Maternal bonding, negative affect, and infant social-emotional development:**A prospective cohort study.**

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Acknowledgements and Declarations

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. The study complied with APA ethical standards in the treatment of the sample.

Data and Materials

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 ($N = 1,623$). The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Abstract

The interrelationships between maternal bonding, negative affect, and infant social-emotional development were examined using multi-wave perinatal data from an Australian cohort study ($N = 1,579$). Self-reported bonding and negative affect were assessed at each trimester, and 8 weeks and 12 months postpartum. The Bayley-III social-emotional scale was administered at age 12 months. Results revealed strong continuities in bonding and negative affect across pregnancy and postpartum. Small associations ($\beta = -.10$ to $-.20$) existed between maternal negative affect during pregnancy and poor early bonding. Higher postnatal maternal bonding predicted infant social-emotional development ($\beta = .17$). Maternal bonding and negative affect are interrelated yet unique constructs, with suggested developmental interplay between mother-to-infant bonding and infant social-affective development.

Keywords: Maternal-infant bonding, antenatal, postnatal, perinatal, infant development, longitudinal.

Theory and empirical research suggest that important associations exist between the constructs of mother-to-fetus/infant bonding, maternal negative affect, and infant social-emotional development; yet critical gaps remain in knowledge about 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., 2019b; Stein et al., 2014). However, the temporal and potentially bi-directional associations between bonding and negative affect across the perinatal period are not yet fully understood (Goebel, Stuhmann, Harder, Schulte-Markwort, & Mudra, 2018), nor the extent to which these factors independently predict social-emotional development in early infancy.

Maternal Bonding and Infant Social-Emotional Development

The affectional 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 (Lindgren, 2001; Rossen et al., 2017; Rossen et al., 2016; Van den Bergh & Simons, 2009). 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). Maternal *postnatal* 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., 2019b) support the hypothesis that a mother's perception of her emotional connection with her child, during both the antenatal and postnatal periods, plays an important 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. (2019b) found that stronger bonding predicted higher quality attachment ($r = .35$), positive infant mood ($r = .27$), lower colic rating (parent-report; $r = .22$), and "easier" temperament ($r = .19$). In all cases, pooled estimates of association were small to moderate. Of further note, both reviews identified a paucity of high-quality longitudinal research, making it difficult to draw firm conclusions about aetiological relationships. Le Bas et al. (2019a) 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 ($N = 1,347$ mother-infant dyads). Results revealed small, yet notable, positive associations between bonding and infant social-emotional competence, independence, emotional stability, and approach behaviour. These predictive effects were evident from the antenatal bond, and increased in strength across the perinatal window (β (range) = .07-.27). Results suggest that maternal bonding is one factor likely to contribute to infant emotional security and a healthy start to life.

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 these negative affective states. Negative affect is a general dimension of subjective distress that encompasses a variety of aversive mood states, commonly including (but 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, in a 20-year prospective cohort study by Patton et al. (2015), symptoms of depression were reported in 19% of pregnancies (109/564); in 16% (93/564) of these pregnancies mental health problems were reported preceding pregnancy.

Maternal expression of negative affect has previously been shown to play a role in healthy infant social-affective development. The first months of infancy are marked by directed co-regulation of the infant's affective states, allowing for development 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 impede a mother's recognition or tolerance of these same states in her baby, and may, in turn, negatively impact the infant's 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 (ADHD), and schizophrenia (Monk, Lugo-Candelas, & Trumpff, 2019; O'Donnell, Glover, Barker, & O'Connor, 2014; Van den Bergh et al., 2017).

Interrelations Between Maternal Bonding and Negative Affect

Theoretical perspectives and empirical evidence suggest that maternal bonding and negative affect play a role in supporting infant social-emotional development (Branjerdporn et al., 2017; Kingston et al., 2012; Le Bas et al., 2019b), but 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 to high 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 connection to the fetus was consistently lower in the context of symptoms of anxiety (reporting small to moderate effects), and argued 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. We are not aware of any studies that 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, prospective multi-wave data are required.

The Current Study

The temporal and potentially bi-directional associations between maternal bonding and negative affect could be better understood by 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. Using a cross-lagged model, the current study had three aims: (1) to examine continuities in maternal-offspring bonding and maternal negative across five time-points in the antenatal (trimesters 1, 2 and 3) and postnatal periods (8 weeks and 12 months the period); (2) to determine the direction and magnitude of transactional paths between maternal bonding and negative affect across the same period after accounting for the antenatal pathways; and, (3) to examine independent contributions of maternal bonding and negative affect from 8 weeks postnatal to infant social-emotional development at 12 months.

Method

Participants and Procedures

Data were from the XX study <<reference (blinded)>>, a longitudinal pregnancy study conducted by the XX and XX, in collaboration with XX. Approval to conduct this research was received from the XX Committee (HREC reference number: 08224, 14 August 2008). This approval was ratified by the following Australian institutions: XX (SSA reference number: 08/RPAH/412, 1 September 2008), XX (SSA reference number: 09/G/097, 1 September 2009), XX (SSA reference number: SSA/11/LPOOL/80, 10 June 2011), and the XX (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. Written informed consent was obtained from all participants. The study complied with APA ethical standards in the treatment of the sample.

Pregnant women were recruited from four major public hospitals 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 the state of recruitment; intention of mother or both parents to be the primary caregiver/s; being mentally able to complete study measures; 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 1 (T1), trimester 2 (T2) and trimester 3 (T3); birth (hospital record data); and, 8 weeks and 12 months postpartum. More detailed information on the cohort is provided in <<reference for cohort profile – blinded>>.

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 1.

****Insert Table 1 about here****

Measures

Maternal and infant demographic information used in this study was collected via structured interview and questionnaires administered in trimester 3 (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.

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 3 of pregnancy (Condon, 1993).

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) and 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).

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).

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 frequency of their 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).

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 focused on composite scores. The Bayley-III: SE has been shown to be a reliable and valid measure (Bayley, 2006).

Data Analysis

All data cleaning, basic analyses, and missing data methods were conducted using Stata 15. Missing data for any given variable was <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 1, and the means and SDs included in Table 2) 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 period). 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, and *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., 2019a). 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 (this was a deliberate sample as the broader study also investigated the effects of maternal substance use on infant development). 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.

Results

Descriptive Statistics

The descriptive statistics for the current sample are shown in Tables 1 and 2. Table 2 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, moderate to strong correlations existed between the same measures at different time points.

****Insert Table 2 about here****

Autoregressive Pathways

The crosslag models for bonding and depression, bonding and anxiety, and bonding and stress are presented in Figures 1, 2, and 3, respectively. With respect to all models, we found strong continuities in maternal-offspring bonding and maternal negative affect across time (i.e., strong positive autoregressive pathways), noting that the effect size when using MAAS to predict MPAS (i.e., shifting from antenatal to postnatal) was weaker relative to relationships within the same measure of bonding.

Transactional Pathways

When examining models for depression and anxiety, small cross-lagged effects were evident during the antenatal period (β s ranging from $-.06$ to $.07$). Stronger, inverse cross-lagged paths existed between depression at T3 and bonding at postnatal 8 weeks ($\beta = -.20$; independent of bonding at T3), and similarly for anxiety at T3 predicting bonding at postnatal 8 weeks ($\beta = -.10$; 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 similarly small (i.e., β s ranging from $-.06$ to $.04$) with a stronger, inverse cross lagged path between stress at T3 and bonding at 8 weeks postpartum ($\beta = -.19$; independent of bonding at T3) and between bonding at T3 and stress at postnatal 8 weeks ($\beta = -.09$).

Prediction of Infant Social-Emotional Development

For all models, higher maternal-infant 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 an indirect path existed from negative affectivity at pregnancy trimester 3 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.

Discussion

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 mostly 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 higher 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.

Continuity of Maternal Bonding and Negative Affect in the Perinatal Period

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).

Notably, the magnitude of effects reduced somewhat when using MAAS to predict MPAS (from pregnancy T3 to 8 weeks postnatal; stats here). 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.

Transactional Associations between Maternal Bonding and Negative Affect

Results from the current study indicate that the transactional pathways between maternal bonding and maternal 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 small or non-existent (β ranged in magnitude from .01 to .07). Results also indicated that depression, anxiety, and stress in T3 of pregnancy predicted poorer bonding at 8 weeks postpartum (cross-lagged effects, which

ranged from $-.10$ to $-.20$). Limited evidence was provided for bonding at T3 predicting negative affect at 8 weeks postpartum (independent of earlier bonding and negative affect), though the pathway between bonding and stress was statistically significant ($\beta = -.09$). 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 and 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.

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 ($\beta = .17$ across all three models). This prospective association aligns with existing research (Branjerdporn et al., 2017; Le Bas et al., 2019b), 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., 2019b). 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, an infant's affective experiences (Ainsworth, Blehar, & Waters, 2014; Belsky, Rovine, & Taylor, 1984). The small effect sizes identified in this study likely reflect the complex interplay of genetic, biological, and environmental pathways in infant development, with maternal bonding identified as one of many possible pathways (Bornstein, 2014; Bronfenbrenner & Ceci, 1994; Gluckman, Hanson, & Mitchell, 2010; Stein et al., 2014).

Limitations and Recommendations

The key strengths of this study include its large sample of mother-infant dyads and use of multi-wave, prospective data. The first key limitation is that 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.

Conclusion

Findings from the current study indicate that maternal bonding difficulties and maternal negative emotionality across the perinatal period are not synonymous constructs and have independent trajectories. 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 important contribution to the literature on perinatal mental health suggests 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 a mother's self-reported bond to her child and her self-report of negative affect each play a role in predicting early infant social-affective development. This suggests that many factors shape social-emotional regulation in infancy and the issue warrants further investigation in longitudinal studies of the perinatal period.

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Tables and Figures

Table 1

Sample Antenatal Demographic and Postnatal Obstetric Characteristics (N = 1,579)^a

	<i>n</i>	%
State of residence^b		
NSW	1,275	81%
WA	304	19%
Country of birth^b		
Australia	904	57%
Other English speaking country	285	18%
Non-English speaking country	385	24%
Socioeconomic status^b		
Low SES	70	4%
Medium SES	483	31%
High SES	1,022	65%
Highest level of education^b		
Less than high school	139	9%
Completed high school	179	11%
Completed TAFE/technical	242	15%
Completed university/college	1,013	64%
Living with partner^b		
Yes	1,440	91%
No	134	8%
Parity^b		
0	869	55%
1-2	628	40%
3+	73	5%
Maternal age at birth (years)^c		
≤24 years	124	8%
25-29 years	336	21%
30-35 years	667	42%
≥36 years.	445	28%
Infant sex^c		
Female	695	48%
Male	761	44%
Infant weight at birth^c		
Normal (>10 th percentile for gestational age)	1,296	82%
Small for Gestational Age (≤10 th percentile for gestational age)	154	10%
Prematurity^c		
Not premature (≥37 weeks)	1,377	87%
Premature (≤36 weeks)	80	5%

Note.

^a Descriptive statistics based on unimputed data, consequently, totals will not equal 1,579 participants/100%.

^b Information collected via structured interview and questionnaire assessments in trimester 3 (28 weeks to birth).

^c Information collected via structured interview and questionnaire assessments at 8 weeks postpartum.

Table 2

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

Measure	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
M	74.01	78.16	79.87	82.28	81.99	5.8	4.74	4.55	4.18	4.88	1.84	2.03	2.19	.94	1.14	4.3	4.1	4.35	3.62	4.06	106.09
SD	8.64	7.19	7.15	7	6.69	5.31	4.52	4.14	3.91	4.16	2.43	2.3	2.51	1.68	2.14	4.02	3.7	3.67	3.26	3.56	15.18
MAAS ^c																					
1 T1 ^b	1																				
2 T2 ^b	0.78***	1																			
3 T3	0.65***	0.75***	1																		
MPAS ^c																					
4 8 weeks	0.3***	0.33***	0.41***	1																	
5 12 months	0.28***	0.3***	0.37***	0.62***	1																
EPDS ^d																					
6 T1 ^b	-0.22***	-0.1***	-0.1**	-0.16***	-0.24***	1															
7 T2 ^b	-0.16***	-0.17***	-0.15***	-0.21***	-0.28***	0.67***	1														
8 T3	-0.14***	-0.14***	-0.22***	-0.25***	-0.28***	0.55***	0.68***	1													
9 8 weeks	-0.1**	-0.1*	-0.16***	-0.44***	-0.31***	0.4***	0.5***	0.56***	1												
10 12 months	-0.05	-0.07*	-0.12***	-0.23***	-0.42***	0.42***	0.46***	0.51***	0.51***	1											
DASS: Anxiety ^d																					
11 T1 ^b	-0.06*	0.01	-0.01	-0.08**	-0.11***	0.55***	0.43***	0.4***	0.32***	0.33***	1										
12 T2 ^b	-0.05	-0.01	-0.02	-0.11***	-0.14***	0.42***	0.53***	0.42***	0.39***	0.36***	0.7***	1									
13 T3	-0.07*	-0.05	-0.11**	-0.12***	-0.13***	0.31***	0.39***	0.52***	0.36***	0.36***	0.48***	0.59***	1								
14 8 weeks	-0.05	-0.05	-0.08*	-0.23***	-0.17***	0.25***	0.33***	0.37***	0.51***	0.33***	0.35***	0.45***	0.47***	1							
15 12 months	0	-0.01	-0.07*	-0.11***	-0.26***	0.29***	0.38***	0.38***	0.37***	0.56***	0.38***	0.45***	0.47***	0.47***	1						
DASS: Stress ^d																					
16 T1 ^b	-0.18***	-0.09**	-0.1**	-0.17***	-0.22***	0.67***	0.49***	0.44***	0.35***	0.37***	0.56***	0.41***	0.31***	0.22***	0.28***	1					
17 T2 ^b	-0.17***	-0.15***	-0.16***	-0.22***	-0.27***	0.49***	0.66***	0.53***	0.44***	0.42***	0.43***	0.53***	0.37***	0.3***	0.35***	0.73***	1				
18 T3	-0.15***	-0.14***	-0.2***	-0.24***	-0.27***	0.41***	0.49***	0.66***	0.43***	0.45***	0.32***	0.37***	0.56***	0.3***	0.37***	0.52***	0.6***	1			
19 8 weeks	-0.16***	-0.16***	-0.2***	-0.48***	-0.35***	0.32***	0.38***	0.44***	0.66***	0.45***	0.28***	0.34***	0.32***	0.54***	0.34***	0.43***	0.48***	0.5***	1		
20 12 months	-0.13***	-0.12***	-0.16***	-0.28***	-0.47***	0.37***	0.39***	0.43***	0.43***	0.69***	0.3***	0.33***	0.34***	0.32***	0.62***	0.44***	0.46***	0.53***	0.54***	1	
Bayley-III: SE ^e																					
21 12 months	0.12***	0.13***	0.14***	0.19***	0.27***	-0.06*	-0.07*	-0.11***	-0.09**	-0.13***	-0.06	-0.06	-0.09**	-0.07*	-0.07*	-0.04	-0.06	-0.11***	-0.09**	-0.16***	1

Note.

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

^a Descriptive statistics based on unimputed data; intercorrelations based on imputed data.

^b In instances where women commenced participation after trimester 1 or 2, pregnancy assessments were completed for earlier waves retrospectively.

^c Higher scores indicate stronger, more adaptive bonding, across all scales of the MAAS and MPAS.

^d Higher scores indicate more symptoms of depression, anxiety, and stress on the EPDS and DASS-21.

^e Higher scores indicate more superior social-emotional functioning.

Figure 1. Crosslag model for MAAS, MPAS, EPDS, and Bayley-III: SE (N = 1,579)^{abc}

Note.

^a Model details β (SE) for each crosslag and autoregressive pathway.

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

^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 2. Crosslag model for MAAS, MPAS, DASS-21:Anxiety, and Bayley-III: SE (N = 1,579)^{abc}

Note.

^a Model details β (SE) for each crosslag and autoregressive pathway.

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

^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 3. Crosslag model for MAAS, MPAS, DASS-21:Stress, and Bayley-III: SE (N = 1,579)^{abc}

Note.

^a Model details β (SE) for each crosslag and autoregressive pathway.

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

^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.

Supporting Information**Maternal Antenatal Attachment Scale (MAAS; Condon, 1993)**

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

- 5 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
- 6 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
- 7 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
- 8 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
- 9 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

- 15 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
- 16 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
- 17 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
- 18 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
- 19 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

Maternal Postnatal Attachment Scale (MPAS; Condon & Corkindale, 1998).

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

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

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.

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