**Maternal-infant bonding and perceptions of infant temperament: The mediating role of maternal mental health.**

**ABSTRACT**

**Background:**There are associations between maternal mental health (anxiety and depression), maternal-infant bonding, and infant temperament. However, few studies have examined these variables simultaneously, and none have applied a parallel mediation analysis to consider maternal mental health as an explanatory variable. We aimed to examine these relationships, and whether mental health (anxiety and/or depression) mediates the observed association between maternal-infant bonding and infant temperament.

**Methods:**Mothers with babies between zero and twelve months (N=527) were recruited to a cross-sectional online survey containing a battery of psychometric measures.

**Results:**Correlation analyses examined relationships between the predictor (maternal-infant bonding), outcome (infant temperament), and mediator (maternal mental health; anxiety and/or depression).  All associations were highly significant (p<.001). A parallel mediation (anxiety and/or depression) model was conducted, showing a significant indirect effect of maternal-infant bonding on infant temperament through anxiety, B = .04 (SE= .01) 95% CI= .01 to .07, but not through depression.

**Limitations:**Homogeneous sampling was an issue with mainly UK, married mothers, with higher socio-economic status and educational attainment participating. Therefore, further replication in diverse samples is required.

**Conclusion:**Associations were identified between maternal-infant bonding, infant temperament, and maternal mental health (anxiety and depression). However, only anxiety mediated the relationship between bonding and temperament. Healthcare professionals should consider the role of maternal anxiety when working with mothers who present with relational issues or report their infant as excessively challenging. These results signify the need to address maternal anxious and depressive symptoms as distinct issues considering their differential effects on parenting behaviour.

**Highlights:**

* Poor maternal mental health can negatively impact bonding and infant temperament
* A significant indirect effect of bonding on infant temperament via anxiety was found
* However, this effect did not occur with depression
* Results indicate the need to address anxious and depressive symptoms as distinct issues
* Results confirm that anxiety and depression have differential effects on parenting and infant behaviours

**Keywords:**

MATERNAL MENTAL HEALTH, POSTPARTUM ANXIETY, POSTPARTUM DEPRESSION, MATERNAL-INFANT BONDING, INFANT TEMPERAMENT, MEDIATION

**INTRODUCTION**

***Maternal-Infant Bonding***

Mothers and infants often have an innate physiological, psychological, and emotional bond. This connection between mother and infant can be termed maternal-infant bonding (Edwards, Phillips, Esterman, Buisman-Pijlman & Gordan, 2017). The formation of this bond is a physiological and psychological need of the infant, instrumental in providing comfort and security (Perrelli, Zambaldi, Cantilino & Sougey, 2014). Bonding represents the maternal dimension of a reciprocal emotional attachment between the primary caregiver and the infant, which begins in pregnancy and is continuously developed throughout the early years of childhood (Fallon, Silverio, Halford, Bennett & Harrold, 2019). It can be impacted by numerous influences which are integral to a normal growth trajectory in both a child’s well-being and their development (Johnson, 2013). Infants have an innate need to interact with those around them, and during early life their survival is entirely reliant upon their primary caregiver who is responsible for safeguarding, nourishing, and nurturing them (Mäntymaa et al., 2006).

It is now understood maternal-infant bonding develops more progressively due to continuous contact and interaction over the course of infancy (Johnson, 2013). In some instances, mothers can experience difficulties generating and/or directing the required warmth and affection towards their infant; referred to as impaired or disordered maternal-infant bonding (Brockington, Macdonald, & Wainscott, 2006), and is characterised by feelings of irritability, hostility, or rejection towards the infant (Hornstein et al., 2006). The maternal-infant bond is considered to be a reciprocal process with infants making eye contact and facial expressions, or crying to encourage maternal interaction and maternal-infant bonding (Figueiredo, Costa, Pacheco, & Pais, 2009). There are numerous factors which can alter and influence maternal-infant bonding. Some can arise from the infant such as prematurity, sleep or health problems, or irritable temperament; whereas others can originate from the mother such as attachment style, availability of social support, and physiological or psychological health (Bienfait et al., 2011).

***Maternal-Infant Bonding and Infant Temperament***

The quality of the maternal-infant bond is thought to directly influence both maternal and infant mental health. It is therefore necessary for this relationship to be intimate, affectionate, and continuous, ensuring it enables both mother and infant to derive pleasure and security. There is a wealth of literature which supports the importance of the role maternal sensitivity plays in developing and maintaining these close and strong bonds (Kobak & Madsen, 2008; Laible, Carlo & Roesch, 2004). Maternal sensitivity can be defined as the extent to which a mother correctly understands and responds to her infant’s cues, in an appropriate and prompt manner, and has been consistently linked to multiple domains of infant and child development (Deans, 2020). Others, such as Landry, Smith, and Swank (2006), propose sustained proximity and responding to an infant in an appropriate and supportive manner can decrease exposure to stress and subsequently impact brain development, while improving the infant’s ability to emotionally self-regulate; which, in turn, aids mental health in later-life.

Considering the effects of maternal sensitivity on early emotion regulation, it is important to understand how maternal responsiveness may be related to infant temperament. Infant temperament is recognised as individual characteristics that determine an individual’s affective state and behavioural regulation (Chess & Thomas, 2013). Although early work suggested infant temperament to be inherent and stable across both time and circumstances, however others have suggested it is more of a fluid, experiential construct, which adapts throughout development (Rothbart & Ahadi, 1994; Gartstein & Hancock, 2019).

Infant temperament has been defined as the biological individual differences in both reactivity and self-regulation, which is influenced by genetics, experiences and maturation (Chess & Thomas, 2013; Rothbart & Ahadi, 1994). Reactivity relates to the level of arousal displayed through cognitive, motor, and emotional reactions in terms of intensity or inactivity, and self-regulation relates to the ability to modulate reactions. As a child matures, emotional reactivity appears to progressively become more self-regulated as a consequence of neurophysiological development and the advancement of cognitive abilities (Thompson, 1991). Therefore, if difficult infant temperament is considered to be a common developmental milestone resulting from immature brain structures and environmental adjustment, it may suggest that the difficult dimensions of infant temperament are merely due to the subjective maternal perceptions of infant temperament as opposed to the objective infant’s behavioural characteristics.

***Maternal Mental Health and Bonding***

Postpartum depression [PPD] refers to a non-psychotic, debilitating, and long-lasting illness, which affects up to 15% of mothers (Pearlstein, Howard, Salisbury, & Zlotnick, 2009). There is compelling evidence suggesting maternal-infant relationships are one of the most important psychological processes during the postnatal period (Brockington, Macdonald, & Wainscott, 2006). Consequently, disturbances to this relationship can have a negative impact on the well-being of the mother (Reck et al., 2006). However, symptoms associated with an impaired maternal-infant bond have been discovered to be present in a high proportion of mothers who have already received a diagnosis of PPD (Klier, 2006; Nonnenmacher, Noe, Ehrenthal, & Reck, 2016) and also within sub-clinical populations (Tietz, Zietlow, & Reck, 2014), indicating bi-directionality in this relationship.

Historically, depressive symptoms have been the focal point of maternal mental health literature with limited research addressing other mental health conditions. However, recent evidence has found anxiety to occur independently, and at a higher rate than depression during the postnatal period (Paul, Downs, Schaefer, Beiler, & Weisman, 2013) with negative outcomes for the infant (Glasheen, Richardson, & Fabio, 2010). Although some levels of anxiety are adaptive in the perinatal period, when postpartum anxiety [PPA] becomes irrational or excessive, it can reduce parenting self-efficacy, which may undermine the ability to respond and care for their infant effectively (Hartman & Belsky, 2018). However, the available literature provides inconsistent findings suggesting PPA either negatively affects bonding (Kaitz, Maytal, Devor, Bergman, & Mankuta, 2010), or is of no significance to the maternal-infant relationship (Murray, Cooper, Creswell, Schofield, & Sack, 2007). It is however, important to note that more recent research, using a childbearing-specific measure of anxiety, suggests higher levels of PPA are associated with impaired maternal-infant bond (Fallon, Silverio, Halford, Bennett & Harrold, 2019), which may reflect previous issues in the measurement of PPA, rather than the relationship between infant bonding and PPA being unclear.

Depression and anxiety are often accepted as interlinked conditions with many mothers diagnosed with PPD thought to also present with co-morbid PPA symptomatology. Depression and anxiety share a common element of distress; however, they are fundamentally dissimilar in terms of symptomology and outcomes (Matthey, Barnett, Howie, & Kavanagh, 2003), such as anhedonia (for PPD) and hyperarousal (for PPA). With regards to the impact on maternal-infant bonding, PPD can negatively impact physical caregiving and maternal responsiveness through various behaviours such as continued lack of positive emotions, loss of interest in activities and others or thoughts of wanting to harm oneself or their infant (Chew-Graham, Sharp, Chamberlain, Folkes, & Turner, 2009). Conversely, PPA does not appear to impact the maternal-infant bond in the same manner due to the fact anxieties are usually infant focused which prompts a maternal response, albeit an exaggerated one (Brockington, Macdonald & Wainscott, 2006).

***Infant Temperament and Maternal Mental Health***

The relationship between infant temperament and maternal mental health (anxiety and depression) remains comparatively under-researched. However, there is evidence to suggest mothers who perceive their infant to be unadaptable and unpredictable (including excessive crying) are more likely to experience depressive symptoms or demonstrate increased maternal distress (Moehler, Brunner, Wiebel, Reck & Resch, 2006; Wolke, Gray, & Meyer, 1994). Additionally, Field et al., (2003) report mothers with lower levels of dopamine and serotonin had infants that also had lower levels of dopamine and serotonin and higher levels of cortisol and norepinephrine, which may provide biological explanation for the relationship. Further research has shown mothers with depressive symptoms felt they had fewer positive maternal-infant exchanges than mothers without depressive symptoms and that mothers with depression noted more difficult infants in comparison to non-depressed mothers (McGrath, Records, & Rice, 2008). These findings are reinforced by work which highlights maternal depression having negative implications for infant temperament, emotionality, and behaviour (Britton, 2011; Morelen, Menke, Rosenblum, Beeghly & Muzik, 2016; West & Newman, 2003). However, another potential explanation for the association between difficult infant temperament and negative maternal mood may arise from a mother’s feelings of self-efficacy. Caring for a difficult infant can potentially lead to the gradual attenuation of the mother’s feelings of competence and subsequently influence maternal affective state resulting in feelings of inadequacy and depression (Leerkes & Crockenberg, 2002). It is important to consider postnatal mental health independently from prenatal mental health as previous work has found differential effects of pre- and post-natal mental health on infant temperament (Della Vedova, 2014).

It is apparent maternal-infant bonding and infant temperament are intrinsically connected via bi-directional associations, and therefore the maternal-infant relationship can be viewed as transactional in nature (Tikotzky, 2016). However, the available literature suggests maternal mental health (anxiety and depression) plays a significant role in both maternal perceptions of infant temperament and aspects of the maternal-infant bond. Therefore, it is conceivable that maternal mental health (anxiety and/or depression) may be a mediating variable. Furthermore, while there is an abundance of literature focusing on the impact of PPD on bonding, there is limited research regarding PPA and how it relates to perceptions of infant temperament.

***Aims***

This study aimed to firstly examine the relationships between maternal mental health (anxiety and depression), maternal-infant bonding, and infant temperament, and secondly investigate whether mental health (anxiety and/or depression) mediated the observed association between maternal-infant bonding and infant temperament. We therefore propose that maternal mental health (anxiety and/or depression) will mediate the relationship between the maternal-infant bond and infant temperament.

**PARTICIPANTS, ETHICS, AND METHODS**

***Participants***

Mothers (N= 527) of infants aged between birth and twelve months of age were recruited via social media platforms such as Facebook and Twitter to complete an on-line questionnaire hosted on Qualtrics survey platform. Participants were predominately from the UK (94%), married (62%), employed in a professional occupation (41%), university level educated (45%), and homeowners (67%). Additionally, 17% of mothers had a clinical diagnosis of anxiety and 14% had a clinical diagnosis of depression (see *Table 1 f*or demographic characteristics).

**<INSERT TABLE 1 HERE>**

***Ethics***

This study received ethical approval from the University Research Ethics Committee (ref: IPHS/2014). Prior to commencing the survey, participants were asked to read an information sheet and electronically sign a consent form. Following this, participants were required to answer whether they were a mother to an infant aged between birth and twelve months. Those answering ‘Yes’ were permitted to enter the main questionnaire, whilst those who were ineligible were screened to an exit message. A full electronic debrief was provided on completion.

***Design and Procedure***

A battery of measures was administered to a cross-sectional population of participants comprising of background demographic characteristics, as well as the following validated psychometric scales: Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden & Sagovsky, 1987); Postpartum Specific Anxiety Scale (PSAS; Fallon, Halford, Bennett & Harrold, 2016); Postpartum Bonding Questionnaire (PBQ; Brockington, Fraser & Wilson, 2006); and Revised Infant Temperament Questionnaire (RITQ-10; Carey & McDevitt, 1978).

***Measures***

*Demographics*

Maternal and infant characteristics were examined at the beginning of the survey including maternal and infant age, country of residence, marital status, occupational prestige, educational attainment, size of household, household ownership status, current diagnosis of anxiety or depression. Background information regarding birth order, gestational age at birth, multiple birth, and feeding practices were additionally determined (see *Table 1*).

*Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden, & Sagovsky. 1987).*

The EPDS is a 10-item measure developed to assess and identify possible symptoms of depression during the postpartum period. Participants are required to answer each question with reference to the last seven days. Each answer is given a score of 0 to 3. The maximum score is 30 and a score of 15 or above may indicate a high probability of clinical depression. Additionally, endorsement of item 10 suggests a possible risk of self-harm. Internal reliability in the current sample was shown to be good, McDonald’s ω= .93.

*Postpartum-Specific Anxiety Scale (PSAS; Fallon, Halford, Bennett, & Harrold. 2016).*

The PSAS is administered to determine the frequency of maternal and infant-focused anxieties experienced during the past week. It is comprised of 51 items across four divergent constructs. ‘Competence and Attachment Anxieties’ (15 items) assess anxieties concerning maternal self-efficacy, parenting competence, and the mother-infant relationship. ‘Safety and Welfare Anxieties’ (11 items) measure fears about infant illnesses, accidents, and cot death. ‘Practical Baby Care Anxieties’ (7 items) examines anxieties relating to infant care such as feeding, sleeping, and general routine. ‘Psychosocial Adjustment to Motherhood’ (18 items) gauges postpartum adjustment anxieties such as management of personal appearance, relationships and support, work and finances and sleep. Each answer is given a score of 1 to 4 with the maximum score being a total of 204, and initial validation demonstrated a score of 112 or above may be indicative of a clinical level of anxiety. Internal reliability was shown to be good, McDonald’s ω= .95.

*Postpartum Bonding Questionnaire (PBQ; Brockington, Fraser, & Wilson, 2006).*

The PBQ is a self-rating questionnaire comprising 25 items designed to measure the maternal-infant relationship. Participants are required to respond to each statement on a six-point Likert scale from ‘Always’ (5) to ‘Never’ (0), with the maximum score being 125. High scores indicate impaired bonding. Answers are categorised into four subscales. Factor 1 (12 items) is a general component; factor 2 (7 items) assesses rejection and anger; factor 3 (4 items) is associated with infant-focused anxiety; and factor 4 (2 items) focuses on recognising risk of harm. The scores are summated for each factor with high scores indicating impaired bond. Internal reliability was shown to be good, McDonald’s ω= .97.

*Revised Infant Temperament Questionnaire (RITQ-10; Carey & McDevitt, 1978).*

The RITQ-10 consists of 10 items measuring nine dimensions: activity level, rhythmicity, approach to novelty, adaptability, emotional intensity, quality of mood, persistence, distractibility, sensory sensitivity; plus, one item on overall manageability. These categories demonstrate infant temperament with each statement relating to different forms of behaviour and emotional expression found within each dimension of temperament. Each item is scored on a 1 to 6 Likert scale with higher scores indicating difficult temperament. Internal reliability was shown to be acceptable, McDonald’s ω= .74.

***Method of Analysis***

A parallel mediation analysis for maternal mental health (anxiety and/or depression) was performed using PROCESS macro for SPSS 24. The significance of the indirect effects was tested using bootstrapping procedures. Unstandardized indirect effects were computed for each of 5,000 bootstrapped samples, and the 95% confidence intervals were reported.

**RESULTS**

Correlation analyses were initially conducted to investigate the associations between maternal-infant bonding, infant temperament, maternal mental health (anxiety and/or depression (see Table 2).

**<INSERT TABLE 2 HERE>**

***Parallel Mediation Analysis Assessing the Relationship Between Bonding on Temperament via Maternal Mental Health (Anxiety and/or Depression)***

A parallel mediation analysis was then conducted to test whether the relationship between maternal-infant bonding and infant temperament was mediated by maternal mental health (anxiety and/or depression). As Figure 1 demonstrates, the association between maternal-infant bonding and anxiety was statistically significant, as was the association between anxiety and infant temperament. Notably, there was an indirect effect of maternal-infant bonding on infant temperament through anxiety, B = .04 (SE= .01) 95% CI= .01 to .07.

Conversely, whilst relationship between maternal-infant bonding and depression was significant, there was no association between depression and infant temperament. Therefore, there was no indirect effect of maternal-infant bonding on infant temperament through depression, B < .01 (SE= .01) 95% CI= -.02 to .02 (see Figure 1).

There was a significant total effect (B = .18 (SE= .01) 95% CI= .16 to .22) between bonding and temperament and the direct effect (after controlling for maternal mental health) remained significant (B = .14 (SE= .02) 95% CI= .11 to .18) although was reduced.

**<INSERT FIGURE 1 HERE>**

**DISCUSSION**

The primary aim of the present study was to examine the relationship between maternal mental health (anxiety and depression), maternal-infant bonding, and infant temperament. We additionally examined whether maternal mental health (anxiety and/or depression) had a mediating effect on the relationship between maternal-infant bonding and infant temperament. Results were supportive of the hypothesis. Findings first demonstrated significant associations between impaired maternal-infant bonding and perceptions of difficult infant temperament. Then, significant associations were identified between impaired maternal-infant bonding and symptoms of negative maternal mental health (anxiety and depression). Next, a significant relationship was identified between symptoms of negative maternal mental health (anxiety and depression) and perceptions of difficult infant temperament. Finally, maternal mental health (anxiety and/or depression) was found to be a significant mediator of the relationship between maternal-infant bonding and infant temperament. However, symptoms of anxiety drove this mediation, whereas depressive symptoms did not.

Results from the individual correlations are largely concurrent with existing literature. First, impaired maternal-infant bonding was highly associated with perceptions of difficult infant temperament. This is supported by numerous studies which conclude the lack of emotional connection often characterised by impaired maternal-infant bonding can result in emotional and behavioural problems in infants and children (Britton, 2011; McGrath, Records, & Rice, 2008; Morelen, Menke, Rosenblum, Beeghly & Muzik, 2016; West & Newman, 2003). It also supports infant temperament research, which finds that challenging infants are more difficult for mothers to form close, loving bonds with in both clinical (Moehler, Brunner, Wiebel, Reck & Resch, 2006) and sub-clinical populations (Wolke, Gray & Meyer, 1994). Given the consistent evidence base regarding this relationship, healthcare professionals should be aware that infants with objective self-regulatory issues (e.g. feeding difficulties, sleeping problems, excessive fussing/crying) might be more prone to maternal-infant relationship issues. However, while there are clear associations between maternal-infant bonding and infant temperament, this relationship is more complex due to reciprocal dysfunctional interactions between a mother and infant and therefore likely bi-directional in nature (Hairston, Solnik-Menilo, Deviri & Handelzalts, 2016). Therefore, it should also be considered that mothers with existing maternal-infant bonding impairments are likely to perceive their infants as subjectively more challenging.

Next, associations were identified between negative symptoms of maternal mental health and perceived difficult infant temperament, which is reflected in existing literature. Numerous studies have found a relationship between maternal depressive symptoms and emotional and behavioural issues during infancy (see Britton, 2011; Morelen, Menke, Rosenblum, Beeghly & Muzik, 2016; West & Newman, 2003). Notably, Field et al., (2003) provide a biological explanation for these findings, demonstrating lower serotonin and dopamine levels are present in infants of mothers who present with postpartum anxiety; indicating a potential carry-over effect. However, research has also shown significant associations between excessive infant crying and maternal distress (Wolke, Gray & Meyer, 1994), meaning this relationship is likely to be cyclical in nature, whereby maternal and infant affective states influencing and exacerbating one another.

Finally, the present study established positive associations between maternal mental health and impaired maternal-infant bonding which again echoes previously conducted research. There is some evidence to support the negative impact of maternal mental health (anxious and depressive symptoms) on the maternal-infant bond, particularly in recent studies using childbearing-specific measures of mood (Fallon, Halford, Bennett, & Harrold, 2016; Fallon, Silverio, Halford, Bennett, & Harrold, 2019; Reck et al., 2006). This study corroborates these findings. Impaired maternal-infant bonding has also been found in mothers with existing PPD (Klier, 2006). Relational interventions, which address maternal-infant bonding in the context of perinatal mental health have been highlighted as particularly effective in mitigating the transmission of risk (Erickson, Julian & Muzik, 2019). However, disturbances to the maternal-infant relationship can also have a negative impact on the well-being of the mother in the absence of a clinical diagnosis of anxiety or depression (Reck et al., 2006). This should be considered in mothers who have experienced disruption to early care giving (e.g. separation from the infant due to hospitalisation or intervention from social services).

To our knowledge, the results of the mediation analyses are previously unexplored and therefore expand the current literature base by further demonstrating the importance of maternal mental health for responsive parenting. The parallel mediation model identified there was a significant indirect effect of maternal-infant bonding on infant temperament via anxiety, but not depression. This infers that whilst there is an association between impaired maternal-infant bonding and negative perceptions of infant temperament independent of symptoms of maternal mental health, one of the underlying mechanisms is anxiety. The study design was not causal, therefore there are two explanations for these findings. Firstly, impaired maternal-infant bonding may create anxious responses, which in turn elicit negative perceptions of infant temperament. Secondly, negative perceptions of infant temperament evoke anxious responses, which may disrupt the maternal-infant bond. Given the existing literature suggests these relationships are bi-directional it is plausible that both pathways exist.

The anxiety items included within the PSAS (Fallon, Halford, Bennett, & Harrold, 2016) bear relevance for both maternal-infant bonding behaviours (e.g. “I have worried about the bond I have with my baby”) and infant temperament (e.g. “I have worried that my baby is less content than other babies”). In line with previous research it is theorised that these childbearing-specific anxieties are more tightly linked to parenting behaviour than the more diffuse general measures (Fallon, Halford, Bennett, & Harrold, 2018; Fallon, Silverio, Halford, Bennett, & Harrold, 2019). In particular, the subscale ‘Parenting Competence and Attachment Anxieties’ directly relates to mothers’ fears about her relationship with her infant and the adequacy of her parenting. This may be a useful subscale to analyse in future research but was beyond the scope of this particular study.

It is often commonplace to adopt the deficit model when conducting perinatal research. Leerkes and Crockenberg (2002) suggest the relationship between infant temperament and maternal-infant bonding may be explained via maternal self-efficacy. However, focusing on more positive aspects of maternal mental health such as well-being and self-efficacy may also be valuable in terms of ascertaining successful coping mechanisms for intervention development. Studies using well-being measures such as the Parental Sense of Competence Scale (PSOC; Gibaud-Wallston & Wandersman, 1978) may provide useful alternatives perspectives.

However, our findings do sit in contrast to prior work which has found increased depressive symptoms to be predictive of both maternal-infant bonding (Tietz, Zietlow, & Reck, 2014) and difficult infant temperament (McGrath, Records, & Rice, 2008). The mediation model identified a significant direct effect between maternal-infant bonding and depression, but not between depression and infant temperament. Classic features of depression include anhedonia and emotional blunting, which may attenuate maternal responsiveness to their infant’s behaviour. Whereas the predominate features of anxiety include hyper-arousal and hyper-vigilance, therefore highly anxious mothers are more likely to be acutely aware of their infant’s behaviour. Alternatively, an explanation may lie in the established co-morbidity between postpartum anxious and depressive symptoms. It has been consistently found that PPA frequently co-occurs with PPD, and also increases the likelihood of onset of PPD (Britton, 2011). However, it has been noted by Matthey, Barnett, Howie, and Kavanagh, (2003) that previous work has usually not measured or controlled for symptoms of anxiety in their analyses of depression. Consequently, it may be that co-morbidity of anxiety in these samples may lead to the over-estimation of the effects of PPD on maternal-infant bonding and perceptions of infant temperament, when in fact a proportion can be accounted for by (potentially unmeasured) PPA.

***Strengths and Limitations***

While our on-line design cultivated the use of self-report measures, it is now important to replicate these findings using objective, lab-based measures of mother-infant interactions and infant temperament. It is possible that negative perceptions of maternal-infant bonding and/or infant temperament do not necessarily manifest in objectively less sensitive caregiving behaviours in samples of healthy postpartum women (see Fallon, Silverio, Halford, Bennett, & Harrold, 2019). Our cross-sectional on-line design enabled a well-powered sample of data for multivariate analyses; however, on-line cross-sectional studies are not without their issues. For instance, desirability bias may affect responses on sensitive items, providing more socially acceptable responses. The length of the survey may also have been problematic with attrition rate calculated at 60% (1,294 starters and 517 completers), which is deemed high for on-line surveys. Short forms of measures (e.g. RITQ-10) were used where possible, but the measure of anxiety in particular was long (PSAS; 51 items) – and something which ongoing work is aiming to rectify. However, we felt it was important to use childbearing specific measures of mental health given the rapidly emerging evidence base behind them (Fallon, Halford, Bennett & Harrold, 2018; Fallon, Silverio, Halford, Bennett & Harrold, 2019; Huizink, Mulder, de Medina, Visser & Buitelaar, 2004; Phillips, Sharpe, Matthey & Charles, 2009).

Homogeneous sampling, as with the majority of on-line designs, was an issue with mainly UK, married mothers, with higher socio-economic status and educational attainment, completing the survey. Replication of findings in more diverse samples is now required as not all backgrounds and cultures experience motherhood in the same manner (Budig, Misra & Boeckmann, 2012; Silverio, Wilkinson, Fallon, Bramante, & Staneva, 2021). Participants in the study were required to evaluate their feelings and experiences at one point in time, which does not reflect the often-transitory nature of depression and anxiety during the postnatal period (Andersson, Sundström-Poromaa, Wulff, Åström & Bixo, 2006). Our results do not account for the role of prenatal mental health, which has been highlighted as important in previous work (Della Vedova, 2014). A prospective cohort design study with repeated measures of mental health beginning in pregnancy would overcome this and also increase the reliability of findings. Additional measurement of paternal mental health and bonding would also provide interesting perspectives. A daily diary study may be an efficient method of implementing this, as would a longitudinal interview method.

***Conclusion***

To summarise, the present study found relationships between maternal mental health (anxiety and depression), maternal-infant bonding, and infant temperament. These findings are well supported by previous literature and it is likely they are bi-directional and transactional in nature. Our mediation analysis demonstrated a significant indirect effect of maternal-infant bonding on infant temperament via anxiety, but not depression. Recommendations from this research include taking both potential directions of the mediation into account (i.e. impaired maternal-infant bonding 🡪 anxious responses 🡪 negative perceptions of infant temperament; or negative perceptions of infant temperament 🡪 anxious responses 🡪 impaired maternal-infant bonding). Future research using a prospective cohort design may help to elucidate this further. Healthcare professionals, clinicians, and psychological practitioners should therefore consider the role of maternal anxiety when working with mothers who present with relational issues with their infant or report their infant as excessively challenging. Improving maternal self-efficacy in parenting competence may simultaneously enhance maternal-infant bonding and perceptions of infant temperament while reducing maternal anxiety. Finally, these results further signify the need to address maternal anxious and depressive symptoms as distinct issues considering their differential effects on parenting behaviour.

**ABBREVIATIONS**

PPA – Postpartum Anxiety

PND – Postnatal Depression

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