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RESEARCH ARTICLE

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Maternal antenatal depression, oxytocin, and infant temperament: The roles of ethnicity and adult attachment avoidance

Jane Kohlhoff[1,2,3] | **Lisa Karlov**[1,4] | **Mark Dadds**[4,5] | **Bryanne Barnett**[1] | **Derrick Silove**[1] | **Valsamma Eapen**[1,3,4]

[1]Discipline of Psychiatry and Mental Health, University of New South Wales, Sydney, Australia

[2]Research Department, Karitane, Sydney, Australia

[3]Ingham Institute for Medical Research, Sydney, Australia

[4]Academic Unit of Child Psychiatry, South Western Sydney Local Health District, Sydney, Australia

[5]School of Psychology, University of Sydney, Sydney, Australia

Correspondence
Jane Kohlhoff, Discipline of Psychiatry & Mental Health, School of Clinical Medicine, University of New South Wales; Karitane, P.O. Box 241, Villawood, NSW, 2163, Australia.
Email: Jane.Kohlhoff@unsw.edu.au

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Abstract

This study examined the associations between maternal depression and oxytocin in pregnancy, caregiving sensitivity and adult attachment style, and infant temperament. One hundred and six women recruited from a public hospital antenatal clinic in Australia, and their infants completed assessments at three time points (Time 1: pregnancy; Time 2: 3-month postpartum; Time 3: 12-month postpartum). Mothers completed self-report questionnaires assessing maternal depression symptom severity at Time 1–3, adult attachment style at Time 2, and infant temperament at Time 3. At Time 1, they also provided a blood sample to assess peripheral oxytocin levels, and at Time 2, participated in a parent–child interaction session, which was later coded for caregiving behavior (sensitivity). Neither maternal depression nor lower levels of oxytocin during pregnancy predicted difficult infant temperament; rather, it was predicted by non-Caucasian ethnicity. When all other variables were free to vary, adult attachment avoidance mediated an association between maternal depression during pregnancy and difficult infant temperament. Results highlight the potential value of interventions focusing on adult attachment insecurity for pregnant women and raise questions about associations between culture/ethnicity and infant temperament.

KEYWORDS
adult attachment style, antenatal depression, infant temperament, oxytocin

1 | INTRODUCTION

Approximately 15% of women experience major depression during pregnancy, with higher rates in low- and lower-middle-income countries (Yin et al., 2021). Antenatal depression can be debilitating and distressing for sufferers and family members, and the impacts on the developing infant are also well recognized. Infants of mothers who experience antenatal depression are more likely to be born preterm and with a low birth weight, and postnatally, to have a more "difficult" temperament (Nomura et al., 2019; Planalp & Goldsmith, 2020).

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Significantly, there is also evidence of longer-term effects including sleep issues (Kim et al., 2020); poorer cognitive, motor, and language development (Bluett-Duncan et al., 2021; O'Leary et al., 2019); and social-emotional, behavioral, and mental health difficulties (Madigan et al., 2018; Rogers et al., 2020).

Evidence suggests that one of the mechanisms through which maternal antenatal depression leads to poor child outcomes is the quality of early parenting. According to attachment theory and research, infants who receive sensitive and appropriately responsive caregiving in the early months of life form mental representations of the caregiver, and of the relationship, as a source of security, comfort, and safety—creating a context within which healthy social, emotional, and cognitive development is optimized (Ainsworth et al., 1978; Bowlby, 1988; Bretherton, 1992; Cooke et al., 2019). Women with antenatal depression are more likely to experience difficulty bonding with their unborn baby, a factor that is known to predict poorer postnatal caregiving sensitivity (Maas et al., 2016; Misri & Kendrick, 2008; Tichelman et al., 2019); they are also more likely to experience early parent–child relationship disruptions (Bind et al., 2021; Hayes et al., 2013; Pearson et al., 2012). Significantly, studies have also shown direct links between antenatal depression and compromised child outcomes, including difficult infant temperament (for a review, see Takegata et al., 2021).

"Infant temperament" has been defined as individual differences in reactivity (i.e., excitability, responsivity, or arousability) and self-regulation (i.e., the neural and behavioral processes that serve to modulate reactivity) that represent an enduring pattern or feature of an individual (Rothbart et al., 2000). In research spanning multiple decades, temperament has been shown to be relatively stable across infancy and childhood (Bornstein et al., 2015; Pedlow et al., 1993). The relevance of considering specific links between antenatal depression and infant temperament is underscored by evidence suggesting that infant temperament is influenced, over time, by a combination of genetics, biology, and experience (e.g., early parenting) (Rothbart et al., 2000). In seeking to understand the unique links between antenatal depression and infant temperament, however, it is important to note that women who experience depression during pregnancy are at increased risk of recurrent depression (Underwood et al., 2016), which is one of the strongest known predictors of poor child outcomes (Netsi et al., 2018; Slomian et al., 2019). While at least one previous study has shown longitudinal links between antenatal depression and difficult infant temperament independent of postnatal depressive symptom severity (Rouse & Goodman, 2014), many of the studies in this area have not controlled for postnatal depression (Chong et al., 2016; Zuckerman et al., 1990), examined maternal antenatal and postnatal depression as a composite variable (Melchior et al., 2012), or failed to find a link between antenatal depression and infant temperament when postnatal depression was controlled for (Austin et al., 2005). Given the complexities and inconsistencies in this area, further research is required to elucidate the relations between antenatal depression and infant temperament, and the relative contributions of postnatal depression and parenting.

Key Findings and their Implications for Practice/Policy

1. Difficult infant temperament was predicted by non-Caucasian ethnicity, and adult attachment avoidance mediated an association between maternal antenatal depression and difficult temperament, underscoring the value of attachment-based interventions for maternal depression.
2. Maternal antenatal oxytocin level did not predict infant temperament.
3. Observed parenting insensitivity did not predict difficult infant temperament.

In seeking to better understand the interplay between antenatal depression, early parenting and child outcomes, biological factors have been considered. Evidence suggests that women with antenatal depression, even those with subclinical symptoms, experience alterations to biological systems including functioning of the immune system and hypothalamic–pituitary–adrenal (HPA) axis (Osborne et al., 2018). These biological impacts are also known to be transmitted across generations, with studies having shown links between HPA axis functioning of pregnant mothers and newborn infants (Gutteling et al., 2004; O'Connor et al., 2013), with effects on infant temperament/behavior and cognitive outcomes (Davis et al., 2007; Davis & Sandman, 2010; de Weerth et al., 2003; Huizink et al., 2003). Another biological mechanism hypothesized to be at play is maternal oxytocin. Oxytocin is a neuropeptide synthesized largely in the hypothalamus, with receptors located throughout the brain (Lee et al., 2009). Oxytocin's role in the initiation of childbirth and lactation is well established (Moberg & Prime, 2013; Uvnäs-Moberg et al., 2019), but emerging data also suggest that women with lower levels of oxytocin are more likely to experience symptoms of antenatal and postnatal depression (Serati et al., 2021; Thul et al., 2020), report poorer mother–infant bonding (Eapen et al., 2014; Levine et al., 2007), and show lower levels of early caregiving sensitivity (Carter, 2017; MacDonald

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& MacDonald, 2010; Swain et al., 2014). Significantly, there is also evidence that maternal antenatal oxytocin is associated with child outcomes including social and emotional outcomes in preschool age children (Galbally et al., 2020), and that maternal oxytocin moderates the impact of maternal depression on child social-emotional outcomes (Apter-Levy et al., 2013).

In considering associations involving maternal antenatal depression, oxytocin, and parenting, and the impact of these relationships on infant outcomes, it is important to consider the role of maternal attachment style. One of the key tenets of Bowlby's attachment theory is that there is an intergenerational transmission of attachment styles, meaning that the experiences that an individual has with their own early attachment figures become internalized into internal working models or "representations," shaping behavior in subsequent interactions and relationships, including with their children (Bowlby, 1988; Main et al., 1985; van IJzendoorn & Bakermans-Kranenburg, 2019). While the Adult Attachment Interview (AAI; Hesse, 2016) is the gold standard measure of adult attachment, adult attachment style has also been measured through self-report questionnaires focusing on an individual's experiences and feelings in close adult relationships (romantic relationships and close friendships) (Mikulincer & Shaver, 2010). These scales typically yield dimensional scores indicating the degree to which the individual shows anxiety or avoidance in close relationships (highly anxious individuals tend to focus on relationships and fear abandonment; highly avoidant individuals tend not to rely on others and isolate themselves from relationships; Brennan et al., 1998). In support of Bowlby's original notion, there is evidence that mothers with higher levels of self-reported attachment anxiety and/or avoidance in relationships are more likely in the postpartum period to report poorer parent–infant bonding (Handelzalts et al., 2021), to be less sensitive, show greater intrusive, withdrawn or hostile behaviors during interactions with their infant (Jones et al., 2015; Rholes et al., 1995), and to rate their infants as more temperamentally "difficult" (Priel & Besser, 2000). Little is known, however, about the role that adult attachment plays as a potential pathway linking maternal antenatal depression and oxytocin to adverse child outcomes, highlighting an important direction for future research.

Taken together, evidence suggests longitudinal links between antenatal depression, early parenting, and child outcomes. However, the interplay of these variables with maternal antenatal oxytocin and adult attachment styles in this process is not well understood. The current study examined the associations between maternal depression during pregnancy and the postpartum, maternal oxytocin in pregnancy, postpartum caregiving quality and adult attachment, and infant temperament. Specific hypotheses were (1) that higher levels of maternal depression symptom severity and lower levels of maternal oxytocin during pregnancy would predict a more "difficult" infant temperament at 12 months, and (2) these associations would be mediated by postnatal maternal caregiving (insensitivity) and maternal adult attachment insecurity (attachment anxiety and/or avoidance).

2 | METHOD

2.1 | Participants

Participants were 106 women recruited from a public hospital antenatal clinic in Sydney, Australia, in 2011–2013, and their infants. Participants were recruited to participate in a longitudinal study examining adult separation anxiety, maternal oxytocin, early parenting, and child outcomes over four time points (Time 1: pregnancy; Time 2: 3 months postpartum; Time 3: 12 months postpartum; Time 4: 3.5 years postpartum). Given the focus on adult separation anxiety in this study, the sample was progressively targeted to include an equal number of participants with and without current adult separation anxiety symptoms. To do this, all participants completed the Adult Separation Anxiety Questionnaire (ASA-27; Manicavasagar et al., 2003) and after the target number of participants scoring below the clinical cutoff for separation anxiety (22 or below) had been reached (in the final five months of the recruitment period) participants were recruited only if they scored over the ASA-27 cutoff (>22). Exclusionary criteria for the study included: mother's age at the time of delivery of <18 years, non-English speaking, multiple pregnancy, not available for follow-up, and presence of an endocrine disease (e.g., thyroid disease).

The current study was conducted using data obtained at the Time 1–3 assessments (i.e., during pregnancy, and at 3- and 12- month postpartum, respectively). Of the total 141 women who were recruited into the study, 29 dropped out or were lost to follow up before the Time 2 assessment leaving a total sample of $n = 112$ (79.4% retention), and a further 6 dropped out or were lost to follow up between the Time 2 and Time 3 assessments, leaving a sample of 106 participants at the Time 3 assessment (75.2% retention from Time 1). The average age of mothers in the final sample ($n = 106$) at the time of recruitment was 29.83 years ($SD = 5.62$) and 37.5% were primigravid. Most were in the second trimester of pregnancy (M gestational age = 20.72 weeks, SD = 6.27). A total of 75.9% were married and 73.9% had continued education beyond secondary school. The sample was ethnically diverse, with around half (49.5%) coming from a Caucasian background and

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the remainder coming mostly from Asian (21.8%), Indian (11.9%), and Arabic (9.9%) backgrounds.

2.2 | Procedure

The study was approved by the South Western Sydney Local Health District Human Research Ethics Committee, and all participants provided written, informed consent prior to participation. A range of measures was administered at the Time 1–3 assessments (i.e., during pregnancy, and at 3- and 12- month postpartum, respectively) but only those relevant to the current study are reported here (for more information about other studies, see Eapen et al., 2014; Kohlhoff et al., 2017; Kohlhoff et al., 2021). The Time 1 assessments (pregnancy) were conducted at the antenatal clinic of a public hospital in South Western Sydney, over two sequential antenatal appointments. At the first appointment, participants completed the ASA-27 (Manicavasagar et al., 2003) and the Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987); at the second appointment, they provided a blood sample. The Time 2 assessments (3-month postpartum) were conducted at a community-based parenting research center. During this assessment, participants initially sat for 20–30 min, during which time they provided demographic details and completed the Attachment Style Questionnaire (ASQ; Feeney et al., 1994). They then participated in the Still Face Procedure (SFP; Tronick et al., 1978), a structured paradigm involving a series of three mother–infant interaction episodes: a baseline interaction episode, the "still-face" episode in which the adult becomes unresponsive and maintains a neutral facial expression, and a "reunion" episode in which the adult resumes normal interaction. During the SFP, the infant sat in a bouncing chair on the floor and the mother sat on the floor. The researcher remained outside the room, giving two knocks on the door to signal the start/end of each still-face episode. In this study, episode 1 (baseline interaction) was 3 min, episode 2 (still face) was 90 s, and episode 3 (reunion) was 2 min. At 12-month postpartum, participants returned to the same community-based parenting research center for the Time 3 assessment. During this assessment, mothers completed the Short Temperament Scale for Infants (STSI; Carey & McDevitt, 1978; Sanson et al., 1987). At the three assessments, additional measures not reported here were also collected (for details see: Eapen et al., 2014; Kohlhoff et al., 2017; Kohlhoff et al., 2021; Mehta et al., 2016).

2.3 | Measures

Maternal depression. Maternal depression symptom severity at the Time 1 assessment was assessed using the EPDS (Cox et al., 1987). The EPDS is a widely used and validated 10-item self-report scale originally designed for use in the postnatal period but also validated for use during pregnancy (Levis et al., 2020). Respondents rate the severity of 10 different depression symptoms in the preceding 7 days on a 4-point scale; higher scores indicate greater depression symptoms.

Maternal oxytocin. Maternal blood samples collected at the Time 1 assessment were analyzed at Max Plank Institute of Psychiatry, Munich, Germany, using the radioimmunoassay (RIA) method. Blood samples were collected in vacutainer tubes and centrifuged at 3000 RPM for 10 min. Plasma was then pipetted and stored at −20°C until extraction, at which time 20-mg heat-activated (700uC) LiChroprep Si 60 (Merck) in 1-mL distilled water was added to each sample, mixed for 30 min, and centrifuged. Pellets were then washed with distilled water and 0.01-N acidic acid and mixed in 60% acetone to elide the neuropeptide. Evaporated extracts were kept at −20°C. Assay buffer (0.05 mL) was added and oxytocin was assessed using a radioimmunoassay. Antibody (0.05 mL) and l-labeled tracer (0.01 mL) were added to each aliquot and after a 3-day incubation period, unbound radioactivity was precipitated by activated charcoal. All evaporated plasma extracts were treated identically. The detection limit was in the 0.5-pg/sample range and antiserum cross-reactivity was <0.7%.

Adult attachment style. Maternal adult attachment style was assessed at the Time 2 assessment using the ASQ (Feeney et al., 1994). The ASQ is a validated 40-item self-report scale designed to assess adult attachment style. For each item, respondents report their feelings and behavior in close interpersonal relationships on a 6-point scale. The items load onto three subscales, "Security," "Anxiety," and "Avoidance"; higher subscale scores indicate greater attachment security anxiety and avoidance, respectively. The Anxiety and Avoidance subscales were used in the current study.

Maternal caregiving behaviors. Maternal behaviors were coded from video recordings of the free play episode of the SFP at the Time 2 assessment using the Global Rating Scales of Mother–Infant Interaction (GRS; Gunning et al., 1999). The GRS's reliability and validity have been demonstrated in multiple studies, for example, in an early study conducted by the GRS developers examining mother–infant interaction differences among women with and without postnatal depression, high intraclass coefficients between independent coders were reported (ICC > .88) (Murray et al., 1996). In a study examining correlations between GRS scales and scores on the Home Observation for the Measurement of the Environment (HOME) (Caldwell & Bradley, 1984), the GRS's concurrent validity was demonstrated (Gunning et al., 2004). In the current study, scores on the maternal good-to-poor scale for the

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first episode of the SFP (baseline interaction) were used. The maternal good-to-poor scale comprises five global dimensions assessed using five-point, bipolar scales: (i) warm/affectionate–cold/hostile, (ii) accepting–rejecting, (iii) responsive–unresponsive, (iv) nondemanding–demanding, and (v) sensitivity–insensitivity. Scores for each dimension are averaged and summed to yield a total score, with higher scores indicating "better" or more sensitive maternal caregiving. The coding was conducted by a coder who was masked to participants' scores on all study variables; 10% of cases were recoded by a secondary masked coder (intraclass correlation coefficient = .73).

Infant temperament. Infant temperament was assessed at the Time 3 assessment using the Short Infant Temperament Questionnaire (SITQ; Sanson et al., 1987). The SITQ is a 29-item parent-report scale designed to assess aspects of temperament in early childhood. It was developed as a shorter version of the longer 95-item Revised Infant Temperament Questionnaire (Carey & McDevitt, 1978), and has been shown to have a sound factor structure and to be internally consistent and reliable (Sanson et al., 1987). For each item, parents report on the child's behavior on a 6-point scale, and the items load onto five subscales, "Approach" (high score = shy, not approaching), "Rhythmicity" (high score = less rhythmic), "Cooperation-Manageability" (high score = less cooperative), Activity–Reactivity (high score = more active/reactive), and "Irritability" (high score = more irritable). A composite Easy–Difficult Scale score can also be calculated (mean of the Approach, Cooperation-Manageability, and Irritability scales; higher score = more difficult temperament). The SITQ Easy–Difficult Scale score was used in the current study.

Control variables. Several variables were also included in the analysis due to their potential association/impact on the key study variables. These variables were all self-reported and included: demographic variables (mother age, ethnicity, education, relationship status; child sex), obstetric factors (number of weeks pregnant at the time of recruitment), and psychological/medication-based factors (anti-depressant medication use at the time of recruitment, maternal depression at T2 and T3, assessed using the EPDS).

2.4 | Analysis

The variables of interest came from three data collection timepoints: Time 1 (T1; maternal oxytocin and maternal depression assessed using the EPDS), Time 2 (T2; maternal self-rated anxious and avoidant attachment styles assessed using the ASQ, maternal sensitivity assessed using the GRS), and Time 3 (T3; "difficult" infant temperament as rated using the SITQ). As an initial step, bivariate correlations were conducted to examine associations between the main study variables and identify potential covariates for the regression analyses (e.g., demographic variables and adult separation anxiety assessed during pregnancy using the ASA-27).

To test the first study hypothesis that higher levels of maternal depression symptom severity and lower levels of maternal oxytocin during pregnancy would predict a more "difficult" infant temperament at 12 months, a hierarchical multiple regression was conducted with difficult infant temperament assessed at T3 as the Dependent Variable (DV). Independent Variables (IVs) were entered into the model in three sequential steps, as follows: *Step 1*-control variables (included on the basis of being part of the recruitment/sample stratification, i.e., ASA-27 score, OR a demographic variable having a significant correlation with the DV or an IV: maternal age, number of weeks pregnant at T1, maternal ethnicity, education); *Step 2*–T1 variables: maternal depression and maternal oxytocin at T1; *Step 3*–T2 variables: adult attachment avoidance, adult attachment anxiety, maternal depression, and maternal postnatal caregiving sensitivity; *Step 4*–T3 variable: maternal depression at T3 (Table 1).

Nonparametric bootstrapping analyses on 5000 samples (Preacher & Hayes, 2004; Preacher et al., 2007) were used to test the second study hypothesis that attachment avoidance attachment anxiety, and maternal sensitivity would mediate the relations between maternal depression during pregnancy and difficult infant temperament, and between maternal oxytocin during pregnancy and difficult infant temperament (with all other variables being free to vary). Mediation was considered significant at $p < .05$ if the 95% Bias Corrected and accelerated confidence intervals for the indirect effect did not include zero. All analyses were performed in SPSS version 28.

3 | RESULTS

At T1 (pregnancy), 15.2% of the sample scored above the threshold for major depression on the EPDS (total score 13 or more), with a mean EPDS score of 6.78 (SD 5.05, range 0–24). At T2 (3.5 months postpartum), 11.6% scored 13 or more (mean 5.67, SD 5.11, range 0–20) and at T3 (12 months postpartum), this rate had reduced to 10.4 (mean 5.62, SD 4.96, range 0–19).

Correlational analysis (Table 1) showed that a more difficult infant temperament at T3 was associated with non-Caucasian ethnicity, being university-educated, having an avoidant attachment style, and maternal depression at T2 and T3. Maternal depression at T1 was associated with being university-educated, higher levels of adult

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TABLE 1 Correlations and descriptive statistics.

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1. Mother age at T1	1.00															
2. Child sex (male)[a]	−.162	1.00														
3. Mother ethnicity (Caucasian)[b]	−.095	−.126	1.00													
4. Mother education (university educated)[c]	.165	.029	−.242*	1.00												
5. Mother relationship status at T1 (partnered)[d]	−.021	.022	−.235	.198*	1.00											
6. Weeks pregnant at T1	.160	.046	−.037	.066	.026	1.00										
7. Maternal oxytocin at T1	.134	.071	.082	.027	.071	.163	1.00									
8. Adult separation anxiety (ASA-27 total) at T1	−.070	.096	−.175	.155	−.034	.118	.035	1.00								
9. Maternal depression (EPDS total) at T1	.047	.185	−.113	.203*	−.124	.022	.038	.748**	1.00							
10. Avoidant adult attachment (ASQ—avoidance subscale) at T2	.142	−.049	−.259**	.129	−.144	.142	−.055	.484**	.386**	1.00						
11. Anxious adult attachment (ASQ—Anxiety subscale) at T2	.151	−.082	−.037	.167	−.138	.220*	.029	.394**	.401**	.638**	1.00					
12. Maternal sensitivity (GRS-sensitivity scale) at T2	.210*	.053	.193*	−.100	−.142	.226*	.108	−.070	−.057	−.028	.223	1.00				
13. Maternal depression (EPDS total) at T2	.221*	−.909	−.071	.134	−.161	.237*	.102	.487**	.530**	.464**	.531**	.032	1.00			
14. Difficult child temperament (SITQ—Easy difficult scale) at T3	.146	.020	−.341**	.224*	.073	.038	.118	.169	.169	.265*	.117	−.126	.257*	1.00		
15. Maternal depression (EPDS total) at T3	.146	−.150	−.144	.336**	−.101	.192*	.011	.538**	.406**	.419**	.457**	−.097	.642**	.212*	1.00	
16. Antidepressant use at T3[e]	.256**	−.129	.213*	−.077	−.143	.065	.160	.290**	.302*	.145	.146	.112	.215**	.017	.333**	1.00
Mean (SD)/%	29.83 (5.62)	48.20	48.20	38.60	90.40	20.77 (6.4)	28.65 (21.00)	22.13 (14.15)	6.78 (5.05)	2.99 (.72)	2.93 (.78)	3.94 (.45)	5.67 (5.00)	2.94 (.65)	5.62 (4.96)	7.00
Range	20–47	–	–	–	–	8–38	4.80–107.00	0–62	0–24	1.60–4.47	1.38–4.54	3–5	0–20	1.42-5.12	0–19	–

[a]Coded as male = 1, female = 0.

[b]Caucasian = 1, other = 0.

[c]University educated = 1, not university educated = 0.

[d]Partnered = 1, single = 0; T1 = Time 1 (pregnancy).

[e]Yes = 1, no =

Abbreviations: ASA-27 = Adult attachment Anxiety—27 item scale; ASQ, Attachment Style Questionnaire; EPDS, Edinburgh Postnatal Depression Scale; GRS, Global Rating Scale; SITQ, Short Infant Temperament Questionnaire; T2 = Time 2 (3 months postpartum); T3 = Time 3 (12 months postpartum).

*$p < .05$.

**$p < .001$.

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separation anxiety at T1, higher levels of attachment anxiety and avoidance, maternal depression at T2 and T3, and antidepressant use at T3. Maternal oxytocin at T1 was not significantly associated with any of the other study variables. Avoidant attachment was associated with higher levels of separation anxiety at T1, and depression at T1–T3. Anxious attachment was associated with greater gestational age at T1, adult separation anxiety at T1, and maternal depression at T2 and T3. Maternal sensitivity at T2 was associated with older mother age, being Caucasian, and greater gestational age at T1. In addition, non-Caucasian ethnicity was associated with not being university-educated, attachment avoidance, and antidepressant use at T3. Being university-educated was associated with being partnered, and higher levels of maternal depression at T3. Greater gestational age at T1 was associated with maternal depression at T2 and T3.

The regression model (DV: difficult infant temperament; Table 2) accounted for 15.9% of the variance in Step 1, 18.1% in Step 2, 22% in Step 3, and 22% when the full model was applied in Step 4. The only significant independent predictor of difficult infant temperament, at any step, was non-Caucasian ethnicity; $p < .05$ at all steps. Thus, in contrast to the hypothesis, higher levels of maternal depression and lower levels of maternal oxytocin during pregnancy did not predict a more "difficult" infant temperament at 12 months.

Bootstrapped mediation analyses were performed to test whether, when all other variables were free to vary, adult attachment avoidance, adult attachment anxiety, or maternal sensitivity mediated an association between maternal depression during pregnancy and difficult infant temperament. Results showed the direct effect of maternal depression during pregnancy on difficult infant temperament to be nonsignificant, $b = .01$, SE = .01, $p = .453$ and the indirect effect to be significant, $b = .01$, SE = .01, 95% CI [.001, .026]. Results were thus consistent with a full mediation model such that higher levels of maternal depression during pregnancy predicted a difficult infant temperament, mediated by higher levels of attachment avoidance.

For adult attachment anxiety and maternal sensitivity, results showed nonsignificant direct effects (adult attachment anxiety: $b = .02$, SE = .01, $p = .168$; maternal sensitivity: $b = .02$, SE = .01, $p = .072$) and nonsignificant indirect effects (adult attachment anxiety: $b = .00$, SE = .00, 95% CI [−.007, .012]; maternal sensitivity: $b = .00$, SE = .00, 95% CI [−.002, .007]). This suggested that neither adult attachment anxiety nor maternal sensitivity mediated the association between maternal depression during pregnancy and difficult infant temperament.

Finally, regarding the question of whether adult attachment avoidance, adult attachment anxiety or maternal sensitivity mediated the association between maternal oxytocin during pregnancy and difficult infant temperament, results showed nonsignificant direct effects (adult attachment avoidance: $b = .4.66$, SE = 3.32, $p = .163$; adult attachment anxiety: $b = .3.78$, SE = 3.24, $p = .246$; maternal sensitivity: $b = 5.15$, SE = 3.33, $p = .124$) and nonsignificant indirect effects (adult attachment anxiety: $b = -.79$, SE = 1.07, 95% CI [−3.24, 1.01]; adult attachment anxiety: $b = .010$, SE = .515, 95% CI [−.906, 1.236]; maternal sensitivity: $b = -.56$, SE = .00, 95% CI [−2.19, .742]). This suggested that neither adult attachment avoidance, anxiety, or maternal sensitivity mediated the association between maternal oxytocin during pregnancy and difficult infant temperament.

4 | DISCUSSION

This study examined the associations between maternal depression and oxytocin during pregnancy, observed parenting and self-reported adult attachment style at 3-month postpartum, and parent-reported infant temperament at 12-month postpartum. The major findings of the study were that (1) neither antenatal depression nor oxytocin predicted difficult infant temperament; (2) non-Caucasian ethnicity predicted difficult infant temperament; and (3) adult attachment avoidance mediated the association between antenatal depression and difficult infant temperament.

The failure to find a significant association between maternal antenatal depression and difficult infant temperament contrasts with data from previous samples (Austin et al., 2005; McGrath et al., 2008; Nomura et al., 2019; Planalp & Goldsmith, 2020). This association was, however, close to significance in the mediation analysis ($p = .08$), when all other variables were free to vary, suggesting that with larger samples (and greater power), significance may have been attained. Future studies with larger numbers of participants should be conducted to test this further as evidence of links between maternal antenatal depression and difficult infant temperament would reinforce the well-acknowledged importance of providing support and treatments for women suffering depression during pregnancy (Curry et al., 2019).

Contrary to expectation, we also did not find a significant association between maternal antenatal oxytocin level and infant temperament, either directly or indirectly through adult attachment style or observed parenting. In a number of previous studies, maternal antenatal oxytocin has been shown to be associated with aspects of parenting in the postnatal period (Carter, 2017; MacDonald & MacDonald, 2010; MacKinnon et al., 2018; Scatliffe et al., 2019; Swain et al., 2014), and it is possible that aspects of our study design may have contributed to the null results.

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TABLE 2 Hierarchical multiple regression, dependent variable: difficult infant temperament.

Independent variables	Dependent variable: difficult infant temperament							
	Step 1		Step 2		Step 3		Step 4	
	β	*p*	*β*	*p*	*β*	*p*	*β*	*p*
Adult separation anxiety at T1	.107	.266	.042	.781	−.076	.641	−.088	.612
Mother age (years)	.110	.249	.084	.384	.044	.669	.042	.682
Weeks pregnant at T1	.003	.974	−.012	.902	−.025	.801	−.026	.797
Maternal ethnicity	−.258	.009*	−.275	.006*	−.226	.029*	−.227	.029*
Maternal education	.154	.115	.146	.139	.141	.157	.135	.200
Maternal depression at T1			.074	.623	.049	.749	.056	.723
Maternal oxytocin at T1			.142	.137	.145	.133	.147	.131
Avoidant adult attachment at T2					.157	.244	.157	.246
Anxious adult attachment at T2					−.109	.409	−.112	.400
Maternal sensitivity at T2					−.071	.480	-.068	.497
Maternal depression at T2					.192	.136	.179	.209
Maternal depression at T3							.029	.831
R^2	.159		.181		.220		.220	
F (full model)	$F(5, 104) = 3.738$, $p = .004$*		$F(7, 104) = 3.052$, $p = .006$*		$F(11, 104) = 2.382$, $p = .012$*		$F(12, 104) = 2.165$, $p = .020$*	

*$p < .05$.

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For example, there are different ways of assessing oxytocin: in our study, we assessed peripheral oxytocin in blood, analyzed using the RIA method, whereas in other studies alternative methods have been used (e.g., Galbally and colleagues used the ELISA method). Regarding observed parenting, in our study, we studied maternal sensitivity using the GRS "good-to-poor" scale, whereas other studies have focused on hostility and warmth (Julian et al., 2018), gaze and synchrony, or parental representations, for example, of parent–infant bonding (Shorey et al., 2023). While parenting sensitivity did not emerge as a significant components of the model in this study, it is possible that in future investigations using different assessment methodologies, or measuring slightly different constructs, and conducted in different samples (i.e., clinical rather than community samples) a different result may emerge. Taken together, our results failed to show an association between maternal antenatal oxytocin levels and infant temperament, either directly or indirectly through adult attachment style or observed parenting. Nevertheless, given the small number of studies in this area, as well as the different measurement tools and time points used in the available studies, more studies are needed to further understand associations between these variables.

The emergence of non-Caucasian ethnicity as a significant predictor of difficult infant temperament was an unexpected finding. The finding does, however, align with evidence from several previous studies showing significant associations between ethnicity and infant temperament (de Boo & Kolk, 2007; Kyrios et al., 1989; Oberklaid et al., 1986). This could reflect cultural differences in parenting behaviors and practices, differences in the ways in which parents report/interpret infant temperament, or a lack of cross-cultural validity for the measures utilized in this study. Future studies should be conducted to test, or control for these possibilities (e.g., include objective ratings of temperament from childcare providers). In addition, in Australia, like in many countries, individuals from ethnic minorities tend to be more socially disadvantaged, and so it is also possible that being non-Caucasian was a proxy in this study for other indicators of social and economic disadvantage that were not measured. It is also possible that the way that ethnicity was assessed/categorized (i.e., participants self-identified themselves as Caucasian vs. non-Caucasian) impacted results and that other indices of ethnicity (e.g., language spoken at home or country of birth), or that subgroup analysis comparing different ethnic groupings (e.g., Indian, Arabic, etc.) may have yielded different results.

While adult attachment avoidance did not emerge as a significant predictor of difficult infant temperament in the hierarchical regression analysis, the finding of an association between these variables in the correlation analyses is of note. Previous studies have documented links between self-reported adult attachment insecurity and difficult child temperament (Pesonen et al., 2004; Priel & Besser, 2000), but the number of studies in this area is minimal and the studies that have been conducted have been cross-sectional, involving only one time point. The current results therefore contribute to understanding in this area as they document an association between attachment insecurity assessed in the early postpartum period and difficult infant temperament at 12 months of age. In thinking about the meaning of this result, we note the many previous studies that have documented links between avoidant attachment styles in the postpartum period and a range of parenting variables including higher levels of parenting stress and lower levels of parenting satisfaction (Rholes et al., 2006), parenting confidence/self-efficacy (Ko et al., 2019; Kohlhoff & Barnett, 2013), withdrawn/remote caregiving (Jones et al., 2015; Rholes et al., 1995), and poorer caregiving sensitivity and responsiveness to infant distress (Edelstein et al., 2004). Theoretically, these relations can be understood as resulting from the avoidant parent's tendency to avoid close personal/intimate relationships—a pattern with potential repercussions for the parent's own well-being, with impacts on parenting (i.e., by distancing themselves from other adult relationships, they may miss opportunities to receive emotional and practical support related to the demands of new parenthood). Importantly, however, the tendency to avoid closeness in relationships is likely to also have impacts on the parent–infant relationship (i.e., by avoiding closeness and intimacy with the infant, the parent–child dyad becomes distant or emotionally nonattuned), and ultimately the infant (i.e., the infant develops compensatory strategies to cope with his/her parent's avoidance, expressed/perceived as temperamental "difficulty"). While a range of additional factors are likely to be at play in the determination of infant temperament (e.g., genetic and biological factors, parental postnatal mood, and other caregiving characteristics), with current results also raising the role of culture/ethnicity, the fact that adult attachment avoidance was associated with difficult infant temperament in this study is important because it highlights a potentially valuable route/focus for intervention and prevention of behavioral difficulties in early childhood. Clearly, the fact that this result emerged in the correlational analysis but not the regression, suggests that further investigations, with a particular focus on ethnicity, are warranted.

Finally, the finding that maternal attachment avoidance mediated the association between maternal antenatal depression and difficult infant temperament is significant as it suggests that attachment-informed interventions focusing on challenging and re-organizing attachment representations among expectant or new parents' may be of

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particular benefit to the child, particularly for women who experience antenatal depression and who have an avoidant attachment style. It is of note that maternal antenatal depression was not associated with difficult infant temperament in the regression analysis (typically referred to as the "c-path"). Various experts have suggested, however, that a significant c path should not be a requirement in mediation models, particularly in cases where there is a priori belief that the effect size is likely to be small or when suppression is a possibility (Collins et al., 1998; MacKinnon & Fairchild, 2009; Shrout & Bolger, 2002; Sidhu et al., 2021). Future studies with larger samples are thus warranted to confirm this result.

This study had several strengths including the assessments conducted at different time points and the use of well-validated measures, but limitations are acknowledged. First, the fact that the study sample was progressively recruited to include an equal number of participants with low and high levels of adult separation anxiety means that the sample is not representative of a general population. To address this issue, we controlled for adult separation anxiety in our analysis. Further studies are required, however, to confirm our results in a normal community sample. Second, our study included only a limited number of variables, which meant that we could not account for the impact of other potentially relevant variables (e.g., genetics, child oxytocin, parenting style, maternal anxiety, and additional demographics including income). The AQS security scale was also not included in our analysis, and while our results were able to show whether attachment avoidance and attachment anxiety were associated with infant temperament, it is possible that the inclusion of the attachment security scale may have provided important new insights. Also, the fact that maternal depression severity was assessed at discreet time points (T1–T3) means that additional and potentially relevant features of participant's experience of perinatal depression were not able to be accounted for, for example, time of depression onset, episode duration, and the presence of recurrent episodes, may have all had an impact. Also, while the mother/child dyads were assessed at different time points, the same measures were not administered at all time points. This means that it was not possible to control for start points and look at change over time, allowing us to make inferences about causal relationships. Third, the use of RIA for oxytocin analysis whereas most recent studies are now using the ELISA method. At the time of data collection, the RIA method was common practice in the field (Kim et al., 2014). Finally, the use of parent-reported measures to assess antenatal depression, adult attachment style, and infant temperament is a study limitation. Parent-report questionnaires can be subject to reporter bias (e.g., mothers with depression may be more likely to rate their children's temperament as more difficult). All the measures used in this study have good psychometric properties, but the study results should still be interpreted with this limitation in mind.

Taken together, the results of this study highlight the potential value of providing interventions or additional support in the perinatal period for women from non-Caucasian backgrounds, and for pregnant women with depression, or who are at risk of depression, particularly those who present with avoidant attachment styles. Future studies should be conducted with larger samples, with a broader range of measures, and using newer methods of oxytocin analysis and sampling (e.g., urine, saliva).

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID

Jane Kohlhoff https://orcid.org/0000-0001-6202-6685

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