Is the Maternal 'Babybrain' Adaptive? Examining Theory of Mind, Emotional State, and the Association With Attachment Over Pregnancy and the Postpartum

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Abstract

Pregnancy is a time of great maternal neuroplasticity with associated cognitive and behaviour change. Cognitive decrements are seen in memory, executive functioning and overall cognitive functioning, and cognitive enhancements in facial and affect processing. It has been proposed that cognitive enhancements may come at the cost of cognitive decrements, due to the brain restructuring in a manner which prioritises adaptive caregiving-related functions. Hoekzema et al. (2016) found significant reductions in the grey matter (GM) volume of first-time pregnant women in the Theory of Mind (ToM) network. On the basis that reduced GM is an indicator of better processing efficiency and specialisation, they proposed that pregnancy may be a sensitive period where ToM may be enhanced to support the maternal-infant attachment relationship. ToM is a multidimensional construct which describes the capacity to understand the mental state of ourselves and others. It has been investigated in maternal-infant attachment as maternal mind-mindedness and parental reflective function. There are very few studies which have investigated individual differences in ToM over the perinatal period and its link to attachment. ***Objective***: The primary aim of this research is to investigate ToM capacity over the perinatal period and its relationship to attachment. ***Method:*** Study 1 was a quasi-experimental, between-groups design comparing third trimester primiparous women's performance on four ToM tasks with that of nulliparous control women. Participants (n=133; 68 pregnant) completed four computer-based ToM tasks: Reading the Mind in the Eyes-Revised (RMET), Hinting, Mind-mindedness, and the Reflective Functioning Questionnaire (RFQ). Prenatal attachment was measured with the Prenatal Attachment Inventory-Revised (PAI-R) and emotional state with the Depression, Anxiety and Stress Scale (DASS-21). It was hypothesised that: ToM would be enhanced in pregnancy; ToM would be associated with pre-natal attachment;

emotional state (depression, anxiety, stress) would be negatively associated with both ToM and attachment. ***Results:*** Study 1 found no between group differences between pregnant and control participants on ToM performance. In the presence of greater depression and stress (both groups) and anxiety (pregnancy only) there was significantly more uncertainty about the mental states of self and others, an aspect of reflective function ToM. ToM in pregnancy was not consistently associated with prenatal attachment. ***Method:*** Study 2 compared ToM measured in pregnancy with caregiving ToM (Parental Reflective Functioning Questionnaire; PRFQ) and maternal-infant attachment (Maternal Postnatal Attachment Scale; MPAS) when mothers and babies were 4-6 months postpartum (n=55). It was hypothesised that ToM in pregnancy would predict parental reflective function and attachment; and that parental reflective function in the postpartum would be concurrently associated with maternal-infant attachment. Emotional state was expected to be negatively associated with both parental reflective function and attachment. ***Results:*** ToM in pregnancy had no consistent relationship to postpartum ToM (PRFQ) or attachment (MPAS). In postpartum women, the presence of poor and rigid caregiver ToM (PRFQ-Pre-Mentalising Modes) was associated with poorer quality of attachment and greater hostility in attachment (both MPAS subscales; r > .3). To explore this relationship further two mediation models were computed. These revealed that under conditions of greater depression or stress, mothers were more likely to use poorer, more rigid, and inappropriate ToM when they reflected on the inner experiences of their baby and themselves and, taken together, these factors were linked to significantly greater levels of hostility in the attachment relationship and poorer overall attachment. For each mediation model, stress and depression accounted for over a third of the basic relationship between caregiver ToM and attachment. ***Conclusions:*** (1) Contrary to Hoekzema et al. (2016), there is no evidence of general ToM enhancement in late pregnancy nor of a consistent relationship between ToM capacity in

pregnancy and postpartum attachment. However, given that pregnant women were also no worse than control women, this might offer preliminary support for a cognitive prioritisation of ToM over general cognition in pregnancy. (2) In postpartum women there was a significant moderate positive relationship between parental reflective function and aspects of maternal-infant attachment. Levels of depression and stress were linked to poorer reflective function and attachment and accounted for over a third of the variance. This research is the first to examine ToM over the perinatal period using multiple measures and to examine the relationship to attachment mediated by mood state.

Keywords: maternal cognition, Theory of Mind, caregiving, reflective function, mind-mindedness, perinatal emotional state, maternal-infant attachment, mediation models

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List of Abbreviations

DASS	Depression, Anxiety and Stress Scale
EEG	Electroencephalography
EF	Executive Functioning
ERP	Event Related Potential
fMRI	Functional Magnetic Resonance Imaging
GM	Grey Matter
HT	Hinting Task
MM	Mind-mindedness
PAI	Prenatal Attachment Inventory
MPAS	Maternal Postnatal Attachment Scale
PRF	Parental Reflective Function
PRFQ	Parental Reflective Function Questionnaire
RCT	Randomised Controlled Trial
RF	Reflective Function
RFQ	Reflective Function Questionnaire
RMET	Reading The Mind in the Eyes Task
SSP	Strange Situation Procedure
ToM	Theory of Mind

Were it not for the peculiar combination of empathy and mindreading, we would not have evolved to be humans at all. This poor teeming planet of ours would be under the thrall of one of the other ten or so branches of the genus *Homo [....]* Without the capacity to put ourselves cognitively and emotionally in someone else's shoes, to feel what they feel, to be interested in their fears and motives, longings, griefs, vanities, and other details of their existence, without this mixture of curiosity about and emotional identification with others, a combination that adds up to mutual understanding and sometimes even compassion, *Homo Sapiens* would never have evolved at all. The niches humans occupy would have been filled with very different apes.

—Hrdy, S. B. (2011) *Mothers and others: The evolutionary origins of mutual understanding*

What does the baby see when he or she looks at the mother's face? I am suggesting that, ordinarily, what the baby sees is himself or herself. In other words, the mother is looking at the baby and *what she looks like is related to what she sees there*.

—Winnicott, D.W. (1971) *Playing and reality*

Theory of Mind and Maternal-Infant Attachment over Pregnancy and Postpartum

This thesis was originally motivated by an interest in neuropsychology paired with curiosity about the cognitive decrements associated with pregnancy, colloquially known as "baby brain". Initial readings in the area of pregnancy emphasised that this stage of the lifespan is accompanied by extensive anatomical and physiological changes across all body systems to ensure positive outcomes for mother and baby (Carlin & Alfirevic, 2008). Cognitive decrements in working memory, executive functioning, and general cognition have also been identified in the third trimester of pregnancy (Davies et al., 2018), which confirm that “baby brain” is more than a subjective experience. Although differences in cognition are generally small to moderate, and detectable only in group studies with adequate power and sensitivity of measurement, the paradox of women experiencing any decline in cognitive functioning during a developmental stage where adaptive functioning is critical seemed surprising.

At that time, the understanding of maternal cognition was in the midst of a theoretical shift. Reviews of the maternal “baby brain” had proposed that the maternal “babybrain” literature needed to re-orient itself theoretically towards adaptive explanations which described cognitive decrements in the context of re-prioritizations of cognitive resources to more relevant domains, especially those proposed to support the maternal-infant attachment relationship (Anderson & Rutherford, 2012). Despite the limited evidence for cognitive enhancement, this adaptive explanation of cognitive change has also been favoured in more recent reviews (e.g., Pawluski et al., 2022). The most well researched area of cognitive enhancement in pregnancy is face processing where some evidence suggests that social cues may be more salient in pregnancy (De Carli et al., 2019). Improvements in visual-spatial working memory have been found in

pregnant rats (Bodensteiner et al., 2006; Macbeth et al., 2008), a finding which has not been replicated in humans (Farrar et al., 2014). Thus, the argument for a re-prioritisation of cognitive resources, where there is a trade-off of some functions (memory, executive functioning, general cognition) for others (social cognition) lacks a broad evidence base and a highly specified theoretical model.

While I was looking for a compelling dissertation research topic, my primary supervisor, Professor Janet Leathem, had also become interested in maternal cognition and its behavioural implications. Around this time a fascinating new study appeared which captured our attention. It showed for the first time that women's brains undergo substantial grey matter (GM) change during pregnancy and that these changes might provide preliminary evidence of enhancements in social cognition, specifically Theory of Mind (ToM; Hoekzema et al., 2016). Consistent with a cognitive 'trade off' explanation, Hoekzema et al. (2016) suggested that this was evidence that pregnancy might be a plasticity window where new skills may be acquired or prioritised to support adaptive role demands of motherhood. Specifically, they suggest that an enhanced ToM would support maternal sensitivity towards her infant and the development of attachment security.

It was immediately clear that the hypotheses from Hoekzema et al. (2016) needed to be tested behaviourally. Doing so would make a novel contribution to furthering the conceptualisation of maternal cognition in the context of caregiving. Thus, the design of the research presented in this thesis was built upon testing behaviourally the hypotheses proposed by Hoekzema et al. (2016). The two primary aims of the present study will now be briefly introduced along with some important background.

Based on their findings of brain plasticity during pregnancy, the first explanatory hypothesis proposed by Hoekzema et al. (2016) is that pregnancy may lead to enhancements in Theory of Mind (ToM) cognition. ToM describes the process of making

inferences about the thoughts, feelings, and perspectives of ourselves and others. Put simply, it allows us to understand ourselves and others through thinking about the mind. One of the difficulties with the construct of ToM and its operationalisation in research is that it encompasses a great number of psychological processes which are dissociable (Warnell & Redcay, 2019) and often existing behavioural measures are not designed for nonclinical adult community samples because of ceiling effects (Bell, 2012).

Theoretical controversies also exist in ToM research. For instance, is ToM best described as a domain general cognitive process (i.e., a general cognitive capacity for meta-representation) or a domain specific process (i.e., a dedicated cognitive module)? Or does it have elements from both with interrelated domain specific and general components? (Stone & Gerrans, 2006). These theories are important as they make different predictions about empirical data, such as whether enhancements in lower-level processes (such as tracking the direction of another's gaze) relate to higher level processes (such as reflecting on the contents of another's mind). Another theoretical controversy centres around how ToM is defined with broader and more narrow views taken in the ToM literature. For instance, there is a great deal of research into accuracy and sensitivity of reading emotions on faces. Some studies refer to this as ToM (e.g., Baron-Cohen, 2000), while others take a narrower view and describe the process as affect recognition or facial perception, with no reference to ToM (e.g., Anderson & Rutherford, 2011; Matsunaga et al., 2018).

The primary aim of the present research is not to clarify these theoretical controversies. Rather, the aim is to examine individual differences in maternal ToM and the relationship to maternal-infant attachment. However, by examining individual differences across several ToM processes there will be some scope to comment on the degree to which study findings are consistent with existing ToM theoretical conceptualisations.

Given this primary aim, the present research will take a broader view of ToM to capture a range of ToM cognitive processes which might be subject to change during pregnancy and associated with attachment. Accordingly, ToM will be used here as an umbrella concept, encompassing a broad understanding of the many mental processes involved in understanding self and others. The current research also assumes that ToM measures are not usually correlated and so to gain further understanding of individual differences in ToM in a specific population, such as pregnant women, multiple measures are best used to capture different aspects of ToM.

As part of this, the present research also examines ToM specific to caregiving. In caregiving, two constructs have been studied: reflective function and maternal mind-mindedness, both of which describe the degree to which caregivers understand the inner experiences of themselves and their children. Reflective function places greater emphasis on the degree to which caregivers think about the contents of their own minds and how accurate it is. Mind-mindedness, by contrast, is more concerned with the spontaneous, appropriate, and accurate use of ToM in mother-child relationships. Research in this area has revealed that when caregiver ToM is combined with sensitivity there is an increase in the likelihood of the formation of a secure maternal-infant attachment (Erickson et al., 2019; Van Ijzendoorn & Bakermans-Kranenburg, 2019; Zeegers et al., 2017). Sensitivity in attachment relationships has been studied as several specific behaviours, such as attuned responding of the mother to the infant (e.g., via touch, voice, rocking) and the degree of behavioural synchrony (e.g., in gaze and mirroring). What these sensitive behaviours have in common is that the mother is aware of the moment-to-moment needs expressed by the nonverbal infant, her own inner responses to these, and is able to adapt her response contingently and appropriately. This moment-to-moment awareness constitutes caregiver ToM which can be understood here as a cognitive capacity which contributes to the behaviour of sensitive caregiving.

The importance of these sensitive caregiver behaviours is to the maternal-infant relationship. Accordingly, the second aim of the present research is to test the hypothesis arising from Hoekzema et al. (2016) that maternal ToM is positively associated with attachment security. The attachment bond describes an infant's early relationship with primary caregivers, which develops from innate behaviours displayed by infants and to which primary caregivers typically respond, ensuring that the infant's needs for protection and security are met. Attachment is considered a biological imperative to healthy normal development; infants who have not received adequate levels of the specialised care necessary to form an attachment relationship can experience persistent difficulties in relational and social-emotional domains (Doyle & Cicchetti, 2017), and in extreme cases of global deprivation of an attachment figure, long term problems in neurobehavioural functioning (Chugani et al., 2001). The need of the child to attach to primary caregivers is such that the child will form an attachment relationship even when it comes at great cost psychologically. Optimal caregiving leading to a secure attachment relationship, conversely, has been found to be linked to a range of benefits for children socially, cognitively, physically, and in terms of their emotional wellbeing (Brumariu & Kerns, 2010; Meins, 1997; Ranson & Urichuk, 2008). For this reason numerous maternal mental health interventions focus on improving the maternal-infant attachment relationship, as the presence of mental distress in mothers is a risk factor for poorer attachment quality (Slade & Sadler, 2019).

While the present thesis will specifically examine ToM and attachment over the perinatal period, it is important to acknowledge the wider developmental context and other factors which impact on caregiving. Psychological, relational, and social factors, for instance, all interact in early caregiving, influencing the capacity to provide attuned responses to an infant's cues, or the manner in which it is provided. Pregnancy and caring for children are also situated within cultural epistemologies which guide local

practices and affect individual experiences of parenthood. While the motivation for the present research came from novel findings in neuroscience and neuropsychology, with a focus on how brain and behaviour may be linked, many factors are dynamic and interacting during the perinatal period which impact on the transition to motherhood and the acquisition of new complex and adaptive behaviours. While this thesis will not specifically examine these broader factors, it is important to acknowledge that they impact greatly on caregiving behaviour, in addition to brain-based hypotheses. New experiences and learning of skills over time also changes brain structure and function so complex relationships likely exist between many factors which influence ToM and attachment - neuroplasticity, cognition, behaviour, learning, relational, social, psychological - and so the development of new caregiving skills over the perinatal period will be influenced by all of these.

To return to the focus of the present study, in summary; the primary aims of the present thesis are to examine ToM capacity and its relationship to attachment over the perinatal period. The neuroimaging study from Hoekzema et al. (2016) provided the initial impetus for this. They found, for the first time, significant and enduring changes in grey matter (GM) volume in the brains of first-time pregnant women in regions which overlapped with the ToM network. The changes in these regions also predicted attachment quality in the postpartum. This, they suggest, is initial evidence of adaptive neurobiological restructuring in service of caregiving. However, these hypotheses need to be tested behaviourally and this is the gap which this research aims to fill. ToM is a multidimensional construct which will be used here as an umbrella term for the many mental processes which relate to understanding the minds of others and reflecting on one's own mind and inner experiences. ToM and sensitive parenting behaviours (those behaviours which meet the infant's need for protection and security) have been linked to

attachment quality, a central concept in developmental and clinical psychology. Given these aims, the next section will provide an overview of the study design considerations.

Study Design Considerations

The present study aimed to test the key hypotheses derived from the Hoekzema et al. (2016) study findings: (1) ToM is enhanced in first time pregnant women and (2) ToM over the perinatal period predicts attachment.

At first, a repeated measures study design was selected to capture potential enhancement in ToM cognition over pregnancy and postpartum. This would have meant testing women on the same ToM measures at two time points to determine whether their performance improved and if it predicted maternal-infant attachment in the postpartum. Practically, a prospective study design was appealing as it would require fewer study participants than a between subjects design and would potentially be more feasible within the scope of a doctoral thesis. This was an important consideration as finding an adequately powered sample of first-time pregnant women was a concern raised by academic staff experienced in working with this population. Around this time a fellow clinical psychology student, Kate Connolly, indicated that she was interested in completing a joint study into maternal cognition. Joining forces in the collection of a larger dataset - with two complementary research objectives – was practical and feasible for both of us and allowed a between group study with more participants to be contemplated.

A second challenge related to finding ToM measures which were suitably broad, captured several cognitive processes, and had good validity and reliability for non-clinical adult community samples. The many cognitive psychology ToM tasks were considered unsuitable as they were designed around tightly controlled experimental paradigms for the elucidation of theory – they did not capture a broad range of ToM processes. ToM has also been researched in clinical and neurodiverse populations, such

as in autism, schizophrenia, substance use, and eating disorder research (Baron-Cohen, 2000; Cucchi et al., 2018; Marjoram et al., 2005; Onuoha et al., 2016). While these provided a good source of ToM measures, there was a persistent difficulty of ceiling effects when used with community samples (Bell, 2012). The neuroimaging ToM measures referred to by Hoekzema et al. (2016) were also unsuitable for behavioural testing due to ceiling effects. These ceiling effects are of no concern in imaging studies given that the measures needed only engage to the brain in the cognitive task, not measure performance and examine individual differences. Moreover, it was considered important to the present study to identify ToM measures which covered as many of the cognitive processes described by Schurz et al. (2014) which Hoekzema et al. (2016) relied on to create their ToM brain map. Taking a broader view of ToM helped in the literature search for measures. For instance, 'reflective function' is usually used interchangeably with the term 'mentalising', rather than ToM. However, with a broader view of ToM these constructs are conceptually very similar. Similarly, 'mind-mindedness' is the term used to describe what is essentially ToM in the early caregiving relationship. In this way, a range of ToM measures was able to be compiled.

Given the primary aim of the present study is to test the hypotheses proposed by Hoekzema et al. (2016) efforts were made to conceptually replicate, as far as possible and as relevant to this study, the study design as used in Hoekzema et al. (2016) where it aided in addressing the principal research questions. See Table 1 below for a comparison of Hoekzema et al. (2016) with the present study.

Finally, given the substantial body of research into the negative impact of emotional state, and in particular depression, on maternal-infant attachment, it was an important study design consideration to test for a relationship between emotional state, ToM, and attachment. Hence, rather than use the Edinburgh Postnatal Attachment scale

which was used in Hoekzema et al. (2016), the present study used the DASS-21 to compare emotional state between pregnant and control women.

Table 1

Design Element Compared: The Present Study and Hoekzema et al. (2016)

	Hoekzema et al. (2016)	The present study
Study design	Prospective neuroimaging study of brain change in pregnancy with between groups comparison	Study 1 - Quasi experimental between groups comparison, Study 2 - Prospective within-subjects design of ToM cognition and association with attachment over perinatal period
Participants	Primiparous pregnant women (*n*=25)	Primiparous pregnant women (*n*=68); postpartum women (*n*=55)
Controls	Age and education matched nulliparous women (*n*=25)	Age and education matched nulliparous women (*n*=65)
ToM	Theory of Mind relying on fMRI meta-analysis to build brain map of ToM (Schurz et al., 2014): (i) False belief tasks (ii) Trait judgment tasks (iii) Strategic games (iv) Social animations (v) Mind in the Eyes tasks (vi) Rational actions	Theory of Mind: encapsulating a broad number of cognitive processes: (i) Verbal Hinting Task – incorporating false belief and trait judgement components (ii) Reading the Mind in the Eyes task (iii) Mind-mindedness Video Task – Video stimuli (nonverbal) presenting a social scene. Incorporating rational action, affect recognition components. (iv) Reflective Functioning Questionnaire – reflecting on emotional and mental states of self and others
Attachment	Maternal Postnatal Attachment Scale, measured postpartum	Maternal Postnatal Attachment Scale, measured postpartum
Emotional State	Measure of postnatal depression (Edinburgh Postnatal Depression Scale)	Measure of depression, anxiety, stress in pregnancy and postpartum (DASS-21)

Structure of the Thesis

This Introduction has provided the background to the current research, including the motivation to examine Theory of Mind in pregnancy with a view to exploring adaptive explanations of cognitive reorganisation in pregnancy. In Chapter 1 an introduction to attachment is presented with an emphasis on its conceptual framework and importance in early development as essential background to the current thesis. The quality of this earliest of relationships provides a foundation of wellbeing for the infant. Chapter 2 is presented in two sections which introduce (1) the neuropsychology of pregnancy, (2) ToM as a multidimensional construct and how it relates to caregiving and attachment. This section also reviews the literature of ToM in pregnancy, outlining the gaps and limitations, before presenting the aims and research questions. In Chapter 3, the method is presented in detail, including the data analysis approach. Chapter 4 presents the results of both studies including descriptive and inferential statistics as well as two preliminary mediation models. Chapter 5 discusses the findings of this research and how it contributes in a novel way to maternal ToM cognition and attachment over the perinatal period. Limitations and suggestions for future research are suggested.

The reader's attention is also drawn to Bicultural Considerations in Appendix Q: Attachment and Tō Hapūtanga in te ao Māori for an examination of these constructs in a local Aotearoa New Zealand context.

Chapter One

The Attachment Relationship: Introduction and Theoretical Considerations

This chapter will present the theoretical foundations of maternal-infant attachment highlighting its significance to early relationships and caregiving. How secure attachment develops will be presented as well as the adverse effects of maternal depression, anxiety, and stress.

Theoretical Origins

The fundamental starting point for attachment theory is that infants are born with an biological preparedness to form an emotional bond with their caregivers (Bowlby, 1979; Bretherton, 1992; Cassidy & Shaver, 2016). This emotional bond is described as an attachment relationship the primary function of which is to meet the child's need for security and protection. Just as the child is born with a biological predisposition to become attached to their caregivers (and especially their primary caregivers), so too will they learn over time to organise their behaviour to maintain the attachment bond. Infant-caregiver attachment behaviours have been extensively studied to understand what patterns are associated with different kinds of attachment relationships. The quality of the primary attachment relationship has implications for the health and wellbeing of the infant as they grow up and has also been shown to lay the groundwork for an internal working model of relationships (Holmes & Farnfield, 2014). Human and animal research has demonstrated that when offspring are deprived of an attachment figure, even when they do have the basics of food, shelter and basic care, there is a risk of serious and long lasting harm and even mortality (Harlow, 1959; Holmes & Farnfield, 2014).

The concept of attachment was originally proposed by the psychiatrist John Bowlby and outlined across his seminal volumes of 'Attachment and Loss' which

appeared between 1969 and 1980 (Bowlby, 1969). It was in these three volumes that he delineated the key concepts drawing on observations from work with young people who had experienced very deprived childhoods (Bowlby, 1969). Attachment theory has been further elaborated in the decades since, becoming one of the most productive areas of research in developmental psychology and an important aspect of clinical psychology practice with children and their families.

It is important to note that attachment theory is not without controversy. Questions surround its theoretical grounding in an evolutionary psychology and individualist framework (e.g., Abed et al., 2019; Fitzgerald, 2021), its potential limitations given the replication crisis (e.g., Van IJzendoorn & Bakermans-Kranenburg, 2021), and some problems with 'uncritical' clinical applications (e.g., Bolen, 2000; Buchanan, 2013; Schuengel & Van Ijzendoorn, 2001). More broadly, the concept of 'innateness', which is central to Bowlby's ethological conceptualisation of attachment and how it has developed as a theory, is considered problematic in terms of how it explains the origins and development of infant behaviour from genotype-to-phenotype correspondences (e.g., Cowie, 2006; Racine, 2013). Competing approaches, for instance, emphasise how children's development is better explained by interacting developmental systems (Ford & Lerner, 1992; Griffiths & Tabery, 2013).

However, despite this, within attachment research itself there is a broad consensus on four important theoretical principles which will now be briefly outlined. Firstly, attachment theorists posit that infants are born with innate behaviours to seek proximity to their caregiver to meet their need for comfort and protection. When a threat is perceived, typically infants become distressed and signal to the caregiver (the attachment figure) that they need emotional support. These signals include looking for, reaching towards, and clinging to gain proximity. These behaviours are signs that the attachment system is activated to gain caregiver protection and comfort. By contrast,

when the child is relaxed the exploratory system is activated. Here, the behavioural signs are that the child appears interested in learning about the world and venturing outwards away from the caregiver. The infant may turn toward something novel or crawl a distance away from their caregiver to play.

Secondly, it is proposed that children organise their attachment behaviour (i.e., how they seek comfort) to manage the relationship with their caregiver. This behavioural organisation is a result of many attachment interactions with caregivers over time and its pattern depends on the child's attachment style, as will be discussed shortly.

The third principle is that the infant's attachment behaviour is maintained even when it comes at a great cost to the child, such as needing to suppress certain emotional or behavioural responses to manage the caregiver's reactions. In this respect the fourth principle goes further by proposing that when the attachment relationship has not met the child's needs for security and comfort, then the child can develop pervasive distortions in thinking and feeling. For instance, this might be in the case when a caregiver is rigid and frightening to the child, emotionally unavailable or preoccupied with their own thoughts and feelings. In this case, when the attachment system is activated, the child experiences fear without the comfort of a secure base relationship to soothe and contain emotional experiences.

Attachment theorists argue that, over time, repeated attachment experiences become encoded in the infant's neurobiology and contribute to a blueprint for how the infant perceives relationships with others (Chambers, 2017; Doyle & Cicchetti, 2017). In children this is known as 'attachment style' and it is proposed that it develops into an internal working model of relationships in the adult (Bretherton, 1999). This working model of relationships shapes how the child sees themselves and how they believe that others will respond to them in times of stress (Holmes & Farnfield, 2014). Thus, the typical relational experiences between the child and primary caregivers becomes a

characteristic of the child rather than merely a characteristic of the relationship (Bretherton & Munholland, 2008) contributing to a range of outcomes over the lifespan for the child (e.g., Chambers, 2017).

What is clear from these principles of attachment is that the primary relationship is understood in terms of its mutuality: It is interactive and iterative, enacting patterns of responding between parent and child which, over time, serve as the context for future relationship interactions. Critically, it can be positively influenced by parental sensitivity and appropriate responses. And naturally, these interaction patterns can be shaped and influenced by wider contextual factors to the caregiver and the child, such as social support and SES (Van Holland De Graaf et al., 2018), access to resources and deprivation (Lickenbrock & Braungart-Rieker, 2015), as well as individual factors such as parent characteristics and child temperament (Laible, 2004; Mangelsdorf et al., 2000).

Child temperament, in particular, has received considerable attention in terms of how it relates conceptually and empirically to attachment. In a major review of over 50 studies examining child temperament and attachment style, Vaughn et al., (2008) found that while there are considerable overlaps, attachment and child temperament cannot be reduced to each other; the former being primarily a quality of the relationship, the latter of the child. They suggest that both attachment quality and child temperament are 'tuned' by childhood experiences with primary caregivers. Primary caregiver and child characteristics thus interact in multiple ways in the construction of the relationship.

Key to the development and empirical validation of attachment theory has been the understanding of caregiver-child interaction patterns and how these relate to different attachment styles. These were originally developed by Mary Ainsworth who proposed that infant attachment could be broadly classified as secure or insecure and proposed a method for measurement via the Strange Situation Procedure (SSP; Ainsworth 1978, Main 1985) a short structured observational assessment of infants with

their mothers. In the SSP, the reactions of children aged between 9-30 months are observed and coded during a period when the mother leaves the room, the child will spend a short time alone, and a friendly stranger will enter the playroom and interact with the child before the mother returns. Behaviours which contribute towards the understanding of the child's attachment style are: The proportion of exploration the child engages in, their reactions to the mother leaving the room and the stranger entering, and the child's response to reunion with their mother upon her return.

It is this reunion behaviour which is proposed to provide the most information about the quality of attachment. For instance, in the SSP caregivers who sensitively tune into the child's distress in a way which is loving and without disapproval of negative emotional states will help the child to regulate and the child will not remain distressed for a prolonged period (e.g., Goldberg et al., 1994). There is a repertoire of comforting caregiver behaviours which demonstrate the degree to which the caregiver is sensitive and attuned—emotionally available and appropriately responding—to their child's needs. These include talking (including in motherese), rhythmic rocking, holding or patting, mutual eye contact, and marked mirroring of select emotional states (e.g., of an infant sad face). Marked mirroring provides the infant with an accurate and contingent emotional display on their mother's face which signals to the child that the emotion displayed relates to the *child's* subjective emotional experience (Ainsworth et al., 1978; De Wolff & Van Ijzendoorn, 1997; Kim et al., 2014). Attuned caregivers are able to understand the needs of the child by reading their attachment cues and providing a secure base. Once calmed, the infant's exploratory system is once again active, and they can again engage in other activities such as play.

Patterns of Attachment

Research into attachment has identified three patterns of insecure attachment which are observable in the SSP (Ainsworth 1978; Main 1985). In the avoidant-anxious

pattern, the child expresses distress, such as by crying and reaching towards the caregiver, and the response of the caregiver is not attuned or soothing. Responses might include ignoring the child's bid, dismissing the concern, rejecting the child when upset, or hostility such as punishing the child for the emotional display. Over time, the child adapts to these caregiver response patterns by learning an alternative strategy to cope with their distress. This is observable in the reunion pattern in the SSP where the child inhibits their outward cues of inner distress. In this way there is a difference between what is experienced internally and what is displayed outwardly to the caregiver (Van Ijzendoorn et al., 1999). In addition, the exploration system seems to play a more significant role in the child's relationship with the caregiver compared to the attachment system. Through this mechanism, it is proposed that the child is able to maintain a close proximity to the caregiver in a manner that is acceptable to the caregiver. This is accompanied by a set of beliefs regarding the child's position in the world and their connection with others.

In an anxious-ambivalent attachment style, the child expresses distress openly but the caregiver's response is not predictable. At times it is rejecting, dismissive or ignoring, other times it is soothing. To cope with this, the child heightens the emotional display with extreme distress to amplify the bid for connection with the caregiver to obtain the secure base. When the caregiver does respond with soothing, the child might be resistant leading to a more conflictual relationship between child and caregiver. In the SSP, after reunion with the mother, the child cannot be soothed. Both of these attachment styles are suboptimal, but they are at least organised systems of behaviour between caregiver and child. The child has a set of strategies which meet some of their attachment needs.

The third style of insecure attachment differs in that it is disorganised (Main & Solomon, 1990). In a disorganised attachment style, the child experiences the caregiver

as frightening, dissociated or other atypical caregiver behaviours (such as sexualized; Benoit, 2004). Frightening caregivers might be hostile and coercive towards the child or others in the family, physically or psychologically abusive, or experiencing severe mental distress themselves (e.g., depressed, grieving) and are unresponsive and withdrawn. When caregivers are frightening, the child is caught in the bind of needing to stay close to the attachment figure for emotional support, all while experiencing a fear response towards the caregiver (Cassidy & Shaver, 2016). Another way in which disorganised attachment style can emerge in children is when caregivers are frightened. When highly anxious, the attachment figure is emotionally absent, not able to offer comfort or a secure base. Disorganised attachment is of clinical concern and prevalence is higher in at risk populations, such as children who have been maltreated (Allen et al., 2018).

Transmission of Attachment

Given the importance of attachment security to infant wellbeing, an important area of attachment research is how attachment status is transmitted across generations. In a large and influential meta-analytic study of 854 parent child pairs, attachment security in the child was strongly correlated with the parent's insecure or secure style of attachment (d=1.06; Van Ijzendoorn, 1995). Similarly, parental dismissive styles are linked to children with anxious avoidant styles; preoccupied parents are more likely to have children who have an ambivalent style, and adults with unresolved loss in their lives are more likely to have children with disorganised attachment styles (Benoit & Parker, 1994). As mentioned previously, severe mental health problems in the parent can contribute to a disorganised attachment in the child. It is still not completely understood how parental attachment status is transmitted to the child; this is known as the transmission gap (Van Ijzendoorn, 1995) and will be discussed again shortly in the context of caregiver sensitivity and Theory of Mind as contributing factors in this intergenerational transmission of attachment.

Maternal Sensitivity, Attunement, and the Transmission of Attachment

Over four decades ago, Ainsworth et al. (1978) defined maternal sensitivity as the ability to interpret infant cues and experiences and then respond in a way that does not misinterpret infant needs in favour of their own needs. Observed behaviours of highly sensitive caregiving as described by Ainsworth (1969) include high levels of attunement to baby's signals with prompt and appropriate responses. This is facilitated by seeing the world through the baby's eyes and not "distorting" the baby's perspective with the parent's own unmet needs. By contrast, insensitive parenting is geared towards the parent's own wishes, moods, and activities and not that of the baby. Parents delay responding to baby's signals and only respond when baby's signals are intense and of a long duration; the response is incomplete and reading baby's perspective inaccurate. Sensitive attuned caregiving supports the child to feel safe, protected, make sense of their subjective emotional experiences, and explore aspects of the world outside the proximity of the caregiver – it promotes a balance between the attachment system and the exploration system. Over time, the child learns that others are reliable and safe, and gains the skills to regulate their own affect.

There are decades of attachment research into the role of maternal sensitivity and attuned caregiving behaviours (e.g., Bornstein, 2013), such as via mutual eye contact, marked mirroring, vocalisations, and how the parent structures the outer world appropriately in language for the child. Supporting the caregiver in this respect is the ability to read their child's inner experiences moment to moment (Meins et al., 2018). An early study which prospectively linked parental mentalising to later child attachment was completed by Fonagy et al. (1991). In this study, 200 first time parents were interviewed using the Adult Attachment Interview (AAI) before the birth of their children. Responses were coded for frequency of the parents' use of mental state language when describing their own childhood. The parents then completed a SSP with their infant children at 12

months and again at 18 months. Results were consistent with the perspective that parents with a general reflective functioning capacity, that is the ability to see behaviour in terms of inner mental and emotional states, were more likely to have a secure attachment relationship with their infants (Slade & Sadler, 2019). The implication is that infants who can be assured that their caregiver will respond appropriately to their needs, including distress as evoked in the SSP, have built an inner representation of the world as a safe and predictable place. This topic – how parental ToM and sensitivity predict attachment – will be considered again in the next chapter.

Perinatal Emotional Disturbances: Depression, Anxiety, and Stress

Pregnancy, childbirth, and the postpartum are a time of great personal and psychological adjustment. Pre-existing psychological, biological, and social vulnerabilities can interact with women's individual perinatal experiences resulting in significant emotional distress and mental health problems. Poor mental health at this time of increased responsibility towards a young baby can amplify and perpetuate distress. Mental health problems over the perinatal period are of concern not only for women but also for the long-term impact they may have on the child's health and development (Dunkel Schetter & Tanner, 2012).

Estimates of the prevalence of depression over the perinatal period vary, however in one high quality systematic review, estimates of depression were between 6.5% to 12.9% across pregnancy and over the first three months postpartum up to 19.2% of women experienced a major depressive episode, with most beginning after delivery of baby (Gavin et al., 2005). Prevalence of maternal depression varies widely between nations, with New Zealand ranking lower than median rank in a meta-analysis of 40 countries on the Edinburgh Postnatal Depression Scale (Hahn-Holbrook et al., 2018). This study also found that sources of variation in depression prevalence were best explained by levels of wealth inequality, indices of maternal and infant health, and

employment patterns. This underscores how environmental and social factors greatly impact on maternal wellbeing. Anxiety symptoms are also common in pregnancy and postpartum, although have been the subject of less research attention (Dunkel Schetter & Tanner, 2012). In a prospective study of community based women (n >8000), Heron et al. (2004) found that 14.6% of 18 week pregnant women had very elevated levels of anxiety. This dropped to 8% of the sample 8 weeks in the postpartum. Both anxiety and depression were reasonably stable over the perinatal period and were usually co-morbid (Heron et al., 2004). Estimates of the prevalence of posttraumatic stress disorder (PTSD) over pregnancy and postpartum vary widely depending on the sample (community or high-risk mothers), geographical location of mothers, and methods of measurement; however in a recent review, community samples of pregnant women PTSD symptomology was as high as 21% (Khoramroudi, 2018). Finally, a recent review of 38 studies identified risk factors associated with greater levels of maternal stress in pregnancy and postpartum finding that the presence of traumatic events, obstetric complications, poorer mental and physical health, lower socio economic status, partner stress and lower social support all contributing to greater levels of stress in women (Saur & dos Santos, 2021).

There are complex and multifaceted relationships between maternal mental health and attachment over pregnancy and into the postpartum. As previously mentioned, many risk factors also impact on maternal wellbeing during the perinatal period, so a priority for future research will be to integrate findings within models of broader biopsychosocial functioning. The impact of maternal depression over the perinatal period is consistent, however. Most studies have shown that greater levels of depression in pregnancy is associated with lower levels of attachment to the unborn baby (McNamara et al., 2019), and that this link may be stronger in mothers with depression of clinical severity (McFarland et al., 2011). Cognitive perseveration starting in

pregnancy might impair a mother's ability to connect with her unborn baby. In one study, levels of depressive rumination in early pregnancy were found to predict impairments in maternal-foetal attachment in late pregnancy (n = 215 pregnant women; Schmidt et al., 2016). Studies consistently find that greater levels of depression in pregnancy predicts impaired maternal-infant attachment in the early postpartum (e.g., Figueiredo & Costa, 2009; Ohoka et al., 2014) demonstrating an ongoing negative impact of maternal depression. In a meta-analytic study of maternal depression and early infant attachment as measured on the SSP, infants of depressed mothers were less likely to have a secure attachment relationship and there was a greatly increased likelihood of disorganised attachment (Martins & Gaffan, 2000). Less is known about the impact of anxiety during pregnancy on attachment, however it does appear to be associated with aspects of maternal bonding, although the picture is less clear (Figueiredo & Costa, 2009). For instance, greater maternal anxiety may have a negative impact on the levels of felt closeness to the unborn baby but not on the overall attachment (McNamara et al., 2019). Nicol-Harper et al., (2007) found that mothers with higher trait anxiety had dampened sensitive responsiveness in play interactions with their young babies, which may affect the formation of secure attachment. More is known about stress, and traumatic stress in particular, in the perinatal period with research showing that women with trauma histories and PTSD symptoms have significantly greater difficulties bonding with their infants and often have problems in the attachment relationship (Erickson et al., 2019). In general, mothers of children of all ages who also have elevated PTSD symptoms experience greater relational problems than non-traumatised mothers; many studies have found less sensitivity, more intrusiveness, greater hostility, and poor mentalising ability via 'distortions' of their child's experiences and behaviour (for a review, see van Ee et al., 2016).

Summary

This chapter has presented the key concepts of attachment theory as important background to the present research, with the understanding that it is adaptive to the needs of the infant. While attachment is not without criticism, particularly around the theoretical propositions of innateness and adaptive explanations, it has nevertheless become a central theory of child development, caregiving, and relationships. The quality of early relationships has been found to have a range of implications for the child across the lifespan, such as academic achievement, emotional regulation ability, the risk of mental health problems, and relationships with others. Ainsworth proposed maternal sensitivity, as measured in a range of attuned caregiving behaviours which were contingent and responsive to the child's needs, as the key to attachment security. The presence of emotional disturbances, such as depression, anxiety, and stress, in the perinatal period is generally associated with a greater likelihood of adverse outcomes for mothers and babies; maternal depression and levels of traumatic stress have been found to negatively impact on the maternal-infant attachment relationship.

The next chapter will first provide an overview of the neuropsychological changes of pregnancy as the background to this research. An in-depth examination of how caregiver ToM is thought to contribute to the sensitive and attuned parental behaviours which underpin attachment quality will then be presented.

Chapter Two

The Neuropsychology of Pregnancy and Theory of Mind in Caregiving

This chapter will be presented in two sections. The first section will focus on the neuropsychology of pregnancy. It introduces neuroplasticity in terms of the structural, functional, cellular, and endocrine modifications of the perinatal period. The purpose of touching on these areas is to emphasise that the brain undergoes substantial changes during pregnancy, at multiple levels of biological functioning, and that in many cases these changes have been found to have adaptive behavioural correlates in caregiving as well as changes in maternal cognition colloquially known as “babybrain”. These findings orient the reader to the initial impetus for the present thesis: That there is an expanding understanding of neuropsychological change during pregnancy which posits that the maternal “babybrain” is far more than a decline in general cognitive functioning. Pregnancy may be a time of structural and functional adaptations in preparation for adaptive caregiving supporting the attachment relationship. The fMRI study completed by Hoekzema et al. (2016) — which showed substantial grey matter changes in first time pregnant women in regions subserving ToM — will be reviewed in detail given its importance to the present research.

In the second section of this chapter, ToM will be introduced in terms of its theoretical origins highlighting how it is a multidimensional construct encompassing numerous cognitive processes. The present thesis argues that, based on this understanding, the very many individual differences studies that use single measures of ToM do not adequately capture the range of cognitive processes involved. Two ToM constructs have been studied within the context of parent-child relationships. Mind-mindedness examines caregiver talk as an indicator of how accurately and spontaneously mothers interpret their baby's inner mental states; it was initially conceived as a way of

explaining maternal sensitivity in an attachment context (Meins, 1997). Parental reflective function has also been studied as an important aspect of parental mentalizing and, like mind-mindedness, considers the relationship to attachment as well as how to support mothers experiencing psychological distress over the perinatal period (Slade, 2005). These two constructs will be introduced as ToM in caregiving. They have also, to a limited extent, been examined over pregnancy in addition to another aspect of ToM, face processing. The small number of studies which have investigated ToM in pregnancy will be reviewed. It will become clear that much less is known about ToM (or enhancements in cognition during pregnancy and their association with attachment) than is known about cognitive decrements and neuroplasticity. This is a critical gap in the empirical understanding of maternal cognition.

The final section of this chapter will return to the present study, outlining methodology and design considerations, and how the present research contributes in an original way to the understanding of maternal ToM cognition and its relationship to attachment security.

The Neuropsychology of Pregnancy

Over the last decade, a proliferation of neuroimaging studies have revealed that the transition to motherhood is a period of significant brain plasticity with associated cognitive and behavioural change (Barba-Müller et al., 2019; Barha & Galea, 2017; Hillerer et al., 2014; Hoekzema et al., 2016, 2020; Kim, 2016; Kim et al., 2016; Martínez-García et al., 2021; Pawluski et al., 2022). While it has been known for some time that the brain undergoes change during pregnancy, findings from neuroimaging studies provide greater specificity which was not possible with older research methods. For instance, autopsy investigations dating back to the nineteenth century revealed that pregnant women's pituitary glands were significantly larger than same age not pregnant women, while their overall brain volume was reduced (Comte, 1898). Early MRI studies

were able to confirm that the pituitary gland undergoes a two-to-three fold enlargement during pregnancy (Gonzalez et al., 1988) and it is now known that this is mainly due to a proliferation of prolactin cells which support breastfeeding (e.g., Karaca et al., 2010). It has also been established via imaging studies that while human brain volume reduces over the course of pregnancy, and is at its smallest at the end of pregnancy, this effect appears to have reversed by 6 months postpartum when the brain returns to its pre-pregnancy size (Oatridge et al., 2002).

Recent reviews of the accumulated evidence base have usefully synthesized the understanding of neuroplasticity in the perinatal period and its link to maternal caregiving behaviour in both humans and animals. Hillerer et al. (2014) reviewed molecular changes in the maternal brain observed in human and animal studies. There is collected evidence for adult neurogenesis in the perinatal period as well as plasticity in synapses and dendrites across regions implicated in non-specific motivation (mesolimbic dopamine system). This is part of a circuit the authors describe as the "maternal circuit" given its role in activating maternal caregiving behaviours, such as licking offspring in rats. There is also evidence for plasticity in the hippocampus, critical to the formation of new memories, reductions in overall volume of the brain at the same time there is increased cell proliferation and survival, reduced dendritic complexity, but increases in spine density (Hillerer et al., 2014).

In another major review of perinatal fMRI studies, Kim et al. (2016) usefully organised the studies according to brain circuits which they propose are most implicated in maternal caregiving behaviour in humans. Specifically, those circuits which support sensitive responses to infant cues which are essential to maternal-infant attachment behaviours. These are reward and motivation, emotion regulation, empathy, and executive function. For each of these brain circuits, the authors detail a growing number of studies showing links between the maternal brain and adaptive maternal responses to

infant stimuli and attachment. Alongside these adaptions, maternal psychopathology, trauma, and substance abuse has been found to negatively impact on neural functioning in these regions as well as on maternal behaviour. For instance, in the case of depressed new mothers, a decreased neural responsivity to negatively valenced emotional stimuli and images of infant distress was found (Kim et al., 2016), consistent with depression increasing maternal insensitivity and poorer attachment (Feldman et al., 2010).

Pregnancy has often been compared to another period of rapid human development: adolescence (e.g., Hoekzema et al., 2016). However, there has been relatively little research into changes in brain morphology during pregnancy, compared to the large number of studies into the developing adolescent brain. The aim of Carmona et al. (2019) was to examine the structural similarity of adolescent and pregnancy-related brain change. They discovered that the structural alterations were strikingly similar, especially a flattening of the cortical surface that would be accounted for by enhanced myelination and synaptic pruning in both pregnant women and adolescent girls. Myelination and synaptic pruning are widely believed to be mechanisms by which the brain enhances its processing specialisation and efficiency. Myelination helps increase speed and synchronisation of information processing, while synaptic pruning supports the process of refining functional networks (Hagmann et al., 2010). Over developmental periods, hormone surges prime the brain for axonal and dendritic pruning of unneeded neural connectivity according to activity and learning experiences (Riccomagno & Kolodkin, 2015). In a neuroimaging study tracing cortical GM development in children into adulthood (4-21 years), Gogtay et al. (2004) demonstrated that higher order association cortex matures only after lower order (and evolutionarily older) sensorimotor cortex regions. In this way, the prefrontal cortex is the last to mature and develops from the back to the front. This longitudinal study was able to pinpoint how this maturation process unfolds and importantly was able to make a link between brain

maturation and cognitive and behavioural development. Viewing the structural and functional brain changes during pregnancy through the lens of a developmental framework, akin to the maturation of adolescence, carries with it a set of theoretical assumptions. Perhaps the most important of these is positioning pregnancy as a stage in a developmental trajectory towards greater competence and adaptiveness.

Neuroendocrinology and Caregiving Behaviour

Maternal neuroendocrinology has advanced in tandem with understandings of neuroplasticity and behavioural correlates in caregiving. Pregnancy is a time when the maternal brain is exposed to unparalleled fluctuations in neurohormones. For instance, the sex steroid hormones progesterone and oestradiol in pregnant women are increased to levels that are greater than an entire lifetime exposure (Soma et al., 2016). Levels of these hormones increase rapidly over the three trimesters before returning to baseline in the postpartum. Causal relationships between neuroendocrinology, cognition, and behaviour have been easier to pinpoint than between brain structure to function (Barba-Müller et al., 2019). Neuromodulatory effects of hormones on cognition and caregiving behaviour has been well established in animal studies and more recently there has also been progress in human studies. The importance of oxytocin is an area of particular research focus (Atzil et al., 2011; Bakermans-Kranenburg & Van Ijzendoorn, 2018; Feldman & Bakermans-Kranenburg, 2017; H.-J. Lee et al., 2009; MacKinnon et al., 2014). Changes in the HPA axis (hypothalamic-pituitary-axis) and changes in sex steroid hormones, such as oestrogen and progesterone, also have effects on cognition and behaviour in ways that are adaptive to caregiving and appear to represent a trade-off in functioning for women throughout the perinatal period.

Oxytocin levels in pregnancy and postpartum, as well as their relationship to caregiving behaviours, have been intensively investigated in animals and, more recently, in humans (e.g., Bakermans-Kranenburg & Van Ijzendoorn, 2018; Feldman &

Bakermans-Kranenburg, 2017; Galbally et al., 2011). Sometimes known as the "attachment hormone," oxytocin is linked to a variety of parent-infant bonding behaviours, including gaze, gentle and affectionate touch, checking on the infant, and "motherese" vocalisations. (e.g., Feldman et al., 2007). Interestingly, it has been discovered that postpartum mothers and fathers have similar levels of oxytocin. These levels have also been linked to a distinctive set of behaviours, including touching, proprioceptive contact, and affectionate touch in mothers and rocking and jiggling the baby in fathers (Gordon et al., 2010). The result that both mothers and fathers have equal amounts in the postpartum period has been explained by evidence suggesting a bidirectional association between parenting styles and oxytocin levels. For instance, in one study, both mothers' and fathers' oxytocin levels rose after a brief interactive play session with the baby. Where there were high levels of affectionate touch (in mothers) or stimulatory touch (in fathers) circulating levels of oxytocin increased as a result (Feldman et al., 2010).

The hypothalamic-pituitary-adrenal axis (HPA axis) is a major neuroendocrine system which helps regulate stress responses and other bodily processes. During pregnancy it is downregulated and is at its most attenuated in late pregnancy (Voltolini & Petraglia, 2014). It is thought that the downregulation of the HPA axis protects the foetus from exposure to high levels of glucocorticoids while reducing the impact of stress on the mother (Voltolini & Petraglia, 2014).

Large fluctuations and high levels of sex steroid hormones during pregnancy and the postpartum, such as oestrogen and progesterone, and in peptide hormones, such as oxytocin, and prolactin, have complex and multiple purposes (Voltolini & Petraglia, 2014; Russell et al., 2001). They have been found to be implicated in structural and functional brain changes during pregnancy in human as well as in animal models (e.g., Workman et al., 2012). Many nonhuman animal studies have demonstrated effects of sex

steroid hormones on cognition. In animal studies, performance on hippocampal-dependent learning and memory tasks has been shown to vary greatly at both high and low levels of progesterone and oestrogen (for a review, see Workman et al., 2012). Oestrogen's effect on learning and memory has also been documented in human studies, with dendritic spine density (the mechanism underlying the formation of new learning) shown to be sensitive to acute and chronic increases in blood plasma levels of oestrogen (Luine, 2014).

In a well-designed prospective study of 55 pregnant women compared to 21 control women, fluctuations in levels of hormones were compared to performance on a range of neuropsychological tests over late pregnancy and postpartum (Henry & Sherwin, 2012). Overall, pregnant women's performance on verbal recall and processing speed were significantly lower than controls in late pregnancy and postpartum. Cortisol levels had an inverse U-shaped relationship with verbal recall scores both during pregnancy and after giving birth, such that high and low levels of cortisol were linked to poorer performance on verbal recall tasks and moderate levels were predictive of better performance. In the postpartum this inverse U-relationship was also observed for spatial abilities. During pregnancy, prolactin was linked to scores on tests of executive function (EF) in a negative linear function, where higher levels of prolactin predicted lower EF. In the postpartum, oestrogen and cortisol had a negative linear relationship to scores of attention. In spite of these relationships, the authors caution that the mechanisms between neuroendocrinology and cognition are not as straightforward as they may appear here. They are likely indicators of multiple neural mechanisms rather than direct causal mechanisms themselves. The major shifts in neuroendocrinology and brain plasticity appear to also place women at greater risk for developing a major depressive episode in the postpartum (for a review, see Sacher et al., 2020). A greater

integration of neurobiological and psychosocial factors in theoretical models of postpartum depression would support the formulation of risk.

In summary, the maternal neuroendocrine system undergoes a range of adaptations during pregnancy which supports caregiving behaviours, but this may come at a cost to general cognitive functioning as well as a heightened risk of mood disturbances. Unlike neuroplasticity, however, less is known about long term changes in neuroendocrinology. It is evident that a substantial body of research from both human and animal studies supports the notion that pregnancy hormones alter the structure and functioning of the maternal brain and this has an impact on cognition and behaviour (Brown & Schaffir, 2019). In addition, the large shifts in hormone levels throughout late pregnancy and into the postpartum appears to influence selective cognitive abilities, such as EF (Henry & Sherwin, 2012). At this point, it is timely to consider the evidence for general cognitive change during pregnancy.

Cognitive Decrements in Pregnancy

To date, most research into women's cognition in pregnancy has focused on memory functioning. At the time of writing, three meta-analyses of maternal cognition have been completed which build on each other and are reviewed here briefly. The first examined memory during pregnancy and included 14 empirical studies (n = 412; Henry & Rendell, 2007). They found that, compared to control women, pregnant women performed significantly lower on working memory and verbal free recall tasks. Overall, most affected were memory tasks which placed the highest demands on cognitive control. Anderson and Rutherford (2012) extended the scope in their meta-analysis to include processing speed and general cognition in addition to memory. A pooled sample of n = 2,041 participants was derived from 22 studies. Overall, small cognitive decrements were found in working memory, verbal recall, prospective memory, and general cognition with effect sizes smaller than those found in Henry and Rendell

(2007). Some novel findings also emerged: A moderate negative effect of pregnancy and processing speed (mean r = -.33) was found as well as a small positive effect of pregnancy and recognition memory (mean r = .14). Overall, the authors interpreted these findings to mean that decrements in cognitive functioning during the reproductive phases of pregnancy and postpartum might not be specific to types of memory, but rather represent general (nonspecific) cognitive changes, as well as potential cognitive advantages.

In the most recent meta-analysis of maternal cognition, Davies et al. (2018) included a pooled sample of n = 1230 (pregnant and control women) from 20 studies. Results revealed the pregnant women were significantly lower in executive functioning, memory, and overall cognitive functioning compared to control women. The overall standardised mean difference (SMD) between pregnant and control participants in general cognitive functioning (which they defined broadly as including executive functioning, attention, processing speed, memory, and verbal and visuospatial abilities) was SMD = 0.52, a medium effect size which they note is not only statistically but also clinically significant. Notably, they also found, for the first time, there were no significant differences in cognitive functioning in the first and second trimesters, suggesting that cognitive change may only be detectable in the final stages of pregnancy.

Overall, Anderson and Rutherford (2012) were the first to reconceptualise maternal cognition through an evolutionary lens. According to this account, while the brain is re-organising, functions which support adaptive caregiving are prioritized over those which are less directly relevant. A corollary to this hypothesis is “morning sickness” in the early stages of pregnancy. Just as research into nausea during pregnancy now emphasizes its protective function (i.e., keeping pregnant women closer to home and safety, reducing the likelihood of accidentally ingesting toxic substances), Anderson and Rutherford (2012) propose that future research into the maternal “baby brain”

would be well served by working from hypotheses which emphasize the potential adaptive function of cognitive changes during human reproduction, such as enhancing social cognition within an adaptationist perspective. This important point will be further developed in the rationale for the current study.

Maternal Neuroplasticity: Supporting Theory of Mind and Attachment?

As discussed earlier, research into structural and functional brain changes during pregnancy has broadly conceptualised a "maternal circuit" made up of various cognitive and affective components (as suggested in Hillerer et al. 2014; Kim et al. 2016). The exception to this broad conceptualisation of a maternal circuit comes from a recent study which showed, for the first time, significant grey matter change before and after pregnancy in first time mothers. This major study offered more specific suggestions concerning the function of maternal brain changes (Hoekzema et al., 2017) and added fresh impetus to the understanding that pregnancy is a time of significant neuroplasticity in service of specific adaptive behaviours. As this study is central to the rationale and design of the present thesis, it will now be presented in detail.

Pregnancy Leads to Significant Long-Term Changes in Brain Structure. In their prospective structural neuroimaging study, Hoekzema et al. (2016) found, for the first time, that the brains of new mothers showed substantial loss in grey matter (GM) volume after their first pregnancy. This GM loss was maintained 2 years postpartum with no further loss or recovery of GM volume, except for recovery in specific hippocampal regions. The sample of women (n = 25) underwent neuroimaging at three time points: Before they were pregnant for the first time, in the early postpartum, and then at a 2-year follow up. Control participants (matched women who had never been pregnant, and the pregnant women's male partners) also had MRI brain scans in the same time periods. The regions with GM volume loss were highly consistent

and were only found in pregnant women. These were primarily located in the medial frontal cortex, the precuneus, the inferior frontal gyri, and the bilateral temporal cortex.

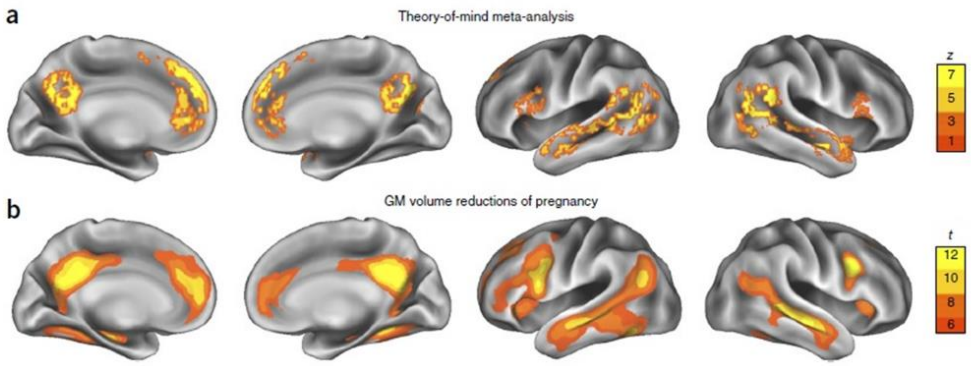
Working on the assumption that the regions with GM volume loss may have specific cognitive and behavioural correlates, the authors compared the regions of GM volume loss with functional maps of the brain. They concluded that the regions of GM volume loss best corresponded to the network subserving ToM processing (see Figure 1). To draw this inference, Hoekzema et al. (2016) relied on a ToM functional map derived from the fMRI meta-analysis of ToM tasks (Schurz et al., 2014). This fMRI meta-analysis aggregated ToM functional maps from 73 fMRI studies (n = 1241) where participants were scanned while performing a range of ToM tasks—from false belief understanding to affect recognition. The study found support for a core ToM network in the brain which is activated whenever people are thinking about the mental states of others, taking perspectives, and reading emotions. The network is located in the medial prefrontal cortex, inferior frontal gyri, and in the bilateral temporal parietal junction (including the precuneus). While there were some task related differences in cortical activation patterns, all ToM tasks overlapped in the medial prefrontal cortex (mPFC) and the bilateral temporal parietal junction (TPJ; Schurz et al., 2014).

Visual inspection of the top and bottom panel in Figure 1 suggests considerable overlap between the map of GM volume loss over pregnancy and the core ToM network, particularly in these latter regions (MPFC, TPJ). Quantified, the ToM network accounts for 20.5% of the GM volume change map (Hoekzema et al., 2017). Importantly, the authors propose from their findings that these substantial GM volume reductions of first pregnancy might represent a refinement and enhancement in processing efficiency in the social cognitive processes of ToM. The proposed developmental corollary is the synaptic pruning seen in adolescence where greater functional specialisation of brain circuitry is

achieved and this is reflected in GM volume reductions as measured by MRI studies (Blakemore, 2008; Sisk & Zehr, 2005).

Figure 1

ToM Functional Network Compared to GM Volume Reductions after First Pregnancy



Note. Top panel shows aggregated fMRI ToM network (Schurz et al., 2014). Bottom panel shows an aggregated map of GM volume reductions after first pregnancy.

Figure from " Pregnancy Leads to Long Lasting Changes in Human Brain Structure, " by E. Hoekzema, E. Barba-Müller, C. Pozzobon, M. Picado, F. Lucco, D. García-García, J. C. Soliva, A. Tobeña, M. Desco, E. A. Crone, A. Ballesteros, S. Carmona and O. Vilarroya, 2017, Nature Neuroscience, 20, 287–296. Copyright 2016 by Springer Nature.

To explore whether there was a relationship between the neuroplasticity of pregnancy and postpartum caregiving, Hoekzema et al. (2016) examined maternal-infant attachment in the postpartum via two measures: a self-report questionnaire measure and an fMRI task where new mothers were shown images of her own baby compared to images of other babies. On the questionnaire measure, GM volume changes significantly predicted scores on two aspects of maternal-infant attachment: attachment quality and absence of hostility towards the infant. Moreover, the GM volume changes also corresponded to neural activity in response to viewing images of own baby. The overlap was quantified as approximately 30% (own infant>other infant/GM volume change). Taken together, these findings are presented as support for the inference that pregnancy

is a time of significant change in brain structure and function in service of adaptive caregiving functioning, specifically attachment.

The Hoekzema et al. (2016) study is unique in hypothesising that it is the ToM network specifically which adapts during pregnancy. From this, they postulate that ToM is a possible mechanism linking neurobiological change to attachment. As others have noted, this interpretation also situates pregnancy as a developmental period, with similar underlying processes operating as other stages of the life span, such as puberty. During puberty, massive neuroendocrine changes are thought to contribute to GM volume loss which may be associated with increases in GM density. GM density is an indirect marker of brain cells (neurons and glia), their blood supply, and associated dendrites and synapses (Gogtay et al., 2004). Changes in the GM structure during adolescence is considered to be the mechanism by which greater functional specialisation and efficiency in certain kinds of cognitive processing is achieved which, over time, supports the young person to acquire the social cognitive skills of adulthood (Andrews et al., 2021; Blakemore, 2008).

Some caution is called for, however, when considering this inference from brain structure to function. The many steps needed in neuropsychology to make an inference from changes in brain structure to function is not straightforward which makes this hypothesis exploratory. A brain structure to function inference is considered a 'backwards inference' (Poldrack, 2006). What is needed is a behavioural study to test this hypothesis regarding ToM functioning in pregnancy and its relationship to maternal-infant attachment.

Finally, a note on fMRI research methodology is called for. fMRI study methodology has encountered serious problems relating to small sample sizes (e.g., $n <$ 25). In studies where marginal or small effects are detected, the risk of the study being underpowered is great and the likelihood of Type 1 errors is increased (Button et al.,

2013). Another factor contributing to the complexity of relying on fMRI research lies in the flexibility it offers in data analysis. This flexibility opens the door to data exploration, which can be valuable for generating exploratory hypotheses and uncovering potential relationships but also carries the risk of chance findings. Significant correlations may emerge because of multiple comparisons or data-driven exploration, leading to false positives or overestimations of effects (Poldrack et al., 2017). These methodological concerns are relevant to maternal cognition research. Notably, many studies in this field have small sample sizes, as seen in Kim et al. (2016). Given the limitations associated with small samples in fMRI studies, caution should be exercised when interpreting and generalizing the findings of such research. The potential for underpowered analyses and the inherent risks of exploratory data analysis underscores the need for larger sample sizes and robust and transparent methodological approaches to ensure reliable results. Again, behavioural research plays a crucial role in testing these exploratory hypotheses.

Summary

In summary, there is now substantial evidence showing that pregnancy is a time of structural and functional neuroplasticity with implications for adaptive maternal caregiving behaviour. Cognitive decrements have also been found. These consist of small to moderate differences in group studies of late-stage pregnant women and reveal reductions in working memory, executive functioning, and overall cognitive functioning in the third trimester of pregnancy. There are also human and nonhuman animal studies which have established links between the neural substrates of a proposed maternal circuit and emotional processing, motivation, and aspects of attuned dyadic caregiving. Hoekzema et al. (2016) were the first to show enduring and significant GM changes during pregnancy located in regions which broadly overlap with ToM processing. They also showed that these GM changes were associated with postpartum maternal-infant attachment. From these findings they hypothesise that the function of brain changes in

pregnancy is to enhance caregiver ToM, sensitive and attuned caregiving behaviour, and attachment security. This is theoretically consistent with viewing pregnancy through a developmental adaptive framework. The next section will introduce ToM in general before providing an overview of the way in which ToM contributes to secure attachment.

Theory of Mind

Theory of Mind (ToM) describes the capacity to reflect on one's own mind and make inferences about the contents of another's mind based on a range of social, emotional, and contextual information. It allows us to observe ourselves from the outside and make estimates about what is going on for others on the inside through a mental shifting of perspectives and to make predictions about behaviour based on the understanding that it reflects mental states. To do this, a range of social information can be used such as knowledge of social scripts and culturally informed schemas, to interpretations of emotional cues and integrating this with contextual information (Apperly, 2012b; Schaafsma et al., 2015). Depending on the situation, ToM can be activated processing a stream of incoming information from different modalities and sources (e.g., verbal, visual, contextual) for more elaborate processing, or it can be quick automatic responses to social cues, such as from fleeting facial expressions. Interpreting these and updating them while minimizing interference, necessarily places demands on executive functioning and working memory and children's development of ToM is associated with their language ability (Apperly, 2012).

Since Premack and Woodruff (1978) originally proposed the concept of ToM, study in this area has largely focused on how ToM emerges from infancy through to late childhood, a knowledge gained through the development of increasingly sophisticated measures of ToM capacity. ToM's development from infancy to adulthood, as well as in populations where ToM is impaired, shows how it is made up of interconnected and dissociable cognitive components that vary in complexity and function (e.g., Andrews et

al., 2021; Blakemore, 2008). Apperly (2012) has suggested that with growing interest in studying ToM in different populations it can be seen more as a 'conceptual domain' than as a construct in the way it has expanded beyond the original understanding and operationalisation in tasks such as classic false belief tasks. As a conceptual domain, covering so many processes, it is questionable whether studies of individual differences that employ single ToM measures can adequately reflect the variety of cognitive processes involved in ToM or their possible correlates.

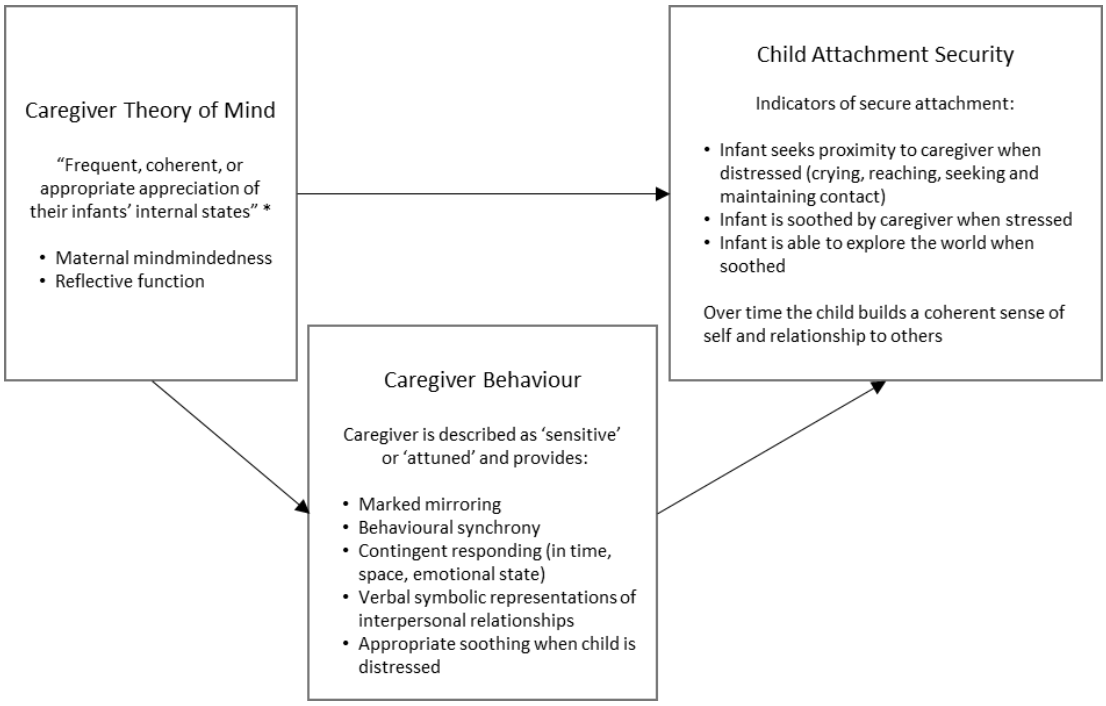
The Importance of Caregiver Theory of Mind

When parents are curious about their children's mental states and desires, and can see the world through their children's eyes, they are also more likely to respond in ways which are sensitive to the child's needs thus fostering a more secure and reciprocal relationship. In the early stages of an infant's life, communication is nonverbal and requires the caregiver to attend to and interpret baby's emotional signals and behaviours (Luyten et al., 2012). Many studies have now accumulated showing that in the early parenting context, the ability of the primary caregiver to accurately appreciate the child as a psychological agent contributes to infant attachment security. In their recent meta-analysis of parents and children aged between 0-36 months old, Zeegers et al. (2017) examined the triangular relations between parental ToM, sensitivity, and attachment. ToM was found to be directly predictive of children's attachment security and also indirectly via parental sensitivity together explaining 12 % of the variance (Zeegers et al., 2017). In this way, parents who are able understand their own and their infant's inner experiences are more likely to provide the foundation for a secure attachment relationship. This is the direct path between parental ToM and attachment. In terms of the indirect path via parental sensitivity, caregivers who can mentally tune into their children's inner experiences, while staying aware of their own thoughts, feelings and reactions, are more able to respond and interact in ways which support their child's

relational wellbeing (Bornstein, 2013). A range of these sensitive and attuned behaviours have been examined; examples are listed in Figure 2 which also provides schematic of the relationship between caregiver ToM, caregiver behaviour and attachment security.

Figure 2

A Direct and Indirect Relationship between Caregiver ToM, Behaviour, and Attachment Security



Note. This schematic illustrates the direct and indirect relationships between Caregiver ToM, Child Attachment Security, and Caregiver Behaviour, as described in the Zeegers et al. (2017) meta-analysis. *(p. 2; Zeegers et al., 2017)

Overall, research into ToM cognition in pregnancy is still at a very early stage. The exception to this is a pocket of research examining face processing in pregnant women. This research has mainly focussed on understanding how the processing of infant faces is related to later parenting behaviours in the postpartum, such as maternal sensitivity to infant cues, the amount of synchrony in maternal-infant interactions, and the impact of maternal emotional state on face processing and attachment. However, there are also several studies which have compared performance of pregnant women on

face processing with matched control women to ascertain whether it is enhanced. Other research methods which have explored this specifically for pregnancy are ones which are longitudinal or those which correlate cognition with biological changes of pregnancy. In addition to face processing, there are a small number of studies which have examined mind-mindedness and reflective function in pregnancy, both of which developed out of attachment research. To our knowledge, there are no studies examining pregnant women's ToM on a range of measures. The following section will review ToM cognition in pregnancy and how it has been found to relate to caregiving, while highlighting gaps and limitations.

1. Face Processing in Pregnancy

Emotions on human faces provide potent social cues about inner experiences and the environmental context (e.g., presence of threat). The processing of social information from faces over the perinatal period has been the subject of a growing number of studies. Research has examined sensitivity to facial emotional cues, how this relates to emotional distress and the endocrinology of pregnancy, as well as how it predicts aspects of caregiving in the postpartum. The recognition of complex emotions on faces is also commonly used as an indicator of ToM, most notably in the Reading the Mind in the Eyes Task (RMET; Baron-Cohen et al., 2001), although this measure has received little research attention in pregnancy.

In a recent systematic review of face processing in pregnancy, De Carli et al. (2019) included 19 studies covering a range of research methods and measures. Seven studies were behavioural with matched not pregnant control groups, the others were fMRI or EEG. The strongest evidence relates to emotion recognition which appears to be enhanced for select emotions especially negative emotions. In terms of adaptive explanations, an enhanced emotion recognition capacity supports quick and accurate understanding of a pre-verbal infant's inner experience, especially distress. The ability to

read emotions in the faces of other adults might facilitate social understanding, and provide clues about where there might be a risk of danger while guiding social responses (Frith, 2008). Some recent findings from this research into adult and infant faces, and correlates, is presented below.

Research into adult face processing in pregnancy has found evidence of increased sensitivity to possible threat cues—both interpersonal and physical—and correlates in emotional distress and hormonal changes. In their longitudinal study (n = 101), Pearson et al. (2009) found that compared to early pregnancy, women in late pregnancy had an enhanced emotion recognition ability for faces displaying negative emotions (fear, anger, disgust, and sadness) with small to moderate effect sizes (0.30 to .050 s.d.). Moreover, pregnant women who were experiencing higher levels of anxiety were significantly better at recognizing fearful and angry faces, compared to women who had low levels of anxiety in pregnancy (0.37 s.d). Given the rise in oestrogen, progesterone, and cortisol between the first and third trimesters of pregnancy, and evidence that greater levels of oestrogen and progesterone are associated greater accuracy in fear recognition (Pearson & Lewis, 2005), Pearson et al. (2009) propose that these hormones might be neurobiological contributors to the enhancement of emotional face recognition in late pregnancy. Consistent with this result, Roos et al. (2012) used an emotional Stroop task to investigate selective attention to emotional faces in their longitudinal study across the three trimesters of pregnancy. Overall compared to control group women (n = 25), pregnant women (n = 44) showed an attentional bias to fearful faces, and this effect was stronger in pregnant women who had greater levels of personal distress. Pregnant women's attentional bias towards threat was also associated with higher levels of circulating oestrogen and progesterone in the second trimester and lower levels of cortisol in the third trimester of pregnancy. In a study into the preference for markers of apparent health in male faces, second trimester pregnant women (n = 115) significantly

preferred male faces with enhanced health indicators compared to not pregnant control women (*n* = 857; Jones et al., 2005). This preference was replicated in women during the luteal phase of their menstrual cycle which, taken together, Jones et al. (2005) interpret as a preference for safety from infection as an effect of elevated progesterone. In a smaller study, pregnant women had an enhanced accuracy to detect out-group male faces compared to controls (*n* = 20 pregnant women, men *n* = 20, and women *n* = 19; Anderson & Rutherford, 2011). These studies reveal multifaceted relationships between pregnant women's enhanced ability to recognize negative emotions on adult faces, endocrinological contributors to this, and likely adaptive explanations from the perspective of reducing threat over pregnancy.

The Reading the Mind in the Eyes Task-Revised (RMET; Baron-Cohen et al., 2001) is a classic measure of the recognition of a range of complex emotions in adults' eyes. It has been used extensively in research into ToM in adults. To date, two related studies have longitudinally examined the relationship between changing levels of oxytocin over the perinatal period, women's general emotion recognition on the RMET, and later maternal-infant interactive behaviours (*n* = 316; MacKinnon et al., 2014, MacKinnon et al., 2018). The studies revealed that when oxytocin levels were at their highest levels in the third trimester of pregnancy, this predicted early postpartum emotion recognition on the RMET. Better emotion recognition was also significantly predictive of less remote and depressive interactive behaviours between mothers and their infants in a play observation coded for sensitivity, intrusiveness, remoteness, and depressive behaviours. Further, oxytocin levels in the third trimester were indirectly correlated with less intrusive and more structured maternal interactive behaviour when the children were 2-3 years and, importantly, this relationship was via maternal emotion recognition. Consistent with accumulated research findings into caregiver ToM, attuned interactive behaviours, and attachment security (Zeegers et al., 2017), MacKinnon et al.

(2018) propose that the endocrinology of late pregnancy appears to support better emotion recognition in general and later adaptive caregiving behaviour.

Infant faces are a special type of social stimuli which cue caregiver emotional responses and behaviour. Accurate recognition of distress in infant faces has also been investigated longitudinally to ascertain if this aspect of emotion recognition in pregnancy relates to later sensitive caregiving behaviour and attachment security. In their longitudinal study, Leerkes (2010) compared late stage pregnant women's accuracy in detecting distress on 10-second videos of crying infant faces with their later sensitive caregiving behaviour towards their own infant's distress at 6-months of age (n = 101). Maternal sensitivity to the 6-month old was assessed via a laboratory task designed to elicit a short negative emotional response in the child and coding maternal responses for sensitivity. Overall, the study revealed that accurately detecting distress on video stimuli of infant faces during pregnancy was predictive of maternal sensitivity to distress when babies were 6-months old. However, the mother's goals for how she would respond to a distressed infant, as well as her own emotional reactions to infant distress, were the strongest predictors of maternal sensitivity in both pregnancy and postpartum. Mothers who experienced high levels of negative emotions when observing infant distress, in particular, were less able to respond sensitively, a finding that is consistent with other research into maternal distress (e.g., Schultheis et al., 2019).

In a further study of the longitudinal relations between infant emotional recognition and later caregiving, late-stage, primiparous pregnant women (n = 105) were measured on their ability to accurately recognise infant emotions and later postpartum maternal sensitivity (5 months) and maternal-infant attachment security (18 months; Bernstein et al., 2014). Results confirmed hypotheses that the ability to accurately recognize infant emotional expressions in late pregnancy predicted secure versus disorganized attachment classification when the children were 18 months old. Other

predictors such as maternal trauma history and sensitivity at 5-months postpartum were not better predictors.

Finally, neuroimaging research provides another lens for explaining the possible mechanisms for selective attention to infant faces and the link to enhanced emotional processing in the postpartum. Zhang et al. (2020) used fMRI to investigate new mothers' (n = 20) whole brain responses to infant emotional faces compared to never pregnant control women (n = 22). The new mothers (2-11 months postpartum) showed greater activation in brain regions associated with facial processing, empathy, and ToM[1] than the control women. Moreover, new mothers' empathy for infant emotional faces was predicted by the magnitude of activation in these brain regions to a greater degree than in the control women. This study offers potential insights into how the experience of maternal caregiving might prime functional brain responses in social cognitive regions, especially those related to ToM, empathic processing, and visual face processing. Given the age of the infants, it is not possible to determine how the neurobiology of pregnancy and experience-related neuroplasticity each contribute to these neural activation differences. In addition, the modest sample size should lead to some caution in interpreting these findings—as has been noted in critiques of underpowered fMRI research in general (Button et al., 2013; Poldrack et al., 2017).

Taken as a whole, the accumulated evidence suggests that face processing of adult and infant emotions is likely facilitated over pregnancy, there is an attentional bias to negative emotions which is influenced by hormonal levels and emotional distress, and this has correlates in maternal caregiving behaviour. However, given that evidence from behavioural studies is still limited, this account must be considered with some caution.

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[1] Postpartum brain activation differences were found in frontal gyri, right temporal gyrus, fusiform gyri, parahippocampal gyri, and occipital gyri.

2. *Reflective Function in Pregnancy*

Reflective function (RF) encapsulates higher order ToM reasoning processes, and unlike other ToM constructs, RF draws attention to one's own mental and emotional processes, as well as that of others. This emphasis on one's own internal processes is what distinguishes RF from other ToM concepts. Parental RF refers to the parent's capacity to understand their own inner experiences as well as that of the child. Parents high in RF are able to respond to what is going on for the infant on the "the inside" rather than focusing on controlling what is going on for the child when viewed from "the outside". Research examining the correlates of RF capacity highlights its importance to adaptive caregiving. For instance, three key findings are that parental reflective functioning is linked with heightened sensitivity to infant emotional cues (Grienenberger, Kelly, & Slade, 2005) and predicts attachment security (Slade et al., 2005). Conversely a lack of reflective function has been found to be associated with reduced sensitivity towards infant's emotional distress (Krink et al., 2018).

RF was originally proposed by Fonagy et al. (1991), as an additional coding dimension from the Parent Development Interview, a semi-structured interview probing adult representations of attachment and usually coded for overall coherence. Later the PRFQ (Parental Reflective Functioning Questionnaire; Slade, 2005) was developed and the RFQ short form (Reflective Functioning Questionnaire; Fonagy et al. 2016) to facilitate research and clinical screening. Given that these measurement instruments draw on slightly different operationalisations of RF caution is needed when comparing findings. For instance, the RFQ has two dimensions, hypermentalising and hypomentalising, both of which are indicators of poor ToM. The PRFQ has three dimensions (Interest and Curiosity of Mental States, Certainty of Mental States, Pre-Mentalising Modes, and an overall scale score). The dimension pre-mentalising modes, which refers to a non-mentalising stance with poor and rigid attributions about the child,

is associated with less parental sensitivity towards the child, greater emotional arousal in the parent and poorer child outcomes (e.g., Suardi et al., 2020).

There are very few studies of RF (on the RFQ) in pregnancy, and none directly examining whether it is enhanced in pregnant women compared to control women. However, there are a few studies examining the longitudinal relationships and correlates of RF. For instance, Rutherford et al. (2018) examined Event Related Potential (ERP) latency induced by infant emotional faces in late-stage pregnant women and compared this to their parental reflective functioning in the postpartum. The amplitude of ERP latency, generated by electroencephalography (EEG), is believed to be a measure of emotional and attentional salience of a stimuli (e.g., Kaltwasser et al., 2014). As expected, greater ERP latency to distressed infant faces compared to neutral faces indicated greater allocation of attention to infant distress. Moreover, the magnitude of the ERP latency in response to infant neutral faces also predicted levels of difficulty in reflective function in the postpartum. Specifically, women whose attention was captured by the neutral faces, were more likely to endorse a pre-mentalising mode of parental RF, whereby malevolence attributions are made of infant behaviour and there is poorer reflecting on one's own internal processes. This study provides an indicator that there are precursors to poor reflective function in the prenatal period relating to emotion recognition.

In a qualitative study into psychosocial risk factors and RF in first time pregnant adolescent women, Sadler et al. (2016) found that social deprivation (poverty, difficult family and neighbourhood environments) as well as the developmental stage of the women, was associated with a very reduced capacity to reflect. Psychosocial deprivation appears to present a cumulative risk for poorer RF – with greater levels of deprivation associated with worse RF (Smaling et al., 2015; Wong, 2016). In particular, poor social support and the presence of substance use problems predicted lower RF, followed by

reduced maternal education (Smaling et al., 2015). The link between the severity of a woman's opioid use during pregnancy and the experience of adversity as a child was significantly mediated by levels of RF, demonstrating how RF can be a protective factor (Macfie et al., 2020). Research has also shown the bidirectional relationship between RF and emotional regulation in parenting. Mothers with poor emotion regulation have been found to use more pre-mentalising modes RF, a poor RF with hostile attributions towards the function of child behaviour (Rutherford et al., 2015). The greater difficulty mothers had in accurately perceiving their child's mental states, the more likely they were to struggle with distress tolerance as measured by self-report and via objective measures of stress (blood pressure, heart rate). Finally, two recent studies have found RF to be stable over the period from late pregnancy into the postpartum (Pitzen, 2021; Wong, 2016).

These studies contribute to our understanding of the factors that precede and are linked to RF within the context of early parenting. They shed light on how psychosocial and emotional risk factors can have a negative impact on an individual's RF capacity. Despite extensive research on the significance of parental reflective functioning during the early years of a child's life, including findings from intervention studies (Krink et al., 2018; Sadler et al., 2013; Schultheis et al., 2019; Slade, 2005; Slade et al., 2020) our understanding of RF capacity during pregnancy remains very limited.

3. Mind-mindedness in Pregnancy

Like RF, Mind-mindedness (MM) emerged out of an interest in understanding the transmission of attachment. MM was originally conceived as an operationalisation of Ainsworth's maternal sensitivity (Meins, 1997; Meins et al., 2001) and like RF it focuses on the ability of the caregiver to interpret their child's behaviour as a function of internal experiences – motivations, beliefs, knowledge – taking into account their developmental stage. It has mainly been studied in terms of mother-infant interactions in the first year

of the child's life (Meins et al., 2013). There is also a body of research into representational MM where the caregiver is asked to 'describe the child' without further prompting to spontaneously elicit mental representations of the child. A manual provides a structured method for coding both measures of MM (Meins & Fernyhough, 2015). The interactional measure has an additional coding compared to the representational measure. An index of non-attuned comments is calculated as well as appropriate comments. These two dimensions are considered orthogonal (i.e., not existing on a continuum of each other). However, research into non-attuned MM comments is still at an early stage (McMahon & Bernier, 2017). The degree to which it bears similarity to the Pre-Mentalising Modes subscale from the PRFQ has yet to be determined.

Despite there now being over 25 years of research into MM (McMahon & Bernier, 2017), just one study has examined MM in pregnancy. In their prospective study, representational MM during pregnancy was compared to interactional MM in the postpartum (Arnott & Meins, 2008). Pregnant women (n = 21) and fathers (n = 17) in the third trimester of pregnancy were asked to describe what they thought their child would be like at 6 months of age. When the babies were 6 months old, participants were invited to a play observation with their children. There was no difference in the levels of antenatal mind-related comments between mothers and fathers – predictions about the future child and use of mentalising attributes were the same. For both mothers and fathers, overall high levels of mind-related comments during pregnancy predicted greater levels of appropriate mind-related comments 6-months postpartum in the play observation. This suggests there is concordance between the two measures and stability over time in MM. For fathers, however, greater use of mind-minded comments during their partner's pregnancy was also predictive of more inappropriate mind-related comments when the child was a few months old. The authors suggest that this might be

a result of less caregiving experience – women are often primary caregivers and so gain greater experience in reading their babies thoughts and feelings. It also suggests that ToM in the context of caregiving has different aspects, not all associated with sensitive caregiving.

The prenatal correlates of MM and its stability over time has been examined longitudinally. McMahon et al. (2016) found that in late stage first time pregnant women, maternal-foetal attachment predicted MM in mother and child interactions coded for appropriate mind-related comments. Mothers with greater attachment security also made fewer non-attuned comments during a play session with their 7-month-old infants. These effects were small but statistically significant. The study usefully contributed understanding of the origins of MM and suggested that the tendency to consider mental states of the child may be present during late pregnancy, and once established is reasonably stable. Finally, the association of MM with attachment security and children's later ToM has been investigated longitudinally. Meins et al. (2001) found that in both mothers and fathers a greater propensity towards MM in interaction with their infants in the first year of life predicted more secure infant–parent attachment relationships. Moreover, levels of MM in caregivers also longitudinally predicted the child's later ToM understanding (Meins et al., 2003).

The Impact of Depression and Anxiety on Theory of Mind in Caregiving

It well established that poor maternal mental health over the perinatal period has been shown to have a range of adverse effects on children's development (Hazell Raine et al., 2020; Howard et al., 2014; Howard & Khalifeh, 2020; Stein et al., 2014). Current or previous episodes of depression in mothers of infants and very young children is associated with reduced behavioural synchrony of the mother towards her child's emotional experience, greater hostility, emotional disengagement, and fewer positive activities and play (Lovejoy et al., 2000). The depressive symptomology itself has been

proposed as the mechanism by which parenting is impaired; so, for instance, the parent who withdraws, has reduced energy, and experiences less pleasure in parenting activities is less able to provide nurturing care to their child. Another explanation relates to information processing biases. People who are depressed have difficulties disengaging attention from negatively valanced thoughts and experiences and have a greater tendency to interpret neutral social information as threatening. Consistent with this latter explanation, in their systematic review Webb and Ayers (2015) found that mothers with postnatal depression and anxiety are more likely to misread infant emotion expressions by falsely identifying negative emotions and having reduced accuracy at identifying positive emotions on infant faces. De Carli et al. (2019) have also suggested that depression and anxiety are likely to impact on the processing of face information. As early as in the first trimester of pregnancy, depressed pregnant women disengaged their attention more quickly from images of distressed infant faces than pregnant women who were not depressed (Pearson et al., 2010). Neurophysiological measures add converging evidence to the hypothesis that depression causes a reduced attentional bias to infant faces. Rutherford (2016) found that in late-stage pregnant women levels of depressive symptomology was correlated with a lowered P300 signal amplitude in response to distressed infant faces. P300 signal is an event related potential (ERP) which is thought to be a measure of attention, memory and varies by task relevance (Polich & Kok, 1995). Lower signal amplitude is thought to be an indicator of reduced processing of the stimulus information. In this case, depression appears to have dampened the attentional bias that pregnant women would normally have to infant distress.

Infant faces are a special kind of social stimuli in the way they capture attention more than adult faces (Brosch et al., 2007) an effect which is stronger in mothers than non-mothers (Thompson-Booth et al., 2014b) in order to elicit the care and protection they require for survival. However, in the case of depressed and anxious mothers, this

adaptation appears to be disrupted. The disruption of the maternal attentional bias to infant faces, and the ability to recognise emotion accurately and fluently, is another way in which depression may have adverse effects on a child's development. The critical importance of maternal-infant reciprocity in facial expressions and its link to infant affect regulation (Mesman et al., 2009), as shown in the seminal still-face paradigm research (Tronick et al., 1978), has underscored the way in which maternal attentional bias for infant faces is adaptive.

Summary and Gaps

This chapter has introduced the brain-behaviour changes of pregnancy, a stage of the lifespan which brings about rapid change across biological, social, and psychological domains. There is now accumulated evidence that the hormonal changes of pregnancy contribute to structural and functional brain changes and the timing of these is associated with a decrement in general cognition, as well in specific domains, such as memory and EF. Hoekzema et al. (2016) were the first to propose that GM structural changes in first time pregnant women were correlated with the ToM network and maternal-infant attachment. Behavioural studies have found limited evidence for cognitive enhancement; face processing is the only aspect of ToM which has received research attention. RF and MM, aspects of ToM in the caregiving context, have been examined in early maternal-infant relationships demonstrating how they positively influence attachment security, how there is evidence of precursors to them in pregnancy, and how parental ToM can be disrupted with the presence of psychosocial adversity and psychological distress. Despite the evidence for the link between ToM and attachment, which along with maternal sensitivity, accounts for a substantial proportion of variance in maternal-infant attachment, not much is known about ToM capacity in pregnancy. Few studies include matched control groups to explore differences related to pregnancy status, consistent with other research into maternal cognition.

ToM is a multidimensional construct which draws on many psychological processes and modalities. It is used here as an umbrella term, like executive functioning, insofar as it is comprised of a number of cognitive components ranging in complexity. In the current study, a wide range of measures capturing different aspects of ToM will be used, making the study more sensitive to possible variability of performance. It has been suggested by Hoekzema et al. (2016), and more recently by Pawluski et al. (2022), that pregnancy might be considered a developmental period of structural and functional change akin to adolescence in terms of neuroplasticity. If so, then we might expect to see components of ToM processing change, while others do not, just as this has been found in adolescence (e.g., Andrews et al., 2021; Meinhardt-Injac et al., 2020). A clearer understanding of ToM over the perinatal period and its relationship to attachment security will contribute to the development of more highly specified descriptive and explanatory models.

The Current Study

The primary aim of this research is to investigate whether pregnant women have enhanced ToM; whether ToM in pregnancy or postpartum predicts attachment, and to ascertain whether emotional state factors impact on this relationship. It was important to the study design to include primiparous, late-stage pregnant women to lend support to the hypothesis that it is the neurobiology of pregnancy itself which might be contributing to any changes in the ToM network, rather than the experience of parenting or of multiple parity. Consistent with most maternal cognition studies a between-groups study design with matched control women is needed. Several secondary aims will be investigated, such as the impact of mood and stress on perinatal ToM and attachment. Two studies were devised to test the specific hypotheses.

Research Design and Hypotheses

Study 1 is a quasi-experimental between groups design comparing first time pregnant women's performance on a range of ToM tasks with that of age- and education-matched control women. Average amount of time spent interacting with children was also measured as a potential co-variate of spontaneous ToM. Participant demographic information was collected to test whether the sample reflected the wider region where the study took place. As ToM is a multidimensional construct, four measures were selected to investigate a range of ToM processes. Another factor in their selection was to reflect comparable ToM processes to the Schurz et al. (2014) fMRI meta-analysis. Two measures that were used can be considered 'classic' as they have been used in multiple studies of ToM (RMET, Hinting). As Reading the Mind in the Eyes task (RMET) is also a measure of emotion recognition this was an important measure in the context of the extant literature into face processing in pregnancy. Given the two research streams into mind-mindedness (MM) and reflective functioning (RF), these measures were selected as relevant to ToM in caregiving.

Study 2 was a prospective study of the relationship between ToM in late-stage pregnancy and parental reflective functioning and maternal-infant attachment in the postpartum. In addition, the relationship between emotional state on ToM and attachment was examined.

Study 1 Hypotheses

It was hypothesised that:

1. Consistent with Hoekzema et al. (2016), pregnant women will have overall enhanced ToM compared to control group women.
2. Pregnant women's ToM capacity will be associated with prenatal attachment.

3. Women with (1) greater levels of emotional distress (depression, anxiety, stress) will have (2) overall reduced ToM capacity; and (3) for pregnant women, levels of emotional distress will be negatively associated with (4) prenatal attachment.

Study 2 Hypotheses

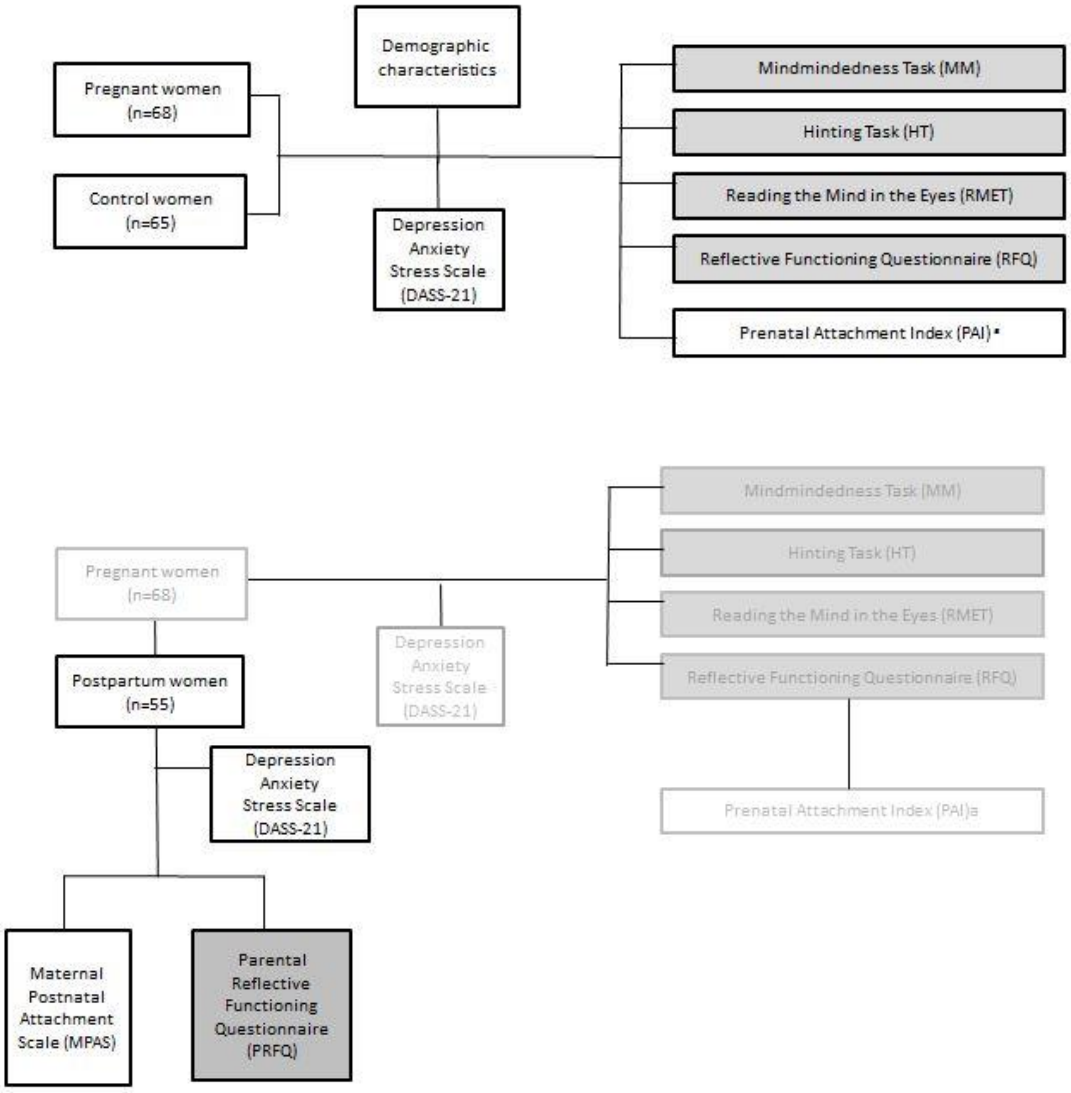
It was hypothesised that:

1. Pregnant women's ToM capacity will be positively associated with postpartum (1) parental reflective functioning and (2) maternal-infant attachment.
2. Postpartum women with (1) greater levels of emotional distress (depression, anxiety, stress) will have poorer (1) reflective functioning and (2) a poorer maternal-infant attachment relationship.
3. Postpartum women's (1) reflective function will be positively associated with (2) maternal-infant attachment.

See Figure 3 below for a schematic of both studies.

Figure 3

Study 1 and Study 2 Schematic Showing Participants and Measures



Study 1 (top), Study 2 (bottom). Theory of Mind measures shown in grey boxes.

Study 1 - Both pregnant and control women completed all measures except [a] pregnant women only. Data on demographic characteristics was collected to ensure pregnant and control women were not significantly different.

Study 2 – Time 2 testing of pregnant women from study 1 when they were 4-6 months postpartum.

Chapter Three

Method

Ethics

Ethical approval was obtained via the Massey University Human Ethics Committee (MUHEC - NOR 17/65, March 2018). The psychological wellbeing of participants and bicultural safety were two areas highlighted by the MUHEC ethics committee as requiring special attention. The Capital and Coast District Health Board and the Hutt Valley District Health Board (2018) approved the study on the basis of the MUHEC approval and in consultation with their women's service ethics committee which allowed for study recruitment in hospital clinics. (Please refer to Appendices O-Q for details of participant follow up and bicultural supervision.)

Two waves of data collection took place corresponding to Study 1 and Study 2. Data were collected by two researchers (KC and KS). As data collection for Study 1 was in-person, testing was devised to be no longer than an hour to minimise any effects of fatigue in pregnant women. Participants were informed of the follow up process with the emotional state measure (DASS-21) and how it would be scored. The follow up process entailed contacting a participant by phone if they scored highly on one of the DASS-21 subscales (depression, anxiety, and stress) and offering support as needed. Participants were informed that none of their data would be scored and analysed at the individual level except for the DASS-21. To reduce the risk of any discomfort while completing measures of emotional state or attachment (e.g., feelings of inadequacy or worry) information provided to participants underscored that the measures were for research only and did not have inherent clinical utility. Participants were also invited to contact the researchers if they had concerns in this respect. Information sheets also reminded

participants that they could discuss any concerns with their GP or Lead Maternity Carer (LMC).

To conduct culturally sensitive and safe data collection, bicultural supervision was sought from a Kaimatai Hinengaro Māori (Māori clinical psychologist) relating to te ao Māori perspectives on *haputanga* (pregnancy) and good practice working with hapū wahine (pregnant Māori women). (See Appendices for details of MUHEC ethical approval, participant follow up, consent forms, measures, and bicultural reflections.)

Participant Characteristics

Recruitment

All participants were recruited from the Greater Wellington region. Eligibility criteria were a minimum age of 18 years and adequate competency in English language. Eligibility for pregnant women was that they were expecting their first baby and could be tested in person between 33 and 39 weeks gestation. Eligibility for control women criteria were that they were not currently pregnant and had not previously had a baby. These eligibility criteria were conveyed to participants via advertising and information sheets. Researchers did not further probe for healthcare information. Recruitment took place via several channels to capture a wide sampling frame. A koha in the form of NZ$20 grocery vouchers were offered by way of thanks to all participants.

Online Advertising. A study Facebook page was created and advertisements targeting pregnant and control participants in the Greater Wellington region were disseminated via this channel (see Appendix J and K for examples of Facebook advertisements). For pregnant women, the audience selected for the Facebook advertisements was women living in the Greater Wellington region and aged between 18-45 years old. As control group women needed to match to the pregnant women on age, this demographic variable was calibrated to match pregnant women as data collection progressed. For instance, when the control group women were on average slightly

younger than the pregnant women, subsequent Facebook advertising was altered to target control group women aged between 28-40 years.

Community Advertising. Study flyers were distributed at community locations (e.g., hospital noticeboards, midwives' clinics, birthing education classes). Pregnant women were also recruited via short presentations offered at antenatal classes in Greater Wellington, birthing classes, and via referrals from midwives (see Appendix for an example of a letter addressed to pregnant women).

Study 2 Recruitment. For Study 2, pregnant women from Study 1 were followed up via email 4-5 months past their baby's due date. The email contained an invitation to complete Study 2 measures on Qualtrics. When participants did not reply to this invitation, a follow up email was sent as a prompt. If there was again no response, no further attempt was made to contact the participants.

Sample Size, Power, and Precision

As previously discussed, four measures were selected for Study 1 to cover different aspects of the ToM multidimensional construct and thereby to increase the study's sensitivity to any between-group differences. To calculate the sample size, literature relating to empirical studies of social cognition in pregnancy was reviewed. This was to determine what might constitute adequate sample size and power on the respective cognitive measures to detect between group differences at $\alpha = .05$ with null hypothesis inferential statistical methods.

The growing number of studies examining face processing in pregnancy was consulted. For example, enhanced emotion recognition by pregnant women (n=19 pregnant, n=19 controls; Anderson & Rutherford, 2011), and recognition of facial expressions (n=25 pregnant, n=28 controls; Matsunaga et al., 2018), compared to control women are reported, but no difference found in empathic processing and affect

recognition in first time pregnant women compared to control women (n = 57 pregnant, n = 53; Boorman, 2018).

Secondly, studies which have used the selected ToM measures in other populations was consulted. For instance, in clinical populations, the Hinting task was sensitive to significant between group differences in age and IQ matched control participants (n = 43) compared to first degree relatives of a person with schizophrenia (n = 41), and patients with schizophrenia (n = 43; Janssen et al., 2003). However, in a smaller sample also using the Hinting measure with a similar population, no significant differences were found (n = 13; Marjoram et al., 2006). Per Cohen (1992), a medium effect size of r = .30, accounting for 9% of the total variance between groups, would require at least two independent samples at least n = 64 participants. This sample size is larger than any of the empirical studies included in the most recent meta-analysis of maternal cognition (e.g., refer to Table 1 detailing sample sizes in Davies et al., 2018 where average sample size is n = 25 per group). Given the very limited number of studies of social cognition in pregnancy, 64 participants per group was selected as an adequate sample size for Study 1 which was also feasible within the constraints of data collection. For Study 2, the goal was to retain as many pregnant participants into the postpartum as possible.

To improve study precision, the pregnancy group were recruited as primiparous to control for effects of multiple gestation, and the control group women were nulliparous to lend support to the explanation that any ToM differences might be related to pregnancy. Control women were age and education matched to the pregnancy group. An additional participant characteristic of 'hours of interaction with children per week' was collected as a possible covariate with the Mind-mindedness measure. A computer-based administration was implemented to reduce any experimenter effects on the administration of measures. Pregnant women were all tested within a narrow timeframe

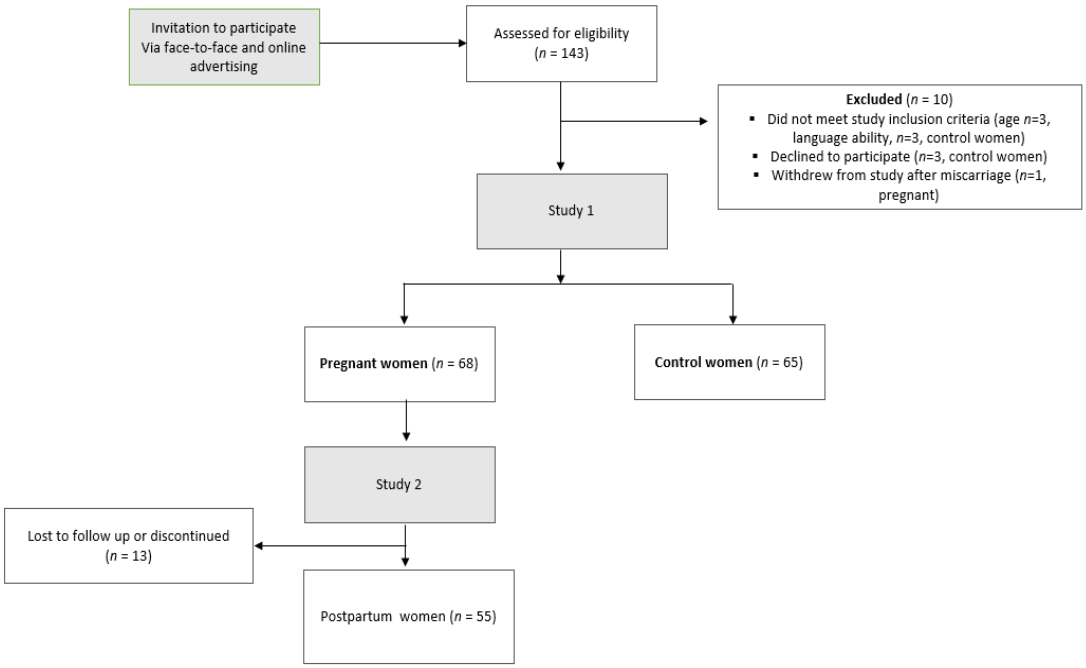
– between 33 and 39 weeks gestation. Control women were recruited as nulliparous to control for the effects of pregnancy.

Participant Flow

For Study 1, 133 participants (n = 68 pregnant) completed the computer-based testing in homes and community locations. Of the original 68 pregnant women from Study 1, 55 women participated in Study 2 (80.1% retention rate). Figure 4 illustrates the flow of participants through Study 1 and Study 2. No participants provided us with further information regarding declining to participate in Study 2 (e.g., pregnancy loss).

Figure 4

Flowchart of Participants in Study 1 and Study 2



Sociodemographic Characteristics

Details of participant age, educational attainment, ethnicity, and hours of child interaction per week are presented in Table 2. These sociodemographic data were

collected to ensure that pregnant and control women were matched on these characteristics. Pregnant and control participants refer to Study 1 data collection; postpartum refers to Study 2 participants.

The average age for pregnancy and control groups did not differ significantly, $t(131) = 1.74$, $p = .085$. The average age for pregnant women was 31.7 years ($SD = 4.1$), and for control women it was 30.4 years (SD= 4.8 years) with a wide range of ages overall (19 years - 42 years). An independent samples Mann-Whitney U test was computed which found no difference in educational attainment between the groups, $U = 2056.50$, $z = -.740$, $p = .46$, although the sample tended towards being highly educated overall, with median educational attainment for both groups an undergraduate degree. Average hours of child interaction per week for pregnant women were not significantly different to that of the control group, $U = 2046.50$, $z = -.791$, $p = .43$, and the mean amount child interaction was '1-2 hours per week', with the full range of 'none' to '20+ hours' represented in both groups. In terms of identified ethnicity, the sample was well represented by wāhine Māori overall (9.8%) compared to the population in Greater Wellington where 14.3% of the population identify as Māori (Stats NZ, 2018). Most women in pregnant and control groups identified with NZ European/Pākehā ethnicity (60.1%) which is slightly less than in Greater Wellington where the sample were collected (74.6%; Stats NZ, 2018).

Table 2

Sociodemographic Characteristics of Participants: Study 1 and Study 2

		Pregnant (*n*=68)		Control (*n*=65)		Postpartum (*n*=55)	
		N	Percent	*N*	Percent	*N*	Percent
Ethnicity [a]	NZ European (Pākehā)	40	58.8%	40	61.5%	34	61.8%
	Māori	5	7.4%	8	12.3%	4	7.3%
	Samoan	1	1.5%	0	0.0%	1	1.8%
	Cook Island Māori	1	1.5%	0	0.0%	1	1.9%
	Tongan	0	0.0%	0	0.0%	0	0.0%
	Niuean	0	0.0%	1	1.5%	0	0.0%
	Chinese	1	1.5%	3	4.6%	0	0.0%
	Indian	4	5.9%	3	4.6%	3	5.5%
	Other (e.g., Dutch, Japanese, Tokelauan)	16	23.5%	10	15.4%	10	18.9%
Education [b]	No formal school qualifications	1	1.5%	0	0.0%	1	1.8%
	NCEA – Level 1	0	0.0%	0	0.0%	0	0.0%
	NCEA – Level 2	0	0.0%	3	4.6%	0	0.0%
	NCEA – Level 3	2	2.9%	6	9.2%	2	3.8%
	Trade Cert/Diploma	8	11.8%	4	6.2%	7	13.2%
	Undergrad Degree	30	44.1%	28	43.1%	26	49.1%
	Postgrad Degree	24	35.3%	23	35.4%	14	26.4%
	Doctoral Degree	3	4.4%	1	1.5%	3	5.7%
Child Interaction [c]	none	32	47.1%	33	50.8%	23	43.4%
	1-2 hours	10	14.7%	16	24.6%	8	15.1%
	3-6 hours	8	11.8%	1	1.5%	7	13.2%
	7-10 hours	2	2.9%	1	1.5%	2	3.8%
	11-20	3	4.4%	4	6.2%	1	1.9%
	20+	13	19.1%	10	15.4%	12	22.6%

Note. *N* = 133 for Study 1 (*n* = 68 for pregnancy condition). *N* = 55 for Study 2 postpartum women.

a Where a participant reported more than one ethnic group, they were counted in each applicable group, as per Statistics NZ Census methodology.

b Education was measured on an 8-point scale, as per Statistics NZ, whereby no qualifications = 0, NCEA Level 1 = 1, NCEA Level 2 = 2, NCEA Level 3 = 3, Trade Certificate/Diploma = 4, Undergraduate Degree = 5, Postgraduate Degree = 6, Doctoral Degree = 7.

c Participants were asked how many hours they spent interacting with children per week and could select from a 6-point scale, whereby 1 = none, 2 = 1-2 hours, 3 = 3-6 hours, 4 = 7-10 hours, 5 = 11-20 hours, 6 = 20+ hours.

Data Collection

Data collection for Study 1 was completed by the principal investigator (KS) and a fellow researcher (KC) for an associated study into maternal cognition. When participants signalled their interest in participating, a personal email was sent along with the Information Sheet. Arrangements to meet were then completed via email. Participants were asked where would be most convenient for them to meet, the only criterion being a quiet room with a table. Although testing was completed in different locations, care was taken to make the environment as free of distractions as possible. A computer-based administration of measures using Qualtrics was used in Study 1 to standardise test administration. The researcher sat quietly near each participant while the 1-hour testing session was completed and responded to any queries as needed. The first three testing sessions for Study 1 were completed jointly by KS and KC to ensure that the computer-based administration was as consistent as possible. For Study 2 an email was sent to women 4-6 months postpartum inviting them to complete the short questionnaires in Qualtrics.

Measures

Order of administration

The order of administration for both Study 1 and Study 2, as well as a brief description of each measure, is shown below in Tables 3 and 4.

Table 3

Study 1 – Measures: Order of Administration and Brief Description

Measure	Description
Demographic Questions	Age, level of education, ethnicity, average number of hours interacting with children, due date. *
Mind-mindedness Task	Two silent videos depicting young children interacting (~2mins each) are presented. After each video, participants type free text in response to the question "Describe the child".
Reading the Mind in the Eyes Task	36 black-and-white pictures of eyes are presented. For each set of eyes, four multiple choice options are offered Only one option accurately describes the emotional experience depicted by the eyes.
Hinting Task	20 short stories describing a social interaction are presented via an audio recording. After each recording, participants type free text in response to a question querying what was meant.
Cognitive measure	*Reaction Time Measure - for KC study.*
Cognitive measure	*Planning Measure - for KC study.*
Depression, Anxiety, Stress Scale	21 item self-report measure of depression, anxiety, and stress.
Reflective Functioning Questionnaire	8 item self-report measure of ability to reflect on mental states.
Prenatal Attachment Inventory-Revised*	18 item self-report measure of a pregnant woman's relationship to her baby.
Self-report measure	*Brief self-report measure of sleep quality - for KC study.*

Note. * Pregnant women only. MMT (Meins, Fernyhough, & Harris-Waller, 2014), RMET (Baron-Cohen et al., 2001), EHT (Corcoran et al., 1995; Marjoram et al., 2005), DASS-21 (Henry & Crawford, 2005; Lovibond & Lovibond, 1995), RFQ (Fonagy et al., 2016; Badoud et al., 2015), PAI-R (Muller & Mercer, 1993; Pallant et al., 2014).

Table 4

Study 2 – Measures: Order of Administration and Brief Description

Measure	Description
Parental Reflective Functioning Questionnaire	18 item self-report measure for caregivers measuring their ability to reflect on their own mental states and that of their children.
The Maternal Postnatal Attachment Scale	19 item self-report measure of attachment to baby.
Depression, Anxiety, Stress Scale	21 item self-report measure of depression, anxiety, stress.

Note. Online administration of measures via Qualtrics when women were postpartum.
PRFQ (Luyten, Mayes, et al., 2017), MPAS (Condon, 2015), DASS-21 (Henry & Crawford, 2005; Lovibond & Lovibond, 1995).

Demographics

Participants completed questions relating to demographics (age, ethnicity, highest qualification achieved), as well as a question relating to the number of hours per week typically spent interacting with children. Pregnant women also gave the estimated due date of their baby.

Theory of Mind

As previously discussed, ToM is a multidimensional construct drawing on several cognitive and affective processes (Apperly, 2012; Frith & Frith, 2012; Schurz et al., 2014). Measures of ToM capture a variety of mental processes which have been conceptualised in different ways. Measures vary according to the modality of stimuli (e.g., auditory, visual, moving image), the complexity of the stimuli (e.g., a hinting vignette compared to a joke), affective content (e.g., affect recognition vs false belief understanding), explicitness of task (e.g., whether participants know that mentalising is being measured; Warnell & Redcay, 2019), and whether they capture domain-specific or domain-general aspects of ToM (Stone & Gerrans, 2006). A further conceptualisation of the aspects of ToM proposes four psychological processes; higher order ToM involves all of these: (1)

automatic or controlled, (2) internally-focused or externally, (3), self-oriented or other oriented, (4) a cognitive process or an affective process (Luyten & Fonagy, 2015).

Given the variety of mental processes involved in ToM, it is perhaps unsurprising that measures have been found to have 'minimal coherence' (Warnell & Redcay, 2019); that is to say that high competency on one ToM task does not usually predict high competency on another ToM task (Bell, 2012). Given that the impetus for the present study was to investigate whether late pregnancy was associated with enhancement in ToM capacity, it was important to use several measures to increase overall measurement sensitivity across the ToM construct.

A further important measurement consideration was that the ToM measures needed to have good psychometric properties in community samples. This was a particular difficulty as most ToM research has focused on early development of ToM in children or differences in clinical populations. Existing measures can lack sensitivity to detect individual differences in adult populations (R. Turner & Felisberti, 2017) with ceiling effects being a common problem (Bell, 2012). For the current study, it was considered most important that measures were acceptable to the participants, had good face, content, and discriminant validity, and could be administered reliably via a computer-based administration. Additionally, it was important for the ToM measures to avoid placing significant demands on processing speed or working memory, as these could potentially act as confounding factors in the context of pregnancy.

Mind-mindedness Measure - Silent Videos. (MM; Meins et al., 2014; Meins, Fernyhough, Russell, & Clark-Carter, 1998). Mind-mindedness refers to the tendency of caregivers to see their child as an individual with their own mental life, perspectives, and emotional experiences and respond accordingly (Meins et al., 2003). Mind-mindedness has been studied in two ways. The first is via the observation of maternal talk to her infant during a play observation, and the second is via an interview

measure where parents are invited to 'describe your child', thus eliciting parents' mental representation of their child (often referred to as representational MM). In both methods, talk is transcribed then scored by segmenting speech into attributes and systematically coding it into exclusive categories relating to internal (or mind-minded) descriptors (e.g., "she was looking sad today, she was probably feeling left out") vs external descriptors of the child (e.g., "she is very quick and is always running around"; see Scoring section below).

A higher proportion of internal descriptors overall is thought to indicate a greater propensity towards spontaneous use of ToM mentalising in the parenting relationship. In the observational measure, talk can be additionally scored for appropriateness and accuracy of the mother's verbal responses to her child, as judged by trained observers. Importantly, in both methods researchers do not prompt participants to talk or interact with their child in any particular way. Accordingly, representational MM is a measure of spontaneous use of ToM which is often conceptualised as being distinct from competence in ToM (Apperly, 2012). Mind-mindedness has been found to have stability over time and is therefore proposed to be a reasonably stable construct (Kirk et al., 2015; Meins et al., 2003). The interview measure has good face and content validity (McMahon & Bernier, 2017), it discriminates between caregivers who have high and low levels of mind-mindedness as well as adults who are asked about different kinds of relationships (Meins et al., 2014).

Procedure . The MM interview measure was adapted for use in the current study in the following way. Participants were seated at a laptop and read the following instructions on screen: 'You will see a video of some young children interacting with caregivers. The video has the sound turned off. Please watch the little girl in the pink top carefully.' (Video 1) and 'Please watch the girl on the right of the screen carefully' (Video 2). Figure 5 provides a screenshot from each video.

Figure 5

Mind-mindedness: Stills from Video Stimuli

Note. Video 1 (left) and Video 2 (right) were sourced from YouTube content freely provided by Early Childhood Australia Learning Hub (https://www.youtube.com/user/EYLFPLP/about).

After viewing each video, participants were prompted to type: 'Please use the space below to describe the little girl in the pink top. Feel free to use as much or as little of the space provided.' All participants were offered typing assistance if they preferred. When requested by a participant, the researcher also clarified which child was being referred to. No further instructions or clarifications were provided so as to capture spontaneous mentalising.

Scoring. Participant data were coded according to the Mind-mindedness Coding Manual (Meins & Fernyhough, 2015). The text is first segmented into speech fragments each of which contain one single child attribute. Each attribute is then coded into categories of child attributes as per the following:

1. Behavioural descriptors relate to activity or temperament (e.g., "He is the kind of kid who is into everything")
2. Style (e.g., "She's very active")
3. Physical (e.g., "She is tall for her age")
4. General (e.g., "She's just adorable")

5. Mental descriptors relate to the child's mental life, interests, preferences, knowledge (e.g., "He loves reading new books")

All categories of talk except 'Mental Descriptors' are considered external characteristics of the child. Mental descriptors relate to the full range of inner experiences. An overall mind-mindedness score is then calculated. This is a ratio of the number of internal descriptors as a proportion of all descriptors (internal + external; Meins & Fernyhough, 2015).

Selection of Video Stimuli. The two silent videos were selected on the basis that they provided ecologically valid stimuli relevant to caregiving. The videos presented babies, toddlers, pre-schoolers, and adult caregivers interacting in a nursery environment. A range of emotions were displayed by the children (e.g., mild frustration, sadness, joy, boredom, delight), social to-and-fro and turn taking, first order ToM, pointing to attract caregiver attention, and a child demonstrating a social script (hosting a tea-party for a playmate). There was also attachment behaviour on display with a baby actively seeking comfort from a carer via raised arms and receiving a hug and smiles, and a child moving away from the carer to explore the environment.

To date, the use of video stimuli to elicit representational MM is new. However, many test stimuli have been used in MM research. For instance, Meins et al. (2014) used pictures of well-known celebrities, different kinds of static images, and also have asked participants to describe a close friend to elicit spontaneous MM. Silent videos as test stimuli have also been used in other ToM measures and have demonstrated good psychometric properties with sensitivity to individual differences, acceptable data spread, and no ceiling effects (Devine & Hughes, 2013; Rice & Redcay, 2015). Typing into a text box has also been used previously in mind-mindedness research and did not differ from spontaneous speech in terms of the overall proportion of MM comments (Meins et al., 2014).

Reading the Mind in the Eyes Task – Revised. (RMET; Baron-Cohen et al., 1997, 2001). Originally developed 20 years ago as a measure to assess complex emotion recognition in autistic populations, this measure has revealed differences in emotion detection ability in a variety of clinical populations, in different age groups, in genders, and in age and IQ matched community samples (Peñuelas-Calvo et al., 2019, Harkness et al., 2010).

Procedure. Participants view 36 black and white images of eyes expressing complex emotions. Participants are invited to choose the option which best describes what the person is thinking or feeling as shown by their eyes. Four multiple choice options are provided (e.g., reflective, irritated, confident, ashamed) where only one option is correct, three are foils. An additional handout gives definitions for all multiple-choice words. Validation studies of this measure have shown that in addition to its excellent discriminant validity, it has good content and face validity (Harkness et al., 2010). Overall scores range from 0-36. Given the only studies of ToM in pregnancy have been in face processing, and affect recognition in particular, and these have often shown significant differences in pregnant women's ability to detect emotions (De Carli et al., 2019), it was considered important to include this affect recognition task.

The Extended Hinting Task (HT). This measure is made up of 10 original short hinting task stories (Corcoran et al., 1995) and an additional 10 stories developed by Marjoram et al (2005). This extended 20-item version has good psychometric properties in healthy controls with good face, content, and discriminative validity as well as sensitivity to detect individual differences in healthy populations (e.g., no ceiling effects observed in healthy control subjects; Bell, 2012).

Procedure. Participants listen to a series of 20 short audio vignettes involving two people talking to each other and one dropping a veiled hint to the other. Participants are then prompted on screen to type their response to the question "what did [character]

mean?" in reference to the hint. When participants have typed their response, they click "next" to proceed to the next short story. The audio was the same audio recording of an Australian male narrator as used in Bell (2012) where the measure's psychometric properties were assessed. Use of an audio recording ensured greater consistency of test administration as a different tone of voice, volume, or prosody across administrations would convey different social information and vary the difficulty of the task. Participants were able to listen to the vignette as many times as they needed. Here is an example vignette ('the broken statue').

Audio Recording Stimuli: "Two children, Emma and Katie, are playing when Emma breaks an old statue belonging to Katie's mother. Emma says to Katie: *'If your Mum finds out it was me that broke it, I won't be allowed to come here anymore.'* What does Emma mean when she says this?"

Example Correct Answers: Emma means "Pretend you broke it." Or "Can we hide it?" Or "Come up with an idea so that I won't get into trouble."

Scoring: For a correct answer of 1 point, participants need to have written something to indicate that Emma wants Katie's help to deceive her mother as to what happened to the old statue. Overall range of scores on this task are 0-20.

Reflective Functioning Questionnaire (RFQ) – short form. (Fonagy et al., 2016; Badoud et al., 2015). The RFQ is an 8-item self-report questionnaire of mentalizing. It contains two subscales measuring the levels of certainty (RFQc) and uncertainty (RFQu) about the mental states of oneself and of others. All items are scored by participants on a 7-point Likert scale, which ranges from "completely disagree" to "completely agree". Extreme scores (both high and low) on these subscales are indicative of problems with reflective functioning, or the ability to accurately reflect on one's own mental state and that of others. For example, a "completely disagree" response to the item "when I get angry, I say things without really knowing why I am saying them" might

reflect inappropriately high levels of certainty about mental states (known as 'hypermentalising'), conversely "completely agree" might indicate inappropriately low levels of certainty about mental states ('hypomentalising').

Research has shown the RFQ has good discriminant validity between clinical and nonclinical populations (Badoud et al., 2015), content and predictive validity with other measures of empathy, mindfulness, and perspective taking (Fonagy et al., 2016). Like all reflective functioning research, the RFQ places an emphasis not only on the ability to use ToM to understand others, but also to use it to consider one's own mental and emotional inner experiences.

***Scoring*:** responses were recoded and scored as per Cucchi et al. (2018). (See Appendix F for details of scoring, including rescaling.)

Emotional State

Depression, Anxiety, Stress Scale (DASS-21). (Lovibond & Lovibond, 1995). The DASS-21 is a 21 item self-report measure which was developed as a short form of the DASS-42. It measures levels of emotional distress on the dimensions of Depression, Anxiety, and Stress. An example Depression item is "I couldn't seem to experience any positive feeling at all". A Likert scale contains four options: (0) = Did not apply to me at all, NEVER, (1) = Applied to me to some degree, or some of the time – SOMETIMES, (2) = Applied to me to a considerable degree, or a good part of time – OFTEN, (3) = Applied to me very much, or most of the time - ALMOST ALWAYS. The DASS-21 is devised with a dimensional approach to the measurement of psychological distress, where the differences in the experience of depression, anxiety and stress in clinical and community samples is a difference of degree. Higher scores indicate more severe experiences of mental distress and cut off scores are provided. The Depression scale is sensitive to hopelessness, dysphoria, lack of interest and involvement, inertia; the anxiety scale measures anxiety sensations, subjective experience of anxiety, muscle

tension, and situational anxiety; finally, stress assesses difficulty in relaxing, agitation and irritability, reactivity and impatience which comes from chronic levels of arousal.

The DASS-21 is used extensively in clinical settings and research with a variety of populations. It has good convergent and discriminant validity (Lee, 2019). Importantly, it has also been found to have good reliability, construct and concurrent validity in a sample of Portuguese pregnant women (Xavier et al., 2016). This makes it a suitable measure to use in both pregnant and not pregnant control women.

Attachment

Prenatal Attachment Inventory-Revised (PAI). (Muller & Mercer, 1993; Pallant et al., 2014). The PAI is a self-report measure of prenatal attachment made up of 18 items describing a pregnant woman's thoughts, emotions, and relationship to her baby in the prenatal period. Higher scores indicate more secure attachment overall and on each of the dimensions. There are four response options: 4=almost always, 3=often, 2=sometimes, 1=almost never. Example items are 'I wonder what the baby looks like now', 'I know why the baby is moving', 'I feel love for the baby'. It contains three scales: Anticipation, Interaction, and Differentiation. Although the PAI was originally proposed as a 1-factor model by Muller (1993), subsequent authors proposed that it was made up of 5-factors (Siddiqui & Hägglöf, 2000) The 5-factor model was critiqued by Pallant et al. (2014) who instead proposed a revision to the scale (removing 3 of the original 21 items) and presented a more psychometrically sound scale containing three factors. Each of the three subscales has good psychometric properties as well as internal consistency (Cronbach α values over 0.70) and can be used both in research and in clinical settings. There has been controversy surrounding the psychometric properties of the 1 factor model (Pallant et al. 2014; Foley et al., 2021). Hence, for the purposes of the current study, the PAI was analysed according to the most well established 3 factor model of

Anticipation, Differentiation, and Interaction. (See Appendix G for items related to these factors.)

Maternal Postnatal Attachment Scale (MPAS). (Condon & Corkindale, 1998). The MPAS is a 19 item self-report measure of secure attachment on three dimensions: Quality of Attachment, Absence of Hostility, and Pleasure in Interaction. A total score is also calculated as a sum of all items where lower scores indicate a problematic mother-infant bond. Sample items for Quality of Attachment are "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". This factor describes the sense of satisfaction and confidence which the mother experiences in the relationship. When the mother experiences few feelings of resentment or negativity towards her infant she will score higher on the Absence of Hostility subscale. A sample item is "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 - (5) Never. Five scale items relate to the Pleasure in Interaction subscale, e.g., "When I have to leave the baby: I usually feel rather sad (5)–I usually feel rather relieved (1)". The range of values for the total MPAS and its subscales are, respectively, 19-95 for the total MPAS, 9-45 for the Quality subscale and 5-25 for both the Pleasure and the Hostility subscales.

The MPAS has been used extensively in research, including in Hoekzema et al. (2016) where it was shown to correlate to grey matter structural brain changes during pregnancy. In a recent review by Wittkowski et al. (2020), self-report measures of maternal infant bonding in the perinatal period have been criticized for lacking sufficient psychometric evaluation. However, the MPAS was an exception and the authors found it to have adequate construct validity in terms of measurement invariance and theoretical grounding and good reliability. It has been found to have adequate levels of internal consistency (α=.78; Condon & Corkindale, 1998) and many studies have also found the

MPAS to have good discriminative validity, including in cross cultural samples (e.g., van Bussel et al., 2010). See Appendix I for further details of scoring.

Study 1 - Test administration

Overall, the Study 1 measures took less than 1 hour to complete by participants, in line with expectations.

Study 2 Theory of Mind

Parental Reflective Functioning Questionnaire (PRFQ). (Luyten, Mayes, Nijssens, & Fonagy, 2017). The PRFQ is an 18 item self-report questionnaire which measures reflective functioning in the context of parenting. Parental reflective functioning describes the ability of parents to appreciate their children's inner mental states (and how behaviour is motivated by these) while also being able to reflect on their own inner experiences while parenting the child (Luyten, Nijssens, et al., 2017; Slade, 2005). Participants rate themselves on a 7-point Likert scale where 1 = "strongly disagree" and 7 = "strongly agree" on statements regarding their relationship to their child's and their own inner experiences. The measure contains three subscales of 6 items each: Pre-Mentalizing Modes, Certainty about Mental States, and Interest and Curiosity in Mental States. Cronbach's alphas for each of the 6 items have been reported as .70, .82, and .75, respectively (Luyten, Nijssens, et al., 2017). The subscales are scored by calculating the mean of the 6 items; an overall PRF score is calculated as a mean of all subscale scores. A sample item for Certainty of Mental States is "I can always predict what my child will do". A sample item for Pre-Mentalizing Modes is "My child cries around strangers to embarrass me", and a sample item for Interest and Curiosity in Mental States is "I like to think about the reasons behind the way my child behaves and feels". The PRFQ has good internal consistency and the subscales have been found to be associated with a parent's attachment status, their emotional availability to the child, and parenting stress levels (Luyten, Mayes, et al., 2017). Moreover, parents' capacity for

reflective function is theorized to play a critical role in the development of children's capacity for reflective functioning which, in turn, fosters better emotion regulation and attachment security (Luyten, Nijssens, et al., 2017). High scores on the subscale Pre-Mentalizing Modes, a measure of very poor mentalizing, has shown to be an indicator of greater mental rigidity, insensitivity towards the child, and misunderstandings of the child's developmental stage (Schultheis et al., 2019) and is associated with higher levels of anxiety and depression in mothers with postpartum depression (Krink & Ramsauer, 2021). Parents who experienced insecure attachment relationships with their own caregivers, typically have greater difficulties in parental reflective functioning and are more likely to exhibit the mental rigidity of pre-mentalising modes and overall hypermentalising (Luyten, Nijssens, et al., 2017).

Data Preparation and Analysis

Data were analysed using the Statistical Package for the Social Sciences (SPSS; version 26 for Windows, IBM Corp., Armonk, NY). Data from all measures were scored and entered into SPSS along with demographic variables.

Coding Mind-mindedness Data. Participant data were entered into MS-Excel then segmented into speech fragments each containing one child attribute (descriptor), as per the Mind-mindedness Coding Manual (Meins & Fernyhough, 2015) respecting rules for repetition of attributes. Each attribute was then coded into an 'Internal' or 'External' category of child attribute. To ensure reliability of coding, a running log was maintained of child attributes (including synonyms) and their coding. The coding of every descriptive term was searched across the entire dataset to ensure consistency. A selection of coded data was reviewed in supervision with reference to the Mind-mindedness Coding Manual to check for validity of coding. A MM score was then calculated for each participant, as previously described.

Data Preparation and Exploration. Descriptive statistics were calculated for the sample: Age, education, ethnicity, years of childcare experience and emotional state. Inferential tests were run to compare similarity between pregnant and control groups on demographic variables. Participant data were checked for normal distribution, homogeneity of variance, skewness, and kurtosis. The distributions of ToM variables were examined for normality via visual inspection as well as calculating Shapiro–Wilk *p*-values. As the data were not normally distributed, nonparametric tests were used.

Data Analysis. Descriptive analysis for each ToM cognitive variable was determined for the entire sample, and separately by pregnancy status group. Nonparametric inferential tests were run to test study hypotheses where appropriate as well as correlations to compare patterns of performance. Where significant relationships were found between variables of interest, further inferential statistical analysis was completed. For Study 2, in addition to the previously described approach to data analysis, mediation models (Jose, 2013) were calculated to ascertain relationships between the variables of interest. For this, parametric tests were used when results were the same as for nonparametric tests. In the case of the preliminary analyses to compute theoretically informed mediation models where the study has found moderate effect sizes in expected directions, to reduce the chance of Type 2 errors, alpha is retained at $p < .05$.

Chapter Four

Results

This chapter presents the results from both Study 1 and Study 2. The first section provides an overview of emotional state descriptive statistics. Section 2 follows with preliminary analyses, including scoring, data treatment, treatment of nonparametric data, and proposed statistical analyses. In section 3, inferential statistical analyses are presented to test the main hypotheses under study. Section 4 concludes this chapter with preliminary mediation models. A discussion of these results follows in Chapter 6.

Section 1: Descriptive Statistics

Participant Emotional State

Descriptive statistics are shown below in Table 5. On average, women were experiencing low levels of mental distress overall as measured on the DASS-21, however there was a full range of scores with a small group of women with very elevated scores in depression, anxiety, and stress ("extreme" range and above). Only pregnant women had a proportion of anxiety scores in the "extremely severe" range. When participants had very elevated scores on one of more of the subscales of the DASS-21, they were followed up as per the study Information Sheet (see Appendix O for details).

Table 5

Study 1 and Study 2: Emotional State on DASS-21 by Participant Grouping

Scale	Group	*n*	Mean	*SD*	*SE*	Range	Descriptor [a]
Depression	Pregnant	68	2.63	3.54	.43	0-16	Normal range
	Control	65	2.69	3.05	.38	0-16	Normal range
	Postpartum	53	3.30	3.66	.50	0-15	Normal range
Anxiety	Pregnant	68	3.71	2.93	.36	0-14	Mild range
	Control	64	2.73	2.37	.30	0-9	Normal range
	Postpartum	54	2.30	2.34	.32	0-10	Normal range
Stress	Pregnant	68	6.60	4.11	.50	0-20	Normal range
	Control	65	5.97	3.90	.48	0-18	Normal range
	Postpartum	54	6.43	3.97	.54	0-15	Normal range

Note. DASS-21 qualitative descriptors as follows: Depression normal range 0-4, mild 5-6, moderate 7-10, severe 11-13, extremely severe 14+, Anxiety normal range 0-3, mild 4-5, moderate 6-7, severe 8-9, extremely severe 10+, Stress normal range 0-7, mild 8-9, moderate 10-12, severe 13-16, extremely severe 17+.

Emotional State in Pregnancy and Postpartum

Independent-Samples Mann-Whitney U Tests were calculated to ascertain whether pregnant and control groups differed on levels of depression, anxiety, or stress. Results indicated no significant difference between pregnant (*Mdn* = 1.0) and control groups (*Mdn* = 1.5) on depression or on stress (pregnant and control *Mdn* = 6.0), however on anxiety there was a small but significant difference, where pregnant women were more anxious (*Mdn*= 3.0) than control women (*Mdn* = 2.0), $U = 1746.00$, $z = -1.98$, $p = .048$, $r = -.17$. This due to some high scores of anxiety (DASS-Anxiety - 10-15; "very severe" range) for pregnant women.

Stability of Emotional State from Pregnancy to Postpartum

To test whether emotional state was stable across pregnancy and into the postpartum, Wilcoxon signed-rank tests were computed. Levels of depression and stress were not significantly different, indicating that these measures of emotional state were

stable: more depressed and stressed women tended to stay depressed and stressed between late pregnancy and postpartum, whereas women without symptoms of depression or stress tended to stay symptom free. Anxiety, by contrast, was significantly lower in the postpartum (*Mdn* = 2.00), than during pregnancy (*Mdn* = 3.00); z = -2.68 p = .007, r = -.24. This small effect is due to a reduction in the range of scores. There were no postpartum women in the "very severe" range of anxiety. This decrement in anxiety also equates to 59.5% of postpartum women having less anxiety on average than during pregnancy.

Theory of Mind and Attachment

Table 6 below presents all dependent variables from Study 1 and Study 2. Sample means, ranges, standard deviations, and standard errors of the mean for pregnant, control group and postpartum women are shown. The standard deviation is an estimate of the average variability of the measure and is presented in the same units as the original data. The standard error, by contrast, is an estimate of the sampling variability of the mean (Field, 2009).

Table 6

Study 1 and Study 2 Dependent Variable Descriptive Statistics – Sample Ranges, Means, Standard Deviations, and Standard Errors

		Range		*M*	*SD*	*SEM*
Pregnant	Mind-mindedness	.07	.95	.46	0.23	.03
***n*=68**	RMET	.58	.94	.79	0.08	.01
	Hinting Task	11	20	16.42	2.05	.25
	RFQ - Certainty §	0	3	1.19	0.77	.10
	RFQ - Uncertainty §	0	1.17	.32	.34	.04
	PAI - Anticipation §	11	24	17.93	3.30	.40
	PAI- Differentiation §	11	24	17.78	3.17	.39
	PAI - Interaction §	12	24	19.37	2.86	.36
Control	Mind-mindedness	.04	1	.50	0.26	.03
***n*=65**	RMET	.64	.97	.81	0.08	.01
	Hinting Task	13	20	17.15	1.87	.24
	RFQ - Certainty §	0	3	1.18	0.81	.10
	RFQ - Uncertainty §	0	1.5	0.42	0.40	.05
Postpartum	MPAS - Attachment Quality §	31.5	45.0	39.63	3.38	.46
***n*=54**	MPAS - Hostility §	9.0	25.0	18.04	3.54	.48
	MPAS - Interaction §	11	25	21.30	2.95	.40
	MPAS - Total score	60.0	92.3	78.96	7.76	1.06
	PRFQ - Pre-Mentalizing Modes §	1.0	3.0	1.70	.53	.07
	PRFQ - Certainty about Mental States §	1.67	6.83	3.55	1.01	.14
	PRFQ - Interest and Curiosity §	3.3	7.0	5.84	.78	.11
	PRFQ - Total score	2.59	4.83	3.70	.42	.06

Note. § = an abbreviation of subscale. Mind-mindedness and RMET are both ratio scores (0-1.00) where a higher score indicates better ToM. Hinting Task is a frequency score (0-20, where higher scores indicate better ToM), RFQc and RFCu scores range from 0-3, where very elevated scores indicate poorer ToM (hypermentalising, hypomentalising respectively), MPAS scores represent sum of all items, low scores indicate poorer maternal-infant attachment, PRF are means of relevant items, where very elevated scores on Pre-Mentalizing Modes and Certainty about Mental States indicates poor ToM, and high scores on Interest and Curiosity indicates better ToM, an overall score is calculated as a mean of the subscale scores.

Section 2: Preliminary Analyses

Data Treatment

Measures were scored and reverse scored where needed. Data were checked for adequate completion. Where participants had skipped an item on a subscale, that item was excluded from analysis (except where described otherwise). No other data were excluded from analysis. Data were entered into IBM SPSS Statistics for Windows, (Version 26.0)

Missing Data

On the PRFQ measure, an error in the Qualtrics survey meant that Q18 was not completed by any participants[2]. This question forms part of the 6-question subscale Interest and Curiosity about Mental States. To remediate this, Q18 was given a mean of the subscale score made up of the other 5 questions. The other two subscales were unaffected by this error. An overall PRFQ score was also calculated, again with Q18 given a mean of the relevant subscale. To provide confidence in this treatment of missing data, the mean and range of PRFQ scores in the present study (including Interest and Curiosity about Mental States) was compared to another study of the same population (3-6 month postpartum mothers, n=63; Rutherford et al., 2017). The scores were found to not significantly differ increasing confidence in the validity of this treatment of missing data.

Scoring Mind-mindedness Data

MM data were sectioned into individual child attributes and coded (as discussed in Method). Validity and reliability of scoring were ensured by maintaining a running log of all child attributes, their scoring, re-checking the entire spreadsheet for consistency, as

[2] This was due to a technical error in the Qualtrics survey set-up for Study 2.

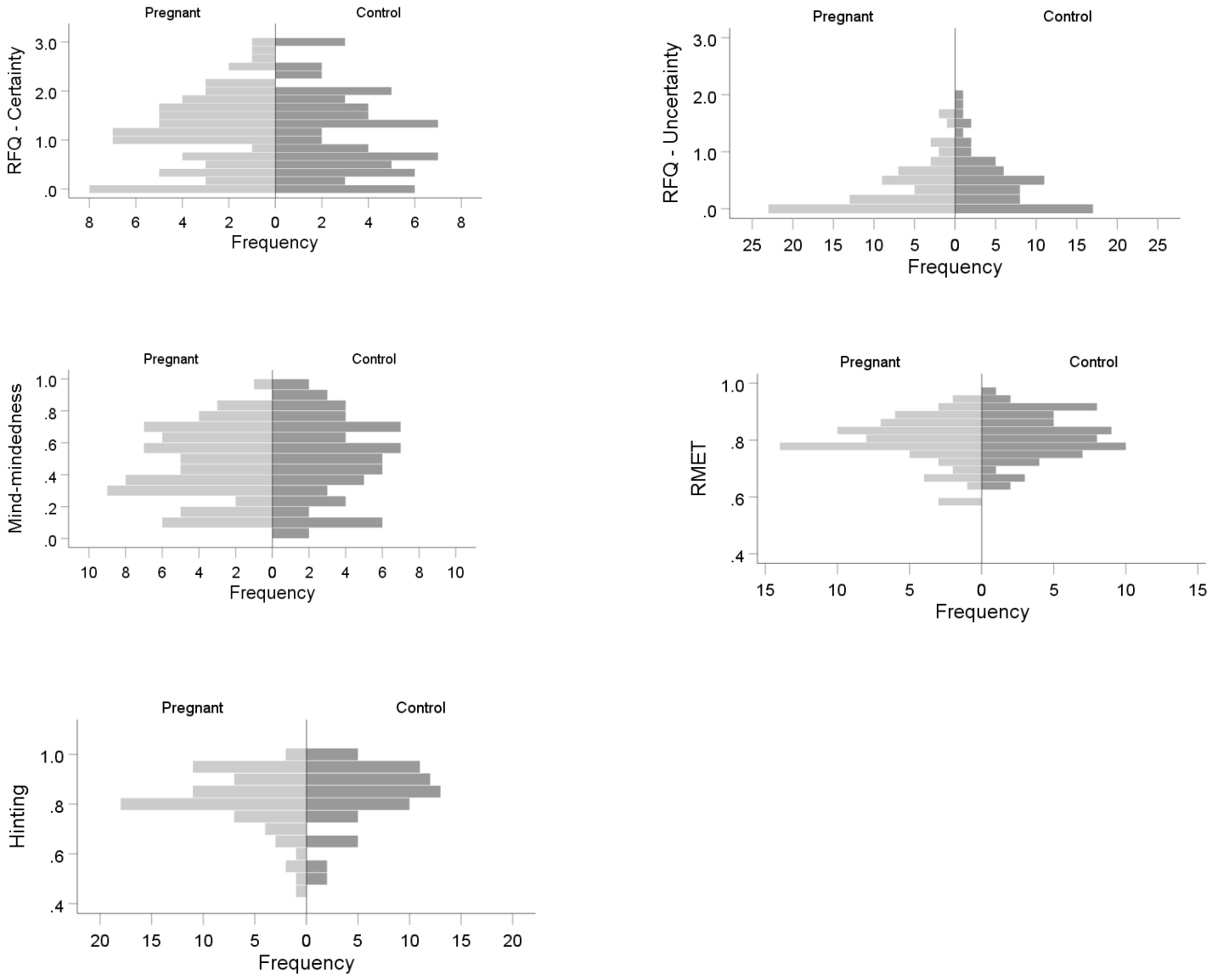
well as taking a sample of coded data to supervision. (See Appendix B for details of Mind-mindedness sample scoring.)

Assumptions of Parametric Data

A visual inspection of all dependent variables and DASS-21 subscales in Study 1 and Study 2 was completed to check for normal distribution as per the statistical assumptions for parametric data (distribution, skewness, and kurtosis). Visual inspection of ToM distributions indicated that RFQ subscales appeared to be positively skewed (data were collecting towards the lower end of each distribution). By contrast, the Hinting Task and the RMET distributions appeared negatively skewed (data were collecting towards the upper end of each distribution as many participants scored highly on these measures). The Mind-mindedness data appeared to have an even distribution with a flat midpoint. (See Figures 6 and Figure 8 for ToM and attachment distribution in Study 1 and Study 2; and Figure 7 and Figure 9 for distribution of the DASS-21 in Study 1 and Study 2.)

Figure 6

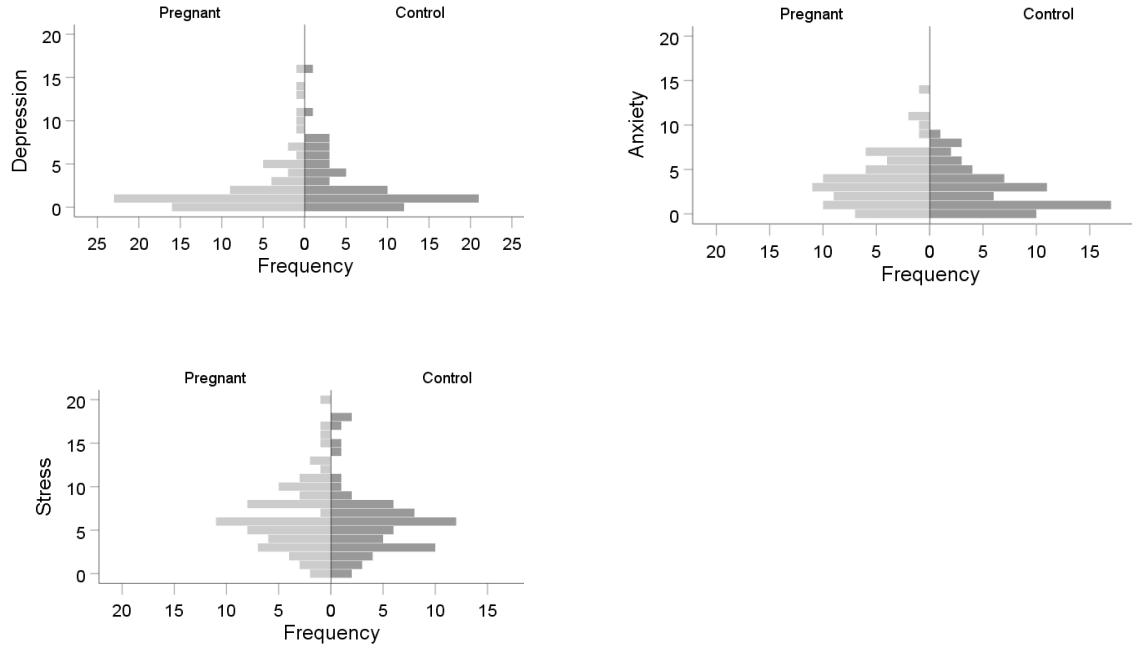
Study 1 - Distribution of Theory of Mind Scores by Pregnancy Status



Note. Raw score data graphs showing panel A and B RFQ (Reflective Functioning Questionnaire, raw scores on each subscale range: 0-3). Panel C shows Mind-mindedness ratio score (ToM comments as a proportion of all comments, range: 0-1.0), Panel D shows RMET (Reading the Mind in the Eyes, % correct), and Panel E shows Hinting Task (% correct).

Figure 7

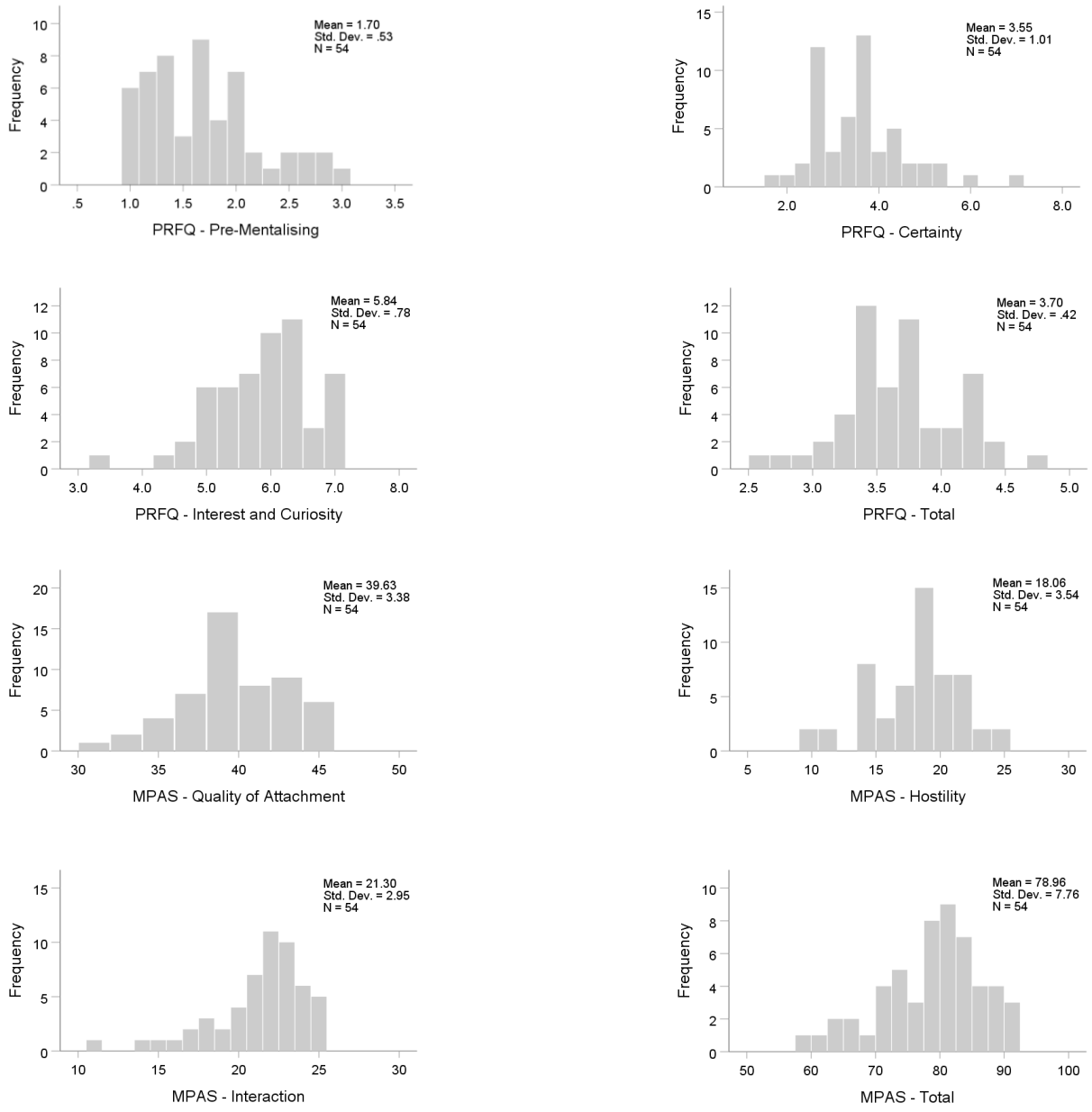
Study 1 - Distribution of Depression, Anxiety, and Stress Scores by Pregnancy Status



Note. Three raw score data graphs showing DASS-21 score variance on Depression (top left panel), Anxiety (top right panel), and Stress (bottom panel).

Figure 8

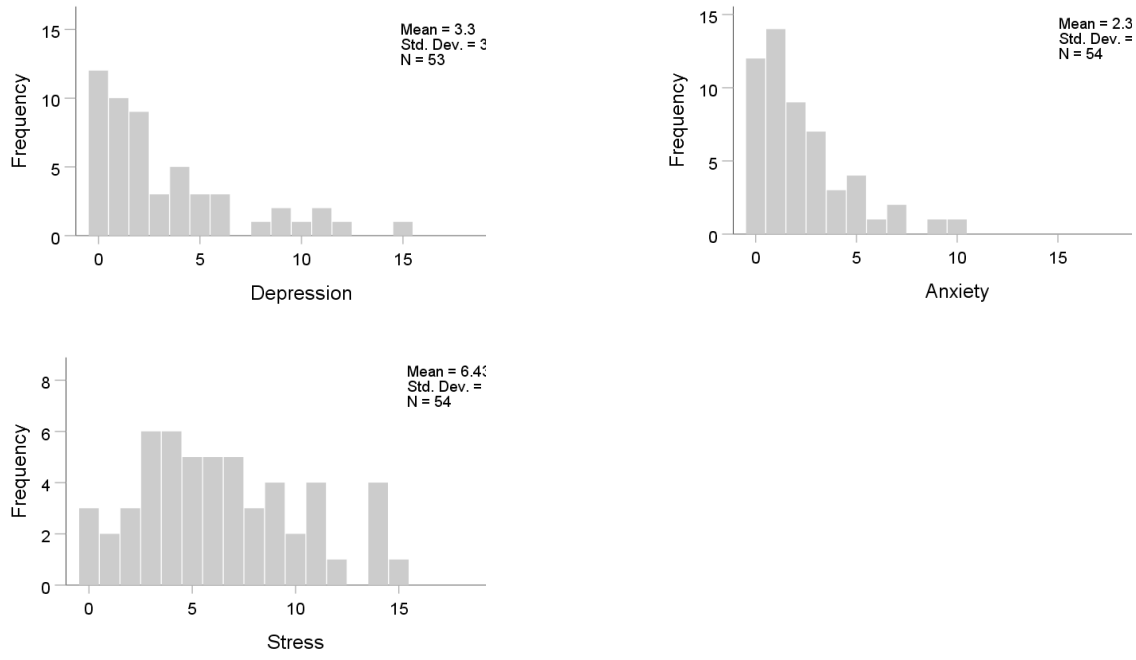
Study 2 –Distribution of PRFQ and MPAS Scores in Postpartum Women



Note. Raw score data graphs on postpartum ToM in Parental Reflective Functioning Questionnaire (PRFQ) and maternal-infant attachment on Maternal Infant Attachment Scale (MPAS). Panels A-C show PRFQ subscales and PRFQ - total score (panel D). MPAS subscales shown on Panels E-G and MPAS total score on Panel H.

Figure 9

Study 2 – Distribution of Depression, Anxiety, and Stress Scores in Postpartum Women



Note. Three raw score data graphs showing DASS-21 score variance on Depression (top panel), Anxiety (middle panel), and Stress (bottom panel) from 4–6-month postpartum women.

Statistical Testing of Assumptions

To ascertain whether the ToM measures deviated from comparable normal distributions with the same means and standard deviations, a Shapiro-Wilk test was calculated. If non-significant at $p>.05$, this indicates that the distributions are likely normal. The results of this showed that all variables significantly violated the Shapiro Wilk test of normality at $p>.05$, including the Mind-mindedness data. The same procedure was run on all other variables under study, including DASS-21, revealing none met the assumptions of normally distributed data.

Inferential Statistical Analyses

Given data likely violate the assumptions of parametric tests, nonparametric tests were used. To test for between group differences, the Mann-Whitney U test was used. This nonparametric test of central tendency tests for difference in median rank. The Wilcoxon signed-rank test was used as a paired samples test of repeated measurements on women in pregnancy and later in the postpartum to assess whether their population mean ranks differ. Like the Mann-Whitney U test, it relies on ranking to overcome problems with nonparametric datasets. For correlation analyses, Spearman's rank order analysis was used.

Mediation Model Calculation

Mediation models as per Jose (2013) were calculated where significant correlations between predictor and outcome variables were found and when these were theoretically relevant to the hypotheses under study.

Section 3: Inferential Statistics

Study 1

Pregnancy and Theory of Mind

Hypothesis 1. Pregnant women will have overall enhanced ToM compared to control group women.

To determine whether pregnant women have enhanced Theory of Mind capacity compared to controls, as measured on the MM Task, Hinting, RMET, RFQ uncertainty and certainty subscales, independent-samples Mann-Whitney *U* Tests were calculated for each measure. The results indicated that there was no significant difference between any of the ToM tasks and pregnancy status: MM $z = 2425$, $p = .33$; RMET $z = 2417$, $p = .35$; Hinting $z = 2570$, $p = .10$; RFQc, $z = 2167$, $p = .85$; RFQu $z = 2501$, $p = 18$. Pregnant women did not have overall enhanced ToM compared to matched control group women.

Additional Exploratory Analysis. To determine whether patterns of performance on ToM differed between pregnant and control group women, Spearman rank order correlations were calculated– see Table 7 for all Study 1 variables of interest. Performance on most ToM variables was not significantly correlated for either pregnant or control group women, consistent with prior research. The exception to this was that, unlike control group women, pregnant women's performance on Hinting and RMET was moderately positively correlated, $r = .32$, $p = .007$.

Theory of Mind and Prenatal Attachment

Hypothesis 2. Pregnant women's ToM capacity will be associated with prenatal attachment.

To determine whether pregnant women's ToM performance was linked to their attachment prenatally, Spearman correlations were calculated across all measures – see Table 7 for details. This revealed that, unexpectedly, ToM ability in pregnancy on Mind-mindedness, RMET and Hinting was not associated with the Prenatal Attachment Index subscales Anticipation or Differentiation. However, the Interaction subscale was significantly associated with RFQ Uncertainty about Mental States, such that pregnant women with greater levels of uncertainty about mental states were also less likely to interact with the unborn baby.

Theory of Mind, Emotional Distress, and Prenatal Attachment

Hypothesis 3. Women with (1) greater levels of emotional distress (depression, anxiety, stress) will have (2) overall reduced ToM capacity; and (3) for pregnant women, levels of emotional distress will negatively impact on (4) prenatal attachment.

As expected, in all women levels of emotional distress (depression and stress) were significantly associated with the RFQ subscales (Certainty and Uncertainty about Mental States), such that higher levels of depression and stress were linked to greater

uncertainty about the mental states of themselves and others on both scales (see Table 7 for details). For pregnant women only, more anxiety was also significantly associated with greater uncertainty about mental states of themselves and others. Unexpectedly, levels of emotional distress were not significantly associated with the other ToM measures; Mind-mindedness, Hinting Task, or the RMET. Levels of emotional distress had no relationship to performance on these measures in pregnant or control group women.

The relationship between emotional distress and prenatal attachment is also shown in Table 7. We were testing the hypothesis that for pregnant women, levels of emotional distress are negatively associated with prenatal attachment. Unexpectedly, greater emotional distress was not associated with any of the prenatal attachment subscales, Anticipation, Differentiation, or Interaction.

Table 7

Study 1 Spearman Rank Order Correlations – Theory of Mind, Prenatal Attachment, and Emotional State

		Variable	1	2	3	4	5	6	7	8	9	10	11
Pregnant	1.	Mind-mindedness	.										
	2.	RMET	-.12	.									
	3.	Hinting Task	-.08	.33**	.								
	4.	RFQ Certainty §	-.05	.01	-.12	.							
	5.	RFQ Uncertainty §	.11	-.08	-.05	-.66**	.						
	6.	PAI Anticipation § [a]	-.05	.08	-.15	-.00	.10	.					
	7.	PAI Differentiation § [b]	-.12	-.10	-.09	.07	-.02	.52**	.				
	8.	PAI Interaction § [c]	-.13	.01	-.20	.13	-.25*	.54**	.56**	.			
	9.	DASS Depression §	.01	-.06	.01	-.27*	.32**	-.16	-.01	-.21	.		
	10.	DASS Anxiety §	.09	-.15	-.20	-.26*	.42**	-.04	-.12	-.19	.55**	.	
	11.	DASS Stress §	-.02	.01	-.05	-.29*	.34**	-.11	-.08	-.11	.61**	.60**	.
Control	1.	Mind-mindedness	.										
	2.	RMET	.10	.									
	3.	Hinting Task	.05	.20	.								
	4.	RFQ Certainty §	.09	-.09	-.15	.							
	5.	RFQ Uncertainty §	-.13	.01	.16	-.60**	.						
	9.	DASS Depression §	-.14	.12	.16	-.33**	.25*				.		
	10.	DASS Anxiety §	-.17	.05	.08	-.21	.15				.47**	.	
	11.	DASS Stress §	-.06	.27*	.02	-.34**	.30*				.63**	.55**	.

[a] [b] [c] Prenatal Attachment Index subscales - for pregnant women only. * p<.05. ** p<.01. (2-tailed)

Study 2

Theory of Mind in Pregnancy, Parental Reflective Functioning, and Maternal-Infant Postnatal Attachment

Hypothesis 1. Pregnant women's ToM capacity will be positively associated with postpartum (1) parental reflective functioning and (2) maternal-infant attachment.

Spearman Rank-Order Correlations were calculated for ToM variables during pregnancy and parental reflective functioning and maternal-infant attachment (when the same women were 5 months postpartum, $n = 54$). These are presented in Table 8 below. Unexpectedly, only one relationship was marginally significant. There was a small negative relationship between performance on the ToM measure RMET and MPAS subscale Absence of Hostility, $r\,(52) = .27$, $p = .047$, such that better performance on RMET in pregnancy was predictive of small but significantly greater levels of hostility in the maternal-infant attachment relationship. This finding was unexpected as it suggests that better ToM as measured by RMET is associated with greater hostility in the attachment relationship postpartum.

Apart from this finding, there is no further evidence from the present study that ToM capacity in late-stage pregnancy is predictive of postpartum attachment or parental reflective functioning. Of note also is that reflective functioning in pregnancy is not associated with later parental reflective functioning in the postpartum.

Table 8

Spearman's Rho and p-values for Pregnancy ToM as a Function of Postpartum Attachment and Parental Reflective Functioning

	MM	RMET	Hinting	RFQc §	RFQu §
MPAS - Quality of Attachment §	.06	-.24	-.09	.09	-.03
MPAS - Hostility §	.00	-.27*	-.16	.24	-.15
MPAS - Interaction §	-.03	-.20	-.13	.18	-.10
MPAS - Total Attachment	.01	-.30	-.17	.20	-.12
PRFQ - Pre-Mentalising §	-.22	.06	.11	.25	.01
PRFQ - Certainty §	.10	-.07	-.09	.13	-.04
PRFQ - Interest and Curiosity §	-.06	.22	.17	.21	.09
PRFQ - Result	-.04	.10	.04	.15	.02

* $p<.05$ ** $p<.01$. (2-tailed)

§ indicates subscales

Parental Reflective Functioning, Emotional Distress, and Maternal Postnatal Attachment

Hypothesis 2. Postpartum women with (1) greater levels of emotional distress (depression, anxiety, stress) will have poorer (1) reflective functioning and (2) a poorer maternal-infant attachment relationship.

As predicted, emotional state variables on the DASS-21 were highly correlated with MPAS Total Attachment and the subscale Quality of Attachment, such that higher levels of Depression, Anxiety and Stress are all moderately associated with a poorer Quality of Attachment and Total Attachment. Moreover, greater levels of depression, anxiety and stress in postpartum mothers were all moderately associated with poorer ToM as measured by PRFQ Pre-Mentalising Modes (See Table 9 for details).

Hypothesis 3. Postpartum women's (1) parental reflective function will be positively associated with (2) maternal-infant attachment.

To examine the association between Parental Reflective Functioning and Maternal Postnatal Attachment in postpartum women, Spearman Rank-Order Correlations were calculated – see Table 9 for details. As predicted, three correlations between ToM and Attachment were significant. The Pre-Mentalising Modes subscale is designed to capture mentalizing without deep reflection where the caregiver is overly rigid and makes negative attributions about the function of the child's behaviour as well as having a poorer understanding of their own mental and emotional states. It is associated with severe problems with caregiver mentalizing. As expected, this subscale was negatively correlated with the Quality of Attachment subscale as well as Total Attachment. Moreover, greater levels of Pre-Mentalising Modes was moderately negatively associated with Absence of Hostility; put simply mothers with greater levels of Pre-Mentalising Modes were more likely to have elements of hostility in the maternal-infant attachment relationship.

Table 9

Study 2 Spearman Rank Order Correlations – Postpartum Attachment, Parental Reflective Functioning, and Emotional State

Measures	1	2	3	4	5	6	7	8	9	10	11
Attachment (MPAS)											
1. Quality of Attachment §	.										
2. Absence of Hostility §	.63**	.									
3. Interaction §	.31*	.26	.								
4. Total Attachment	.90**	.81**	.55**	.							
Caregiver ToM (PRFQ)											
5. Pre-Mentalising Modes §	- .48**	-.35**	-.23	-.46**	.						
6. Certainty §	.34*	.07	.07	.26	-.20	.					
7. Interest & Curiosity §	-.02	-.04	.28*	.05	-.35*	.04	.				
8. Result	.04	-.16	.09	-.00	.06	.78**	.46**	.			
Emotional State (DASS-21)											
9. Depression §	-.52**	-.46**	-.14	-.55**	.33*	-.37**	.06	-.13	.		
10. Anxiety §	-.59**	-.26	-.20	-.49**	.32*	-.38**	-.07	-.18	.52**	.	
11. Stress §	-.69**	-.50**	-.09	-.62**	.28*	-.27	.19	.05	.67**	.57**	.

* $p<.05$. ** $p<.01$. (2-tailed)

Significant relationships between key variables of interest in bold.

Section 4: Preliminary Models

Mediation Analyses of ToM, Emotional State and Attachment in Postpartum Caregiving

Table 9 above shows the relationships between attachment, parental reflective function, and emotional state in women 4-6 months postpartum. There are statistically significant relationships between all three variables of interest in expected directions. Poorer emotional state is associated with poorer parental reflective function and poorer maternal-infant attachment; parental reflective function is also associated with poorer maternal-infant attachment.

Where there is collinearity between variables of interest, it can be useful to test a theoretically-informed mediation model which specifies the conceptual relationship between predictors and outcome with a mediating variable operating as a mechanism contributing to the overall effect (Baron & Kenny, 1986; Jose, 2013). Since the data presented here are cross-sectional it is not possible to infer causation, hence this mediation model is preliminary.

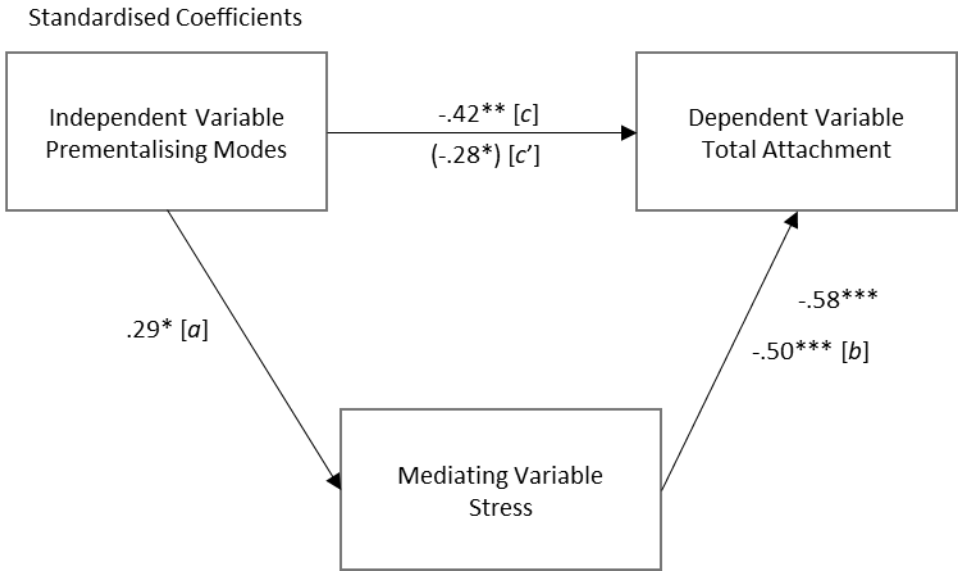
1. Mediation Model: Maternal Pre-Mentalising Modes and Postpartum Maternal-Infant Attachment is Mediated by Maternal Stress

Two regressions were performed to ascertain the effect of PRFQ Pre-Mentalising Modes on MPAS Total Attachment under conditions of stress. Stress was chosen as a mediator as it is theoretically linked to both Pre-Mentalising Modes and attachment and had the strongest relationship to total attachment of the three emotional state variables. Total Attachment was selected as it is made up of all three subscales and so is reflective of the construct as a whole. Stress was first regressed on Pre-Mentalising Modes, then Total Attachment was regressed on Pre-Mentalising Modes. Statistical output was then taken from these analyses and imputed into Medgraph (Jose, 2013) and yielded a statistically significant result, Sobel's z = - 1.96, p = .04.

As Figure 10 demonstrates, the basic negative relationship between Pre-Mentalising Modes and Total Attachment (r = .-42) is partially explained by levels of maternal stress: Stress accounts for 34% of the relationship between Pre-Mentalising Modes and Total Attachment. The model shows that under conditions of high stress, mothers are more likely to be using poorer, more rigid, and inappropriate ToM when they reflect on the inner experiences of their baby and themselves and, taken together, these predict a worse attachment relationship.

Figure 10

Relationship of Pre-Mentalising Modes ToM to Maternal Total Attachment Mediated by Maternal Stress



Note. The numerical values in the parentheses are beta weights taken from the second regression and the other values are zero order correlations. * p<.05. ** p<.01 *** p< .001

a - The relationship between Pre-Mentalising Modes and Stress
b - The relationship between Stress and Attachment
c - The basic relationship between Pre-Mentalising Modes and Total Attachment
c' - The direct effect
*a*b* - The indirect effect

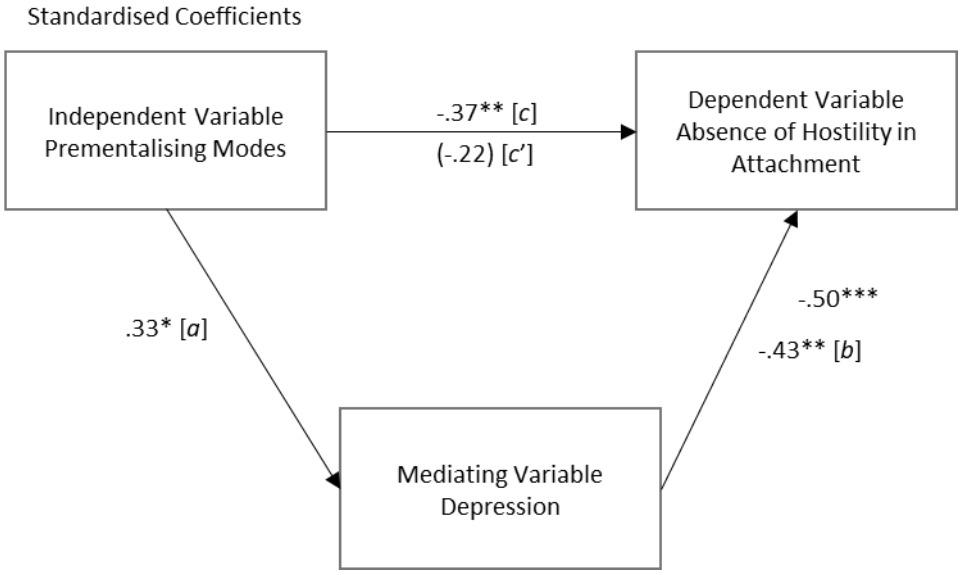
2. *Mediation Model: Pre-Mentalising Modes, Depression, and Absence of Hostility in Attachment*

To explore the relationship between maternal levels of depression, poor ToM as measured in Pre-Mentalising Modes and Hostility in the attachment relationship, a mediation model was calculated. Figure 11 shows the significant relationships between these variables.

The model shows that under conditions of greater depression, mothers are more likely to be using poorer, more rigid, and inappropriate ToM when they reflect on the inner experiences of their baby and themselves and, taken together, this predicts greater levels of hostility in the attachment relationship. Overall, depressive symptoms account for 38% of the basic relationship between Pre-Mentalising Modes and Absence of Hostility in Attachment (r = .-.37, p <.001).

Figure 11

Relationship between Pre-Mentalising Modes and Absence of Hostility in Attachment Mediated by Depression



Note. The numerical values in the parentheses are beta weights taken from the second regression and the other values are zero order correlations. * p<.05. ** p<.01 *** p< .001

a - The relationship between Pre-Mentalising Modes and Depression
b - The relationship between Depression and Absence of Hostility in Attachment
c - The basic relationship between Pre-Mentalising Modes and Absence of Hostility in Attachment
c' - The direct effect
*a*b* - The indirect effect

Chapter Five

Discussion

This research has considered Theory of Mind (ToM) and its relationship to attachment security and emotional state over pregnancy and postpartum. The overarching aim was to contribute to the growing literature of maternal cognition through an adaptive lens.

Study 1

To our knowledge, study 1 is the first to examine pregnant women's ToM across a range of behavioural measures and to include a matched control group consistent with other studies of maternal cognition. Specifically, in Study 1 ToM was measured with a mind-mindedness video task, a verbal hinting task, the Reading the Mind in the Eyes task (RMET), and the Reflective Functioning Questionnaire (RFQ) to capture a range of ToM processes. Pregnant women also completed a measure of prenatal attachment to the foetus, and all participants completed measures of emotional state (depression, anxiety, and stress).

Contrary to expectations, primiparous pregnant women's performance across the four ToM behavioural measures was no different to nulliparous matched control group women, nor was their ToM capacity concurrently related to prenatal attachment. Levels of emotional distress unexpectedly had no relationship to most ToM or attachment measures. The exception was that for all women, the presence of greater levels of depression, stress (and anxiety in pregnant women only) was linked to significantly greater uncertainty about the mental states of themselves and others, an aspect of reflective functioning. On the whole, the ToM measures were uncorrelated, consistent with other evidence that they represent distinct competencies (Krink & Ramsauer, 2021; Warnell & Redcay, 2019). The one exception was a moderate correlation on the verbal

hinting and RMET tasks in pregnant women only, which may have been an artefact of exploratory analysis.

These findings suggest that, in spite of neuroimaging evidence of substantial brain restructuring during pregnancy in regions which overlap with the proposed ToM network (Hoekzema et al., 2017; Schurz et al., 2014), evidence to date does not support a general enhancement of ToM in the third trimester of pregnancy. Most prior research into ToM in pregnancy has been in face processing which has revealed a variety of more specific enhancements, especially in negative emotion recognition in adult and infant faces (De Carli et al., 2019; Webb & Ayers, 2015). It has been found that pregnant women have increased selective attention to fearful adult faces (Roos et al., 2012), a preference for apparent health markers in adult faces (Jones et al., 2005), and an enhanced ability to decode angry, disgusted, fearful, and sad faces (Pearson et al. 2009).

Pregnancy is also associated with greater processing of infant emotional faces (Thompson-Booth et al., 2014b). In the postpartum, infant faces have been found to elicit greater attentional allocation in mothers compared to non-mothers (Thompson-Booth et al., 2014a; Zhang et al., 2020). The current study also included a measure of general emotion recognition. The RMET assesses the global ability to recognise complex emotions from eyes (e.g., disgust, fear, thoughtfulness) and can discriminate between clinical and neurodiverse populations compared to controls (Bell, 2012; Peñuelas-Calvo et al., 2019). On the RMET, pregnant women's performance was no different to control women's, and emotional state was unrelated to RMET performance. Taken as a whole, it appears that changes in face processing capacity in pregnancy are more likely in specific aspects of emotion recognition and attentional processing of adult and infant faces rather than general changes across emotion recognition.

The other area of ToM cognition which has received some very limited research attention in pregnant women is mind-mindedness (MM) and reflective function (RF).

The current study examined these aspects of ToM with a measure of representational MM in a novel, ecologically valid, silent video task, and self-reported levels of RF. To our knowledge, just one study has examined MM in pregnancy. Arnott and Meins (2008) asked pregnant women and expectant fathers to describe their future child as a measure of representational MM. Consistent with the current study, Arnott and Meins (2008) found no between group differences in MM and MM capacity was not associated with prenatal attachment. They did find that in fathers, prenatal MM had different correlates in postpartum play interactions compared to mothers. In fathers it was associated with greater non-attuned interactional MM, which was not the case in mothers. This finding raises questions about the role of non-attuned, or poor mentalising, in the transition to parenthood and how the experience of pregnancy itself might impact on MM.

In terms of RF, to our knowledge no studies have examined pregnant women's reflective functioning (on the RFQ) compared to controls. However, on a new measure of prenatal parental reflective functioning (Pajulo et al., 2015) pregnant women scored higher overall on prenatal RF and on the factor 'reflecting on the foetus-child' compared to expectant fathers (n = 491; Vahidi et al., 2021). This, as well as the factor 'the dynamic state of mental states', predicted parent-foetus attachment. This new self-report measure provides preliminary evidence that prenatal reflective functioning may be an aspect of ToM which is dynamic in pregnancy. Taken together, it is possible that MM and RF in pregnancy, as measures of a *general* capacity to think of others in terms of internal attributes (MM) or to reflect on the contents of one's own mind and that of others (RF), is not enhanced but that specific aspects of these capacities is affected by pregnancy. However, given the very limited literature examining MM and RF in pregnancy, any conclusions must be interpreted with caution.

Returning to the original impetus for the present research, the most parsimonious explanation of findings from Study 1 integrated with existing literature is

that, contrary to the brain-to-behaviour hypothesis proposed by Hoekzema et al. (2016), there is no evidence for *general* enhancement of ToM functioning in late-stage pregnant women. However, there is a small body of evidence from behavioural, imaging and EEG studies of *specific* enhancements and which may relate to greater processing efficiency in specialised subcomponents of ToM (e.g., lower order perceptual processes, such as aspects of face processing; De Carli et al., 2019) and, consistent with this, some preliminary support for specific aspects of MM and prenatal RF shifting over pregnancy.

An alternative theoretical conceptualisation of these findings might be in terms of a cognitive prioritisation. To date, the maternal 'babybrain' literature has largely focused on understanding the changes in general cognition via behavioural studies where decrements in working memory, executive functioning, and general cognitive function have been seen (Davies et al., 2018). While in the present research pregnant women performed no better than control women in general ToM tasks, they also did no worse. The large number of findings from behavioural, clinical, and intervention research which have shown the importance of ToM mentalising to attachment security in caregiving (e.g., Camoirano, 2017; Luyten et al., 2017; Sharp & Fonagy, 2008; Slade et al., 2020) alongside structural neuroimaging findings from Hoekzema et al. (2016) lend conceptual support to a modified hypothesis; that general ToM might be a prioritised cognitive function which is maintained or preserved over the perinatal period. Anderson and Rutherford (2012) originally proposed that the general cognitive decrements of pregnancy might be reflective of a 'trade off' of aspects of cognition which are less relevant to caregiving while others which represent more ecological relevance are enhanced. Developing this further, pregnancy could thus be conceptualised as a sensitive period of development where some social cognitive functioning is enhanced, such as face processing, while still maintaining performance in other social cognitive domains, such as general ToM. The cost of brain restructuring—the trade off as it has been proposed–is

in general cognition (general cognition, memory, executive functioning) in the third trimester of pregnancy (Davies et al., 2018) when the brain is restructuring.

These theoretical considerations underscore that the conceptualisation of maternal cognition is still at an early stage. There is a need for greater integration of findings from basic neuroscience research with more behavioural studies into social cognition to test these preliminary hypotheses further and integrate them into more highly specified models of brain and behaviour functioning. One promising new avenue is the concept of a 'maternal circuit'. There have been various proposals of a 'maternal circuit' in humans (Hillerer et al., 2014; Pawluski et al., 2022; Pereira, 2016; Swain et al., 2007) an approach which has been favoured in nonhuman animal studies for some time (e.g., Featherstone et al., 2000; Gammie, 2005). Most recently Pawluski et al. (2022) have conceptualised the maternal circuit as involving changes in motivation, affect, empathy, and attachment. This explanation invites further consideration into how these multiple components interact. For instance, how might specific components of ToM which appear to be sensitive to neurobiological changes over the perinatal period interact with changes in motivation or empathy? Do changes in motivation and empathy impact on general ToM as a potentially prioritised cognitive function?

Limitations and Suggestions for Future Research

One overall difficulty in the study of ToM in adult community populations is the relative lack of behavioural measures. Recently, Quesque and Rossetti (2020) have commented that there is a lack of specificity in the measures used to operationalise ToM and call for more measures to consider ecological validity in their design. Unlike other cognitive domains (memory, attention, executive functioning), ToM does not have well-established, highly sensitive and specific neuropsychological test batteries for adult populations. Previous studies of maternal cognition have benefited from the existence of

well-researched measures.[3] Given the number of dissociable cognitive processes which are encapsulated by ToM, as an umbrella concept, it is proposed here that individual difference studies best use multiple measures of ToM, as is usual in research into other cognitive domains.

While the measures used in the present study have all been researched in nonclinical adult samples, only MM has been used once in pregnant women. A limitation therefore on the present research is that the selected measures may not have had the sensitivity to detect between group differences in pregnant women at this sample size. Estimation of sample size is determined by effect sizes, power, significance level, and method of statistical analysis (Kang, 2021). Determining power for measures which have not been studied in a given population adds complexity to the estimation. However, what the present research does contribute is that at this sample size, there were no large or medium differences in general ToM between pregnant and control women; smaller differences may exist in larger studies with greater power to detect any differences.

The use of culturally validated measures of social cognition and ToM will also be a priority for future research. It is curious that the concept of the maternal 'babybrain' appears to be a particularly western idea, and there is little research into the effects of labelling women with 'deficits' in cognition over the perinatal period and how this might contribute to unhelpful stereotypes, negative perceptions, and the expectation of worse performance. In a small qualitative study of 'baby brain' experiences in New Zealand, Māori women were less likely to be concerned with pregnancy-related problems in cognition than Pākehā women, suggesting that the 'baby brain' narrative is culturally situated (Turner, 2019).

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[3] For instance, maternal cognition research into attention, memory, executive functioning etc., has used subtests from well-known test batteries including the *Wechsler Adult Intelligence Scale, California Verbal Learning Test, Rey Auditory Verbal Learning Test, Controlled Oral Word Association Test, Wisconsin Card Sorting Test*.

In keeping with the impetus to develop more ecologically valid measures of ToM, the present research contributed a novel protocol for the measurement of representational MM by using silent videos of children playing as test stimuli. Silent videos have been used in ToM research previously to good effect (Devine & Hughes, 2013; Rice & Redcay, 2015). They require participants to attend to nonverbal social information which can be tailored to the study domain with ecologically relevant test stimuli. Two further improvements to the MM video task are suggested which might improve measurement sensitivity. Firstly, for the present study it was difficult to find appropriate video stimuli to use; open-source film from an Australian provider of early childhood education was eventually secured after a long search. It might have been better to create short videos of early mother-infant interactions to improve the task relevance for pregnant women. Secondly, an additional coding for inappropriate or non-attuned MM would improve the sensitivity of the measure to detect poor ToM. In study 1, data were coded following the MM coding manual for representational MM (Meins & Fernyhough, 2015). Scoring consisted of segmenting participant data into individual attributes, then coding each as internal or external characteristics of the child. An overall ratio score is then calculated which represents the proportion of internal child attributes as a function of all attributes. Unlike the MM observational measure, which has typically been used in semi-structured play observations of mother-child dyads, the MM representational measure does not code for poor or non-attuned/inappropriate ToM. This coding is possible in the MM observational measure as the quality of mother-child interactions are included in the analysis.

To improve study 1, the MM video task could have also been coded more specifically for the presence of highly non-attuned internal descriptors of the children in the video task. For instance, it was notable during scoring that some participants described the two pre-schoolers in ways which were clearly misattributions of internal

states, but these descriptions were nevertheless coded as MM comments. For instance, if a participant had noted that “the child is trying to manipulate her friend” this might be evidence of mentalising, albeit it is also poor mentalising in the context of the video and the developmental age of the child. To code for appropriate vs inappropriate MM, the video stimuli from the MM task could be coded into agreed child attributes by child development or clinical psychologists which would allow this extra coding of participant MM data, consistent with the observational MM measure. This would allow for an examination of non-attuned representational MM and its correlates.

Alongside the development of better behavioural measures of social cognition and ToM, there is also a need for well-designed and methodologically sound research in neuroscience. Button et al., (2013) and Poldrack et al., (2017) highlight how underpowered studies with small sample sizes and data-driven hypotheses can generate false results in fMRI research. As detailed in Chapter 2, many novel findings in maternal social cognition research come from fMRI studies with small sample sizes of $n<25$ (e.g., De Carli et al., 2019; Kim, 2016). While the main finding from Hoekzema et al., (2017), that pregnancy led to long lasting changes in the human brain structure, provided persuasive evidence of GM structural change, the interpretation of this finding (that this structural change is related to functional ToM processing and the postpartum maternal-infant attachment) relies on fMRI evidence, some of which may be more exploratory than confirmatory. For instance, in Hoekzema et al., (2017), a commonly-used ‘own infant vs. other infant’ fMRI paradigm was employed with the mothers in the postpartum as a measure of maternal-infant attachment with a relatively small sample size (n = 25).

A further limitation which relates to this study as well as the field of maternal cognition in general is the role of sleep quality in pregnancy and its relationship to cognitive functioning. Typically, maternal cognition research uses matched between

group designs to test pregnant and control group women on cognitive measures. However, late pregnancy is associated with a reduction in sleep quality (Sedov et al., 2018) which may be negatively impacting on pregnant women's cognitive functioning. This would mean that the observed decrements in third trimester general cognitive functioning are an overestimation. Hence, a priority for future research will be to include measures of sleep quality in maternal cognition research to match groups on this variable and to also test the relationship between pregnancy and sleep quality.

One further point in this respect relates to the present study. All women in the present study completed the Epworth Sleep Quality Scale as part of KC's joint study into maternal cognition (Connolly, 2018). It was found that pregnant women had significantly lower processing speed and a trend indicative of impairment in one executive functioning task. Moreover, while pregnant women did have significantly worse sleep quality than control women of a moderate effect size (Epworth Sleep Quality Scale; d = .69), this was not associated with their cognitive functioning. A limitation of the present study and its interpretation is that it did not include this sleep quality data in the analysis of results.

Finally, research into maternal cognition is undergoing rapid advancement at present. It will be important that the interpretation of scientific findings from neuroscience and behavioural studies, and their wider dissemination in the popular press (e.g., Conaboy, 2022), remains cautious so that strong claims of the adaptive function of maternal brain changes are not jumping ahead of the evidence base.

Study 2

Study 2 hypothesised that ToM in pregnancy would be associated with parental reflective function in the postpartum and maternal-infant attachment. First, contrary to expectations, general measures of ToM in pregnancy were not indicators for later parental reflective functioning in caregiving nor were they related to attachment over the

perinatal period. To our knowledge, this is the first study to test the longitudinal relationship between general ToM capacity in pregnancy with later parental reflective functioning and attachment. Second, in support of the study's hypotheses, women's levels of emotional distress were negatively associated with parental reflective functioning, and this poorer form of reflective functioning was linked to poorer maternal-infant attachment. To clarify the results from Study 2, preliminary mediation models were calculated describing the relationship between emotional distress, pre-mentalising modes (poor parental RF) and attachment. Both models were significant and theoretically consistent. The first showed that when mothers were experiencing greater levels of depressive symptomology, they were also likely to be using pre-mentalising modes to reflect on their own and their infant's mental states and taken together both predict greater hostility in the attachment relationship. The second mediation model showed that mothers who reported greater levels of stress were also more likely to be using pre-mentalising modes and these factors predict lower levels of overall attachment.

The Pre-Mentalising Modes dimension on the PRFQ is sensitive to the presence of rigid and concrete ToM. For instance, there is an absence of self-reflection in the parenting role (e.g., 'Often, my child's behaviour is too confusing to bother figuring out') combined with the presence of negative attributions of child behaviour (e.g., 'My child sometimes gets sick to keep me from doing what I want to do'). The Absence of Hostility subscale of the MPAS is a measure of the levels of annoyance and resentment towards the infant in the attachment relationship (e.g., 'When I am caring for the baby I get feelings that the child is deliberately being difficult or trying to upset me') with low scores indicating higher levels of hostility.

These mediation models, although preliminary, are theoretically consistent with studies showing that poor and absent ToM harms attachment quality and is associated

with a range of adverse sequalae for children (Camoirano, 2017; Rutherford et al., 2015; Schultheis et al., 2019). For instance, women with PTSD following childbirth have been found to have greater levels of hostility towards their infants on this measure (Davies et al., 2008). Elevated depressive and anxiety symptomology has also been associated with great hostility and resentment towards the infant on this and similar attachment measures (Scopesi et al., 2004; van Bussel et al., 2010).

To our knowledge this is the first study to compute mediation models in a community sample of postpartum women describing the concurrent relationships between pre-mentalising, emotional state, and attachment. The finding that levels of emotional distress accounted for over a third of the variance between pre-mentalising and attachment as well as the moderate effect sizes is consistent with research into the detrimental effects of postpartum maternal distress on the attachment relationship.

Limitations and Suggestions for Future Research

Some limitations should be noted. First, the nature of this cross-sectional study prevents inferences about the direction of causality; this would need to be tested longitudinally. It may be, for instance, that a poorer maternal-infant attachment is due to third variables (e.g., social deprivation, limited parental capacity, child factors) which contribute to greater parental emotional distress and pre-mentalising. These variables likely have complex inter-relationships, such a moderating as well as mediating effects. Second, while these results lend support to early intervention for new mothers experiencing emotional distress in the early parenting context, care should be taken regarding the translational value of results from nonclinical samples to clinical practice. For instance, in this research women were experiencing low levels of emotional distress overall which limits the generalisability of the finding to mothers who present at secondary healthcare services with more elevated and complex mental health problems. Third, while the relationships between elevated emotional distress, pre-mentalising, and

attachment security had moderate effect sizes and were significant (at alpha .05), most studies into the pre-mentalising construct have been in clinical populations where pre-mentalising is much more elevated (e.g., Krink et al., 2018; Slade et al., 2020). A priority for future research would be to investigate the impact of pre-mentalising and emotional distress on parent-child relationships in community samples.

Finally, it would be useful for future researchers to consider the interrelationships between the two streams of mind-mindedness and parental reflective functioning, which have been referred to in the current work under the umbrella term of parental ToM. A useful way to consider them together in future research might be to compare inappropriate or non-attuned MM on a video task with Pre-Mentalising Modes on the PRFQ. This would support understanding whether the rigid and poor mentalising observed in pre-mentalising relates to spontaneous, non-attuned MM when describing a child in a play context.

Summary and Conclusion

The results from these two studies advance the understanding of ToM over the perinatal period and the relationship to caregiving in several ways. First, there was no difference between late-stage pregnant and matched control women on measures of ToM (covering spontaneous mind-mindedness, inference of meaning in hints, reflective functioning and general affect recognition) in spite of evidence that pregnant women experience a significant decline in general cognitive functioning in the third trimester of pregnancy (Davies et al., 2018). This is the first time that ToM, and social cognition in general, has been examined across several measures in pregnancy with a control group design.

The rationale for this study was to test behaviourally the hypotheses proposed by Hoekzema et al. (2016) that structural changes to women's brain during pregnancy in the ToM network serve to support the imminent caregiving demands of motherhood, by

re-organising the brain in a way which prioritises adaptive caregiving behaviours, such as attuned, sensitive responses to an infant.

Second, in study 2 we showed that performance on ToM in pregnancy was not an indicator of attachment or of later parental reflective functioning, a measure of ToM in caregiving. Preliminary analyses showed a significant role for poor and rigid ToM reflective functioning—pre-mentalising modes—relating to greater hostility and poorer overall quality in maternal-infant attachment. In the context of emotional distress, depressive and stress symptomology, this relationship was stronger. This replicates the findings from many studies which have found caregiver insensitivity to be particularly damaging to infant and maternal wellbeing (e.g., van Ee et al., 2016).

Although there are prior studies showing increments in select areas of social cognition in late pregnancy – face processing in particular – and an even greater number of studies which have found structural and functional changes in both human and animal studies, there are ongoing debates regarding how to conceptualise brain-to-behaviour changes over this pivotal stage in the lifespan. Our results lend support to the possibility that ToM enhancement is likely more specific, rather than general, and despite decrements in general cognition and greater levels of anxiety in late pregnancy, ToM might be a prioritised cognitive function.

Considering the literature as a whole, there is now accumulated evidence to conceptualise women's cognitive changes in pregnancy as part of an adaptive developmental change rather than a phase of 'babybrain' impairment. While these findings indicate that there appears to be no enhancement of general ToM, there is preliminary support for general ToM being a preserved cognitive function, given that pregnant women perform as well as control women in general ToM tasks, despite significant decrements in general cognitive functioning in the third trimester, worse sleep quality, and that their higher levels of anxiety negatively impact on reflective

functioning making them more uncertain about mental states of themselves and others. This is theoretically consistent with the proposed 'maternal circuit' that posits that functions adaptive to caregiving are prioritised over the perinatal period. Finally, given the significance of early relationships to infant health and wellbeing, an awareness of signs of social cognitive factors associated with insensitive caregiving and poor attachment provides health care professionals with a useful risk indicator and starting place to support community-based women struggling with the adjustment to early parenting.

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Appendices

Appendix A - Participant Demographic and Contact Information

1. What is your name? _____
2. What is your email address?_____
3. What is your date of birth?_____
4. *If you are pregnant*, what is your due date? (If you are uncertain, how many weeks pregnant are you?)_____
5. Have you ever given birth to a child before? _____
6. Which ethnic group do you belong to? (Mark the one or ones which apply to you)

- NZ European (Pakeha)
- *Māori*
- Samoan
- Cook Island Māori
- Tongan
- Niuean
- Chinese
- Indian
- Other (such as Dutch, Japanese, Tokelauan). Please state_____

7. What is your highest qualification?

- NCEA – Level 1 (School Certificate or equivalent)
- NCEA – Level 2 (Sixth Form Certificate or equivalent)
- NCEA – Level 3 (seventh Form Certificate or equivalent)
- Trade Certificate/Diploma
- Undergraduate Degree
- Postgraduate Degree
- Doctoral Degree

8. How many hours per week do you typically spend interacting with children?

- none
- 1-2 hours
- 3-6 hours
- 7-10 hours
- 11-20
- 20+

Appendix B - Mind-mindedness Task – Silent Videos

(Meins et al., 1998, 2014)

The following task was adapted from the Mind-minded interview task. In this task participants are shown two 2-minute videos of young children interacting in a daycare context and are instructed to observe one child in particular. The sound is muted to increase the difficulty of the task and encourage the participants to attend to other social information available. At the end of each video an on-screen prompt instructs participants to "*Describe the child*". A textbox is available for participants to type into.

Scoring

Participants' text is subsequently sectioned then coded into exclusive categories of descriptive talk, as per the coding manual (Meins & Fernyhough, 2015). Categories of talk are:

- **Behavioral descriptors** related to activity or temperament,
- **Style** (e.g., "She's very active"),
- **Physical** (e.g., "She is tall for her age"),
- **General** (e.g., "She's just adorable"),
- **Mental descriptors** related to the child's mental life, interests, preferences, knowledge (e.g., "He loves reading new books").

A global mind-mindedness score is then calculated. This score is a proportion of mental descriptors used as a proportion of all other types of descriptors of the child.

Mind-Mindedness sample scoring (anonymised)

Participant Data	*Coding*
The little girl	External attribute
in the pink top	External attribute
has short	External attribute
blond hair	External attribute
All young children look pretty symmetrical, she does too	External attribute
She is generally curious	Internal attribute
and seeks to please	Internal attribute
or get reassurance from her caregiver	Internal attribute
She doesn't seem interested in playing with her peers	Internal attribute
She has no trouble pointing	External attribute
Her facial expression is somewhat neutral	External attribute

Scoring

Internal Descriptors – 4

External Descriptors – 7

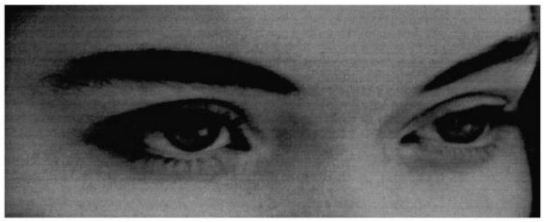
Internal Descriptors / all Descriptors = 4/11

Mind-mindedness ratio score = .36

Appendix C - Reading the Mind in the Eyes Task

(Baron-Cohen et al., 2001)

Participants are shown 39 black-and-white test stimuli of male and female eyes. For each set of eyes, participants must infer the emotion the person is experiencing from examining their eyes. There are four multiple choice emotions for each set of eyes representing complex emotions. See below for an example.



Word choice: Reflective (correct), aghast, irritated, impatient

Scoring

Participants receive 1 point for each correct word choice (max 39 points)

Appendix D - The Extended Hinting Task

(Corcoran et al., 1995; Marjoram et al., 2005)

A sample vignette from the 20-item Extended Hinting Task is presented below. Note that in the current study, any additional hints were not presented to participants as these have been found to not improve measurement in normal populations (Bell, 2012).

Audio recording

Two children, Emma and Katie, are playing when Emma breaks an old statue belonging to Katie's mother. Emma says to Katie: *'If your Mum finds out it was me that broke it, I won't be allowed to come here anymore.*

Question

What does Emma mean when she says this?

Scoring

For a correct answer, participants need to have written something to indicate that Emma wants Katie's help to deceive her mother as to what happened to the old statue. Participants received 1 point for a correct answer and 0 points for an incorrect answer.

Example correct answers: Emma means "Pretend you broke it." Or "Can we hide it?" Or "Come up with an idea so that I won't get into trouble."

Appendix E - The Depression, Anxiety and Stress Scale

DASS-21 (Henry & Crawford, 2005; Lovibond & Lovibond, 1995).

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.

The rating scale is as follows:

0 Did not apply to me at all
1 Applied to me to some degree, or some of the time
2 Applied to me to a considerable degree, or a good part of time
3 Applied to me very much, or most of the time

1.	I found it hard to wind down	0	1	2	3
2.	I was aware of dryness of my mouth	0	1	2	3
3.	I couldn't seem to experience any positive feeling at all	0	1	2	3
4.	I experienced breathing difficulty (e.g., excessively rapid breathing, breathlessness in the absence of physical exertion)	0	1	2	3
5.	I found it difficult to work up the initiative to do things	0	1	2	3
6.	I tended to overreact to situations	0	1	2	3
7.	I experienced trembling (e.g., in the hands)	0	1	2	3
8.	I felt that I was using a lot of nervous energy	0	1	2	3
9.	I was worried about situations in which I might panic and make a fool of myself	0	1	2	3
10.	I felt that I had nothing to look forward to	0	1	2	3
11.	I found myself getting agitated	0	1	2	3
12.	I found it difficult to relax	0	1	2	3
13.	I felt down-hearted and blue	0	1	2	3
14.	I was intolerant of anything that kept me from getting on with what I was doing	0	1	2	3
15.	I felt I was close to panic	0	1	2	3
16.	I was unable to become enthusiastic about anything	0	1	2	3
17.	I felt I wasn't worth much as a person	0	1	2	3
18.	I felt that I was rather touchy	0	1	2	3
19.	I was aware of the action of my heart in the absence of physical exertion (e.g., sense of heart rate increase, heart missing a beat)	0	1	2	3
20.	I felt scared without any good reason	0	1	2	3
21.	I felt that life was meaningless	0	1	2	3

Scoring

Depression: 3, 5, 10, 13, 16, 17, 21
Anxiety: 2, 4, 7, 9, 15, 19, 20
Stress: 1, 6, 8, 11, 12, 14, 18

	Depression	Anxiety	Stress
Normal	0 - 4	0 - 3	0 - 7
Mild	5 - 6	4 - 5	8 - 9
Moderate	7 - 10	6 - 7	10 - 12
Severe	11 - 13	8 - 9	13 - 16
Extremely Severe	14 +	10 +	17 +

Appendix F – Reflective Functioning Questionnaire– short form

(Fonagy et al., 2016; Badoud et al., 2015).

Please work through the next 8 statements. For each statement, choose a number between 1 and 7 to say how much you disagree or agree with the statement, and write it beside the statement. Do not think too much about it – your initial responses are usually the best. Thank you.

Use the following scale from 1 to 7:

Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree

1. People's thoughts are a mystery to me
2. I don't always know why I do what I do
3. When I get angry I say things without really knowing why I am saying them
4. When I get angry I say things that I later regret
5. If I feel insecure I can behave in ways that put others' backs up
6. Sometimes I do things without really knowing why
7. I always know what I feel
8. Strong feelings often cloud my thinking

Scoring

Two subscales:

RFCc - Certainty about Mental States (hypermentalizing)

*RFCu - Undercertainty about Mental States (*hypomentalising)

Recoding and scoring of the RFQ from Cucchi et al. (2018). Items 2, 3, 4, 5, 6 are used in both RFQc and RFCu subscales but in opposite directions. Items 1 and 3 are uniquely coded for the RFQc; items 7 and 8 are uniquely coded for the RFQu.

Item		Coding for RFQc (Certainty = Hypermentalising)							Coding for RFQu (Uncertainty = Hypome					
	RESPONSE:	Strongly Disagree.....Strongly Agree							Strongly Disagree.....Strongly Agree					
		1	2	3	4	5	6	7	1	2	3	4	5	6
RFQ2	I don't always know why I do what I do	3	2	1	0	0	0	0	0	0	0	0	1	2
RFQ4	When I get angry I say things that I later regret	3	2	1	0	0	0	0	0	0	0	0	1	2
RFQ5	If I feel insecure I can behave in ways that put others' backs up	3	2	1	0	0	0	0	0	0	0	0	1	2
RFQ6	Sometimes I do things without really knowing why	3	2	1	0	0	0	0	0	0	0	0	1	2
RFQ1	People's thoughts are a mystery to me	3	2	1	0	0	0	0				NOT USED		
RFQ3	When I get angry I say things without really knowing why I am	3	2	1	0	0	0	0				NOT USED		
RFQ7	I always know what I feel.				NOT USED				3	2	1	0	0	0
RFQ8	Strong feelings often cloud my thinking				NOT USED				0	0	0	0	1	2

Appendix G — Prenatal Attachment Inventory – Revised

(Muller & Mercer, 1993; Pallant et al., 2014)

	Almost never	Sometimes	Often	Almost always
1. I wonder what the baby looks like now.	1	2	3	4
2. I imagine calling the baby by name.	1	2	3	4
3. I enjoy feeling the baby move.	1	2	3	4
4. I think that my baby already has a personality.	1	2	3	4
5. I let other people put their hands on my tummy* to feel the baby move.	1	2	3	4
6. I know things I will do make a difference to the baby.	1	2	3	4
7. I plan the things I will do with my baby.	1	2	3	4
8. I tell others what the baby does inside me.	1	2	3	4
9. I imagine what part of the baby I'm touching.	1	2	3	4
10. I know when the baby is asleep.	1	2	3	4
11. I can make my baby move.	1	2	3	4
12. I feel love for the baby.	1	2	3	4
13. I like to sit with my arms around my tummy*.	1	2	3	4
14. I dream about the baby.	1	2	3	4
15. I know why the baby is moving.	1	2	3	4
16. I stroke the baby through my tummy*.	1	2	3	4
17. I know the baby hears me.	1	2	3	4
18. I get very excited when I think about the baby.	1	2	3	4

Scoring

Anticipation: 1, 27, 9, 14, 18.

Differentiation: Items 4, 6, 10, 11, 15, 17.

Interaction: 3, 5, 8, 12, 13, 16.

*The word “tummy” was changed to “belly” consistent with modern New Zealand usage.

Appendix H — Parental Reflective Functioning Questionnaire

(Luyten, Mayes, Nijssens, & Fonagy, 2017)

Listed below are a number of statements concerning you and your child. Read each item and decide whether you agree or disagree and to what extent.

Use the following rating scale, with 7 if you strongly agree; and 1 if you strongly disagree. The midpoint, if you are neutral or undecided, is 4.

Strongly Disagree	1	2	3	4	5	6	7	Strongly Agree

1. The only time I'm certain my child loves me is when he or she is smiling at me.
2. I always know what my child wants.
3. I like to think about the reasons behind the way my child behaves and feels.
4. My child cries around strangers to embarrass me.
5. I can completely read my child's mind.
6. I wonder a lot about what my child is thinking and feeling.
7. I find it hard to actively participate in make believe play with my child.
8. I can always predict what my child will do.
9. I am often curious to find out how my child feels.
10. My child sometimes gets sick to keep me from doing what I want to do.
11. I can sometimes misunderstand the reactions of my child.
12. I try to see situations through the eyes of my child.
13. When my child is fussy he or she does that just to annoy me.
14. I always know why I do what I do to my child.

15. I try to understand the reasons why my child misbehaves.
16. Often, my child's behaviour is too confusing to bother figuring out.
17. I always know why my child acts the way he or she does.
18. I believe there is no point in trying to guess what my child feels.

Scoring

Reverse score Q11 and Q18, 1=7; 2=6, 3=5; 4=4; 5=3; 6=2; 7=1. Calculate overall PRF score by calculating a mean.

Three subscales:

Pre-Mentalizing Modes: PRFQ1, PRFQ4, PRFQ7, PRFQ10, PRFQ13, PRFQ16

Certainty about Mental States: PRFQ2, PRFQ5, PRFQ8, PRFQ11, PRFQ14, PRFQ17

Interest and Curiosity in Mental States: PRFQ3, PRFQ6, PRFQ9, PRFQ12, PRFQ15, PRFQ18

Appendix I — The Maternal Postnatal Attachment Scale

(Condon, 2015; Condon & Corkindale, 1998)

1. When I am caring for the baby, I get feelings of annoyance or irritation:

   Very frequently

   Frequently

   Occasionally

   Very rarely

   Never

2. When I am caring for the baby I get feelings that the child is deliberately being difficult or trying to upset me:

   Very frequently

   Frequently

   Occasionally

   Very rarely

   Never

3. Over the last two weeks I would describe my feelings for the baby as:

   Dislike

   No strong feelings towards the baby

   Slight affection

   Moderate affection

   Intense affection

4. Regarding my overall level of interaction with the baby, I:

   Feel very guilty that I am not more involved

   Feel moderately guilty that I am not more involved

Feel slightly guilty that I am not more involved

I don't have any guilty feelings regarding this

5. When I interact with the baby I feel:

   Very incompetent and lacking in confidence

   Moderately incompetent and lacking in confidence

   Moderately competent and confident

   Very competent and confident

6. When I am with the baby I feel tense and anxious:

   Very frequently

   Frequently

   Occasionally

   Almost never

7. When I am with the baby and other people are present, I feel proud of the baby:

   Very frequently

   Frequently

   Occasionally

   Almost never

8. I try to involve myself as much as I possibly can PLAYING with the baby:

   This is true

   This is untrue

9. When I have to leave the baby:

   I usually feel rather sad (or it's difficult to leave)

   I often feel rather sad (or it's difficult to leave)

   I have mixed feelings of both sadness and relief

   I often feel rather relieved (and it's easy to leave)

   I usually feel rather relieved (and it's easy to leave)

10. When I am with the baby:

    I always get a lot of enjoyment/satisfaction

    I frequently get a lot of enjoyment/satisfaction

    I occasionally get a lot of enjoyment/satisfaction

    I very rarely get a lot of enjoyment/satisfaction

11. When I am not with the baby, I find myself thinking about the baby:

    Almost all the time

    Very frequently

    Frequently

    Occasionally

    Not at all

12. When I am with the baby:

    I usually try to prolong the time I spend with him/her

    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:

    Intense pleasure at the idea

    Moderate pleasure at the idea

    Mild pleasure at the idea

    No feelings at all about the idea

    Negative feelings about the idea

14. I now think of the baby as:

    Very much my own baby

    A bit like my own baby

    Not yet really my own baby

15. Regarding the things that we have had to give up because of the baby:

    I find that I resent it quite a lot

    I find that I resent it a moderate amount

    I find that I resent it a bit

    I don't resent it at all

16. Over the past three months, I have felt that I do not have enough time for myself or to pursue my own interests:

    Almost all the time

    Very frequently

    Occasionally

    Not at all

17. Taking care of this baby is a heavy burden of responsibility. I believe this is:

    Very much so

    Somewhat so

    Slightly so

    Not at all

18. I trust my own judgement in deciding what the baby needs:

    Almost never

    Occasionally

    Most of the time

    Almost all the time

19. Usually when I am with the baby:

    I am very impatient

    I am a bit impatient

    I am moderately patient

    I am extremely patient

Scoring

Items in brackets ( ) are reverse scored

Quality of attachment: 3 4 5 6 (7) (10) (14) 18 19

Absence of hostility: 1 2 15 16 17

Pleasure in interaction: all reversed (8 9 11 12 13)

Total score – sum of all items, with low scores indicating a problematic maternal-infant bond (van Bussel et al., 2010).

To ensure equal weighting of all questions, it is recommended that response options be recoded to represent a score of **1 (low attachment) to 5 (high attachment)** for every question. For example, question PM4 would be scored as: 1; 2.3; 3.6; 5; Question 8 would be (reverse) scored as: 5; 3.6; 2.3; 1.

Appendix J – Facebook Advertisement for Pregnant Women (Example)

LOOKING FOR WOMEN HAVING THEIR FIRST BABY

Kia ora!

We are Massey University researchers looking at the phenomenon commonly termed "baby brain". The idea that women may not be as 'mentally sharp' during pregnancy/haputanga is one that forms part of the common rhetoric for pregnant women and we are trying to understand this further.

We hope to recruit a group of pregnant women/hapū wahine who are:

- having their first baby,
- at least 33w pregnant
- are native or near native speakers of English
- living in Greater Wellington/Te Whanganui-a-Tara

Participation is simple! We meet with participants for 1 hour at a convenient time and place in order to complete some cognitive measures (like puzzles). Participants report that they enjoy participation and that it is not tiring!

All participants are thanked for their time with $20 grocery vouchers.

Can you help us? If so, please message us through this page and we can send further information!

Looking forward to hearing from you - Ngā mihi nui

Appendix K –Facebook Advertisement for Control Women (Example)

LOOKING FOR WOMEN TO PARTICIPATE IN VALUABLE RESEARCH INTO WOMEN'S COGNITION

We are looking for women to join our Massey University School of Psychology research into women's cognition. We are looking for women who are:

- aged between 25 and 40 years old
- competent in English (native or near native)
- **not pregnant**/hapu and have not had a child before
- live in Greater Wellington region/ Te Whanganui-a-Tara.

Participation is simple! We meet with you for an hour at a convenient time and place so we can give you some cognitive measures to complete (which are like puzzles) and questionnaires.

All participants are compensated with a $20 grocery voucher.

By participating you would contribute to our understanding of whether not women experience differences in their thinking during pregnancy.

Can you help us? If so, please message us through this page and we can send further information!

Ngā mihi nui - thank you, we are so grateful for your support!

Appendix L – Participant Information Sheet

Invitation to participants

Hello, my name is Kate and I am a Doctoral student of Clinical Psychology at Massey University, Wellington. As part of my doctoral programme, I am carrying out research into women's cognition during pregnancy. Specifically, I am investigating whether pregnant women have different patterns of performance on some kinds of cognitive tasks compared to not pregnant control women, and whether these patterns of performance are associated with parenting behaviours when baby is born.

I am recruiting women who are having their **first baby** as well as **not pregnant control group women** who have not yet had a child.

Participation involves completing some cognitive measures (which are like puzzles) and questionnaires. For the pregnant women, there are some additional short questionnaires to complete when baby is born.

If you would like to know more about this research after reading the enclosed information pack, please contact Kate, I will very much look forward to hearing from you.

Contact:

Phone: 0800 [redacted]

Email: [redacted]

INFORMATION SHEET (FOR PREGNANT WOMEN)

"Baby brain" Reconsidered: Theory of Mind Capacity in Pregnancy and the Association with Caregiving.

What is the purpose of the study?

We are interested in finding out more about what is popularly called "baby brain", or women's cognition (thinking skills) during pregnancy. To investigate this area, we will be looking at pregnant and not pregnant women's patterns of performance on a number of short tasks. These tasks—which are similar to puzzles—involve problem solving, recognizing emotions, and flexible thinking. There will also be some short questionnaires about mood, levels of stress, and feelings about motherhood and baby.

How does it work?

If you are interested in participating, then please read all the information here then get in touch with us via our contact methods listed below.

We can then set up a convenient time and place to meet where you will be given a consent form to sign and can complete the short tasks. The meeting will be around an hour and will take place when you are in the third trimester of pregnancy (ideally sometime during 33-36 weeks).

To compensate you for your time we can offer you a $20 grocery voucher.

When you are 2-3 months postpartum, we will send you an email inviting you to complete three additional short questionnaires online.

Because the measures are for research and not for a clinical assessment, the results of your performance on the measures will not be provided. However, you may request a summary

of the research findings by indicating so on the consent form. The summary will be posted or emailed to you at the conclusion of the project.

Compensation for your time

To thank you for your participation, we will give you a supermarket gift voucher of $20.

Are there any downsides?

There is a possibility that some women may experience discomfort when responding to the self-report measures (e.g., around levels of depression or anxiety or attachment to your baby). We are always available to talk through any concerns with you in the first instance. Your midwife, LMC or GP would be helpful if you still have ongoing concerns.

Privacy and confidentiality

Please know that all personal information will be kept private and confidential and will not be viewed by anyone outside the research team. Any information published will not be able to be personally identified. De-identified data from this study may be included in a public online repository as per Open Science practices. This is so it can be made available to peers who wish to repeat or elaborate on the study.

Who is eligible to take part?

We are looking for pregnant women who are:

- Having their first baby
- 19 years of age or older
- Proficient in English
- Living in the Greater Wellington Region.

What are the benefits to you?

By participating in this research, you will be contributing to our understanding of women's cognitive functioning during pregnancy, what factors may be impacting on it, and how it may be related to caregiving.

Neuropsychological research into women's cognitive changes over the lifespan has been a neglected area of study until very recently. We hope that our study will contribute to this emerging field.

Your rights

You are under no obligation to accept this invitation and if you decide to participate, you have the right to:

- Decline to answer any particular question
- Withdraw from the study during our meeting or up to two weeks after
- Ask any questions about the study at any time during participation
- Provide information on the understanding that your name will not be used
- Be given access to a summary of the project findings when it is concluded.

If you have any questions regarding this research, please feel free to contact us via the options listed below.

Warm wishes,

Kate

Contact: Phone: 0800 [redacted] Text: babybrain Email: [redacted]	College of Humanities and Social Sciences, Massey University, Private Box 756, Wellington New Zealand

This research is being conducted under the supervision of Professor Janet Leathem, Dr. Tatiana Tairi, and Dr. Stephen Hill of Massey University. This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application NOR 17/65. If you have any concerns about the conduct of this research, please contact Associate Professor David Tappin (Chair), Massey University Human Ethics Committee: Northern, email humanethicsnorth@massey.ac.nz

INFORMATION SHEET - CONTROL WOMEN

"Baby brain" Reconsidered: Theory of Mind Capacity in Pregnancy and the Association with Caregiving.

What is the purpose of the study?

We are interested in finding out more about what is popularly called "baby brain", or women's cognition (thinking skills) during pregnancy. To investigate this area, we will be looking at women's patterns of performance on a number of short tasks and comparing that to women who are pregnant. These tasks—which are similar to puzzles—involve problem solving, recognizing emotions, and flexible thinking. There will also be some short questionnaires about mood and levels of stress.

How does it work?

If you are interested in participating, then please read all the information here then get in touch with us via our contact methods listed below.

We can then set up a convenient time and place to meet where you will be given a consent form and can complete the tasks. The meeting will be around an hour. To compensate you for your time we can offer you a $20 New World voucher.

Because the measures are for research and not for a clinical assessment, the results of your performance on the measures will not be provided. However, you may request a summary of the research findings by indicating so on the consent form. The summary will be posted or emailed to you at the conclusion of the project.

Compensation for your time

To thank you for your participation, we will give participants a New World gift voucher of $20.

Are there any downsides?

There is a possibility that some women may experience discomfort when responding to the self-report measures (e.g., around levels of depression or anxiety). We are always available to talk through any concerns with you in the first instance. Your GP would be helpful if you still have ongoing concerns.

Privacy and confidentiality

Please know that all personal information will be kept private and confidential and will not be viewed by anyone outside the research team. Any information published will not be able to be personally identified. De-identified data from this study may be included in a public online repository as per Open Science practices. This is so it can be made available to peers who wish to repeat or elaborate on the study.

Who is eligible to take part?

We are looking for women who are:

- Not pregnant and have not yet had a child,
- 19 years of age or older,
- Proficient in English,
- Living in the Greater Wellington Region.

What are the benefits to you?

By participating in this research, you will be contributing to our understanding of women's cognitive functioning over the lifespan. Neuropsychological research into women's cognitive changes over the lifespan has been a neglected area of study until very recently. We hope that our study will contribute to this emerging field.

Your rights

You are under no obligation to accept this invitation and if you decide to participate, you have the right to:

- Decline to answer any particular question
- Withdraw from the study during our meeting or up to two weeks after
- Ask any questions about the study at any time during participation
- Provide information on the understanding that your name will not be used
- Be given access to a summary of the project findings when it is concluded.

If you have any questions regarding this research please feel free to contact us via the options listed below.

Warm wishes,

Kate

Contact: Phone: 0800 [redacted] Text: babybrain Email:[redacted]	College of Humanities and Social Sciences, Massey University, Private Box 756, Wellington New Zealand

This research is being conducted under the supervision of Professor Janet Leathem, Dr. Tatiana Tairi, and Dr. Stephen Hill of Massey University. This project has been reviewed and approved by the Massey University Human Ethics Committee: Northern, Application NOR 17/65. If you have any concerns about the conduct of this research, please contact Associate Professor David Tappin (Chair), Massey University Human Ethics Committee: Northern, email humanethicsnorth@massey.ac.nz

Appendix M — Study 2 Invitation to Participants

Hi [participant],

It's Kate here again from the "babybrain" research team at Massey University. We met last year when you were pregnant and were kind enough to participate in our "baby brain" research. I hope you are doing well!

You may remember from our study Information Sheets there is now a very quick survey to complete (7-10 minutes) which will complete the data collection for our studies. This will give us valuable information about what's going on for you now, for baby, and if that relates back to your results from when you were pregnant.

It's very short - You can complete it on any device (e.g., phone, tablet, computer) just by clicking on this link: [Link]

It was such a pleasure to meet you and the other generous women who participated last year!

We hope your valuable contribution to our research will increase our understanding of women's cognition and relationship to caregiving.

I am more than happy to chat if you have any queries about the study or participation. Please free to call or text me.

Warm wishes to you and whānau,

Kate

Appendix N – Massey University Human Ethics Approval

MASSEY UNIVERSITY
TE KUNENGA KI PŪREHUROA
UNIVERSITY OF NEW ZEALAND

Date: 14 March 2018

Dear Kate Pennell

Re: Ethics Notification - **NOR 17/65** - **"Baby brain" Reconsidered: Theory of Mind Capacity in Pregnancy and the Association with Caregiving.**

Thank you for the above application that was considered by the Massey University Human Ethics Committee: **Human Ethics Northern Committee** at their meeting held on **Wednesday, 14 March.**

Approval is for three years. If this project has not been completed within three years from the date of this letter, reapproval must be requested.

If the nature, content, location, procedures or personnel of your approved application change, please advise the Secretary of the Committee.

Yours sincerely

Dr Brian Finch
Chair, Human Ethics Chairs' Committee and Director (Research Ethics)

Research Ethics Office, Research and Enterprise
Massey University, Private Bag 11 222, Palmerston North, 4442, New Zealand **T** 06 350 5573; 06 350 5575 **F** 06 355 7973
E humanethics@massey.ac.nz **W** http://humanethics.massey.ac.nz

Appendix O — Follow up Guidelines for Participants

Follow up guidelines for participants endorsing critical items or extremely elevated scores on the DASS-21, such as scores in the 'extremely severe' range in one or more of the DASS-21 subscales, received a follow up phone call, with guidelines provided below.

Phone script:

Hi [participant name], my name is _____ from Massey University. I am calling as a follow up from the maternal cognition testing we did together recently.

Purpose of call:

Within the questionnaire you answered, there were a series of questions about mood, stress, and anxiety. I was keen to follow up with you today because your score on these questions was elevated [specify on which scale stress/anxiety/depression, specify any critical items]. This does not necessarily mean that you should be concerned – it may be quite understandable in the context of what has been going on for you around the time of our testing. Importantly, you are probably the best person to know how you have been generally feeling, and I wonder how this information relating to your score fits with how you have been feeling lately.

Allow the conversation to continue in a natural fashion.

If they are not concerned (and you are comfortable): Thank them again for their time and let them know they are able to contact us at any time if they do have any concerns.

If they are concerned: We recommend that you let your lead maternity carer, GP, or other health professional know and they can provide further assessment and advice if required. If it would be helpful for you, we can put this information in a letter for you to take along to show them. Alternatively, we can try and contact your lead maternity carer, GP, or other health professional directly so that they can follow up with you.

Appendix P – Bicultural Supervision

MASSEY UNIVERSITY
SCHOOL OF PSYCHOLOGY

12th March 2018

Research Ethics Office
Courtyard Complex
Turitea Campus
Massey University/Te Kunenga ki Purehuroa
Private Bag 11222
Palmerston North 4442

Tēnā koutou

Re: **HDEC Application – Emily (Kate) Pennell**
Baby brain" Reconsidered: Theory of Mind Capacity in Pregnancy and its Association with Caregiving

The co-ordinating investigator, Kate Pennell, is in the process of seeking ethical approval to conduct doctoral research which will investigate stability and change in women's cognition between pregnancy and the postpartum. Specifically, Kate's study will examine Theory of Mind (ToM) and Executive Functioning (EF) and explore their relationship with attachement.

I have reviewed Kate's ethics application and read a comprehensive research proposal. She has also met with me in person seeking cultural advice regarding her project. I was particularly impressed with the depth of reading that Kate has engaged in related to hauora Māori as well as Māori perspectives pertaining to pre- and post-natal care. On the basis of these considerations and discussions, I don't have any outstanding concerns regarding ethics from a bicultural perspective and in fact believe that Kate is well prepared to ably and sensitively facilitate Māori participation in her study and on that note I am hopeful that Māori are well represented in this study.

I have a close working relationship with Kate's first supervisor Professor Janet Leathem and have indicated my availability to have an ongoing bicultural consultative role in this project should significant cultural issues arise with her participants. I have encouraged Kate to contact me should cultural/bicultural issues arise during the course of her fieldwork and if she needs assistance in engaging effectively with Māori stakeholders I would also be happy to help facilitate this.

If you have any further enquires please don't hesitate to contact me.

Noho ora mai rā,

Simon Bennett, PhD
Ngāti Whakaue, Ngāti Wai, Ngāi Tahu
Kaimatai Hinengaro Matua: Maori Clinical Psychologist, Senior Lecturer
School of Psychology, Massey University Wellington
Telephone: +64 (04) 801 5799 ext. 63609
Email: S.T.Bennett@massey.ac.nz

Appendix Q – Bicultural Considerations: Attachment and Tō Hapūtanga in te Ao Māori:

This research was conducted in Greater Wellington (Māori: Te Whanganui-a-Tara) with participants who reflect New Zealand's broader demographics, including participants who came from Māori, Pacifica, and other non-Western minority populations. A requirement of clinical psychology training in Aotearoa New Zealand is familiarity and good practice consistent with the Code of Ethics. Good bi-cultural practice supports the dignity of research participants and sensitivity to cultural and social diversity. In keeping with this, the following short review of attachment within a te Ao Māori cultural lens was compiled as well as research into a Māori cultural understanding of pregnancy.

Attachment: Cross-Cultural Considerations

Bowlby's original claim was that attachment relationships with primary caregivers were innate and evolved as an evolutionary adaptation (1969/1982). This implies that attachment is more than just a theory; it is a universal law of human development that may be discovered in any society, regardless of local environment. In light of this universality concept, the basic tenets of attachment theory have been reviewed. It has been suggested that the attachment classification system of secure and insecure dyads, as well as assumptions within attachment theory tenets, are culturally relative rather than universal in the sense that they carry normative Western value systems about relationships, family contexts, and childrearing practices (Rothbaum et al., 2000). Moreover, cross cultural reviews of attachment have found difficulties in the strange situation task as the key method for the measurement of maternal-infant attachment (e.g., Van Ijzendoorn & Kroonenberg, 1988). One clear problem is that while Mary's Ainsworth's attachment classification system was originally developed based on her detailed observations of 28 mother-infant dyads in Uganda (Ainsworth, 1967), the

majority of attachment research has been conducted in Western, individualist societies where nuclear families are the social norm as well as mother-infant dyads as the primary relationship (Van Ijzendoorn & Sagi-Schwartz, 2008). While there is evidence for the universality of attachment in general terms, what is clear is that there is a dearth of research into culture-specific dimensions, different family contexts (e.g., collectivist cultures) and attachment relationships where the maternal-infant dyad is not the primary relationship (Cassidy & Shaver, 2016). This poses problems for the theoretical understanding of attachment and its correlates as well as for practitioners seeking to understand and support people experiencing distress in the parenting relationship.

Attachment security through a Māori lens

Recent kaupapa Māori scholarship has contributed to the understanding of attachment through a te Ao Māori perspective. In a culturally adapted version of the Mellow Parenting Programme – Oranga Whānau for Māori parents, the attachment based 14 week parenting course was tested for its efficacy in a group of socially disadvantaged mothers and grandmothers (Penehira & Doherty, 2012). The Mellow Parenting programme was originally developed in the UK for parents of young children (0-8 years) who are experiencing life difficulties. The approach includes both support for parental mental health and strategies to support attunement to the child's signals, increased parental reflective functioning and sensitivity to the child's inner experiences (MacBeth et al., 2015). It is recommended in the United Kingdom and in California as an evidence-based approach to help and employs group sessions, home-based video feedback of parent-child interactions, and a structured curriculum delivered by experienced facilitators over 14 weekly sessions. The therapeutic mechanism which is proposed to improve parent and child outcomes in the Mellow Parenting programme is that parenting interventions which increase the sensitivity of parents to their young children's attachment signals leads to increases in levels of attachment security. This is

in line with findings from a comprehensive meta-analysis of more than 70 parent-child interventions (Bakermans-Kranenburg et al., 2003).

The kaupapa Māori adaptations to the Mellow Parenting programme included a focus on tino rangatiratanga (self-determination) within the parenting context, supporting cultural aspirations of the participants (e.g., connection with te reo, tikanga), an emphasis on whānau and whānaungatanga as central to the parenting role, and kaupapa Māori approaches to learning. Retention rates in the programme was high. Mothers reported an increase in their mental wellbeing, less parenting stress and an improvement in their children's behaviour (Penehira & Doherty, 2012).

These findings are in line with quantitative evaluations of the efficacy of this attachment-based parenting programme (MacBeth et al., 2015). The Hoki ki te Rito Whānau parenting programme has also been adapted with Māori and Pacifica fathers and achieved positive results. There were increases in fathers' wellbeing, reductions in children's problematic behaviours from clinical range to non-clinical range for mean scores on the Strengths and Difficulties Questionnaire (children) questionnaire and the Parenting Daily Hassles questionnaire (measuring parental stress), as well as improvements in parent-child interactions as measured by naturalistic video observations. The improvements were significant and retained in a 3 month follow up of the participants (Doherty, 2019). Overall, the positive outcomes of these attachment-based, culturally-adapted Mellow Parenting interventions lend support to the evidence base that increasing parental mentalizing and reflection in fathers, mothers, and grandparents, while attending to parental stress, supports attachment security within a kaupapa Māori parenting context.

A recent contribution in an Aotearoa New Zealand context is a critical review of the western concept of Attachment contrasted with a Māori view of attachment (Fleming, 2016). In a Māori perspective of attachment, the infant has a close dyadic

relationship with a primary caregiver, but the dyad is held within the context of multiple close kindship relationships in the whānau system. Multiple secure attachments was the norm in pre-European Māori caregiving practices (Hart & Jenkins, 2011). Hapu and iwi provide wider *whānaungatanga* relationships which support the infant's psychological development and wellbeing through continuous care offered by multiple people. Viewing attachment through the lens of the dyad without these connections misses this important aspect of how Māori view attachment within collectivist family systems. For this reason, Māori scholarship emphasizes whānau groups more than individual dyads (Fleming, 2016). Connections to land (*whenua* in Māori which also means placenta), *whakapapa* (ancestral links), and *wairua* are also emphasized as giving meaning to attachment relationships and supporting caregiving practices. Attachment relationships are thus seen more broadly in a te Ao Māori parenting context. While the dyad is important, the role of multiple caregivers within a wider family context is essential to understanding how Māori infants and their parents are cared for.

Tō Hapūtanga in te Ao Māori

As is demonstrated with the dual meaning of *whenua* in Māori *(*land and placenta*)*, language sheds light on the significance of cultural practices and the meaning ascribed to them by a people (Moorfield, 2011). In te Reo Māori, *whānau* is a central organising concept which refers to the act of giving birth as well as being born. It also refers to the extended family and the family group. *Whānaungatanga* means relationship, kinship, and the sense of family connection through shared experiences (such as working together, feelings of reciprocity). *Hapū* is to be pregnant or conceived in the womb. It also refers to kinship group or a section of a larger kinship group. *Te Whare tangata* refers to the womb as well as more broadly to the creative potential of wāhine (women) as is implicit in the meaning of these terms (Smith, 2015). Hinetaiwaiwa is the traditional goddess of childbirth who watched over women in

labour. Women's role as creators of life was very significant in traditional Māori society. The ability of wahine hapū 'through te whare tangata to bind the past, present and future generations together was a well-respected role they carried' (p.23, Smith, 2015).

Many traditional practices supported women practically, emotionally, and spiritually in bringing the next generation into the world via childbirth. (For in depth reviews and discussions of pre-European and traditional Māori pregnancy and childcare practices, see Hart & Jenkins, 2011; Smith, 2015). Practical guidance for clinicians and researchers working with wahine hapū can be found here: Te Hiringa Hauora/Health Promotion Agency (2021).

Appendix R – Case Study: Reflections on Research and its Application to Clinical Practice

Case Study 6

Becoming a Scientist-Practitioner: Reflections on how Conducting Doctoral Research has Contributed to my Emerging Clinical Psychology Practice

A case study presented in partial fulfilment of

The degree of

Doctorate of Clinical Psychology

E. Kate Spill

2019

This case study represents the work of Kate Spill during her research from 2017 to 2018 and reflections as an Intern Psychologist in 2019.

Abstract

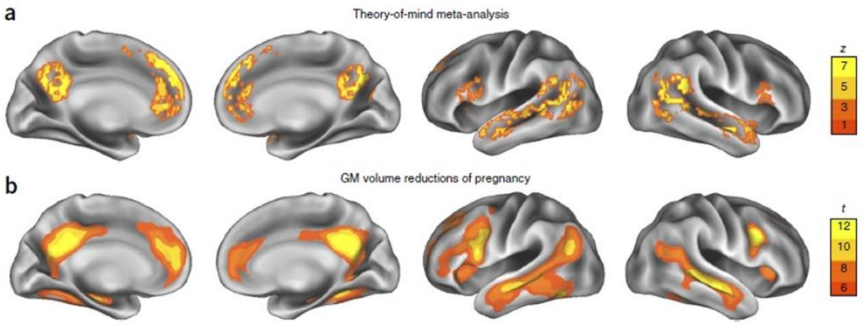
The current case study discusses the influences of conducting doctoral research on my emerging clinical practice. The first section provides an overview of my research, including the rationale for choosing this topic, my initial considerations, study design, aims, and the process of data collection. The second section reflects on how thinking about science methodology has made me a more careful scientist-practitioner, how the process of conducting research ethically has been an essential introduction to the practice of ethical clinical psychology practice, how the concepts of Theory of Mind and attachment have informed my clinical practice and, more broadly, how clinical formulation is a science as well as an art.

Background to Doctoral Research

My doctoral journey began in December 2016 when, scrolling through a neuroscience research feed, I came across an intriguing study which showed, for the first time, that pregnant women undergo substantial structural grey matter changes to their brains during their first pregnancy (Hoekzema et al., 2017). These changes are enduring and are primarily located in regions which subserve social cognition processing, specifically Theory of Mind (see Figure 1). Theory of Mind (ToM) is a psychological concept which refers to the way humans are able to make inferences about others' thoughts, feelings, and perspectives and to adapt the way we respond accordingly in real time. It emerges over the early developmental period, first during joint attentional processes with caregivers, later with perspective taking which is scaffolded in language, and develops with increasingly sophisticated skills which allow children to master the idea that others can act in accordance with false beliefs, and that we can "read" the minds of others via linguistic inferences by decoding emotions on faces, and connecting our prior knowledge of how the world works with what we are seeing and hearing in front of us (Apperly, 2012b). Hoekzema et al. (2016) hypothesised that if there are changes in Theory of Mind capacity during pregnancy then this must surely serve an adaptive purpose—in order to support the survival of the vulnerable infant. This was a clear re-framing of these cognitive changes during pregnancy into an evolutionary psychology explanatory narrative, away from a "baby brain" deficit narrative.

Figure 1

Brain Changes During First Pregnancy Compared to Theory of Mind Functional Network



Note. Top panel shows aggregated fMRI ToM network (Schurz et al., 2014). Bottom panel shows an aggregated map of GM volume reductions after first pregnancy.

Figure from " Pregnancy Leads to Long Lasting Changes in Human Brain Structure, " by E. Hoekzema, E. Barba-Müller, C. Pozzobon, M. Picado, F. Lucco, D. García-García, J. C. Soliva, A. Tobeña, M. Desco, E. A. Crone, A. Ballesteros, S. Carmona and O. Vilarroya, 2017, Nature Neuroscience, 20, 287–296. Copyright 2016 by Springer Nature.

The hypotheses that women's ToM improves during pregnancy and that it might be adaptive was just waiting to be tested behaviourally. Hypotheses about behaviour from imaging studies of the brain are considered exploratory which is to say they are not as persuasive as confirmatory behavioural studies. Inferences made on the basis of imaging to behaviour have been called backwards inferences (Poldrack, 2011). They are useful for providing hypotheses for further research, however. What was now needed was a good behavioural study to test this hypothesis.

This was very motivating for me for another reason. Testing these hypotheses behaviourally was the chance to contribute to an understanding of the neuropsychology of women. Women's neuropsychological functioning over the lifespan, rather like women's healthcare, is an under researched area. For instance, only in the past 10 years has enough research amassed for the publisher Springer to produce *The Neuropsychology of Women* (Fletcher-Janzen, 2009) as part of their substantive neuropsychology series. This collection of articles details the various effects which

women's reproductive and endocrine status, as well as lifespan experiences and social roles, have on neuropsychological functioning. What was also appealing about this research was the opportunity to take an integrated perspective of cognitive functioning within the context of a person's life. This is the approach to clinical neuropsychology which was very persuasive to me, and which had been emphasised in my studies in clinical neuropsychology, with Professor Janet Leathem, who would become my primary supervisor. In this way, neuropsychological functioning can only be understood within the context of a myriad of individual and contextual factors, such as motivation, mood, sleep, physical health, and social and cultural roles. Cognitive functioning refers here more narrowly to measurable thinking skills (as measured by behavioural tests), such as different kinds of memory and attention, affect recognition, and ToM.

In the second year of this thesis, pregnancy also became highly topical in New Zealand as our Prime Minister became the first leader of a western democracy to become pregnant, give birth, and go on parental leave while in office. This sparked wider interest and discussions in both national and international media about pregnancy, women's capabilities (physical and mental), women's roles in the workplace while pregnant, and necessarily about "babybrain.". Around this time, a study appeared out of Australia and also made international media headlines. The Davies et al., (2018) meta-analysis synthesized the available empirical research of maternal cognition and its message was clear: "babybrain is real". This was an opportunity to explore the possibility of cognitive advantages over this period in the lifespan and situate the research into a new potentially more broadly considered understanding of cognitive change during pregnancy.

The second research aim addressed by this thesis was to understand whether ability in ToM during pregnancy predicted aspects of caregiving in the postpartum. If pregnant women are becoming better equipped to parent their young babies during pregnancy, what is the evidence which supports this second claim that better ToM is

predictive of better parenting? Reviewing the clinical treatment literature into parenting programmes which aim to improve mothers' ability to accurately read and respond to their baby's behaviour provides one persuasive line of evidence (e.g., as discussed in Allen, Fonagy, & Bateman, 2008; Luyten, Mayes, Nijssens, & Fonagy, 2017; Meins, Fernyhough, Russell, & Clark-Carter, 1998; Meins et al., 2002; Sadler et al., 2013). The treatment target of these programmes is to increase ToM capacity in mothers which, in turn, increases their ability to accurately respond to their child's needs and parent sensitively. This has been shown to have flow on positive effects in the development of secure attachment, which is a psychological construct describing how parents can provide a consistently secure base for their infants and children allowing them to emotionally regulate and explore the world at their own pace (Holmes & Farnfield, 2014). Other work examining attunement, maternal sensitivity, and parental reflective functioning provide similar lines of evidence that better ToM is associated with more adaptive parenting behaviours and attachment in the child (Zeegers et al., 2017).

Selecting measures for this study was no easy task. Much of 2017 was spent searching for measures which would capture ToM in normal populations without ceiling effects and which would adequately capture the various components of ToM. I was also hoping that the measures would bear some relevance to caregiving, and thus have ecological validity as well as other good psychometric properties. Research design always involves trade-offs: Some designs are simply too time consuming or expensive, others require large amounts of participants which might not be easy to recruit into the study, all designs rely on measures being sensitive and specific enough to test what is under consideration. Where there was ToM research in nonclinical adult populations, the measures were primarily from cognitive psychology and are designed primarily with the goal of elucidating aspects of theory. These measures are tightly controlled experiments unsuitable for my study into individual differences. I did finally find some

measures which were suitable – it took some creativity and networking with other researchers and gaining their thoughts to do this. I also learnt that there was no such thing as perfect measures –which was a good reflection for clinical work too. It would be a mistake to equate performance on any cognitive test with the cognitive ability itself. There can be many and various reasons why the assumptions unpinning the measures and the performance on the day undermine that assumption. I was very lucky with my research to be able to team up with a fellow psychology student, Kate Connolly, who was also interested in doing research into maternal cognition. Sharing the workload of advertising for participants, recruiting them, collecting data was enormously helpful and made data collection practical and feasible.

Method

Ethics

Ethical approval for the study was granted by Massey University Human Ethics Committee (NOR 17/65), as well as by the Capital and Coast DHB human ethics committee.

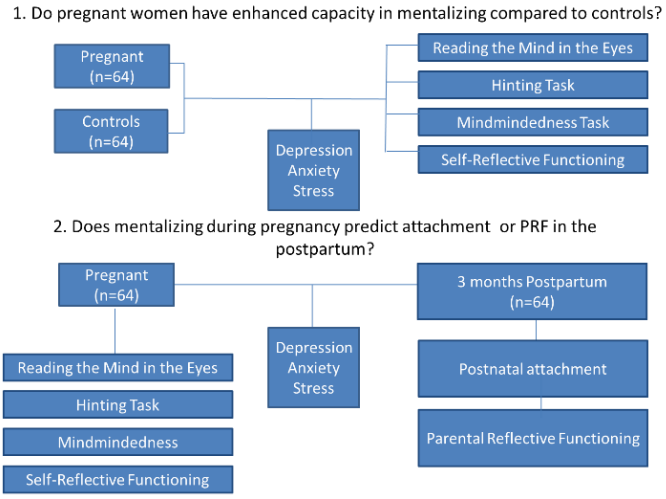
Cultural supervision

Cultural supervision was sought from Dr. Simon Bennett (Ngāti Whakaue, Ngāti Wai, Ngāi Tahu) Kaimatai Hinengaro Matua: Maori Clinical Psychologist, Senior Lecturer. My research collaborator Kate Connolly and were fortunate to benefit from Dr. Bennett's deep knowledge of hauora Māori as well as Māori perspectives relating to pre- and post-natal care.

Study Design

As per the schematic below, pregnant women's performance on a number of cognitive tasks was compared to never-pregnant, age and education matched control women. Pregnant women completed cognitive testing in the third trimester of

pregnancy, and then at 6 months postpartum they completed self-report measures of attachment and reflective functioning.



Recruitment

A community sample of women was recruited via word of mouth, flyers, advertisements, short presentations at antenatal classes, and online marketing (e.g., study Facebook page). The study did not have access to participants' medical records or collect healthcare information.

Administration of Measures

Testing consisted of cognitive measures and self-report measures. The test battery took participants around an hour. Preference was given to testing in neutral locations, such as a community spaces or the university, but most participants preferred home visits. Privacy of participants and safety of the researcher was attended to in these cases. Cognitive measures were chosen based on the following criteria:

a) Sound psychometric properties

b) Designed for use with adults

c) Good measures of the domains of interest

d) Contributing to a battery which would take no longer than 60 minutes to administer.

Participant demographic information was also collected including age, ethnicity, highest qualification, and how many hours per week is spent interacting with children. This was to ensure that both the pregnant group and control group were substantially similar.

Table 1

Study 1 and 2 and Measures

Study I Measures	Description
Reading the Mind in the Eyes task	Affect recognition. In this task participants are shown 39 black-and-white test stimuli of eyes. For each set of eyes, participants must infer the emotion the person is experiencing just from examining their eyes. There are four proposed complex emotions for each test stimuli and participants must choose one.
Mind-mindedness Task	In the mind-mindedness task, participants are shown a short video with the sound muted of a group of children engaged in play. Participants are then asked simply "*Describe the child*".
Extended Hinting Task	In this task, participants hear a recorded series of 20 short stories. Each story requires a social inference to be made to answer a question correctly at the end.
Depression, Anxiety and Stress Scale (DASS-21)	The DASS-21 is a 21 item self-report measure designed to screen for depression, anxiety, and stress symptoms. This questionnaire gauges the severity of the subjective experiences of these symptoms.
Reflective Functioning Questionnaire – short form	The RFQ is an 8-item self-report measure of the ability to reflect on behaviour, an aspect of ToM.
Prenatal Attachment Inventory-Revised	18 item self-report measure of a pregnant woman's relationship to her baby.

Study 2 Measures	Description
Maternal postnatal attachment inventory	19 item self-report measure of attachment to baby
Parental Reflective Functioning Questionnaire	8 item self-report measure of ability to reflect on mental states in the context of parenting.
Depression, Anxiety and Stress Scale (DASS-21)	The DASS-21 is a 21 item self-report measure designed to screen for depression, anxiety, and stress symptoms. This questionnaire gauges the severity of the subjective experiences of these symptoms.

Clinical Psychology Internship

This year I have worked across two services: The Massey University Student Health and Counselling Service where I was until late July and then at Explore Specialist Advice until December 2019. My Explore work was split between two contracts. The first was Positive Behaviour Support (PBS) in a disability context which is work for clients who have Needs Assessment and Service Co-ordination (NASC) funding to support them with behaviour that challenges (e.g., behaviour where there are safety concerns to the person or to others). The second contact was work on the Piki pilot programme, a government-funded programme to provide free mental health care in primary practice for 18-25 year olds. The latter is based on the British programme Increasing Access to Psychological Therapies (IAPTS). The PBS work in the disability sector often involved helping family/whānau who have a child with challenging behaviour in the context of autism spectrum disorder (ASD). Piki work was varied in terms of presentations and provided good experience in supporting young adults at this stage of the lifespan as was the MU Student Health and Counselling (MUSHCS) service role. Both services provided primary medical care and mental health referrals. Clients presented with low mood, anxiety, adjustment difficulties, relationship difficulties, undiagnosed neurodevelopmental disorders (ASD, ADHD), trauma, and substance use problems.

The Translation of Psychological Science into Clinical Formulation

In the early part of this year, I conducted ASD assessments with young adults who presented with anxiety and self-harm. More recently I have been working on supporting families whose children struggle with challenging behaviour in the context of autism. It has been an enormous privilege to get to know these individuals and their families, hear their stories, and offer my support in clinical assessment and treatment. I have been struck by the diversity of their experiences and also commonalities. Knowledge from psychological science has helped this. For instance, knowledge of ToM has been useful when working with autistic clients. According to one account of autism, it is the difficulty reading others' minds automatically (e.g., affect, intentions, implied meaning) which contributes in part to aspects of autistic behaviour (Baron-Cohen, 1995). This conceptualisation has supported thinking about how to formulate difficulties in social functioning. Theories of attachment have also been a useful concept with my work with young adults. For instance, a number of my clients who presented for help with their depression and anxiety also reported psychological and physical trauma from their early formative development.

Understanding how these attachment experiences had contributed to their current relational frame, and might bear on their current functioning, was an important consideration, and a delicate one to work on as a clinician. This translation of psychological theory into clinical practice involves an active collaboration between clinician and clients to formulate the individual's experiences and difficulties. Psychological theory informs the formulation but does not determine it – this is something these clients taught me time and again.

Learning to balance findings from psychological science with the individual's experiences and preferences for explaining their experiences is a clinical skillset where science and the 'art' of therapy meet. Clinical formulation aims to explain the individual

client's presenting problems in the context of their life and context, history, and experiences. It is important to remember that individuals are complex, and they do not represent research findings. At a basic level, in quantitative research, effects of moderate size are reasonably rare; so, you need sufficiently large groups of people to detect these effects. Typically, psychological findings also have a variety of moderating and mediating factors involved and always context matters. Hence, when using psychological knowledge to inform formulation with a client careful, tentative work is required which, on the one hand, honours the evidence-base, while on the other hand attends to the individual, their experiences, and set of circumstances. Making no assumptions, while difficult in practice, is a concept to hold in mind when suggesting processes which might have led to current difficulties or hold the difficulties in place. As a clinician, it is helpful to hold space for unexpected factors. Expertise is brought to the table, in a collaborative fashion, with the awareness that acting ethically is also about taking care with the power inherent in the clinical relationship. Ethics must come before practice in this respect, just as it does with research. Tolerating the various tensions inherent in the work is part of that.

Science, Ethics, and Clinical Practice

When I first began reflecting how doctoral research had influenced my clinical practice, my focus was primarily on how knowledge of findings and theory from psychological science could inform an evidence-based practice. It took a while to realise that the influence of conducting research itself had also contributed to my emerging practice also, especially as it relates to research ethics. At its essence, conducting research requires the ability to hold opposites in tension without resolving them. The process of conducting science requires attention to dignity and care of participants and anticipating potential for harm. It also requires navigating bureaucracy, remaining persistent, while also holding space for creative problem solving and considering trade-

offs along the way—in methodology, in approach, in what is possible. It requires being persuasive while not overreaching. It requires standing your ground at times, while being open to changing your mind. As a doctoral candidate, you are also invited to wear a 'cloak of expertise' in your topic area, as in the details of your investigation, you may know more than your supervisory team. Taking on authority in your area of investigation requires confidence but also care as people listen to what you now say. In all these ways, doctoral research is a process of taking on a new role with many inherent tensions, just as evidence-based clinical work is also. Awareness of these ethical tensions is a research skill as well as a clinical practice skill.

Another way in which the practice of research influenced my clinical practice was simply the experience of data collection. The large effort which went into data collection for my doctoral thesis in participants' homes provided me with useful skills of working in community settings. As this is where my PBS work takes place, it was useful to have had this experience of being a visiting professional. This setting provides great opportunities to meet with clients in their own environment in a more relaxed way and also to gain valuable information about their functioning. Here maintaining boundaries is important, although sometimes this is more difficult. For instance, for clients who are experiencing loneliness or isolation and wish to extend the visit, it is hard to maintain time limits. Some clients may wish to follow cultural hosting practices, considering how to respond respectfully while also keeping to the purposes of the work, and managing time requires a range of skills. Working in an environment where other family members may be present poses a challenge for confidentiality and privacy, as well as the therapeutic relationship. Navigating these issues takes practice in process skills and finding the right way of addressing potential problems. Experience helps this along.

The Replication Crisis in Psychology and Clinical Practice

During my doctoral research I became interested in science methodology and the serious problems which have been well documented in the replication crisis (Everett & Earp, 2015; Maxwell et al., 2015; Shrout & Rodgers, 2018). Interested in following developments in the replication crisis and connecting with other science researchers internationally, I made a twitter profile and feed pertaining to my research interests. This turned out to be a good way of connecting with a research community in this area. In this way, I connected with a prominent professor of neuropsychology from Oxford University, Dorothy Bishop, who penned a powerful blogpost summarizing the research practices which have led to poor science. Recently edited and re-published in *Nature*, it is worth quoting her introduction which gives a sense of the flavour:

> More than four decades into my scientific career, I find myself an outlier among academics of similar age and seniority: I strongly identify with the movement to make the practice of science more robust. It's not that my contemporaries are unconcerned about doing science well; it's just that many of them don't seem to recognize that there are serious problems with current practices. By contrast, I think that, in two decades, we will look back on the past 60 years — particularly in biomedical science — and marvel at how much time and money has been wasted on flawed research. (Bishop, 2019, p. 1)

The problems which Bishop outlines here are summarized by the acronym HARKing (Hypothesizing After the Results are Known; Kerr, 1998), which basically refers to presenting a finding which was found in multiple post hoc analyses as an a priori hypothesis, or failing to report post hoc findings with a null result. This—alongside other poor practices, such as multiple comparisons, and poor use of inferential

statistics—has resulted in bias in the literature, which is detrimental to scientific progress, as research results tend to be confirming rather than falsifying hypotheses. The hope is that the emerging Open Science movement, which aims to prevent these methodological problems via pre-registration of study aims, hypotheses, and analysis methods, will improve the quality of psychological and biomedical research. It is, in essence, a more reflective and transparent science practice which, as it is increasingly taken up in universities, places pressure on journals to also accept null results and view favourably results from studies which followed Open Science pre-registration practices.

Before gaining an interest in this area, I don't think I would have cast such a critical eye on research methodology. This has influenced how I read scientific literature now, my thinking around its persuasiveness and its clinical utility. When researching for my clinical practice this year, I have tried to think critically about the value of findings in informing my clinical approach. The American Philosophical Association (APA) has defined critical thinking as 'purposeful, self-regulatory judgment that uses cognitive tools such as interpretation, analysis, evaluation, inference, and explanation of the evidential, conceptual, methodological, criteriological, or contextual considerations on which judgment is based (Facione, 1990, p. 4). Conducting research hones this skill in a way which reading research does not, as there is more active engagement with the process and thus awareness of the multiple decisions along the way. As a result, I have found that I am more circumspect and careful about drawing conclusions – the training in research methods and philosophy of science laid the groundwork for this, doctoral research has been a further apprenticeship. I aim in my clinical practice to be balanced in how I present psychological theory and findings with clients. Aiming to match the science communication to the context, and with caution where needed, is another way of supporting the therapeutic formulation and clinical relationship.

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