these constructs, while controlling for earlier bonding and negative affect. Importantly, results indicate that bonding and negative affect are interrelated yet unique constructs (Brockington, 2004; Brockington et al., 2006), emphasising the need for screening and intervention to be tailored to their distinct symptom profiles.

9.5.4. **Prediction of infant social-emotional development.**

Results further indicated that higher maternal bonding at 8 weeks postpartum predicted more optimal infant social-emotional development at 12 months (β = .17 across all three models). This prospective association aligns with existing research (Branjerdporn et al., 2017; Le Bas et al., in press, Study I), including meta-analytic findings, indicating small to moderate associations between higher mother-to-infant bonding and more secure infant attachment, lower colic rating, easier temperament, and positive mood (Le Bas et al., in press, Study I). Consistent with major theories of
relational development, a mother’s felt bond to her child appears to implicate the
timing and attunement of her interactions, and in turn, her child’s affective
experience (Ainsworth, Blehar, & Waters, 2014; Belsky, Rovine, & Taylor, 1984). It
is noted that the small effect sizes identified in this study are likely reflect the
complex interplay of genetic, biological, and environmental pathways in infant
development, with maternal bonding identified as one important pathway (Bornstein,
2014; Bronfenbrenner & Ceci, 1994; Gluckman, Hanson, & Mitchell, 2010; Stein et
al., 2014).

9.5.5. Limitations and recommendations.

The key strengths of this study include its large sample of mother-infant
dyads and use of multi-wave, prospective data. However, there are a number of
limitations to note. First, the current sample represents a somewhat advantaged
sample of predominantly Anglo-Saxon families, and thus the observed effects are
likely to represent conservative estimates, relative to clinical sub-populations
(De Falco et al., 2014). Future research could address this limitation by using more
diverse samples with greater variability in bonding and negative affect. Second, the
measures were assessed via maternal report and consequently self-reporting bias may
be a limitation (Condon & Corkindale, 1998). For example, mothers with a stronger
affectional bond to their baby may be more likely to report advanced social-affective
functioning in their infants. Alternatively, however, it has been argued that maternal
report measures capture intimate, lived, and long-term knowledge of a child’s social-emotional development, allowing for meaningful and accurate insight (Bayley,
2006). Whilst the measures used in this study are widely used in the literature and
have established psychometric properties (Bayley, 2006; Condon, 1993; Condon &
Corkindale, 1998; Cox et al., 1987; Lovibond & Lovibond, 1996), future research
could include observational assessments alongside maternal reports of bonding.
9.5.6. Conclusion.

Findings from the current study indicate that maternal bonding difficulties and negative emotionality are not synonymous constructs and can occur in isolation. Bonding difficulties are characterised by a mother’s negative feelings towards her child. Reciprocally, a mother may experience elevated depression, stress and/or anxiety yet may report a healthy bond to her infant. This provides an important contribution to the literature on perinatal mental health, suggesting that screening and intervention efforts during pregnancy and postpartum should target both symptom profiles. Findings also indicate considerable continuity in maternal bonding and negative affect across the antenatal and postnatal periods, underscoring the importance of early screening and prevention efforts in the antenatal period. Finally, results indicate that maternal bonding and negative affect play a small yet significant role in predicting early infant social-affective development. Fostering a healthy maternal affective experience, during this critical period of mother-to-child relational formation, may have important flow on benefits for mothers; in addition to supporting a healthy start to offspring emotional life in infancy.
9.6. References


10. Discussion

The current thesis used a systematic, meta-analytic review in combination with data from a prospective, multi-wave Australian cohort study, to investigate associations between maternal bonding, negative affect, and early infant outcomes, with a focus on social-emotional development. The thesis offers two key contributions to the literature on perinatal and infant mental health. First, findings revealed associations between a mother’s perceived emotional connection with her child and indicators of social-emotional development. Specifically, meta-analytic findings revealed associations between higher maternal bonding and attachment security, lower colic rating, easier temperament and positive infant mood (Study I). Empirical findings also prospectively linked higher bonding to infant social-emotional and adaptive behaviour development, emotional stability, and approach behaviour (Study II). Further, early postnatal bonding was found to be a stronger predictor of infant social-emotional development than maternal negative affect. However, an indirect pathway was identified between symptoms of depression, anxiety, and stress and infant social-emotional development, via early postnatal bonding (Study III).

The current thesis also found evidence to suggest that maternal bonding and negative affect are interrelated yet distinct constructs (Study III). Strong, independent associations of bonding and negative affect were evident across the perinatal period. Transactional associations were isolated to the time-points closest to birth, with elevated symptoms of negative affect during trimester three of pregnancy predicting postnatal bonding difficulties.

When taken together, the results of this thesis provide support for preventative intervention to: (1) foster maternal affective experience during this critical early period of maternal-infant relational formation; and, (2) promote a
healthy start to emotional life in offspring during infancy. The results of this thesis need to be interpreted in the context of several study limitations (described in section 10.5 below). Findings are summarised below, and the theoretical, research, and clinical implications are discussed.

10.1. Summary of Findings

10.1.1. Study I findings.

Study I comprised a systematic and meta-analytic review of the research on antenatal and postnatal maternal bonding and infant development, with two main findings of note. First, this review identified a marked paucity of empirical work on the role of maternal bonding in infant development, and in particular, a lack of high-quality longitudinal research. Nineteen articles met inclusion criteria and were included in qualitative synthesis (79 effect sizes); fifteen articles were suitable for aggregation in a series of 14 meta-analyses (51 effect sizes). Notably, only five studies investigated the associations between postnatal bonding and later infant development. Second, meta-analytic findings indicated that bonding plays a role in determining social-affective outcomes. Four meta-analysed effects were statistically significant; higher maternal bonding was associated with attachment security (superordinate meta-analysis; \( N \) effects = 4; \( r = .35 \)), parent-reported lower colic rating (\( N \) effects = 2; \( r = .22 \)), easier temperament (superordinate meta-analysis; \( N \) effects = 36; \( r = .19 \)), and positive infant mood (\( N \) effects = 5; \( r = .27 \)). It is a notable limitation that the small number of effects identified for review may have resulted in low statistical power. Nevertheless, Study I identified an important gap in the available research; highlighting the need for high-quality, longitudinal studies that investigate the role of bonding across a range of infant developmental domains.
10.1.2. Study II findings.

Study I provided a strong rationale for Study II. The purpose of Study II was to use perinatal data from a longitudinal pregnancy cohort study to examine the extent to which higher maternal bonding predicts offspring development across a range of developmental domains. These domains included temperament and cognitive, language, motor, social-emotional, and adaptive behavioural development. Maternal bonding predicted four key indicators of social-affective development; these were social-emotional competence, adaptive behaviour, emotional stability, and approach behaviour. Effects were evident antenatally, increasing in strength across the perinatal window (β (range) = .07-.27). Prediction did not extend to cognitive, language, and motor outcomes (β (range) = .06-.07). Consistent with the findings from Study I, results indicated that the mother-to-fetus/infant bond plays a role in early social-emotional development.

10.1.3. Study III findings.

Study III utilised data from the same pregnancy cohort to investigate the interrelations between maternal bonding and indicators of negative affect (depression, anxiety, and stress) across three antenatal and two postnatal time-points. Results revealed strong, independent (autoregressive) associations for bonding and negative affect, highlighting considerable continuity in these constructs across the perinatal period. Moreover, the cross-lagged model indicated that bonding and negative affect are relatively independent constructs. Transactional associations (β (range) = -.10 to -.20) were identified between elevated negative affect in trimester three of pregnancy and early postnatal bonding difficulties. Notably, bonding at eight weeks postpartum was an independent predictor of infant social-emotional development at 12 months (β = .17 across all three cross-lagged models); whereas negative affect at eight weeks postpartum did not independently predict
infant social-emotional development. Despite this, early postnatal bonding was found to moderate the path between depression, anxiety, and stress during pregnancy (pooled indirect effect = -0.12, -0.10, and -0.13, respectively) and infant social-emotional development.

10.2. Maternal Bonding Predicts Infant Social, Emotional, and Behavioural Development

In this section, the first key finding from the current thesis will be interpreted in the context of theoretical and empirical perspectives. Across all three studies, evidence was found for maternal bonding predicting indicators of early social-affective outcomes. Findings align with theoretical perspectives, which suggest that developmental outcomes are influenced by shared affective states with the caregiver (Ainsworth, Blehar, & Waters, 2014; Bornstein, 2014; Brockington, 2004; Greenspan & Shanker, 2009; Winnicott, 1965). Infants have limited capacity to regulate negative emotions, and as such, learn strategies for controlling and managing emotions through interactions with caregivers (Bornstein, 1989; Grant, McMahon, Reilly, & Austin, 2010). Findings also align with the Branjerdporn, Meredith, Strong, and Garcia (2017) review, which concluded that higher antenatal bonding was associated with more optimal infant development. Results from the current thesis extend the findings of the Branjerdporn et al. (2017) review by highlighting the independent contributions of mother-to-fetus and mother-to-infant bonding to infant social-emotional development.

Notably, maternal bonding was a somewhat stronger predictor than the three indicators of maternal negative affect examined in this thesis (depression, stress and anxiety). Extensive research has demonstrated associations between postnatal depression (and other mood disorders) and child development (Monk, Lugo-Candelas, & Trumpff, 2019; O'Donnell, Glover, Barker, & O'Connor, 2014; Van den
Bergh et al., 2017). In comparison, only a handful of studies have considered the contribution of maternal bonding to child development (Branjerdporn et al., 2017). This marked paucity of empirical work on bonding and infant development may be due to confusion in the conceptualisation and measurement of bonding. Maternal bonding difficulties are typically considered equivalent to postnatal depression, yet these constructs appear to comprise somewhat distinct symptom profiles, as evidenced in Study III. The implications of this finding are discussed further in section 10.3.

10.2.1. Importance of effect sizes in the interpretation of findings.

The magnitude of the effect sizes identified in this thesis should be considered in the context of the samples examined (Studies I through III), which comprised a majority of Anglo-Saxon participants from advantaged (medium-to-high economic status) backgrounds. The associations identified are thus likely to represent somewhat conservative estimates relative to clinical sub-populations (De Falco et al., 2014). Within this context, across all studies, the magnitude of associations identified between bonding and infant social-emotional outcomes were in the small to moderate range (Study I: $r = .19-.35$; Study II: $\beta = .07-.27$; Study III: $\beta = .18$). This is important to consider in the interpretation of the thesis findings. Consistent with theory, maternal bonding plays a role in infant social-emotional-development, but it is likely that there are other, potentially stronger predictors not examined in this thesis (e.g., real and observable experiences of caregiving, particularly under conditions of stress). Effects in this range also align with theoretical and empirical perspectives which posit that infant mental health is multiply determined by a complex interplay of genetic, biological, and environmental factors (Bornstein, 2014; Bronfenbrenner & Ceci, 1994; Gluckman, Hanson, & Mitchell, 2010; Stein et al., 2014).
10.2.2. Theorised mechanisms between maternal bonding and infant social, emotional, and behavioural development.

Explanatory mechanisms for the associations between maternal bonding and infant development are considered in the context of familial pathways, including the quality of maternal care, shared genes, and the impact of a pregnant mother’s distress (perceived stress, life events, depression, and anxiety) on fetal and infant brain development (Monk et al., 2019; Stein et al., 2014). These three mechanisms are discussed in turn.

10.2.2.1. Quality of maternal care.

Maternal affect is thought to influence infant development through the quality of maternal care, which includes factors such as health-related behaviours during pregnancy and maternal-infant interactions (Ainsworth et al., 2014; Bornstein, 2014; Brockington, 2004; Monk et al., 2019; Stein et al., 2014; Winnicott, 1965). In other research on this sample, poor antenatal bonding has been associated with negative health behaviours during pregnancy including alcohol and nicotine use (Rossen et al., 2016), which may in turn have a detrimental effects on child outcomes (Barker, 1990; Hutchinson, Mattick, Braunstein, Maloney, & Wilson, 2014). In addition, results from the current thesis suggest a cumulative influence of maternal affective experience during pregnancy on postnatal affective experience and mother-infant relational formation, consistent with the extant literature (Heron et al., 2004; Patton et al., 2015; Rossen et al., 2016). Symptoms of depression, anxiety, and stress during pregnancy were also found to intensify early postnatal bonding difficulties.

Further to this, postnatal bonding independently contributed to early social-emotional development in infancy, after accounting for the role of antenatal bonding. Higher affectional bonding may indicate more nurturing interactions, characterised by maternal sensitivity to infant cues and affective involvement. These
maternal behaviours are likely to encourage display of social-emotional behaviours (e.g., interest, touch, smiles, play, adaptivity, approach, emotional regulation; Feldman, Greenbaum, Mayes, & Erlich, 1997; Greenspan & Shanker, 2009; Nicol-Harper, Harvey, & Stein, 2007). On the other hand, poor maternal bonding has been associated with more atypical, non-contingent maternal behaviour, including higher withdrawal and intrusiveness (Lara-Cinisomo et al., 2018; Schechter et al., 2008). Given that mother-infant interactions are reciprocal and co-regulated (Fogel, 1982; Kuzava & Bernard, 2018), a child’s display of positive social and emotional attributes is likely to influence a mother’s perceived connection with her child, and in turn, the quality of her maternal care.

10.2.2.2. Shared genes.

Shared genetic risk factors also account for a proportion of variance in associations between maternal affective experience and infant development (Kendler & Gardner, 2001; Rice et al., 2010; Stein et al., 2014). The relative contribution of genes depends on the disorder; for example, the genetic influence of bipolar disorder is higher than in unipolar depression (Gilbert & Miles, 2000). Shared genes may also determine susceptibility to environmental effects (Jonas et al., 2013; Weikum et al., 2013). For example, a study by Rice et al. (2010) investigated the genetic and environmental influences on associations between prenatal stress and offspring outcomes. This was done by comparing related, and unrelated mother-child pairs (as a result of in vitro fertilisation). Results revealed: (1) in both pairs, prenatal stress was associated with birth weight, gestational age, and antisocial behaviour; and, (2) in related pairs only, there was an association between prenatal stress and offspring attention deficit hyperactivity disorder. Findings indicate that links between prenatal stress and offspring development and psychopathology arise from both inherited and environmental factors (Rice et al., 2010). Notably, genetic susceptibility to the
environment is likely to be determined by many interactive variations in the genome (Stein et al., 2014).

10.2.2.3. Impact of pregnant women’s distress on fetal and infant brain development.

A recent review by Monk et al. (2019) outlines the theorised mechanisms by which pregnant women’s distress (perceived stress, life events, depression, and anxiety) affects fetal and infant brain-behaviour development. These mechanisms are summarised in Table 4 and include hypothalamic-pituitary-adrenal (HPA) axis regulation, maternal immune activation (MIA), placental functioning, mitochondrial dysfunction, alterations in the composition of the gut microbiota, and prenatal sensory experiences. Taken together, results from the current thesis suggest that a mother’s perceived emotional connection to her fetus/infant plays a small yet significant role in early social-emotional development, and that complex familial pathways are likely to be involved.
Table 4

Theorised Mechanisms between Pregnant Women’s Distress and Fetal and Infant Brain-Behaviour Development

<table>
<thead>
<tr>
<th>Biological system</th>
<th>Mechanism by which maternal distress affects offspring development</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypothalamic-pituitary-adrenal (HPA) axis</td>
<td>- The HPA axis is responsible for secreting glucocorticoids and alerting the organism to potential threats.</td>
</tr>
<tr>
<td></td>
<td>- Prenatal maternal distress may be associated with alterations in HPA axis regulation.</td>
</tr>
<tr>
<td></td>
<td>- Higher levels of glucocorticoids can affect placenta functioning and cross the placenta and reach the fetus.</td>
</tr>
<tr>
<td></td>
<td>- This affects the offspring’s HPA circuitry and brain development and increases risk of future psychopathology.</td>
</tr>
<tr>
<td>Maternal immune activation (MIA)</td>
<td>- MIA can occur in response to infection, diet, and psychosocial stresses during pregnancy.</td>
</tr>
<tr>
<td></td>
<td>- MIA is associated with compromised neurodevelopmental and psychiatric functioning.</td>
</tr>
<tr>
<td></td>
<td>- MIA may affect fetal development through maternal cytokines: crossing the placenta, causing placental inflammation, and creating fetal immune dysregulation.</td>
</tr>
<tr>
<td>Placental functioning: DNA modification</td>
<td>- Maternal distress can alter placental biology and lead to cellular dysfunction (e.g., reduction in oxygen, nutrients, and waste transport by the placenta) and altered fetal growth</td>
</tr>
<tr>
<td>The placenta: mitochondrial dysfunction</td>
<td>- Mitochondria are essential for biological functioning, including energy production.</td>
</tr>
<tr>
<td></td>
<td>- Prenatal stress has been associated with decreases in placental mitochondria and energy-producing capacity.</td>
</tr>
<tr>
<td></td>
<td>- Mitochondria dysfunction has been associated with adverse offspring social-affective outcomes.</td>
</tr>
<tr>
<td>The gut microbiome</td>
<td>- Prenatal distress has been associated with alterations in the composition of the gut microbiota.</td>
</tr>
<tr>
<td></td>
<td>- Mother-infant microbiome transmission occurs through the placental barrier, or through fetal ingestion of amniotic fluid.</td>
</tr>
<tr>
<td></td>
<td>- Alternations in the gut microbiome influences metabolism, nutrient extraction, brain maturation, and potentially risk for psychopathology.</td>
</tr>
<tr>
<td>Sensory experiences</td>
<td>- Prenatal distress may influence pregnancy-related behaviours and prenatal sensory exposures.</td>
</tr>
<tr>
<td></td>
<td>- There is evidence that fetuses register sensory experience (e.g., recognising maternal voice over another woman’s voice), which may implicate fetal and infant development.</td>
</tr>
</tbody>
</table>

Source: Monk et al. (2019).
10.2.3. Prediction did not extend to cognitive, language, and motor developmental outcomes.

Another important finding was that maternal bonding was not found to meaningfully predict non-social-affective domains of infant development, including cognitive, language, and motor development. It is possible that these developmental domains are more strongly influenced by factors such as parental IQ (i.e., cognitive and language development), and physical engagement (i.e., motor development; Bornstein, 2014). Findings are also likely to be influenced by shared method variance. Namely, all measures of bonding and infant social-affective outcomes were assessed via maternal self-report; whereas cognitive, language, and motor development were assessed via clinician report (observational assessments). This may explain why the associations with these outcome domains were smaller. Importantly, these domains are not independent of one another. Reciprocal relationships exist, for example, between affective signalling, shared problem-solving, and the emergence of language (Bayley, 2006; Greenspan & Shanker, 2009). Future research could investigate the role of perinatal bonding using multi-method assessments of maternal and child factors assessed over a longer period of development (i.e., across childhood).

10.3. Maternal Bonding Difficulties are Distinct from Negative Affect

The second key finding of the current thesis was that maternal bonding and negative affect are interrelated yet distinct constructs. The lack of cross-lagged associations in Study III between these constructs suggests that these symptom profiles can occur independently and that bonding-related difficulties are different from the constructs of depression, anxiety, and stress. Although this finding aligns with current theoretical and empirical perspectives (Brockington, 2004; Brockington, Aucamp, & Fraser, 2006; Klier, 2006; Kumar, 1997; Righetti-Veltema, Conne-
Perréard, Bousquet, & Manzano, 2002), bonding difficulties are not commonly considered separate from symptoms of depression, anxiety, and distress. Indeed, bonding disorders are not formally recognised as an independent disorder in the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013) but rather, represent a specifier of major depressive disorder (i.e., postpartum onset). Bonding difficulties may include symptoms of low mood, anhedonia, and anxiety, but are characterised specifically by negative feelings towards the child (Brockington & Guedeney, 1999; Klier, 2006; Kumar, 1997). Study III consequently provides an important contribution to the literature on perinatal mental health by demonstrating that these constructs are not synonymous and can occur independently. This finding has important implications for screening, prevention and intervention, and treatment, discussed in the next section.

10.4. Screening, Prevention and Early Intervention, and Treatment

10.4.1. Screening.

The results of this thesis have a range of implications for screening, prevention and early intervention, and treatment. First, the finding that maternal bonding difficulties and symptoms of negative affect are largely independent constructs offers important considerations for screening. Specifically, a mother may experience postpartum depression yet report a healthy bond to her infant. Reciprocally, a mother with bonding-related difficulties may not report elevated negative affect. This suggests that screening of women in pregnancy and postpartum should include a focus on both negative affect (depression, stress and anxiety), as well as bonding, and that different measures will be required to adequately capture these differing symptom profiles.

Ideally, screening should form part of standard antenatal and postpartum care via hospital services, general practitioners, and maternal child health nurses. Valid
and reliable screening measures examined in the current thesis include: the Maternal Antenatal Attachment Scale (MAAS; Condon, 1993); the Maternal Postnatal Attachment Scale (MPAS; Condon & Corkindale, 1998); the Edinburgh Antenatal and Postnatal Depression Scale (EPDS; Cox, Holden, & Sagovsky, 1987); and the short-form of the Depression Anxiety and Stress Scales (DASS-21; Lovibond & Lovibond, 1996). There are, however, other well validated measures available, depending on the extent of information required. Such screening questionnaires could be used to systematically identify mothers who would benefit from additional support and to monitor intervention/treatment progress.

10.4.2. Prevention and early intervention.

The establishment of a loving and connected relationship between a mother and her baby is arguably one of the most central and critical psychological processes that occurs during the perinatal period (Brockington, 2004). Results from the current thesis emphasise the importance of prevention and early intervention for improving maternal affect, maternal-infant relational formation, and infant social-affective outcomes. Study III findings indicate considerable continuity in maternal bonding and negative affect across the antenatal and postnatal periods. Further, there was some evidence of symptoms of negative affect during pregnancy predicting subsequent postnatal bonding difficulties. Findings support a broad call for optimized timing of interventions offered by health services (Barlow, Bennett, Midgley, Larkin, & Wei, 2015). Pregnant women should be routinely screened for both bonding difficulties and symptoms of negative affect during the antenatal and postnatal periods. It is likely that offering additional support to women experiencing subthreshold symptoms during pregnancy may improve postnatal outcomes, including preventing the onset of more severe psychiatric disorders (e.g., maternal bonding disorders or major depressive disorder with peripartum onset).
Importantly, prevention and early intervention initiatives that improve a mother’s bond to her infant and her affective state are also likely to improve subsequent infant social-emotional outcomes. The current thesis provided evidence for maternal bonding and negative affect being two potentially modifiable predictors of infant social-emotional development. In his seminal review, Bornstein (2014, p.145) stated, “Infancy introduces the part and also sets the stage for the unfolding drama that is to follow” – suggesting that experiences during the antenatal and postnatal periods influence later development, including clinical disorders (Bornstein, 2014; Frost et al., 2019; Gluckman et al., 2010; Lyneham, Rapee, & Hudson, 2014; Monk et al., 2019; O'Donnell et al., 2014; Van den Bergh et al., 2017). This is also consistent with past research which has identified links between elevated maternal negative affect in pregnancy and increased risk for later child psychopathology, including anxiety, depression, attention deficit hyperactivity disorder, and schizophrenia (O'Connell et al., 2014; Trapolini, McMahon, & Ungerer, 2007; Van den Bergh et al., 2017). Taken together, results suggest that prevention and early intervention initiatives that foster a mother’s affective experience during this critical period of mother-to-child relational formation may have important benefits for the mother and her developing child.

10.4.3. Treatment.

The results of this thesis also reinforce the importance of targeting treatment to specific symptom profiles, be it maternal bonding difficulties, symptoms of negative affect, or comorbid presentations. As noted elsewhere in this thesis, maternal negative affect is indicated by symptoms such as low mood, anhedonia, hopelessness, irritability, difficulty relaxing, nervous tension and potential suicidality. Cognitions may be specific to pregnancy and motherhood, for example, guilt about not being a good enough mother (Riecher-Rössler & Steiner, 2005) and
anxiety about an infant not thriving (Riecher-Rössler & Steiner, 2005). In contrast, maternal bonding difficulties are indicated by a mother experiencing negative feelings towards her child (Brockington & Guedeney, 1999; Klier, 2006; Kumar, 1997). Kumar (1997) describes four categories of bonding difficulties: (1) “mild” – occasional dislike or neutral feelings towards the child, with consistent care; (2) “moderate” – negative feelings towards the child, with consistent care and some intermittent affection; (3) “severe” – hatred and wishing the child away or dead, and impulses to harm; and (4) “extreme” – neglect, harm, and possibly relinquishment of care. Whilst this thesis did not examine these specific categories, results emphasise the need for clinicians to routinely screen for, and target treatment to, differing symptom profiles.

Therapeutic work could be undertaken with a psychologist or other health professional with expertise in perinatal mental health. Symptoms of negative affect occurring in isolation of bonding difficulties may be suited to individual therapy, with the focus being the mother’s affective experience (as opposed to focusing specifically on the maternal-infant relationship). This may yield benefits to a mother’s levels and management of both general negative affect and postnatal bonding difficulties. Comparatively, in treating maternal bonding difficulties, the aim would be to enhance the quality of a mother’s felt bond to her infant. Intervention could include improving maternal sensitivity to infant cues, providing information on newborn communication (e.g., crying at night indicates the infants need for safety and protection by the caregiver), and encouraging affectionate handling (Brockington & Brierley, 1984; Wendland-Carro, Piccinini, & Millar, 1999). A focus on the bond may yield benefits for a mother’s pleasure in interacting with her infant as well as feelings of competence in her capacity to understand and meet her child’s needs. Reciprocally, more nurturing maternal-infant interactions set the stage for an infant’s
own expectations and affective experience, and scaffold social and emotional development. Treatment of comorbid presentations would ideally include a focus on both symptom profiles.

10.5. **Methodological Strengths and Limitations**

10.5.1. **Study I: Systematic review and meta-analysis.**

Study I addressed a key gap in the literature on maternal bonding and infant development. The review extended the findings of the Branjerdporn et al. (2017) review by: (1) including studies on both mother-to-fetus and mother-to-infant bonding; (2) employing a systematic and extensive search strategy; (3) reporting on the magnitude of associations; and, (4) including a series of meta-analyses to quantitatively evaluate and statistically combine results of comparable studies.

There are three key limitations of this review. The main limitation is that the majority of the meta-analyses included only two to five effects. As such, confidence intervals for heterogeneity statistics were large, and some caution is warranted in the interpretation of results (Schroll, Moustgaard, & Gøtzsche, 2011). Second, for both stages of screening (titles/abstracts and full text), only one author screened 100% of articles, with a second author screening 10% of articles for reliability analysis. This approach is considered standard and valid, however, full double screening may have increased reliability (Haddaway & Westgate, 2018). Lastly, few meaningful moderation and sensitivity analyses could be conducted due to the limited number of available effects. Consequently, it is difficult to make inferences about how methodological differences between studies may have influenced results.
10.5.2. Studies II and III: Empirical studies.

There are some important strengths of the empirical studies included in the current thesis. First, these studies used data from a large, longitudinal sample of mother-infant dyads \(N = 1,623\) assessed prospectively across the perinatal period (Hutchinson et al., 2017). Second, the cohort included assessment of a range of maternal variables collected across multiple antenatal and postnatal waves, allowing for examination of critical risk periods. Third, assessments were multi-method, including self-report and clinical assessments. Fourth, the current thesis addresses a striking gap in empirical work, examining bonding across multiple assessment waves and its associations with a wide range of infant developmental outcomes. Finally, transactional and bi-directional associations were examined between maternal bonding and negative affect, accounting for the stability of these constructs across the perinatal period.

Despite the aforementioned strengths, there are also number of methodological limitations to note. The first limitation relates to the generalisability of findings. The Triple B cohort consists of predominantly Anglo-Saxon, Australian mothers, with medium-to-high economic status. This may limit the generalisability of the results to other, more diverse populations. As such, replication is recommended in more diverse, clinical samples, where greater variability in bonding, negative affect, and infant development is likely.

A second limitation is that the measures of bonding, negative affect, and infant social-emotional development employed in this study were all collected via maternal self-report; thus, results may have been influenced by self-report bias or social desirability. For example, a mother with strong feelings of affection toward her infant may be more likely to view her infant’s development positively and vice versa. Additional bias may have been introduced with some mothers completing
retrospective assessments of bonding and negative affect for pregnancy trimesters one and two (i.e., mothers recruited into the study in trimester three completed retrospective assessments). However, 85% of women completed their first survey mid-pregnancy and as such, any retrospective recall was minimal and based on recent recall of information. Arguably, it is also important to assess bonding and infant social-affective outcomes via maternal report as this is the most common assessment method used in population level screening, intervention, and clinical practice. Measures of maternal bonding also require a focus on the mother’s felt affective bond to her infant, rather than factors likely to mediate or indicate the presence of bonding, such as maternal attitudes, beliefs, or behaviours (Condon & Corkindale, 1998; Lamb, 1974). Moreover, measures of social-emotional development require the respondent to have in-depth knowledge of the child and the ability to provide meaningful insight (Bayley, 2006). Measures included in the current thesis were gold-standard with established validity (Bayley, 2006; Condon, 1993; Condon & Corkindale, 1998). Future research could include observational assessments to further validate maternal-report instruments (e.g., maternal emotional availability and infant attachment).

A third limitation is that findings may have been influenced by the use of two related yet different scales to assess maternal bonding across both the antenatal and postnatal periods. These scales are the Maternal Antenatal Attachment Scale (MAAS; Condon, 1993) and the Maternal Postnatal Attachment Scale (MPAS; Condon & Corkindale, 1998). The MAAS focuses on a mother’s feelings towards her developing baby, whereas the MPAS focuses on feelings towards her infant. This may explain the slightly weaker association identified between bonding in trimester three and eight weeks postpartum (i.e., \( \beta = .37-.40 \) across the three models) than was evident between assessments within the antenatal and postpartum periods.
(i.e., $\beta = .74-.78$ and $\beta = .59-.62$, respectively). Nevertheless, the difference in these associations was relatively small overall and it did not change the main conclusions drawn from this thesis.

10.6. **Recommendations for Future Research**

The aforementioned limitations and the paucity of extant research warrant further investigation of the prospective associations between maternal bonding, negative affect and offspring development. Future studies could include more diverse samples, with greater variability in bonding, negative affect, and infant development. Further, transactional relations between predictors of infant social-emotional development could be examined over a longer developmental period, including both maternal-report and observational assessments of caregiving experiences. Lastly, future research could investigate the impact of perinatal bonding on a range of child outcomes over a longer developmental span.
10.7. Conclusion

The current thesis makes two key contributions to theory and empirical research on perinatal and infant mental health. First, results identify maternal bonding and negative affect as potentially modifiable predictors of infant social-emotional development. Specifically, a mother’s perceived emotional connection to her fetus/infant was found to predict indicators of infant social-emotional development, including attachment quality, positive mood, easier temperament, lower colic rating, global social-emotional development, adaptive behaviour, emotional stability, and approach behaviour. Further, early postnatal bonding was identified as a moderator of the impact of negative affect during pregnancy on infant social-emotional outcomes. Results also indicated that maternal bonding and negative affect are interrelated yet distinct constructs, with considerable continuity in these constructs across the antenatal and postnatal periods. Transactional relations were unique to the time-points surrounding birth, suggesting that symptoms of negative affect during pregnancy may intensify postnatal bonding difficulties. Taken together, results highlight the importance of routine screening and early intervention for both maternal bonding difficulties and symptoms of negative affect. This in turn confers the potential to support maternal-infant relational formation and optimal infant social-emotional development across childhood and beyond.
10.8. References


11. Appendices

11.1. Appendix A. Authorship Statement for Study I

1. Details of publication and executive author

<table>
<thead>
<tr>
<th>Title of Publication</th>
<th>Publication details</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Role of Antenatal and Postnatal Maternal Bonding in Infant Development: A Systematic Review and Meta-Analysis</td>
<td>Provisionally accepted for publication by Social Development.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Name of executive author</th>
<th>School/Institute/Division if based at Deakin; Organisation and address if non-Deakin</th>
<th>Email or phone</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genevieve Le Bas</td>
<td>School of Psychology</td>
<td><a href="mailto:glebas@deakin.edu.au">glebas@deakin.edu.au</a></td>
</tr>
</tbody>
</table>

2. Inclusion of publication in a thesis

<table>
<thead>
<tr>
<th>Is it intended to include this publication in a higher degree by research (HDR) thesis?</th>
<th>Yes / No</th>
<th>If Yes, please complete Section 3 If No, go straight to Section 4.</th>
</tr>
</thead>
</table>

3. HDR thesis author’s declaration

<table>
<thead>
<tr>
<th>Name of HDR thesis author if different from above. (If the same, write &quot;as above&quot;)</th>
<th>School/Institute/Division if based at Deakin</th>
<th>Thesis title</th>
</tr>
</thead>
<tbody>
<tr>
<td>As above</td>
<td>School of Psychology, Deakin University</td>
<td>Maternal Bonding and Negative Affect: Association with Infant Social-Emotional Development</td>
</tr>
</tbody>
</table>

If there are multiple authors, give a full description of HDR thesis author’s contribution to the publication (for example, how much did you contribute to the conception of the project, the design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)

Conceptualised and designed the study, completed data acquisition, contributed to data analysis and interpretation, and wrote and submitted the manuscript.

I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.

<table>
<thead>
<tr>
<th>Signature and date</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Genevieve Le Bas</td>
<td>29/05/2019</td>
</tr>
</tbody>
</table>

Signature Redacted by Library
4. **Description of all author contributions**

<table>
<thead>
<tr>
<th>Name and affiliation of author</th>
<th>Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>George Youssef, School of Psychology, Deakin University</td>
<td>Conceptualised and designed the study, supervised data acquisition, completed data analysis, contributed to the interpretation of data, supervised the write-up of results, and revised the manuscript.</td>
</tr>
<tr>
<td>Jacqui Macdonald, School of Psychology, Deakin University</td>
<td>Supervised data acquisition, contributed to data analysis and interpretation, and revised the manuscript.</td>
</tr>
<tr>
<td>Larissa Rossen, National Drug and Alcohol Research Centre, University of New South Wales</td>
<td>Completed data acquisition, contributed to data interpretation, and revised the manuscript.</td>
</tr>
<tr>
<td>Sam Teague, School of Psychology, Deakin University</td>
<td>Completed data acquisition, contributed to data interpretation, and revised the manuscript.</td>
</tr>
<tr>
<td>Emily Kothe, School of Psychology, Deakin University</td>
<td>Supervised data acquisition, contributed to data interpretation, and revised the methods and results sections of the manuscript.</td>
</tr>
<tr>
<td>Jennifer McIntosh, School of Psychology, Deakin University</td>
<td>Critically reviewed and revised the manuscript for important intellectual content.</td>
</tr>
<tr>
<td>Craig Olsson, School of Psychology, Deakin University</td>
<td>Critically reviewed and revised the manuscript for important intellectual content.</td>
</tr>
<tr>
<td>Delyse Hutchinson, School of Psychology, Deakin University</td>
<td>Conceptualised and designed the study; coordinated and supervised data acquisition, analysis, and interpretation; and revised the manuscript.</td>
</tr>
</tbody>
</table>

5. **Author Declarations**

I agree to be named as one of the authors of this work, and confirm:

i. that I have met the authorship criteria set out in the Deakin University Research Conduct Policy,

ii. that there are no other authors according to these criteria,

iii. that the description in Section 4 of my contribution(s) to this publication is accurate,

iv. that the data on which these findings are based are stored as set out in Section 7 below.

If this work is to form part of an HDR thesis as described in Sections 2 and 3, I further

v. consent to the incorporation of the publication into the candidate’s HDR thesis submitted to Deakin University and, if the higher degree is awarded, the subsequent publication of the thesis by the university (subject to relevant Copyright provisions).

<table>
<thead>
<tr>
<th>Name of author</th>
<th>Signature*</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>George Youssef</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Jacqui Macdonald</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Larissa Rossen</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Sam Teague,</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Emily Kothe</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Jennifer McIntosh</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Craig Olsson</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Delyse Hutchinson</td>
<td></td>
<td>29/05/2019</td>
</tr>
</tbody>
</table>

*Signatures Redacted by Library*
6. Other contributor declarations

*I agree to be named as a non-author contributor to this work.*

<table>
<thead>
<tr>
<th>Name and affiliation of contributor</th>
<th>Contribution</th>
<th>Signature* and date</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* If an author or contributor is unavailable or otherwise unable to sign the statement of authorship, the Head of Academic Unit may sign on their behalf, noting the reason for their unavailability, provided there is no evidence to suggest that the person would object to being named as author.

7. Data storage

The original data for this project are stored in the following locations. (The locations must be within an appropriate institutional setting. If the executive author is a Deakin staff member and data are stored outside Deakin University, permission for this must be given by the Head of Academic Unit within which the executive author is based.)

<table>
<thead>
<tr>
<th>Data format</th>
<th>Storage Location</th>
<th>Date lodged</th>
<th>Name of custodian if other than the executive author</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This form must be retained by the executive author, within the school or institute in which they are based.

If the publication is to be included as part of an HDR thesis, a copy of this form must be included in the thesis with the publication.
11.2. Appendix B. Authorship Statement for Study II

1. Details of publication and executive author

<table>
<thead>
<tr>
<th>Title of Publication</th>
<th>Publication details</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Role of Antenatal and Postnatal Maternal Bonding in Infant Development</td>
<td>Submitted to <em>Child Development</em> (18 May 2019).</td>
</tr>
<tr>
<td>Name of executive author</td>
<td>Email or phone</td>
</tr>
<tr>
<td>Genevieve Le Bas</td>
<td><a href="mailto:glebas@deakin.edu.au">glebas@deakin.edu.au</a></td>
</tr>
</tbody>
</table>

2. Inclusion of publication in a thesis

<table>
<thead>
<tr>
<th>Is it intended to include this publication in a higher degree by research (HDR) thesis?</th>
<th>Yes / No</th>
<th>If Yes, please complete Section 3 If No, go straight to Section 4.</th>
</tr>
</thead>
</table>

3. HDR thesis author’s declaration

<table>
<thead>
<tr>
<th>Name of HDR thesis author if different from above. (If the same, write “as above””)</th>
<th>School/Institute/Division if based at Deakin</th>
<th>Thesis title</th>
</tr>
</thead>
<tbody>
<tr>
<td>As above</td>
<td>School of Psychology, Deakin University</td>
<td>Maternal Bonding and Negative Affect: Association with Infant Social-Emotional Development</td>
</tr>
</tbody>
</table>

If there are multiple authors, give a full description of HDR thesis author’s contribution to the publication (for example, how much did you contribute to the conception of the project, the design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)

Conceptualised and designed the study, contributed to data acquisition, contributed to data analysis and interpretation, and wrote and submitted the manuscript.

I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.

<table>
<thead>
<tr>
<th>Signature and date</th>
<th>Signature Redacted by Library</th>
</tr>
</thead>
<tbody>
<tr>
<td>Genevieve Le Bas</td>
<td>29/05/2019</td>
</tr>
</tbody>
</table>
## 4. Description of all author contributions

<table>
<thead>
<tr>
<th>Name and affiliation of author</th>
<th>Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>George Youssef, School of Psychology, Deakin University</td>
<td>Conceptualised and designed the study, supervised data acquisition, completed data analysis, contributed to the interpretation of data, supervised the write-up of results, and revised the manuscript.</td>
</tr>
<tr>
<td>Jacqui Macdonald, School of Psychology, Deakin University</td>
<td>Contributed to data interpretation and revised the manuscript.</td>
</tr>
<tr>
<td>Richard Mattick, National Drug and Alcohol Research Centre, University of New South Wales</td>
<td>Established and co-led all aspects of the broader cohort study. Critically reviewed and revised the manuscript for important intellectual content.</td>
</tr>
<tr>
<td>Sam Teague, School of Psychology, Deakin University</td>
<td>Contributed to data acquisition and revised the manuscript.</td>
</tr>
<tr>
<td>Ingrid Honan, National Drug and Alcohol Research Centre, University of New South Wales</td>
<td>Contributed to data acquisition and revised the manuscript.</td>
</tr>
<tr>
<td>Jennifer McIntosh, School of Psychology, Deakin University</td>
<td>Critically reviewed and revised the manuscript for important intellectual content.</td>
</tr>
<tr>
<td>Sarah Khor, School of Psychology, Deakin University</td>
<td>Contributed to data acquisition and revised the manuscript.</td>
</tr>
<tr>
<td>Larissa Rosser, National Drug and Alcohol Research Centre, University of New South Wales</td>
<td>Contributed to data acquisition and revised the manuscript.</td>
</tr>
<tr>
<td>Elizabeth Elliot, Discipline of Paediatrics and Child Health, University of Sydney</td>
<td>Chief investigator involved in setting up and overseeing the cohort study. Critically reviewed and revised the manuscript for important intellectual content.</td>
</tr>
<tr>
<td>Steve Allsop, Queensland Alcohol and Drug Research and Education Centre and Schools of Public Health and Social Science, University of Queensland</td>
<td>Chief investigator involved in setting up and overseeing the cohort study. Led the WA data collection team. Critically reviewed and revised the manuscript for important intellectual content.</td>
</tr>
<tr>
<td>Lucinda Burns, National Drug and Alcohol Research Centre, University of New South Wales</td>
<td>Chief investigator involved in setting up and overseeing the cohort study. Critically reviewed and revised the manuscript for important intellectual content.</td>
</tr>
<tr>
<td>Craig Olsson, School of Psychology, Deakin University</td>
<td>Chief investigator involved in setting up and overseeing the cohort study. Critically reviewed and revised the manuscript for important intellectual content.</td>
</tr>
<tr>
<td>Delyse Hutchinson, School of Psychology, Deakin University</td>
<td>Established and co-led all aspects of the broader cohort study. Conceptualised and designed this specific study; coordinated and supervised data acquisition, analysis, and interpretation; and revised the manuscript.</td>
</tr>
</tbody>
</table>
5. **Author Declarations**

I agree to be named as one of the authors of this work, and confirm:

i. that I have met the authorship criteria set out in the Deakin University Research Conduct Policy,

ii. that there are no other authors according to these criteria,

iii. that the description in Section 4 of my contribution(s) to this publication is accurate,

iv. that the data on which these findings are based are stored as set out in Section 7 below.

If this work is to form part of an HDR thesis as described in Sections 2 and 3, I further

v. consent to the incorporation of the publication into the candidate’s HDR thesis submitted to Deakin University and, if the higher degree is awarded, the subsequent publication of the thesis by the university (subject to relevant Copyright provisions).

<table>
<thead>
<tr>
<th>Name of author</th>
<th>Signature*</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>George Youssef</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Jacqui Macdonald</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Richard Mattick</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Sam Teague</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Ingrid Honan</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Jennifer McIntosh</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Sarah Khor</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Larissa Rossen</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Elizabeth Elliott</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Steve Allsop</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Lucinda Burns</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Craig Olsson</td>
<td></td>
<td>29/05/2019</td>
</tr>
<tr>
<td>Delyse Hutchinson</td>
<td></td>
<td>29/05/2019</td>
</tr>
</tbody>
</table>
6. Other contributor declarations

*I agree to be named as a non-author contributor to this work.*

<table>
<thead>
<tr>
<th>Name and affiliation of contributor</th>
<th>Contribution</th>
<th>Signature* and date</th>
</tr>
</thead>
<tbody>
<tr>
<td>N/A</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

* If an author or contributor is unavailable or otherwise unable to sign the statement of authorship, the Head of Academic Unit may sign on their behalf, noting the reason for their unavailability, provided there is no evidence to suggest that the person would object to being named as author.

7. Data storage

The original data for this project are stored in the following locations. (The locations must be within an appropriate institutional setting. If the executive author is a Deakin staff member and data are stored outside Deakin University, permission for this must be given by the Head of Academic Unit within which the executive author is based.)

<table>
<thead>
<tr>
<th>Data format</th>
<th>Storage Location</th>
<th>Date lodged</th>
<th>Name of custodian if other than the executive author</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital data is stored on Deakin servers, physical data is stored in a locked filing cabinet in the School of Psychology (swipe-card access only to the floor).</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

This form must be retained by the executive author, within the school or institute in which they are based.

If the publication is to be included as part of an HDR thesis, a copy of this form must be included in the thesis with the publication.
11.3. Appendix C. Ethics

11.3.1. Ethics approval from Deakin University Human Research Ethics committee for Triple B: Life at 8 follow-up study.

Memorandum

To: Dr Delyse Hutchinson
   School of Psychology
   B

From: Deakin University Human Research Ethics Committee (DUHREC)

Date: 16 February 2017

Subject: 2016-347
   Triple B Pregnancy Cohort Study: Life at 8 years (x-ref 2016-298)

Please quote this project number in all future communications

DUHREC considered the application for this project at its meeting held on 07/11/2016 and found it to comply with the National Statement on Ethical Conduct in Human Research (2007).

DUHREC has granted approval for Dr Delyse Hutchinson, School of Psychology, to undertake this project from 16/02/2017 to 16/02/2021.

The approval given by the Deakin University Human Research Ethics Committee is given only for the project and for the period as stated in the approval. It is your responsibility to contact the Human Research Ethics Unit immediately should any of the following occur:

- Serious or unexpected adverse effects on the participants
- Any proposed changes in the protocol, including extensions of time.
- Any events which might affect the continuing ethical acceptability of the project.
- The project is discontinued before the expected date of completion.
- Modifications are requested by other HRECs.

In addition, you will be required to report on the progress of your project at least once every year and at the conclusion of the project. Failure to report as required will result in suspension of your approval to proceed with the project.

DUHREC may need to audit this project as part of the requirements for monitoring set out in the National Statement on Ethical Conduct in Human Research (2007).

Human Research Ethics Unit
research-ethics@deakin.edu.au
Telephone: 03 9251 7123
11.3.2. Candidate certificates of completion.

This is to certify that

**GENEVIEVE LE BAS**

has successfully completed the compulsory Human Research Ethics Training.

**Human Research Ethics Unit – Deakin University**  
research-ethics@deakin.edu.au

Date: 11/7/2016

Authentication number: 212530743v1

This is to certify that

**GENEVIEVE LE BAS**

has successfully completed the compulsory Research Integrity online training.

**Research Integrity – Deakin University**  
research-integrity@deakin.edu.au

Date: 11/7/2016

Authentication number: 212530743v4


The next lot of questions asks about your thoughts and feelings about your developing baby:

1. Over the past two weeks I have thought about, or been preoccupied with the baby inside me:
   - 1. Almost all the time
   - 2. Very frequently
   - 3. Frequently
   - 4. Occasionally
   - 5. Not at all

2. Over the past two weeks when I have spoken about, or thought about the baby inside me I got emotional feelings which were:
   - 1. Very weak or non-existent
   - 2. Fairly weak
   - 3. In between strong and weak
   - 4. Fairly strong
   - 5. Very strong

3. Over the past two weeks my feelings about the baby inside me have been:
   - 1. Very positive
   - 2. Mainly positive
   - 3. Mixed positive and negative
   - 4. Mainly negative
   - 5. Very negative

4. Over the past two weeks I have had the desire to read about or get information about the developing baby. This desire is:
   - 1. Very weak or non-existent
   - 2. Fairly weak
   - 3. Neither strong nor weak
   - 4. Moderately strong
   - 5. Very strong
Over the past two weeks I have been trying to picture in my mind what the developing baby actually looks like in my womb:

1. Almost all the time
2. Very frequently
3. Frequently
4. Occasionally
5. Not at all

Over the past two weeks I think of the developing baby mostly as:

1. A real little person with special characteristics
2. A baby like any other baby
3. A human being
4. A living thing
5. A thing not yet really alive

Over the past two weeks I have felt that the baby inside me is dependent on me for its well-being:

1. Totally
2. A great deal
3. Moderately
4. Slightly
5. Not at all

Over the past two weeks I have found myself talking to my baby when I am alone:

1. Not at all
2. Occasionally
3. Frequently
4. Very frequently
5. Almost all the time I am alone

Over the past two weeks when I think about (or talk to) my baby inside me, my thoughts:

1. Are always tender and loving
2. Are mostly tender and loving
3. Are a mixture of both tenderness and irritation
4. Contain a fair bit of irritation
5. Contain a lot of irritation
10 The picture in my mind of what the baby at this stage actually looks like inside the womb is:
   1 Very clear
   2 Fairly clear
   3 Fairly vague
   4 Very vague
   5 I have no idea at all

11 Over the past two weeks when I think about the baby inside me, I get feelings which are:
   1 Very sad
   2 Moderately sad
   3 A mixture of happiness and sadness
   4 Moderately happy
   5 Very happy

12 Some pregnant women sometimes get so irritated by the baby inside them that they feel like they want to hurt it or punish it:
   1 I couldn’t imagine I would ever feel like this
   2 I could imagine I might sometimes feel like this, but I never actually have
   3 I have felt like this once or twice myself
   4 I have occasionally felt like this myself
   5 I have often felt like this myself

13 Over the past two weeks I have felt:
   1 Very emotionally distant from my baby
   2 Moderately emotionally distant from my baby
   3 Not particularly emotionally close to my baby
   4 Moderately close emotionally to my baby
   5 Very close emotionally to my baby

14 Over the past two weeks I have taken care with what I eat to make sure the baby gets a good diet:
   1 Not at all
   2 Once or twice when I ate
   3 Occasionally when I ate
   4 Quite often when I ate
   5 Every time I ate
When I first see my baby after the birth, I expect I will feel:
1 Intense affection
2 Mostly affection
3 Dislike about one or two aspects of the baby
4 Dislike about quite a few aspects of the baby
5 Mostly dislike

When my baby is born, I would like to hold the baby:
1 Immediately
2 After it has been wrapped in a blanket
3 After it has been washed
4 After a few hours for things to settle down
5 The next day

Over the past two weeks I have had dreams about the pregnancy or baby:
1 Not at all
2 Occasionally
3 Frequently
4 Very frequently
5 Almost every night

Over the past two weeks I have found myself feeling, or rubbing with my hand, the outside of my stomach where the baby is:
1 A lot of times each day
2 At least once per day
3 Occasionally
4 Once only
5 Not at all

If the pregnancy was lost at this time (due to miscarriage or other accidental event) without any pain or injury to myself, I expect I would feel:
1 Very pleased
2 Moderately pleased
3 Neutral (i.e., neither sad nor pleased; or mixed feelings)
4 Moderately sad
5 Very sad

The next lot of questions asks how you feel about your infant and what it is like caring for him/her:

1. When I am caring for the baby, I get feelings of annoyance or irritation:
   1. Very frequently
   2. Frequently
   3. Occasionally
   4. Very rarely
   5. Never

2. When I am caring for the baby, I get feelings that the child is deliberately being difficult or trying to upset me:
   1. Very frequently
   2. Frequently
   3. Occasionally
   4. Very rarely
   5. Never

3. Over the last two weeks I would describe my feelings for the baby as:
   1. Dislike
   2. No strong feelings towards the baby
   3. Slight affection
   4. Moderate affection
   5. Intense affection

4. Regarding my overall level of interaction with the baby I:
   1. Feel very guilty that I am not more involved
   2. Feel moderately guilty that I am not more involved
   3. Feel slightly guilty that I am not more involved
   4. I don’t have any guilty feelings regarding this

5. When I interact with the baby I feel:
   1. Very incompetent and lacking in confidence
   2. Moderately incompetent and lacking in confidence
   3. Moderately competent and confident
   4. Very competent and confident
6 When I am with the baby, I feel tense and anxious:
   1 Very frequently
   2 Frequently
   3 Occasionally
   4 Almost never

7 When I am with the baby and other people are present, I feel proud of the baby:
   1 Very frequently
   2 Frequently
   3 Occasionally
   4 Almost never

8 I try to involve myself as much as I possibly can PLAYING with the baby:
   1 This is true
   2 This is untrue

9 When I have to leave the baby:
   1 I usually feel rather sad (or it's difficult to leave)
   2 I often feel rather sad (or it's difficult to leave)
   3 I have mixed feelings of both sadness and relief
   4 I often feel rather relieved (and it's easy to leave)
   5 I usually feel rather relieved (and it's easy to leave)

10 When I am with the baby:
   1 I always get a lot of enjoyment/satisfaction
   2 I frequently get a lot of enjoyment/satisfaction
   3 I occasionally get a lot of enjoyment/satisfaction
   4 I very rarely get a lot of enjoyment/satisfaction

11 When I am not with the baby, I find myself thinking about the baby:
   1 Almost all the time
   2 Very frequently
   3 Frequently
   4 Occasionally
   5 Not at all

12 When I am with the baby:
   1 I usually try to prolong the time I spend with him/her
   2 I usually try to shorten the time I spend with him/her
13 When I have been away from the baby for a while and I am about to be with him/her again, I usually feel:
   1 Intense pleasure at the idea
   2 Moderate pleasure at the idea
   3 Mild pleasure at the idea
   4 No feelings at all about the idea
   5 Negative feelings about the idea

14 I now think of the baby as:
   1 Very much my own baby
   2 A bit like my own baby
   3 Not yet really my own baby

15 Regarding the things that we have had to give up because of the baby:
   1 I find that I resent it quite a lot
   2 I find that I resent it a moderate amount
   3 I find that I resent it a bit
   4 I don't resent it at all

16 Since the baby was born, I have felt that I do not have enough time for myself or to pursue my own interests:
   1 Almost all the time
   2 Very frequently
   3 Occasionally
   4 Not at all

17 Taking care of this baby is a heavy burden of responsibility. I believe this is:
   1 Very much so
   2 Somewhat so
   3 Slightly so
   4 Not at all

18 I trust my own judgment in deciding what the baby needs:
   1 Almost never
   2 Occasionally
   3 Most of the time
   4 Almost all the time

19 Usually when I am with the baby:
   1 I am very impatient
   2 I am a bit impatient
   3 I am moderately patient
   4 I am extremely patient
11.4.3. Edinburgh Antenatal and Postnatal Depression Scale (EPDS; Cox, Holden, & Sagovsky, 1987).

*Please tick the answer box that comes closest to how you have felt IN THE LAST 7 DAYS, not just how you feel today.*

1. I have been able to laugh and see the funny side of things:
   - 1. As much as I always could
   - 2. Not quite as much now
   - 3. Definitely not so much now
   - 4. Not at all

2. I have looked forward with enjoyment to things:
   - 1. As much as I ever did
   - 2. Rather less than I used to
   - 3. Definitely less than I used to
   - 4. Hardly at all

3. I have blamed myself unnecessarily when things went wrong:
   - 1. Yes, most of the time
   - 2. Yes, some of the time
   - 3. Not very often
   - 4. No, never

4. I have been anxious or worried for no good reason:
   - 1. No, not at all
   - 2. Hardly ever
   - 3. Yes, sometimes
   - 4. Yes, very often

5. I have felt scared or panicky for no very good reason:
   - 1. Yes, quite a lot
   - 2. Yes, sometimes
   - 3. No, not much
   - 4. No, not at all

6. Things have been getting on top of me:
   - 1. Yes, most of the time I haven’t been able to cope at all
   - 2. Yes, sometimes I haven’t been coping as well as usual
   - 3. No, most of the time I have coped quite well
   - 4. No, I have been coping as well as ever

7. I have been so unhappy that I have had difficulty sleeping:
   - 1. Yes, most of the time
   - 2. Yes, sometimes
   - 3. Not very often
   - 4. No, not at all

8. I have felt sad or miserable:
   - 1. Yes, most of the time
   - 2. Yes, quite often
   - 3. Not very often
   - 4. No, not at all

9. I have been so unhappy that I have been crying:
   - 1. Yes, most of the time
   - 2. Yes, quite often
   - 3. Only occasionally
   - 4. No, never

10. The thought of harming myself has occurred to me:
    - 1. Yes, quite often
    - 2. Sometimes
    - 3. Hardly ever
    - 4. Never
### 11.4.4. Depression Anxiety and Stress Scales (DASS-21; Lovibond & Lovibond, 1996).

*Please read each statement and circle a number 0, 1, 2 or 3 which indicates how much the statement applied to you OVER THE PAST WEEK. There are no right or wrong answers. Do not spend too much time on any statement.*

<table>
<thead>
<tr>
<th>Statement</th>
<th>Not at all</th>
<th>Some degree, or some of the time</th>
<th>Considerable degree, or a good part of the time</th>
<th>Very much, or most of the time</th>
</tr>
</thead>
<tbody>
<tr>
<td>A I found it hard to wind down</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>B I was aware of dryness in my mouth</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>D I experienced breathing difficulties (e.g. excessively rapid breathing, breathlessness in the absence of physical exertion)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>F I tended to over-react to situations</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>G I experienced trembling (e.g., in the hands)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>H I felt that I was using a lot of nervous energy</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I I was worried about situations in which I might panic and make a fool of myself</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>K I felt myself getting agitated</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>L I found it difficult to relax</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>N I was intolerant of anything that kept me from getting on with what I was doing</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>O I felt I was close to panic</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>R I felt that I was rather touchy</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>S I was aware of the action of my heart in the absence of physical activity (e.g., sense of heart rate increase, heart missing a beat)</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>T I felt scared without any good reason</td>
<td>0</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>

Below is a list of words that describes babies. How do these descriptions fit your infant?

<table>
<thead>
<tr>
<th></th>
<th>Very like him/her</th>
<th>Like him/her</th>
<th>Unlike him/her</th>
<th>Very unlike him/her</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Placid</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>B</td>
<td>Grizzly</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>C</td>
<td>Happy</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>D</td>
<td>Alert</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>E</td>
<td>Serious</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>F</td>
<td>Angry</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>G</td>
<td>Demanding</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>H</td>
<td>Cuddly</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>I</td>
<td>Smiley</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>J</td>
<td>Social</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>K</td>
<td>Unsettled</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
<tr>
<td>L</td>
<td>Difficult</td>
<td>1</td>
<td>2</td>
<td>3</td>
</tr>
</tbody>
</table>
## 11.5. Appendix E. Supplementary Materials for Study I

Table E1
*Search Terms for Systematic Review*

<table>
<thead>
<tr>
<th>AND →</th>
<th>Maternal</th>
<th>Bonding</th>
<th>Infants</th>
<th>Longitudinal</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR ↓ (free text + subject headings for relevant database)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Free text</strong></td>
<td>Maternal</td>
<td>Bond*</td>
<td>Infan*</td>
<td>Prospective</td>
</tr>
<tr>
<td></td>
<td>Mother*</td>
<td>Attach*</td>
<td>Child*</td>
<td>Retrospective</td>
</tr>
<tr>
<td>EBSCOhost databases:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Pregnant wom?n&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informit:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Pregnant woman&quot; OR &quot;Pregnant women&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embase:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Pregnant woman' OR 'Pregnant women'</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EBSCOhost databases:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Follow up&quot; OR Followup</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Informit:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&quot;Follow up&quot; OR Followup</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Embase:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>'Follow up’ OR Followup</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caring</td>
<td>Bab*</td>
<td>Cohort</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurtur*</td>
<td>Toddler*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Thesaurus subject headings (PsycINFO)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expectant mothers</td>
<td>Attachment behavior</td>
<td>Infant development</td>
<td>Prospective studies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mother child relations</td>
<td>Neonatal development</td>
<td>Retrospective studies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Intimacy</td>
<td></td>
<td>Longitudinal studies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Caring behaviors</td>
<td></td>
<td>Cohort analysis</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nurturance</td>
<td></td>
<td>Followup studies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Love</td>
<td></td>
<td>Predictability (measurement)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sensitivity (personality)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parental investment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Emotional security</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parental attitudes</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mother child communication</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parental involvement</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parental expectations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Parental role</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Object relations</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Child care</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Affection</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Empathy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MeSH subject headings (MEDLINE Complete and Informit)</td>
<td>Mothers</td>
<td>Maternal-fetal relations</td>
<td>Infant</td>
<td>Prospective studies</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Pregnant women</td>
<td>Mother-child relations</td>
<td>Infant, newborn</td>
<td>Retrospective studies</td>
<td></td>
</tr>
<tr>
<td>Love</td>
<td>Infant care</td>
<td>Maternal behavior</td>
<td>Follow-up studies</td>
<td></td>
</tr>
<tr>
<td>Infant</td>
<td>Object attachment</td>
<td>Empathy</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CINAHL subject headings (CINAHL Complete)</th>
<th>Mothers</th>
<th>Parent-infant bonding</th>
<th>Infant</th>
<th>Prospective studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expectant mothers</td>
<td>Prenatal bonding</td>
<td>Infant, newborn</td>
<td>Concurrent prospective studies</td>
<td></td>
</tr>
<tr>
<td>Motherhood</td>
<td>Mother-infant relations</td>
<td>Nonconcurrent prospective studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intimacy</td>
<td></td>
<td>Retrospective design</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Caring</td>
<td></td>
<td>Panel studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurturing behavior</td>
<td></td>
<td>Retrospective panel studies</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Love</td>
<td>Maternal attitudes</td>
<td>Maternal role</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant care</td>
<td>Affection</td>
<td>Maternal behavior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emtry subject headings (Embase)</td>
<td>Mother</td>
<td>Social bonding</td>
<td>Infancy</td>
<td>Prospective study</td>
</tr>
<tr>
<td>Pregnant woman</td>
<td>Emotional attachment</td>
<td>Infant</td>
<td>Retrospective study</td>
<td></td>
</tr>
<tr>
<td>Expectant mother</td>
<td>Mother-child relation</td>
<td>Toddler</td>
<td>Longitudinal study</td>
<td></td>
</tr>
<tr>
<td>Mother fetus relationship</td>
<td>Progeny</td>
<td>Cohort analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Intimacy</td>
<td>Baby</td>
<td>Panel study</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nurturing behavior</td>
<td>Newborn</td>
<td>Predictor variable</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Love</td>
<td>Object relation</td>
<td>Child care</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal behavior</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Empathy</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Google search</th>
<th>Mother</th>
<th>Bond</th>
<th>Infant</th>
<th>Prospective</th>
</tr>
</thead>
<tbody>
<tr>
<td>&quot;Pregnant woman”</td>
<td>Attach</td>
<td>Child</td>
<td>Retrospective</td>
<td></td>
</tr>
<tr>
<td>&quot;Expectant mother&quot;</td>
<td>Intimacy</td>
<td>Offspring</td>
<td>Longitudinal</td>
<td></td>
</tr>
<tr>
<td>Maternal</td>
<td>Caring</td>
<td>Baby</td>
<td>Cohort</td>
<td></td>
</tr>
<tr>
<td>Nurturing</td>
<td>Toddler</td>
<td>Panel</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Love</td>
<td>Newborn</td>
<td>Predictor</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sensitivity</td>
<td>&quot;Follow up”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investment</td>
<td>Security</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Table E2
“Search Syntax for Systematic Review"

<table>
<thead>
<tr>
<th>Database</th>
<th>Syntax</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>PsycINFO</strong></td>
<td>(maternal OR mother* OR “pregnant wom?n” OR (DE &quot;Mothers&quot;) OR (DE &quot;Expectant Mothers&quot;)) AND (bond* OR attach* OR intimacy OR caring OR nurtur* OR love OR sensitivity OR investment OR security OR (DE &quot;Attachment Behavior&quot;) OR (DE &quot;Mother Child Relations&quot;) OR (DE &quot;Intimacy&quot;) OR (DE &quot;Caring Behaviors&quot;) OR (DE &quot;Nurturance&quot;) OR (DE &quot;Love&quot;) OR (DE &quot;Emotional Security&quot;) OR (DE &quot;Parental Involvement&quot;) OR (DE &quot;Parental Expectations&quot;) OR (DE &quot;Parental Role&quot;) OR (DE &quot;Object Relations&quot;) OR (DE &quot;Child Care&quot;) OR (DE &quot;Affection&quot;) OR (DE &quot;Empathy&quot;)) AND (infan* OR child* OR offspring OR bab* OR toddler* OR newborn* OR (DE &quot;Infant Development&quot;) OR (DE &quot;Neonatal Development&quot;)) AND (prospective OR retrospective OR longitudinal OR cohort OR follow#up OR panel OR predictor* OR (DE &quot;Prospective Studies&quot;) OR (DE &quot;Retrospective Studies&quot;) OR (DE &quot;Longitudinal Studies&quot;) OR (DE &quot;Cohort Analysis&quot;) OR (DE &quot;Followup Studies&quot;) OR (DE &quot;Predictability (Measurement)&quot;))</td>
</tr>
<tr>
<td><strong>MEDLINE Complete</strong></td>
<td>(maternal OR mother* OR “pregnant wom?n” OR (MH &quot;Mothers&quot;) OR (MH &quot;Pregnant Women&quot;)) AND (bond* ORattach* OR intimacy OR caring OR nurtur* OR love OR sensitivity OR investment OR security OR (MH &quot;Maternal-Fetal Relations&quot;) OR (MH &quot;Mother-Child Relations&quot;) OR (MH &quot;Infant Care&quot;) OR (MH &quot;Maternal Behavior&quot;) OR (MH &quot;Object Attachment&quot;) OR (MH &quot;Empathy&quot;)) AND (infan* OR child* OR offspring OR bab* OR toddler* OR newborn* OR (MH &quot;Infant&quot;) OR (MH &quot;Infant, Newborn&quot;)) AND (prospective OR retrospective OR longitudinal OR cohort OR follow#up OR panel OR predictor* OR (MH &quot;Prospective Studies&quot;) OR (MH &quot;Retrospective Studies&quot;) OR (MH &quot;Longitudinal Studies&quot;) OR (MH &quot;Cohort Studies&quot;) OR (MH &quot;Follow-Up Studies&quot;))</td>
</tr>
<tr>
<td><strong>Informit</strong></td>
<td>((MH_PHRASE=&quot;Follow-Up Studies&quot;) OR (MH_PHRASE=&quot;Cohort Studies&quot;) OR (MH_PHRASE=&quot;Longitudinal Studies&quot;) OR (MH_PHRASE=&quot;Retrospective Studies&quot;) OR (MH_PHRASE=&quot;Prospective Studies&quot;) OR (predictor*) OR (panel) OR (followup) OR (&quot;follow up&quot;) OR (cohort) OR (longitudinal) OR (retrospective) OR (prospective)) AND ((MH_PHRASE=&quot;Infant, Newborn&quot;) OR (MH_PHRASE=&quot;Infant&quot;) OR (newborn*) OR (toddler*) OR (bab*) OR (offspring) OR (child*) OR (infan*)) AND ((MH_PHRASE=&quot;Empathy&quot;) OR (MH_PHRASE=&quot;Object Attachment&quot;) OR (MH_PHRASE=&quot;Maternal Behavior&quot;) OR (MH_PHRASE=&quot;Infant Care&quot;) OR (MH_PHRASE=&quot;Love&quot;) OR (MH_PHRASE=&quot;Mother-Child Relations&quot;) OR (MH_PHRASE=&quot;Maternal-Fetal Relations&quot;) OR (security) OR (investment) OR (sensitivity) OR (love) OR (nurtur*) OR (caring) OR (intimacy) OR (attach*) OR (bond*)) AND ((MH_PHRASE=&quot;Pregnant Women&quot;) OR (MH_PHRASE=&quot;Mothers&quot;) OR (&quot;pregnant women&quot;) OR (&quot;pregnant woman&quot;) OR (mother*) OR (maternal))</td>
</tr>
<tr>
<td>Database</td>
<td>Search Terms</td>
</tr>
<tr>
<td>--------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>CINAHL Complete</td>
<td>(maternal OR mother* OR “pregnant woman” OR (MH &quot;Mothers&quot;) OR (MH &quot;Expectant Mothers&quot;) OR (MH &quot;Motherhood&quot;)) AND (bond* OR attach* OR intimacy OR caring OR nurtur* OR love OR sensitivity OR investment OR security OR (MH &quot;Parent-Infant Bonding&quot;) OR (MH &quot;Prenatal Bonding&quot;) OR (MH &quot;Mother-Infant Relations&quot;) OR (MH &quot;Intimacy&quot;) OR (MH &quot;Caring&quot;) OR (MH &quot;Nurturing Behavior&quot;) OR (MH &quot;Love&quot;) OR (MH &quot;Maternal Attitudes&quot;) OR (MH &quot;Maternal Role&quot;) OR (MH &quot;Infant Care&quot;) OR (MH &quot;Affection&quot;) OR (MH &quot;Maternal Behavior&quot;) OR (MH &quot;Empathy&quot;)) AND (infant* OR child* OR offspring OR baby* OR toddler* OR newborn* OR (MH &quot;Infant&quot;) OR (MH &quot;Infant, Newborn&quot;)) AND (prospective OR retrospective OR longitudinal OR cohort OR followup OR panel OR predictor* OR (MH &quot;Prospective Studies&quot;) OR (MH &quot;Concurrent Prospective Studies&quot;) OR (MH &quot;Nonconcurrent Prospective Studies&quot;) OR (MH &quot;Retrospective Design&quot;) OR (MH &quot;Panel Studies&quot;) OR (MH &quot;Retrospective Panel Studies&quot;) OR (MH &quot;Predictive Research&quot;))</td>
</tr>
<tr>
<td>Embase</td>
<td>(maternal OR mother* OR ‘pregnant woman’ OR ‘pregnant women’ OR ‘mother’/de OR ’pregnant woman’/de OR 'expectant mother'/de) AND (bond* OR attach* OR intimacy OR caring OR nurtur* OR love OR sensitivity OR investment OR security OR 'social bonding'/de OR 'emotional attachment'/de OR 'mother child relation'/de OR 'mother fetus relationship'/de OR 'intimacy'/de OR 'nurturing behavior'/de OR 'love'/de OR 'object relation'/de OR 'child care'/de OR 'maternal behavior'/de OR 'empathy'/de) AND (infant* OR child* OR offspring OR baby* OR toddler* OR newborn* OR 'infancy'/de OR 'infant'/de OR 'progeny'/de OR 'baby'/de OR 'toddler'/de OR 'newborn'/de) AND (prospective OR retrospective OR longitudinal OR cohort OR ‘follow up’ OR followup OR panel OR predictor* OR 'prospective study'/de OR 'retrospective study'/de OR 'longitudinal study'/de OR 'cohort analysis'/de OR 'panel study'/de OR 'predictor variable'/de)</td>
</tr>
<tr>
<td>Google search</td>
<td>(mother “pregnant woman” “expectant mother” maternal) (bond attach intimacy caring nurturing love sensitivity investment security) (infant child offspring baby toddler newborn) (prospective retrospective longitudinal cohort panel predictor “follow up”)</td>
</tr>
<tr>
<td>Measure</td>
<td>Original study</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>-------------------------------------------------------------------------------</td>
</tr>
</tbody>
</table>
| **Maternal Fetal Attachment Scale (MFAS)**  | Cranley, M. S. (1981). Development of a tool for the measurement of maternal attachment during pregnancy. Nursing Research, 30(5), 281-284. | A 24-item self-report measure to assess a mother’s attachment to her fetus. Items are rated on a 5-point Likert scale. Five subscales: differentiation of self from the fetus, interaction with the fetus, attributing characteristics to the fetus, giving of self, and taking responsibility. Total scores range from 24-120. | Higher, more adaptive bonding.                            | Internal consistency:  
  o $\alpha = .52-.73$ for the five subscales  
  o $\alpha = .85$ for the total scale  
 - All subscales were positively associated with the total scale ($r = .61-.83$)  
 - Correlations among subscales were positive ($r = .29-.60$), but low enough to indicate they were not measuring the same construct. |
| **Working Model of the Child Interview (WMCI)** | Zeanah, C. H., Benoit, D., Hirshberg, L., Barton, M., & Regan, C. (1994). Mothers’ representations of their infants are concordant with infant attachment classifications. Developmental Issues in Psychiatry and Psychology, 1(1), 1-14. | This one-hour semi-structured interview is designed to elicit and classify caregivers’ perceptions of and subjective experience of their child and relationship with their child. The interview is recorded and transcribed. Five-point rating scales are used to assess the content and affective tone of the caregiver’s representation. Primary scales: richness of perception, openness to change, intensity of involvement, coherence, caregiving sensitivity, acceptance, and infant difficulty. Representations are classified as balanced, disengaged, or distorted. | Categorical: Balanced classification indicates higher, more adaptive bonding. | Mean inter-rater agreement of 85% across the primary scales  
 - Interrater agreement of 83% for the overall classification |
| **Working Model of the Child Interview - Disrupted (WMCI-D)** | Crawford, A., & Benoit, D. (2009). Caregivers’ disrupted representations of the unborn child predict later infant–caregiver disorganized attachment and disrupted interactions. Infant Mental Health Journal, 30(2), 124-144. | Same interview as the WMCI but includes an additional scale for coding the presence of disrupted representations. Disrupted behaviour is rated according to five subscales: affective communication errors, role/boundary confusion, disorientation, intrusiveness/negativity, withdrawal. A collective total WMCI-D score is used to classify representations as disrupted or non-disrupted. | Categorical: Non-disrupted classification indicates higher, more adaptive bonding. | Inter-rater reliability:  
  o $\kappa = .48$ for affective communication errors  
  o $\kappa = .79$ for role/boundary confusion  
  o $\kappa = .61$ for disorientation  
  o $\kappa = .56$ for intrusiveness/negativity  
  o $\kappa = .30$ for withdrawal |
<table>
<thead>
<tr>
<th>Measure</th>
<th>Original study</th>
<th>Detail of measure</th>
<th>Higher scores indicate</th>
<th>Psychometric information from original study</th>
</tr>
</thead>
</table>
| **Maternal Antenatal Attachment Scale (MAAS)** | Condon, J. T. (1993). The assessment of antenatal emotional attachment: Development of a questionnaire instrument. British Journal of Medical Psychology, 66(2), 167-183. | A 19-item self-report measure that asks a mother to report on her thoughts and feelings about her developing baby. Items focus on the past two weeks and are rated on a 5-point Likert scale, with the scale options varying between items. Items are summed to provide three scores: quality of bonding, intensity of preoccupation, and a global total (19-95). | Higher, more adaptive bonding. | - Internal consistency:  
  o $\alpha = .82$ at trimester three of pregnancy |
| **Maternal Postnatal Attachment Scale (MPAS)** | Condon, J. T., & Corkindale, C. J. (1998). The assessment of parent-to-infant attachment: Development of a self-report questionnaire instrument. Journal of Reproductive and Infant Psychology, 16(1), 57-76. | A 19-item self-report measure that asks a mother to report on her thoughts and feelings about her infant over the past two weeks. The number of response options varies between items (2-, 4-, and 5-point Likert scales); all response options are recoded to represent a score of 1-5. Items are summed to provide four scores: quality subscale, absence of hostility, pleasure in interaction, and a global total (19-95). | Higher, more adaptive bonding. | - Internal consistency:  
  o $\alpha = .78$ at four weeks postpartum  
  o $\alpha = .79$ at four months postpartum  
  o $\alpha = .78$ at eight months postpartum  
  - Test-retest reliability:  
  o $r = 0.86$ |
| **Prenatal Attachment Inventory (PAI)** | Muller, M. E., & Mercer, R. T. (1993). Development of the prenatal attachment inventory. Western Journal of Nursing Research, 15(2), 199-215. | A 21-item self-report measure to assess a mother's affectionate feelings towards her fetus. Items are rated on a 4-point Likert scale. Total scores range from 21-84. | Higher, more adaptive bonding. | - Internal consistency:  
  o $\alpha = .81$  
  Construct validity: PAI and MFAS scores were strongly correlated ($r = .72$). |
| **Postpartum Bonding Questionnaire (PBQ)** | Brockington, I., Fraser, C., & Wilson, D. (2006). The postpartum bonding questionnaire: A validation. Archives of Women's Mental Health, 9(5), 233-242. | A 25-item self-report measure designed to detect disorders of the mother-infant relationship. Items are rated on a 6-point Likert scale. This measure is based on four components: weakened bonding (WB), rejection and pathological rage (RR), anxiety about the baby/anxiety about caring for the baby (A); imminent abuse/risk of abuse (IA). Total scores range from 0-125. | Poorer bonding | - Specificity was .61, sensitivity 0.84, and positive predictive value 0.79 for the total scale.  
  - Internal consistency:  
  o $\alpha = .74-.95$ for the five subscales |
<table>
<thead>
<tr>
<th>Measure</th>
<th>Original study</th>
<th>Detail of measure</th>
<th>Higher scores indicate</th>
<th>Psychometric information from original study</th>
</tr>
</thead>
<tbody>
<tr>
<td>Social Distance Scale (SDS)</td>
<td>Wolfgang, A. (1973). Projected social distances as a measure of approach-avoidance behavior toward radiated figures. Journal of Community Psychology.</td>
<td>An unstructured, projective technique used to describe the mother’s feelings of closeness with her child. The mother is presented with an already drawn stick-figure (representing herself) on a line, and is asked to draw another stick-figure representing her baby at the distance she feels most comfortable. Scores are calculated by measuring the distance between these figures.</td>
<td>Poorer bonding (i.e., greater emotional distance).</td>
<td>- Internal consistency: $r = .71$</td>
</tr>
</tbody>
</table>

*Note.*

Some measures are termed “attachment” measures, but their conceptual content closely approximates our definition of “bonding”. See manuscript for further information.
11.6. Appendix F. Supplementary Materials for Study II

Table F1
Regression Results for Antenatal Maternal Bonding and Infant Bayley-III Subscales 
\((N = 1,347)^a\)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Pregnancy T1: MAAS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted(\beta)</td>
<td>(0.07)</td>
<td>(0.06)</td>
<td>(0.05)</td>
<td>(0.06)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.02 (0.04))</td>
<td>(0.01 (0.03))</td>
<td>(0.02 (0.03))</td>
<td>(0.02 (0.04))</td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>(0.06)</td>
<td>(0.04)</td>
<td>(0.02)</td>
<td>(0.06)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.02 (0.03))</td>
<td>(0.01 (0.02))</td>
<td>(0.01 (-0.01, 0.02))</td>
<td>(0.02 (0.03))</td>
<td></td>
</tr>
<tr>
<td><strong>Quality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted(\beta)</td>
<td>(0.02)</td>
<td>(0.02)</td>
<td>(0.05)</td>
<td>(0.03)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.01 (-0.02, 0.04))</td>
<td>(0.01 (-0.01, 0.03))</td>
<td>(0.03 (0.06))</td>
<td>(0.02 (-0.01, 0.05))</td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>(0.01)</td>
<td>(0.01)</td>
<td>(0.04)</td>
<td>(0.03)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.01 (-0.03, 0.04))</td>
<td>(0 (-0.02, 0.03))</td>
<td>(0.02 (-0.01, 0.05))</td>
<td>(0.02 (-0.01, 0.05))</td>
<td></td>
</tr>
<tr>
<td><strong>Intensity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted(\beta)</td>
<td>(0.09)</td>
<td>(0.07)</td>
<td>(0.05)</td>
<td>(0.08)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.05 (-0.02, 0.07))</td>
<td>(0.03 (-0.01, 0.05))</td>
<td>(0.02 (0.05))</td>
<td>(0.04 (-0.01, 0.07))</td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>(0.08)</td>
<td>(0.06)</td>
<td>(0)</td>
<td>(0.07)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.04 (-0.02, 0.07))</td>
<td>(0.02 (0.04))</td>
<td>(0 (-0.02, 0.03))</td>
<td>(0.03 (-0.01, 0.06))</td>
<td></td>
</tr>
<tr>
<td><strong>Pregnancy T2: MAAS</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted(\beta)</td>
<td>(0.06)</td>
<td>(0.04)</td>
<td>(0.04)</td>
<td>(0.04)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.02 (0.04))</td>
<td>(0.01 (0.02))</td>
<td>(0.01 (-0.01, 0.03))</td>
<td>(0.02 (-0.01, 0.04))</td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>(0.06)</td>
<td>(0.02)</td>
<td>0</td>
<td>(0.04)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.02 (0.04))</td>
<td>(0.01 (-0.01, 0.02))</td>
<td>0 (-0.02, 0.02)</td>
<td>(0.01 (-0.01, 0.03))</td>
<td></td>
</tr>
<tr>
<td><strong>Quality</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted(\beta)</td>
<td>(0.04)</td>
<td>0</td>
<td>(0.04)</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.03 (-0.01, 0.07))</td>
<td>(0 (-0.03, 0.03))</td>
<td>(0.03 (-0.01, 0.07))</td>
<td>(0.01 (-0.03, 0.05))</td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.03)</td>
<td>(0.01)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.03 (-0.02, 0.07))</td>
<td>(0 (-0.04, 0.02))</td>
<td>(0.02 (-0.02, 0.06))</td>
<td>(0.01 (-0.04, 0.05))</td>
<td></td>
</tr>
<tr>
<td><strong>Intensity</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted(\beta)</td>
<td>(0.07)</td>
<td>(0.06)</td>
<td>(0.03)</td>
<td>(0.05)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.04 (-0.01, 0.07))</td>
<td>(0.02 (0.05))</td>
<td>(0.01 (-0.02, 0.04))</td>
<td>(0.03 (0, 0.06))</td>
<td></td>
</tr>
<tr>
<td>Unadjusted</td>
<td>(0.06)</td>
<td>(0.04)</td>
<td>(-0.02)</td>
<td>(0.05)</td>
<td></td>
</tr>
<tr>
<td>(b) (95% CI)</td>
<td>(0.03 (-0.01, 0.06))</td>
<td>(0.02 (-0.01, 0.04))</td>
<td>(-0.01 (-0.04, 0.02))</td>
<td>(0.03 (0, 0.06))</td>
<td></td>
</tr>
<tr>
<td>-------------------</td>
<td>--------------------------</td>
<td>---------------------</td>
<td>---------------------</td>
<td>------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Total</td>
<td>Adjusted&lt;sup&gt;b&lt;/sup&gt; β</td>
<td>.06</td>
<td>.02</td>
<td>.04</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>.02 (0, .04)</td>
<td>0 (-.01, .02)</td>
<td>.01 (-.01, .03)</td>
<td>.01 (-.01, .03)</td>
</tr>
<tr>
<td></td>
<td>Unadjusted β</td>
<td>.05</td>
<td>0</td>
<td>0</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>.02 (0, .04)</td>
<td>0 (-.01, .02)</td>
<td>0 (-.02, .02)</td>
<td>.01 (-.01, .03)</td>
</tr>
<tr>
<td>Quality</td>
<td>Adjusted&lt;sup&gt;b&lt;/sup&gt; β</td>
<td>.05</td>
<td>.01</td>
<td>.03</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>.04 (0, .08)</td>
<td>.01 (-.02, .04)</td>
<td>.03 (-.02, .07)</td>
<td>.02 (-.03, .07)</td>
</tr>
<tr>
<td></td>
<td>Unadjusted β</td>
<td>.04</td>
<td>0</td>
<td>0</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>.03 (-.01, .08)</td>
<td>.0 (-.03, .04)</td>
<td>.02 (-.03, .06)</td>
<td>.02 (-.03, .07)</td>
</tr>
<tr>
<td>Intensity</td>
<td>Adjusted&lt;sup&gt;b&lt;/sup&gt; β</td>
<td>.05</td>
<td>.02</td>
<td>.03</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>.03 (0, .06)</td>
<td>.01 (-.02, .03)</td>
<td>.02 (-.01, .05)</td>
<td>.01 (-.02, .05)</td>
</tr>
<tr>
<td></td>
<td>Unadjusted β</td>
<td>.05</td>
<td>0</td>
<td>-.01</td>
<td>.02</td>
</tr>
<tr>
<td></td>
<td>b (95% CI)</td>
<td>.03 (0, .06)</td>
<td>0 (-.02, .02)</td>
<td>-.01 (-.04, .02)</td>
<td>.01 (-.02, .04)</td>
</tr>
</tbody>
</table>

Note. Quality = Quality of Attachment subscale, Intensity = Intensity of Preoccupation subscale. Values in bold indicate \( p < .05 \).
<sup>a</sup> Higher scores indicate more optimal infant development.
<sup>b</sup> Adjusted for state of residence, country of birth, socioeconomic status, highest level of education, living arrangement, parity, maternal age at birth, infant sex, infant weight at birth, prematurity.
## Table F2

Regression Results for Postnatal Maternal Bonding and Infant Bayley-III Subscales ($N = 1,347$)$^a$

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted$^b$</td>
<td>$\beta$</td>
<td>.04</td>
<td>.02</td>
<td>.05</td>
<td>.05</td>
</tr>
<tr>
<td>Unadjusted</td>
<td>$\beta$</td>
<td>.01 (-.01, .03)</td>
<td>.01 (.01, .02)</td>
<td>.02 (0, .04)</td>
<td>.02 (0, .04)</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td></td>
<td>.02</td>
<td>.01</td>
<td>.04</td>
<td>.05</td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted$^b$</td>
<td>$\beta$</td>
<td>.06</td>
<td>.02</td>
<td>.04</td>
<td>.04</td>
</tr>
<tr>
<td>Unadjusted</td>
<td>$\beta$</td>
<td>.05 (.01, .1)</td>
<td>.01 (.02, .05)</td>
<td>.03 (.01, .07)</td>
<td>.03 (-.02, .08)</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td></td>
<td>.02</td>
<td>.05</td>
<td>.04 (-.01, .09)</td>
<td>.04 (-.01, .09)</td>
</tr>
<tr>
<td>Hostility (Low)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted$^b$</td>
<td>$\beta$</td>
<td>.01</td>
<td>.03</td>
<td>.04</td>
<td>.03</td>
</tr>
<tr>
<td>Unadjusted</td>
<td>$\beta$</td>
<td>0 (.04, .05)</td>
<td>0 (.04, .03)</td>
<td>.03 (.02, .07)</td>
<td>.04 (-.01, .08)</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td></td>
<td>.02</td>
<td>.03</td>
<td>.04 (-.01, .09)</td>
<td>.04 (-.01, .09)</td>
</tr>
<tr>
<td>Pleasure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted$^b$</td>
<td>$\beta$</td>
<td>.02</td>
<td>.03</td>
<td>.04</td>
<td>.03</td>
</tr>
<tr>
<td>Unadjusted</td>
<td>$\beta$</td>
<td>.02 (.04, .07)</td>
<td>.02 (.02, .06)</td>
<td>.03 (.02, .08)</td>
<td>.03 (-.02, .09)</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td></td>
<td>.02</td>
<td>.02</td>
<td>.01</td>
<td>.03</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted$^b$</td>
<td>$\beta$</td>
<td>.01</td>
<td>0</td>
<td>-.01</td>
<td>.01</td>
</tr>
<tr>
<td>Unadjusted</td>
<td>$\beta$</td>
<td>0 (.02, .03)</td>
<td>0 (.02, .02)</td>
<td>0 (.02, .02)</td>
<td>0 (.02, .02)</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td></td>
<td>.01</td>
<td>-.01</td>
<td>-.02</td>
<td>0</td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted$^b$</td>
<td>$\beta$</td>
<td>.02</td>
<td>.03</td>
<td>-.01</td>
<td>0</td>
</tr>
<tr>
<td>Unadjusted</td>
<td>$\beta$</td>
<td>.02 (.03, .07)</td>
<td>.02 (.02, .06)</td>
<td>0 (.05, .04)</td>
<td>0 (.05, .05)</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td></td>
<td>.02</td>
<td>.04</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Hostility (Low)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted$^b$</td>
<td>$\beta$</td>
<td>.02</td>
<td>-.01</td>
<td>-.03</td>
<td>.02</td>
</tr>
<tr>
<td>Unadjusted</td>
<td>$\beta$</td>
<td>.02 (.03, .06)</td>
<td>-.01 (.04, .03)</td>
<td>.02 (-.07, .02)</td>
<td>.02 (-.03, .07)</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td></td>
<td>.02</td>
<td>-.03</td>
<td>.03</td>
<td>.02</td>
</tr>
<tr>
<td>Pleasure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adjusted$^b$</td>
<td>$\beta$</td>
<td>-.02</td>
<td>-.02</td>
<td>.01</td>
<td>-.01</td>
</tr>
<tr>
<td>Unadjusted</td>
<td>$\beta$</td>
<td>-.02 (.08, .03)</td>
<td>-.01 (.05, .03)</td>
<td>.01 (.04, .06)</td>
<td>.01 (-.07, .05)</td>
</tr>
<tr>
<td>b (95% CI)</td>
<td></td>
<td>-.02</td>
<td>-.03</td>
<td>.01</td>
<td>-.02</td>
</tr>
</tbody>
</table>

Note. Quality = Quality of Attachment subscale, Hostility (Low) = Absence of Hostility subscale, Pleasure = Pleasure in Interaction subscale.
Values in bold indicate $p < .05$.

$^a$ Higher scores indicate more optimal infant development.
$^b$ Adjusted for state of residence, country of birth, socioeconomic status, highest level of education, living arrangement, parity, maternal age at birth, infant sex, infant weight at birth, prematurity.