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Parental cognitive vulnerability during the perinatal period and its effect on mental health and the parent-infant relationship

Results from the NorBaby-study

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Foreword

I first came into the Northern Babies Longitudinal Study (NorBaby) during my studies. Me and my fellow student Åsne Lindahl wanted to write our master thesis on a clinical subject with prof. Catharina E. A. Wang as a supervisor. Luckily, she was looking for students to her newly started project; NorBaby. It soon became clear that this was an ambitious project, with many collaborators both from different research groups within the university, and outside UiT. As prof. Wang said, "I'll be happy to supervise your master thesis, if you are prepared to roll up your sleeves". And so we did.

Among the researchers involved was prof. Gerit Pfuhl, and under her supervision I contributed to developing the Tromso Infant Faces database on a summer scholarship in 2015. Images from this database were used in the cognitive tasks we included in NorBaby. Our master thesis, due in the spring of 2016, examined two of these tasks in an inpatient group.

Data acquisition for NorBaby started in 2015 with one PhD-candidate (Nordahl) on the observation part of the study, while a Postdoc (Høifødt) ran the intervention-study, in close collaboration with the rest of the research group. After finishing my studies in 2016, I stayed in touch with prof. Wang and the research group while on maternity leave and applied for a PhD in NorBaby. Returning to the project as a PhD-candidate in February 2017, the data collection was rolling and desperately calling for more human resources. With recruitment, six assessment points including filming, neuropsychological testing, cognitive tasks, and an intervention, it is a wonder that we managed without external funding.

The NorBaby study has been conducted in collaboration with the communal health care services in Tromso (Forebyggende helsetjenester; FHT) and the maternity ward at the University Hospital of Northern Norway (UNN). The midwives at FHT and UNN were the front-line of recruitment, handing out information about the study and having participants sign up. Furthermore, public health nurses in FHT and employees at the maternity ward at UNN were educated to do the Newborn Behavioral Observation by associate prof. Inger Pauline Landsem, and along with Landsem from the project group they were responsible for completing the intervention part of the study. Several students have served as research assistants, and the whole NorBaby-team has contributed to the data collection. Data collection was completed in the fall of 2018.

The first half of my PhD consisted largely of data collection, including recording parent-infant interaction and neuropsychological testing of more than a hundred babies. Completing data collection, we started organizing, cleaning, and scoring all data, including almost 400 films. Even though I worked clinical full time for two years during my PhD-journey, while the rest of the team kept the project going, not all data was ready in time for me to include in my PhD. For example, while writing this, scoring of parent-infant interaction films is soon to be completed and our ECG-data has just been analyzed.

While finishing my thesis I know that it is not my last contribution in the NorBaby-study. I would have liked to include especially the interaction data in my thesis, but I am happy knowing we will analyze it and publish when it is ready. We still have hypotheses we want to investigate, and data we want to examine. We would also very much like to do a follow-up study of our NorBaby-families. My thesis is not the end of the NorBaby, although it is the end of my PhD-journey. At moments, especially during data collection, we laughfully called it our "monstrous project", but looking back I am very grateful that I got to be a part of NorBaby. It's been a blast!

Acknowledgements

First and foremost, thank you to my excellent team of supervisors. I really won the supervisor lottery. Vibeke, you have been so kind and welcoming, building good relations across our research groups, welcoming us into your home, and introducing me to fellow researchers both inland and abroad. Thank you for bringing your infant expertise into this work.

Gerit, words cannot describe how grateful I am for our cooperation. You have a magnificent brain, and every time I work with you, I feel some of your magic rubbing off on me, leaving me feel a little bit smarter – at least until I am back in my own office and all the magic is gone. I have learned so much from you. Thank you for prioritizing my project and for being so efficient and fast responding. It is truly valuable for an impatient soul. I hope we will do more projects together in the future.

Catharina, you have been a mentor to me. Thank you for guiding me in academia, for your sharp clinical focus, for laughing out loud a lot, and for diving into existentialist conversations. Your values, taking the dissemination of research seriously, giving back to society, building cooperation instead of competition, are most appreciated. You are an inspiration, and I am truly grateful for all our time together.

In addition to my supervisors, the team of NorBaby is a group of wonderful, engaged, and skillful researchers; thank you Ragnhild, Dag and Inger Pauline. I would also like to thank the whole clinical research group, for all good laughs, inspiring conversations, and supportive atmosphere. Yngvild, you are truly special. You really are the crème de la crème.

Importantly, I would like to thank all participating families in NorBaby. Without your contribution there would be no thesis. Having gone through the perinatal period three times myself, I am amazed that you put in all the effort and time it took to answer all our questions and tasks. Also, thank you for so many lovely meetings with your little ones.

Thank you to our partners at the University Hospital in Northern Norway and in Tromso commune, who helped recruiting families, collecting data, and performing the Newborn Behavioral Observation intervention.

Thank you to my supportive colleagues and leaders at BUP Tromso, facilitating a smooth PhD-journey and allowing me to stay in touch with the clinic all the way.

Thank you to my dear siblings, to family, friends, and neighbors – you are the best village!

To my parents, thank you for my secure attachment, good confidence and for always letting me thrive. My dear mother, you are so brave, so loving and so open to new experience. Thank you for being a good role model, and for teaching me that life is better when you accept not being perfect. My dear father, I have always felt so close to you. So, thank you for the

seriously strong bonding from the day I was born. Thank you for always listening, and always being compassionate and supportive no matter the cause.

My dearest Espen, thank you so much for being the best companion in life. Thank you for passionately discussing psychology even though it is not your field. Your reflections mean more to me than I think you know. Thank you for being engaged when I talk about nerdy stuff. Thank you for reminding me to speak clearly and "plain Norwegian" when I use too many academic terms. Thank you for being my safe haven, and proudly cheering me on.

And finally, thank you to my beloved children. August, if you had not existed, winds would have taken me other places. You lit my interest and engagement for infant mental health and the perinatal period. You were my first meeting with the strongest love one can ever experience. Ellinor, thank you for being my test subject during data collection and for your unconditional love every day. Einar, my evening star, thank you for letting me once again experience the true meaning of life. And all of you, for always keeping me in the present.

List of Papers

Paper I

Bohne, A., Høifødt, R. S., Nordahl, D., Landsem, I. P., Moe, V., Wang, C. E. A., & Pfuhl, G. (2022). The role of early adversity and cognitive vulnerability in postnatal stress and depression. *Current Psychology*. https://doi.org/10.1007/s12144-021-02651-1

Paper II

Bohne, A., Høifødt, R. S., Nordahl, D., Landsem, I. P., Vannebo, U. T., Holstad, S. L., Moe, V., Wang, C. E. A., & Pfuhl, G. (under review). Transaction of parental cognition, stress and depressive symptoms, and infant regulatory problems.

Paper III

Bohne, A., Nordahl, D., Høifødt, R.S., Moe, V., Landsem, I.P., Wang, C.E.A., Pfuhl, G. (in press). Do parental cognitions during pregnancy predict bonding after birth in a low-risk sample? *Frontiers in Psychology.*

Summary in Norwegian

Det overordnende målet med denne avhandlingen var å undersøke hvordan kommende og nybakte foreldres informasjonsprosessering og tankemønstre virker inn på deres psykiske helse i perinatal periode, deres relasjon til barnet og til barnets utvikling postnatalt. Perinatal periode er en stor og krevende overgang i livet, noe som fører til økt risiko for psykiske helseutfordringer. Nedsatt psykisk helse hos foreldrene utgjør en risiko for foreldre-barn relasjonen og for barnets utvikling. Økt kunnskap om hva som fører til psykiske problemer og lidelser i perinatal periode kan dermed bidra til virkningsfull forebygging.

Spedbarnet er avhengig av sine omsorgsgivere for å være i god utvikling. Gjennom samspillet med sine omsorgsgivere utvikler barnet emosjonsregulering og sosiale ferdigheter. Dersom psykiske vansker hos foreldrene kommer i veien for deres evne til å være sensitive og responderende til barnets signaler, kan dette få uheldige konsekvenser for barnets utvikling. Foreldre som blir fanget i repeterende negative tanker kan ha lite kapasitet til å plukke opp barnets signaler. Videre kan foreldrenes egne negative barndomserfaringer virke negativt inn på deres holdninger til spedbarnet og foreldrerollen. En negativ oppmerksomhetsdreining kan føre til at foreldre henger seg mer opp i negative enn positive uttrykk hos spedbarnet, noe som i sin tur kan forsterke negative tanker og holdninger til spedbarnet og til sin egen rolle som foreldre. Målet for studiene i denne avhandlingen var å undersøke slike selvforsterkende mønstre hvor foreldrenes kognitive sårbarhet virker inn på foreldrenes egen psykiske helse, foreldre-barn relasjonen og på barnets utvikling. Problemstillingene var som følgende; Hvordan påvirker foreldres repeterende negative tanker, negativ oppmerksomhetsdreining og implisitte holdninger til spedbarn foreldrenes egen psykiske helse i perinatal periode? Hvordan virker sosiodemografiske variabler inn? Og hvordan påvirker foreldrenes kognisjoner foreldre-barn relasjonen og barnets utvikling?

God start for Små i Nord (NorBaby) er en longitudinell observasjonsstudie som ble gjennomført i Tromsø kommune. Deltagerne ble rekruttert under svangerskap av jordmødre i Forebyggende helsetjenester og ved Universitetssykehuset i Nord-Norge. Både mødre og deres partnere ble invitert til å delta i studien. Det ble gjennomført tre målinger under svangerskap, og tre etter fødsel. Deltagerne besvarte spørreskjema vedrørende sin psykiske helse, tankemønstre, egne barndomserfaringer og sosiodemografisk informasjon, samt utførte kognitive tester. Etter fødsel ble i tillegg barnets daglige rytme og regulering observert, og barnets tegn til sosial tilbaketrekning ble vurdert basert på atferd under en nevropsykologisk undersøkelse av barnet.

Resultatene viste at repeterende negative tanker var et viktig sårbarhetstrekk hos foreldre i perinatal periode, som henger sammen med foreldres mentale helse etter fødsel, og deres relasjon til barnet. Vi fant ikke signifikante effekter av andre kognitive faktorer, nemlig oppmerksomhet og implisitte holdninger. Videre fant vi at flergangsmødre hadde en klar fordel av sin erfaring, ved at dette var beskyttende for depressive symptomer og foreldrestress hos mor, samt reguleringsvansker hos barnet. Det å ha barn fra før var også relatert til sterkere

tilknytning til barnet for mødre. For fedre derimot, så var det å ha barn fra før negativt for tilknytningen til den nyfødte, samt at det ikke virket inn på fedrenes egen helse eller barnets regulering. Dette må trolig sees i sammenheng med at ansvar for tidligere barn gjerne tilfaller far i de tidlige månedene etter fødsel. Sosial støtte blant familie og venner viste seg også som en viktig faktor for foreldrenes mentale helse i perinatal periode.

Avhandlingen har viktige implikasjoner for helsetjenester i perinatal periode. Repeterende negative tanker bør kartlegges hos foreldre under svangerskapet. Hjelp til å redusere slike tanker kan ha positive ringvirkninger både for foreldrene selv, men også for deres relasjon til barnet. Helsetjenester i perinatal periode kan også bidra til å fremme sosialt nettverk rundt familier som venter barn, og være særlig bevisst på psykiske utfordringer hos førstegangsforeldre.

Summary in English

The aim of the present thesis was to investigate thinking style and processing biases in expecting and new parents, and how this relates to their mental health, the parent-infant relationship, and infant development in the perinatal period. The perinatal period is one of the largest transitions in life and comes with increased risk of mental illness. Mental illness in the parents serve as a risk factor for the parent-infant relationship and infant development. To develop effectful interventions, understanding of the mechanisms that lead to illness is essential.

Infants are dependent on their caregivers for healthy development. Through interaction with their caregivers the infant develops adaptive emotion regulation, and social skills. Parental mental illness could affect parents' sensitivity and responsiveness to infant cues, and thereby negatively affect infant development. Being caught up in negative thoughts occupies cognitive capacity, and therefore might reduce the parental emotional availability. Further, adverse childhood experiences can have a negative effect on parents' schemas and attitudes towards infants and the parental role. Biased attention can cause parents to notice more of the infant's negative expressions and emotionality, which further can strengthen negative thoughts and attitudes towards the infant and parental role. Patterns like this, where vulnerability in the parents affects their own health, the parent-infant relationship and infant development, were of interest in the present thesis.

The Northern Babies Longitudinal Study recruited participants in the commune of Tromso and followed them longitudinally throughout pregnancy and 7 months postnatally. Both mothers and their partners were invited to participate. There were three assessments during pregnancy, and three after birth. Participants answered a broad range of measurements, including cognitive tasks and questionnaires about their mental health, negative thoughts, adverse experiences, and sociodemographic information. After birth, the infant's daily rhythm and regularity was observed, and signs of social withdrawal was assessed during neuropsychological screening of the infant.

Results indicate that repetitive negative thoughts serve as a vulnerability trait in parents during the perinatal period, as they predict parental depressive symptoms and stress after birth, and the parent-infant relationship. Such thoughts can be identified already during pregnancy. We did not find significant relations between other cognitive factors, attentional bias and implicit attitudes, and parental health or parent-infant relationship. Further, parity was a clear protective factor for mothers, as it was related to lower levels of depressive symptoms and parenting stress, and infant regulatory problems. Parity was also related to stronger maternal bonding. In fathers, on the other hand, parity was negatively related to bonding, and did not significantly affect fathers' mental health or infant regularity. Probably, this can be explained by the father's engagement and responsibility for previous children during the early months after birth. Social support from friends and family also turned out as a significant protective factor for both mothers and fathers.

The present thesis has important implications for perinatal health care services. Repetitive negative thoughts should be identified during pregnancy. Reduction of such thoughts could have a positive effect on parental mental health, as well as the parent-infant relationship. Perinatal health care services should also help facilitate social support for expecting parents, and be especially aware of the mental health of first-time parents.

Abbreviations

ACE	Adverse Childhood Experiences
ADBB	Alarm Distress Baby Scale
DP	Department of Psychology
EDP	Emotional Dot Probe
EPDS	Edinburgh Postnatal Depression Scale
FHT	Communal health care services (Forebyggende helsetjenester)
GP	General practitioner
IAT	Implicit Association Task
MPAS	Maternal Postnatal Attachment Scale
NorBaby	Northern Babies Longitudinal Study
PPAS	Paternal Postnatal Attachment Scale
PSI	Parenting Stress Index
RNT	Repetitive Negative Thoughts
SES	Socioeconomic status
UiT	UiT The Arctic University of Tromso
UNN	University Hospital of Northern Norway

The first cry of a newborn. Such a beautiful moment. It happens every day, all over the world, and has happened through all human history. Another couple of parents placed a chunk of their hearts in a little infant's body, making them more vulnerable than ever before. At the same time, multiplying the love, pride, and joy a person can experience. Maybe it is not their firstborn, maybe they already have little ones walking around carrying chunks of their hearts. Maybe love is all around. But also, so much more to worry about. No matter where the unfortune strikes, if one of the little ones get hurt, the parents will feel the pain even stronger.

The first cry of a newborn. The end of a pregnancy. It might have been filled with joy and great expectations. Will expectations be fulfilled? Or will they be disappointed? Is overwhelm at hand? The pregnancy might have been awful, both physically and mentally. Is this the new beginning? Where the suffering is past? Or will the suffering last?

The first cry of a newborn. Will he a cry a lot? Although the sound is beautiful at first, how can one concentrate on anything else when a baby cries? How can one even finish a thought? Except for those dark thoughts. Maybe she feels she is not up for the task. Maybe that thought repeats itself again and again until she believes it. She is not good enough. The baby would be better off without her. Her thoughts feel like the truth, and she dares not say them aloud to see if her partner agrees.

The first cry of a newborn. Maybe the cry is easily soothed. They speak the same language. She knows what he needs and offers it warmly. They are synchronized, as they are one.

The first cry of a newborn. Such a universal moment. Nothing special, just a natural part of being human. But for that family, it is all that matters. How was the journey here, and how will it continue?

Introduction

Having a baby is one of the largest transitions in life, often referred to as being wonderful, where new parents will experience the strongest love there is and the true meaning of life. However, as with all transitions, childbearing comes with a struggle to adapt and with an increased risk of illness. In fact, many new parents experience mental health issues during the perinatal period, perhaps contrary to what they themselves and the network and society around them expects. Perinatal mental health problems can have a negative effect not only on the parents themselves, but also on the parent-infant relationship, as well as infant development. Therefore, when discussing perinatal mental health, one must consider the entire family.

The mental health of the family in the perinatal period is a clash of disciplines. It is adult psychiatry and children psychiatry. It is normal psychology and development, and adjustment difficulties. It is public health and prevention and specialist health services. It is family perspective and individual perspective. Interactions and transactions. The complexity often causes these families to slip through the net, as they are everyone's and no one's responsibility. The present thesis therefore wanted to focus on the families struggling in the perinatal period, specifically examining the role of cognitive vulnerability in the parents. It is my wish to contribute to health care services that embrace the complexity of the perinatal period and offers helpful interventions and care for both the individual family members and the family as a whole. Let us tighten the net!

In the following introduction, I will firstly present the prevalence and consequences of perinatal mental health problems in society. Secondly, I elaborate on symptoms and characteristics of perinatal depression and parenting stress. Thirdly, I will discuss infant development and developmental needs, and how this can be affected by parental mental illness. A transactional view of the perinatal period will be presented. Further, I will discuss theories of vulnerability to depression and what mechanisms might cause vulnerability in some individuals. I will discuss cognitive vulnerability in the perinatal period, and how it could affect parenting. Finally, aims of the present thesis will be presented.

Perinatal mental health

The definition of the perinatal period varies and is often broader in psychological research than in medicine. The ICD-10 defines the perinatal period as starting at 23 weeks of gestation to seven days after birth (World Health Organization, 2016). However, this definition is due to classifying stillbirths and neonatal deaths. When discussing perinatal mental health, a common definition is from pregnancy to one year after birth (Bauer et al., 2014), as this is a period of increased risk of mental illness. This definition is used in the present thesis. Similarly, when discussing infants, I refer to children in their first year of life.

Although prevalence estimates of perinatal mental illness vary somewhat across countries and definitions, mental illness in this period is common, and affects around 10-20% of women (Bauer et al., 2014; O'Hara & Wisner, 2014). Norwegian numbers are similar, where the prevalence of postnatal depression in women is found to be 10% (Glavin et al., 2009). During the covid-19 pandemic though, numbers were even higher as 32% of postpartum women reported elevated levels of depressive symptoms (Eberhard-Gran et al., 2022). Postnatal depression is the most common complication of childbearing (Grace et al., 2003). Perinatal depression affects fathers as well, where prevalence of is around 8-10% (Rao et al., 2020). In addition to depression, there is an increased risk of anxiety, post-traumatic stress disorder, obsessive compulsive disorder, eating disorders and psychosis in the perinatal period, but the prevalence is less studied (Bauer et al., 2014). However, anxiety disorders might be even more prevalent than depression, as meta-analyses suggest 15-20% of women have at least one anxiety disorder (Dennis et al., 2017; Fawcett et al., 2019). It is probable that many of these women have anxiety comorbid to depression (Gale & Harlow, 2003).

It is important to note that childbearing comes with natural and normal worries and mood swings as well. Most women (up to 84% according to O'Hara & Wisner, 2014) will experience "baby blues" known as feeling low, crying, and experiencing mood lability a couple of days after birth. This is perfectly normal and must not be mistaken for pathology. The baby blues will lessen after the first week and for most women it will not last longer than the first couple of weeks (O'Hara & Wisner, 2014). Possibly, the baby blues is caused by the abrupt hormonal changes, withdrawal of estrogen and progesterone, following birth (Gale & Harlow, 2003).

The perinatal period also comes with other normal challenges, like abrupted sleep and tiredness. One must be careful to "pathologize" the parents, the infant or the parent-infant relationship too soon (Cierpka, 2016), but at the same time beware of the possible detrimental outcomes if families do not get help when needed. This broad specter of challenges, from normal struggles and adjustment issues to severe mental illness complicates identification and intervention of families in need. It can be challenging to know where the threshold between normal challenges and psychopathology lies.

In their report, Bauer et al. (2014) conclude that the socioeconomic costs of perinatal mental health problems are extremely high. Perinatal mental illness can cause heightened use of health care services, absence due to sickness, and is one of the leading causes of death for women in this period due to suicide (Bauer et al., 2014). In addition, poor perinatal mental health of the parents does not only affect themselves, but is also a risk for their infant's development (Stein et al., 2014).

Despite this knowledge it remains unclear how the health care services should identify and follow up parents with perinatal mental health problems, as Norwegian national guidelines are diffuse (Høivik et al., 2021). Further, there are no recommendations or guidelines regarding the evaluation or treatment of parent-infant interaction and bonding when one of the parents

are mentally ill, or detecting early signs of infant mental health problems (Høivik et al., 2021).

Perinatal depression

Depression is an emotional disorder characterized by low mood, loss of interest, lack of energy and low self-esteem (ICD-10; World Health Organization, 1992). In cognitive theory, the depressive triad is described as a negative view of the self, the world and the future (Beck & Alford, 2009). Perinatal depression is characterized by the same symptoms as non-perinatal depression, but with the load of expecting or having a newborn baby as a central aspect. The content of the negative thoughts and distress often concerns the parental role and the infant (Gale & Harlow, 2003).

Depression in general is a highly heterogenous disease, where symptoms and severity varies much between individuals (Monroe & Anderson, 2015). Severely depressed individuals may function very differently from mildly depressed individuals, in regards of both range and intensity of symptoms, and functional impairment (Zimmerman et al., 2018). Thereby, the consequences for both the depressed individual and the network around them may differ significantly based on severity. Further, depression is often comorbid with anxiety (Gorman, 1996). Probably, anxiety is even more prominent in perinatal depression than non-perinatal depression (Gale & Harlow, 2003; Massoudi et al., 2013). Fredriksen et al. (2017) illustrated the heterogeneity of perinatal depression in women when they identified distinct subgroups that differed based on onset and time course. They found that the subgroups also differed in severity of symptoms and associated psychosocial adversities. Because of the heterogeneity, one must be careful to generalize findings across depressed individuals.

Causes of perinatal depression

There is a variety of possible causes to perinatal depression. Well-known risk factors are history of depression, poor social support, quality of marital relationship, stressful life events, and lower socioeconomic status (O'Hara & Wisner, 2014). As with non-perinatal depression, the explanation is complex. In depression research, there is a distinction between social risk factors and individual vulnerability. Social risk factors are stressors in the environment, like adverse experiences, losses, or conflicts that burdens the individual, while individual vulnerability can be both innate factors like genes or personality traits, or acquired traits evolved based on experiences or trauma, like negative self-schema. Without this individual vulnerability, the social events might not trigger depression (Wang, 2012).

The perinatal period is a unique period with major biological and physiological changes for women, where individual vulnerability may present itself, as there are many possible stressors. The abrupt hormonal changes following birth is an example of a unique factor for the perinatal period, and might trigger the onset of depression in women (Gale & Harlow, 2003). However, this happens to all women, and most do not get depressed. Women might be

differentially sensitive to the withdrawal of hormones, so that it causes mood symptoms in some (O'Hara & Wisner, 2014) but not in all.

Further, a natural part of the perinatal period is reduced sleep quality. Frequent awakening is inevitable. Sleep disruption is associated with depression and may thereby contribute to depression in the perinatal period (Gale & Harlow, 2003). Psychological factors can also play a part, where adjusting to the new role as a parent can trigger depression in some (Moustafa et al., 2020). Having a baby, at least first time, involves a major transition where your identity changes and women report a loss of their sense of self (Newby et al., 2021).

To prevent mental illness in the perinatal period we need to identify vulnerability factors. The present thesis will specifically examine cognitive vulnerability in the parents, and how this affects their mental health, their bonding to their infant and their infants' socioemotional development.

Parenting stress

Parenting stress arises when parents perceive that the demands of parenting exceed their resources (Abidin, 1992; Deater-Deckard, 2004). Although circumstances like income, social support and education play a role in the experience of resources, parenting stress is a subjective experience of childrearing, regardless of the absolute and concrete resources that surrounds the family (Deater-Deckard, 2004). Although associated with parental mental illness (Leigh & Milgrom, 2008; Mazzeschi et al., 2015), parenting stress can be heightened without symptoms of mental illness, but can also precede, co-exist and predict mental illness (Deater-Deckard, 2004). As with anxiety and emotional disorders in general, parenting stress is strongly associated with neuroticism (Deater-Deckard, 2004).

Parenting stress can affect the quality of parenting (Crnic et al., 2005), maternal sensitivity (Dau et al., 2019), and is associated with both externalizing and internalizing problems in the child (Barroso et al., 2018; Fredriksen et al., 2018). It is also related to relational problems between the parents (Mazzeschi et al., 2015). Thus, higher levels of parenting stress can have adverse effects on the parents' mental health, the parent-infant relationship and the infant's development. Therefore, it is paramount to understand what leads to experiencing high levels of parenting stress.

Infant development

The brain goes through remarkable changes during the first two years of life, with rapid synaptic growth and almost doubling of the brain size (Richards & Conte, 2020). Brain development is a complex interactive process between intrinsic maturation, genetic factors and experience (Richards & Conte, 2020). Exposure to and experience with different environmental factors affect the synaptic growth, so that areas in the brain concerned with what the infant experiences will develop accordingly. Because of the dramatic change in the early years, experience might have a particularly large influence on selective brain growth in

infancy (Richards & Conte, 2020). Factors found to influence brain development are nutrition, health and psychosocial stimulation, leaving families with lower socioeconomic status in higher risk of developmental issues (Richards & Conte, 2020).

The newborn infant is completely dependent on their caregivers for survival. Not just for feeding and protection, but for support in regulating their behavioral state, organizing impressions, and adjusting to the environment. From the moment they are born, infants start the process of adjusting to the new environment, self-regulating their physiological system that has been regulated in their mother's womb until now. With an immature neural system, the newborn needs support regulating both their physiological and emotional state (Nugent et al., 2007). The newborn infant is easily overwhelmed by sensory impressions like sounds, light, or temperature changes, and needs their caregivers to actively support in regulating arousal. Parents co-regulate. Further, infants move between behavioral states, and they have different needs based on what state they are in (Nugent et al., 2007). For example, when awake and alert the infant may be ready to engage in social interaction, while when fuzzy or crying, they might need support to go to sleep, or soothing to calm the arousal. Caregivers' sensitivity and responsivity is crucial in this regard, so that the infant's cues are read, and needs are met.

To some extent, regulatory problems during infancy are normal and transient. As infants are in rapid development, their needs, signals, and reactions change continuously during the early months, and parents must adapt accordingly to meet the infant's demands (Cierpka, 2016). For example, during the first weeks, the infant may move in and out of sleep without much assistance. However, as the infant matures, the capacity to interact with the environment increases, and the infant may be affected by their surroundings to a higher degree, perhaps causing them to need more co-regulation to find sleep. These changes give rise to periods where parents struggle to regulate their infant before they have adapted to the new needs of the infant (Cierpka, 2016). In line with the selective brain growth, when the infant experience support and co-regulation from their caregivers, the infant's self-regulation increases as they repeatedly have experienced regulation.

Despite the immature brain, infants are born with the capacity to communicate and engage in social interactions (Bornstein & Tamis-LeMonda, 2010; Feldman, 2007). Already from start, infants prefer facial stimuli and imitate facial movement in others (Pascalis et al., 2011). During their second month of life, infants spend more time in an awake and alert state, setting the scene for the social smile to emerge (Mitsven et al., 2020). Just a couple months old, the infant engages in social give-and-take interactions with vocal behaviors, smiles, and motor activity (Bornstein & Tamis-LeMonda, 2010; Feldman, 2007). Maybe just as important as engaging in social interaction, the infant has the competence to self-regulate or signal the need for regulation support when they are overwhelmed or tired. An infant can look or turn away at such moments, withdrawing from the social stimulation, or signal distress (Tronick, 1989). As the infant matures, more sophisticated social interactions take place, where the infant is capable of social initiation to a greater extent (Feldman, 2003). Parents and their

infant engage in mutual social interaction, where they take turns initiating and following, and through this interplay the infant develops social skills and emotion regulation.

Successful co-regulation lays the foundation for both healthy self-regulation and positive parent-infant interactions and relationship (Nugent et al., 2007). Fonagy and Target (2002) pose that this early relationship experience will have an enduring effect on stress reactions, attention, and the capacity to interpret mental states in both them and others. A healthy interplay lays the foundation for secure attachment, where the infant experience their caregivers as a safe haven who both sooths them when overwhelmed, tired, or distressed, and supports their exploration of the world, and stimulates further development. Secure attachment is predictive of healthy development, perhaps most importantly because it allows for healthy development of self-regulation through positive experience with co-regulation from caregivers during a critical time of rapid brain growth (Fonagy & Target, 2002).

Infant temperament

Infants' own regulatory capacity often affects how they are perceived. Infants who are predictable and display less negative emotionality are often described as having an easy temperament, while less predictable infants who might be more easily overwhelmed and express more negative emotions, might be perceived as more difficult. Definitions of infant temperament vary, but there is agreement about some aspects, namely that temperament refers to individual differences and reflect behavioral tendencies (Costa & Figueiredo, 2011). Although temperament might be affected and shaped by environmental factors and change somehow over time, it is considered biologically based and thereby more stable like a component of personality (Costa & Figueiredo, 2011).

Infant maldevelopment

Infant development is unfortunately not always on a healthy track. Causes of maldevelopment can be complex. Well-baby clinics monitor weight gain and milestones that gives important indications of healthy development. However, aberrant psychosocial development can be difficult to detect. Infants are not able to describe their problems to us, so we are left with reading infant behavior cues. From a health care perspective, this can be challenging as health professionals often only see infants briefly, and any distress expressed by the infant could be explained by completely normal circumstances like tiredness, skepticism to an unknown environment or unknown person, hunger etc.

However, based on knowledge of normal infant development, some warning signs can be helpful. As we know that infants in an alert state are highly capable of social interaction, we should be aware of infants who are difficult to engage (Guedeney et al., 2013). Infants who display withdrawn behavior might be challenging to get eye contact with, they might display fewer facial expressions, vocalize less, and be less motorically expressive. For both parents and health professionals, withdrawn infants can be challenging to interact with. These are cues that can signal hampered development.

Other than behavioral cues from the infant themselves, parental report can be helpful. A concern often raised by parents in well-baby clinics regards the infant's regulatory capacity, meaning that they either cry a lot and are difficult to sooth, or that they do not eat or sleep well. As mentioned, regulatory problems are often transient and in the normal range. However, when the regulatory problems are more stable over time, this could indicate difficulties in the parent-infant interaction, the parents' mental health, or the infant's general regulatory capacity or neurodevelopmental vulnerability (Cierpka, 2016). Further, regulatory problems in infancy are predictive of both dysregulation and behavioral problems in later childhood (Hemmi et al., 2011; Hyde et al., 2012; Winsper & Wolke, 2014). Regulatory problems are therefore an important factor to consider for health professionals meeting infants.

Infant development and parental mental illness

Based on the knowledge of the importance of the early parent-infant interplay for infant development, it is not hard to imagine that parental mental illness can interfere. In their review, Kingston et al. (2012) summarizes evidence for the effect of maternal psychological distress on infant development, and concludes there is some evidence that prenatal maternal distress negatively impacts behavioral, cognitive and psychomotor infant development. Regarding postnatal maternal psychological distress, they find an association with cognitive development and to a lesser degree socioemotional development. Of note, maternal sensitivity moderates the effect of maternal postnatal depression on socioemotional infant development (Kingston et al., 2012). Importantly, Kingston et al. (2012) examined only infant outcome, excluding child outcome after the first year.

Looking at childhood and adolescence as well, Stein et al. (2014) found evidence that maternal perinatal depression (and anxiety, but there are few studies) is linked to both externalizing and internalizing difficulties in the child, across childhood. Regarding fathers' mental illness, Stein et al. (2014) concluded that effects are similar to that of mothers' at least on externalizing problems. More recently, Fredriksen et al. (2018) found that paternal depression was specifically associated with language development. It seems, paternal depression has its own specific effect on child development, independent of maternal depression (Fredriksen et al., 2018; Ramchandani et al., 2005; Stein et al., 2014).

Understanding the mechanisms of how this intergenerational transmission takes place can help develop effective interventions. Possible explanations are numerous, and most likely an interplay between several factors. For example, there is an important genetic inheritance that can explain how psychopathology runs in the family. Also, recent research argues for an effect of epigenetics in that the mother's stressful experiences during pregnancy affects the foster's development through cortisol levels (Talge et al., 2007). After birth, as already mentioned, several psychosocial factors play a part, like socioeconomic status, social support, parental illness, parenting behavior, and the parent-infant relationship. Importantly, this

intergenerational transmission of illness is not inevitable. Indeed, in the absence of severe or chronic maternal mental illness or other adversities, effect sizes are small (Stein et al., 2014).

Parent-infant bonding

In the previous sections I have described characteristics of perinatal mental illness in the parents, infant development, and briefly how they interact. Struggles in the perinatal period may manifest themselves in the parent-infant relationship, exemplified in the parental bonding process. As I will briefly review below, bonding is an important factor to consider for both parental and infant well-being (e.g. absence of symptoms and healthy development) in the perinatal period.

Bonding is defined as the emotional bond from the parent to the infant, namely the parents' thoughts and feelings about their infant (Bicking Kinsey & Hupcey, 2013). Bonding is found to be relatively stable from pregnancy to toddlerhood, although at its strongest during the first year after birth (de Cock et al., 2016). Although bonding concerns the parents' thoughts and emotions, it is important for the infant's development.

In their review and meta-analysis, Le Bas et al. (2020) concluded that stronger maternal bonding is associated with more optimal infant development, specifically factors linked to less difficult temperament and regularity. Further, de Cock et al. (2017) found that high quality of postnatal bonding is positively associated with the infant's executive function at 24 months. The relation between bonding and infant development may be explained by how bonding affects parenting style. Low quality of bonding can lead to less positive maternal feelings and more irritability and hostility towards the infant (Bicking Kinsey & Hupcey, 2013; Brockington, 2004). Poor bonding is not just related to infant health, it is also related to parents' well-being, as it predicts parenting stress (de Cock et al., 2017).

As bonding is an important factor to consider for both parental and infant well-being in the perinatal period, identifying those at risk for low bonding can help facilitate a good bonding process. Findings indicate that poor mental health of the parent, especially depression, negatively affects bonding (Dubber et al., 2015; Mason et al., 2011; Rossen et al., 2016). However, vulnerability to depression might overlap with vulnerability to relationship difficulties in general, and therefore some of the same factors might be involved in poor bonding. In the NorBaby study we found that mothers' own attachment style was related to postnatal maternal-infant bonding (Nordahl et al., 2020). Similarly, we also investigated mothers' early maladaptive schemas and found they were negatively associated with prenatal maternal-foetus bonding (Nordahl et al., 2019). This indicates that parents' predispositions in the form of cognitive and relational styles can affect bonding to their child, maybe even to a higher degree than mental health in general.

Transactions between parents and infants

To broaden our understanding of how both parent and infant characteristics affect each other in a dynamic interplay, I will now present the transactional model.

To understand individual development, one must understand how the individual is affected by the environmental context, and how the individual itself affects the context, while they both are ever changing. This is the basis of the transactional model (Sameroff, 2009b). As opposed to interactions, where static entities interact with each other but remain the same, transactions require entities to change each other (Sameroff, 2009b). A transactional view is of course relevant for understanding child development beyond the infant age as well, but for the present thesis the transactional model will be presented using early parent-infant relationships as examples.

When describing parent-infant relationships, a transactional view means that the parents are adapting to their infant and changing their behavior (and thoughts and feelings) accordingly, and at the same time, the infant is affected, adapting, and developing based on its parents' behavior. They change each other in a continuous dynamic interplay. Optimally, the parents are sensitive to infant cues and mostly experience that they can handle the parenting role, and the infant is easily regulated and has an easy temperament. In turn, this lays the foundation for joyful interactions which reinforces the reciprocal relationship.

This is not to say that there are no miscommunications or conflictual interactions. On the contrary, as Tronick (1989) explained, conflictual interactions followed by repair and attunement is the normal pattern of the relationship. These conflictual interactions lay the foundation for adaptive emotion regulation in the child. The infant experiences that negative emotions are brief, and that regulation strategies (e.g., self-soothing like looking away or signaling distress to the caregiver) are effective. In turn, this prepares the infant to handle future stressful situations.

A normal parent-infant interaction is characterized by coordination, miscoordination, and back to coordination again. Changing within seconds. Parent and infant reacting and adjusting to each other. As Feldman (2007) puts it; this is the essence of human dialogue. The affective communication between parent and infant involves them actually changing the experience and behavior of each other (Tronick, 1989), as ongoing transactions.

Feldman (2007) applies the term "synchrony" to describe the parent-infant interactions (and interpersonal relationships more generally). Parent-infant synchrony is the temporal coordination of micro-level social exchanges, like the social gaze between parents and infant or matching of arousal level. Feldman (2007) describes in detail how micro-transactions between mother and child takes place already straight after birth. She describes how the earliest maternal behavior (gazing at the infant's face, affectionate touch etc.) is an innate behavior like that of licking and grooming seen in other mammals.

Further, Feldman (2007) notice how the parent-infant synchrony develops in accordance with the infant's maturation, from the early social gaze it goes on to coordinated social exchanges, shared attention, and even further to symbolic play. When synchronized, it is like a dance, where the parents attune and adjust to the infant's cues within seconds. The infant is engaged in social exchange when attentive and content, and soothed and put to rest when tired. From lower to higher arousal, from engaged interaction to rest, from miscoordination to repair, together they dance.

A transactional view of difficulties and disorders

The transactions between parent and infant may also be hampered. Reduced parent-infant synchrony characterizes risk conditions, for instance when there is maternal depression (Feldman, 2007). As opposed to the normal parent-infant interaction characterized by brief miscoordinations, abnormal parent-infant interaction would contain less coordination and longer lasting negative emotions that might not be followed by repair (Tronick, 1989). Infants who experience more abnormal interactions depend on self-regulatory mechanisms to a larger degree, like looking away, escaping, withdrawing (Tronick, 1989). Maternal depression is associated with more negative emotionality in interactions, hostility, intrusive parenting, less sensitive and responsive parenting behavior (Lovejoy et al., 2000; Tronick & Reck, 2009). Notably, many depressed parents are able do display sensitive and responsive parenting despite their condition, so one must be careful to generalize. Parental depression does not yield negative child outcomes in all cases, far from it.

Considering the transactional model, not only parental characteristics affect parenting behavior, but characteristics in the infant can also affect parenting behavior (Calkins et al., 2004; Popp et al., 2008). For example, the infant might have a difficult temperament that makes the parents struggle and feel that the demands exceed their ability. This may lead to higher levels of parenting stress, and less optimal parenting behavior where parents show more hostility, act more intrusively, or disconnect, and the infant might therefore display more negative emotionality or passivity, which can lead to fewer joyful interactions. Worst case, over time this can deteriorate the parent-infant relationship, the mental health of the parents, and the infant's development.

Transactions occur not only between parents and their infant, but of course between partners as well. It is not surprising then, that maternal and paternal perinatal depression is correlated and predict each other (Ngai & Ngu, 2015; Paulson & Bazemore, 2010). Quality of the marital relationship is a significant factor in both maternal and paternal depression (Demontigny et al., 2013; Fredriksen et al., 2017; Ramchandani et al., 2011; Serhan et al., 2013). The network around the family also affects the family, and social support is a well-known factor that influences parental well-being in the perinatal period (Leigh & Milgrom, 2008; Racine et al., 2020).

Newborn Behavioral Observation

By now, it should be clear that promoting sensitive parenting and parent-infant synchrony will benefit both the parents and the infant individually, and the dynamics of the family. As a part of the NorBaby study we therefore wanted to evaluate an intervention called the Newborn Behavioral Observation (NBO; Nugent et al., 2007). I will now briefly describe the intervention and the results we found in NorBaby.

The NBO is a consultation method where the parents together with a health professional curiously observe the newborn infant's competencies, behavioral repertoire, and communication cues. It is a relationship-based intervention that aims at building competence and confidence in the parents, thereby improving parent-infant relationship and sensitive parenting (Nugent et al., 2007). It takes about 20-40 minutes to complete and consists of 18 neurobehavioral observations along the dimensions: attentional-interactional, autonomic, motor and state organization.

The observation is always tailored to the infant's state, so that if they sleep one might see how the baby reacts to light or sound, if they are calm and awake one can observe how they attend to stimuli and turn to their parents' voices, and if they are crying one might test techniques to sooth. Thereby, one will not go through all 18 observations in all consultations, but the ones that fit the infant's states during the consultation. The health professional involves the parents in the observation, to promote curiosity and understanding of their infant's cues and capacity.

In the NorBaby-study, participants were assigned to either the intervention group or care as usual group based on their home address as this determined the well-baby clinic they belonged to. The intervention group received three NBO consultations, while the control group received care as usual. We found no effect of the NBO on maternal depressive symptoms, parenting stress, maternal confidence or bonding (Høifødt et al., 2020). The NBO-group did however report to have learnt more about their infant's sleep, social interaction, and crying/fuzziness.

A few other studies have examined the effect of the consultation, and found that the NBO increased maternal engagement (Sanders & Buckner, 2006) and sensitivity (Nugent et al., 2017). However, as we found no effect in NorBaby, the consultation (intervention) is left out of most analyses in the articles of the present thesis.

Cognitions and vulnerability

Although 10-20% of mothers experience depression in the perinatal period, 80-90% do not. Having a child comes with heightened risk of depression, but most new parents do not experience this, even though they might be under comparable stress to those who do get ill. Therefore, the life situation alone does not explain why someone gets ill during the perinatal period. Some parents might be more vulnerable than others. Vulnerability-stress models explain how some are more susceptible to mental illness, i.e., what triggers illness in some

may not trigger illness in others. Vulnerability can be defined as stable underlying factors in the individual that makes them less resistant to stress; like personality traits, genetic makeup or cognitive factors (Ingram & Luxton, 2005). The following section will review how cognitive factors serve as vulnerability traits for mental illness, especially depression.

Cognitive vulnerability to depression

There is broad agreement that depression comes with certain cognitive deficits and biases, like repetitive negative thoughts and mood-congruent biases in attention, interpretation, and memory (Gotlib & Joormann, 2010; LeMoult & Gotlib, 2019). However, there has been uncertainty to whether these cognitions are present outside a depressive episode, i.e., being stable traits in the individual making them vulnerable to illness, or if the cognitions are simply a symptom of the depressive state. Are the characteristic depressive cognitions present only during the illness (state) or more generally in the individual (trait)? Or perhaps both?

According to Beck's theory of depression certain cognitive structures, or schemas, that guide information processing can be activated depending on circumstances around the individual (Beck & Alford, 2009). A schema characteristic of depression will activate negative thoughts of oneself, the world, and the future, with themes of loss and failure. When activated, the individual will tend to interpret situations according to the schema, reinforcing the negative view (Beck & Alford, 2009). For example, faced with a lunch at work where your colleagues barely talk to you, depression might cause you to think that your colleagues do not like you. You might think you are such a failure because you cannot make friends at the office. The truth might be that they are just busy and have no time to chat, but through the lens of depression that explanation might not be available to you. During a depression, this schema is activated, and gives rise to depressive interpretations.

While earlier research posed that the depressive state itself could explain the processing biases characteristic of depression, there is now broad agreement that individuals vulnerable to depression tend to have these negative processing biases in the face of stress, also when currently not depressed (Nolen-Hoeksema et al., 2008; Scher et al., 2005). This can be described as a cognitive reactivity, where negative cognition and processing biases linked to depression might be activated by internal or external stressors (Beck & Alford, 2009; Scher et al., 2005). The schema serves as a latent vulnerability in the individual, that leads to biased processing and negative cognitions when activated. Cognitive vulnerability might therefore not always be visible, as it might not present itself when not activated. This is how persons with and without a depressive schema, or a cognitive vulnerability to depression, can appear similar when assessing cognitive biases and information processing. Because if the schema is not activated, the processing biases might not appear. This can explain why the empirical evidence for cognitive biases outside a depressive episode is elusive. However, priming designs where low mood or self-focus is induced before assessment consistently demonstrate a vulnerability in previously depressed persons (Scher et al., 2005). Also, longitudinal studies

largely support a latent cognitive vulnerability that can be activated based on present circumstances (Scher et al., 2005).

For the present thesis, we expected vulnerability to present itself, as childbearing is a large transition and becoming a parent places great and novel demands on a family, which can lead to experiencing parenting stress. I will now present theories that seek to explain the mechanisms involved in cognitive vulnerability.

Theories of cognitive vulnerability mechanisms

Koster et al. (2011) proposed the impaired disengagement hypothesis as an explanation of vulnerability to depression. They pose that both repetitive negative thoughts and mood-congruent biases in attention and memory are caused by an attentional control deficit that makes it difficult to disengage from negative self-referential material. While non-depressed individuals often ignore negative material, or quickly shift their attention to something else (e.g. Joormann & Gotlib, 2007), depressed or depression prone individuals seem to get caught up in negative material. Eye-tracking studies have confirmed that it is in fact the lack of disengagement that separates groups of depressed individuals from controls, as groups do not differ in early orienting to emotional images or faces (Armstrong & Olatunji, 2012; Suslow et al., 2020).

Koster et al. (2011) argues that when negative thoughts or emotions are triggered, vulnerable individuals will have low attentional control to help them reappraise, distract themselves or repair their mood. As in the example above, a depressed individual that has started ruminating about what a failure they are, might not have the cognitive resources to remind themselves about their strengths, coming up with alternative explanations of the situation, shifting their attention to something more positive. Instead, they might be stuck in their own negative thoughts.

Koster and colleagues' explanation (2011), an impaired disengagement or lack of cognitive attentional control is in accordance with Beck's schema theory (2009). An activated depressive schema will not create any conflict with the negative affect or self-critical thoughts that arises from the situation at hand (Koster et al., 2011). Whereas in non-vulnerable individuals, a negative experience will create a conflict that helps reallocating attentional resources, and thereby repairing mood and not persisting in negative thoughts. In our example above, such a cognitive conflict could be thinking to yourself that you know that you are a nice person, so it does not make sense that your colleagues do not want to chat with you. This conflict can help create other explanations, like they might just not have time to talk to you right now. Maybe next time instead. This would be a functional emotion regulation that avoids being stuck in negative thoughts. With an activated depressive schema, there would be no cognitive conflict, and thereby no functional emotion regulation (Koster et al., 2011).

Joormann (2010) came to a similar conclusion when explaining vulnerability to depression, namely that reduced cognitive inhibition is a key mechanism. Joormann argued that when

faced with a negative event, and thereby negative mood and cognitions, deficits in cognitive inhibition will cause access of negative material in working memory and an inability to expel negative material from working memory. This results in increased rumination, and decreased reappraisal and accessibility of positive material. In turn, this reinforces the long-term memory for negative material and increases negative mood and cognitions in the future.

These theories agree that vulnerability to depression is dependent on cognitive factors, more specifically linked to attentional control deficits that causes vulnerable individuals to get caught up on negative material and have difficulty disengaging. However, Joormann (2010) did not speculate how this vulnerability occurs and if it is involved in the first onset of depression. Koster et al. (2011) did not elaborate on how the impaired disengagement evolves in the first place but pose that a negative self-schema lays the foundation.

Maladaptive schemas are negative emotional and cognitive patterns that affects self-assumptions and relationships (Bach et al., 2018). Such schemas are developed through negative relational experiences in childhood. When basic emotional needs are not met, this affects child development and can have both immediate and long-term effect on health and well-being, as it leads to developing maladaptive schemas (Roediger et al., 2018). Maladaptive schemas are found predictive of depressive episodes (Halvorsen et al., 2010) and several of these schemas are found to be stable over time, regardless of depressive episodes (Wang et al., 2010). Thereby, early experiences and adversity play a part in evolving cognitive vulnerability to depression.

Parental early adversity

Adverse childhood experiences (ACEs) refer to abuse, neglect and household dysfunction during childhood, which are well-known risk factors for both somatic and mental health problems and psychosocial difficulties (Felitti et al., 1998). Many ACEs are related to later episodes of depression (Chapman et al., 2004; Cheong et al., 2017), hereby also in the perinatal period for both mothers and fathers (Racine et al., 2020; Skjothaug et al., 2014). Maternal ACE is also associated with parenting stress (Moe et al., 2018), and can have a negative impact on their infant's health (Esteves et al., 2020).

There is a strong dose-response relationship between ACEs and illness. Regarding depression, Chapman et al. (2004) found that ACEs are highly interrelated, so if you have experienced any ACEs, you often have experienced more than one. Even so, there is cumulated risk with each additional ACE. Analyzing which ACE was most strongly related to depression, Chapman et al. (2004) found this was emotional abuse. This may indicate that experience with dysfunctional relationships is involved in creating vulnerability to depression, which is in line with a theory of early maladaptive schemas (Roediger et al., 2018).

The present thesis discusses cognitive vulnerability in the perinatal period. I define risk and vulnerability as two different categories. As mentioned, vulnerability is a stable and underlying individual trait, that affects the individual's thoughts, feelings, appraisal, and

behavior across situations. Risk factors can be defined as circumstances or experiences that increase the likelihood of illness but are not in themselves causal of the illness. Contrary to a vulnerability factor, a risk factor is not a trait in the individual, but something external. Adverse childhood experiences can therefore be seen as risk factors for mental illness, but such experiences can lead to social, emotional and cognitive impairments (Felitti et al., 1998), contributing to more stable vulnerability in the individual. In fact, neuropsychological studies on both animals (e.g. Stuart et al., 2019) and humans (e.g. Duncan et al., 2015) showed that early adversity is associated with affective biases in adulthood, structural changes of the brain and increased stress reactivity (Duncan et al., 2015; Marsman et al., 2019).

Attentional bias

I will now present the three specific cognitive factors that are examined in this thesis, starting with attentional bias.

Attentional bias towards a stimulus indicates that the stimulus causes greater cognitive engagement, in that it captures or holds the attention to a greater extent than other stimuli. The attentional bias characteristic of depression is the tendency to focus on or have difficulty disengaging from mood-congruent material (De Raedt & Koster, 2010; LeMoult & Gotlib, 2019). This bias is found both in currently depressed and previously depressed individuals, establishing attentional bias as a cognitive vulnerability factor (LeMoult & Gotlib, 2019). Mood-congruent material would be negative or depression-related material, like sad faces or words. To evoke a mood-congruent bias, it is also essential that the material is self-relevant (Bohne et al., 2021). As mentioned, eye-tracking studies have demonstrated that this mood-congruent bias in depression is characteristic of later stages of information processing, not initial attention allocation (Suslow et al., 2020). In response time paradigms, like the emotional dot-probe task applied in NorBaby, sufficient stimulus presentation time (≥ 1000 ms) is therefore essential to evoke the bias (LeMoult & Gotlib, 2019).

While a mood-congruent attentional bias for adult faces in depression is well established (LeMoult & Gotlib, 2019), less is known about bias to infant faces. Prior to our research, some studies had investigated processing of emotional infant faces, but they had mostly investigated interpretation biases. However, the interpretation biases to infant faces in depression seemed to be the same as to adult faces (mood-congruent, see Webb & Ayers, 2014 for a review). Depressed individuals interpret both neutral and sad infant faces as more negative than healthy controls (Webb & Ayers, 2014). As the interpretation bias to infant faces was comparable to that of adult faces, we expected an attentional bias to infant faces as well.

We therefore compared a group of participants from the NorBaby-study with elevated levels of depressive symptoms to a matched group with low levels of symptoms, and found the expected difference in attentional bias to sad infant faces (Bohne et al., 2021). The group with depressive symptoms disengaged slower from sad infant faces than the control group. As highlighted above, several models pose that such biases are involved in vulnerability to

depression (Joormann, 2010; Koster et al., 2011) and also to less sensitive parenting (DeJong et al., 2016). Being more attentive to the infants' negative emotionality can reinforce both the infants' negative emotionality and the parents' negative thoughts about the infant, which further can make the parents less available and responsive and make the parent-infant interplay less positive. I will discuss this in more detail later. Anyhow, attentional bias was a natural variable to include in the present thesis

Repetitive negative thoughts

In depression research, the cognitive thinking style of intruding and repetitive negative thoughts are referred to as rumination. The conceptualization and operationalization of this term originates from the response styles theory (Nolen-Hoeksema, 1991). Rumination is defined as a mode of responding to distress where one focuses on one's negative feelings and problems. However, although rumination is a thinking style most typical for depression, similar thinking styles are found in other mental illnesses as well. In anxiety research, worry has been investigated as a key symptom. Although worry is typically described as future-oriented thoughts, and rumination typically past-oriented thoughts, the thinking styles are highly correlated (McEvoy et al., 2013). They share most characteristics, like being negative, frequent, and uncontrollable, and might be considered the same (McEvoy et al., 2013).

Ehring et al. (2011) and McEvoy et al. (2013) argued that although the content of the thoughts may differ somehow between the emotional disorders, repetitive negative thoughts (RNT) can be seen as a transdiagnostic thinking style. It is present in and characterizes most emotional disorders and general distress. Moulds et al. (2022) defined RNT as the overarching term of such thought processes, while rumination and worry are types of RNT. In the literature, RNT, rumination and worry are sometimes applied interchangeably (DeJong et al., 2016; Stein et al., 2009). In the present thesis I will use the term "repetitive negative thoughts" to address both depressive rumination and RNT more generally.

Repetitive negative thoughts are not just a symptom of mental illness (state), but also linked to the onset of depression and found to be a stable vulnerability trait in a person (Nolen-Hoeksema et al., 2008). In their recent review, Moulds et al. (2022) concluded that RNT are consistently associated with concurrent perinatal depression and anxiety in cross-sectional studies, while the evidence of the predictive value of RNT for onset of perinatal depression and anxiety is mixed. Further, RNT are associated with parenting stress in parents of children above infant age (Moreira & Canavarro, 2018). Exploring the content of the thoughts in postnatal RNT, Newby et al. (2021) found that the discrepancy between expectations and reality was the main theme, in addition to adjustment to the profound change and a sense of loss or mourning over how life used to be. RNT are also associated with parenting behavior and bonding, which I will review in its own section below.

Implicit attitudes

Early maladaptive schemas might not only affect romantic or social relations, but also the parent-infant relationship (Nordahl et al., 2019). Attitudes can be understood as schemas or beliefs based on previous experience. When having a child, schemas concerning infants or child rearing might be activated. Parents' own experiences with upbringing might therefore be activated and affect how the current situation is perceived. Parents' confidence and experiences of mastering novel situations might also affect their attitudes to their new role as a parent and to infants. Attitudes towards infants may influence parenting behavior (Keller et al., 2003). Although most will report positive attitudes towards infants when asked directly, some may have implicit negative attitudes towards infants. In fact, Sun et al. (2021) demonstrated that pregnant women's reported attitudes towards infant crying were not related to their implicit attitudes to the sounds of infant crying. Under stress, behavior becomes more automatized and situations are less elaborated, acting on implicit attitudes (Friese et al., 2008). Since the perinatal period is stressful for some, we included a measure of implicit attitudes to investigate its role on parental stress, depression, bonding and infant socioemotional development in the articles presented in this thesis.

Influence of demographic factors

As mentioned, socioeconomic status is related to both parental mental illness (O'Hara & Wisner, 2014) and infant development (Richards & Conte, 2020). Social support is found protective of prenatal depressive symptoms (Leigh & Milgrom, 2008; Racine et al., 2020), parenting stress (Chich-Hsiu et al., 2011; Racine et al., 2019; Östberg & Hagekull, 2000) and postnatal depressive symptoms (Racine et al., 2020). However, regarding bonding, Kinsey et al. (2014) found a negative effect of socioeconomic status. They posed that more educated women could be more likely to be honest about having both positive and negative feelings about their infant and being less biased by social desirability. Another possible explanation is that higher educated women have more demanding jobs, possibly interfering with bonding as it could take up cognitive capacity. Cuijlits et al. (2019) also reported a negative effect of education on prenatal bonding in mothers, but not on postnatal bonding. The association between education level and postnatal depressive symptoms varies between studies though (Norhayati et al., 2015).

Another important factor to consider in the perinatal period is parity. Maternal parity is found to be positively related to sleep duration in the infant (Kaley et al., 2012) and being protective of crying problems (Kurth et al., 2010). However, fathers are more likely to have high levels of bonding to their firstborn child than to later-born children, while parity benefits maternal bonding (de Cock et al., 2016).

Parental cognitions and parenting

Although genetic and biological factors are involved in the transfer of disturbance from parents to their children, it is also essential to understand the psychosocial mechanisms

involved to develop effective interventions. Therefore, examining how parenting behavior is affected by mental illness in the parent is highly relevant. Stein et al. (2009) argued the role of maternal cognition might be a key mechanism to examine, especially RNT (or "preoccupation" as Stein et al., 2009 calls it). Mothers who are preoccupied by their own negative thoughts might not be available for sensitive parenting behaviors.

DeJong et al. (2016) proposed a model to explain how depression affects parenting behavior through RNT, cognitive biases and cognitive control deficits. An interplay between reduced cognitive control and negative cognitive biases increases the amount of negative material being processed and ruminated on. Further, this decreases the emotional availability and sensitivity to the child. The parent is therefore less attuned and responsive to infant cues, which again may increase negative emotionality and regulation problems in the infant, giving the parent more negative experiences to notice and ruminate on. Parents are thereby less available to co-regulate and support the infant's development of self-regulation.

In accordance with the proposed theories, Stein et al. (2012) demonstrated that RNT affected maternal responsiveness in mothers with anxiety and, to a lesser degree, depression. Other empirical studies have found that RNT are negatively related to maternal bonding (Müller et al., 2013; Schmidt et al., 2017), maternal sensitivity (Tester-Jones et al., 2017), and parental problem-solving (O'Mahen et al., 2015). Both Stein et al. (2009) and DeJong et al. (2016) included attentional biases in their explanation of how parental cognitions could affect parenting and thereby infant development, but there is a lack of empirical studies in this area. A few studies have assessed attentional bias at the preliminary level (240 ms stimulus presentation) and found that early orienting toward distressed infant faces positively predicts maternal sensitivity (Dudek & Haley, 2020) and bonding (Pearson et al., 2011). These findings may indicate that parental sensitivity starts as an automatic or unintentional response at a preliminary level of processing. However, being caught up in negative material is associated with later levels of processing.

Aims of the thesis

The aims of the present thesis were to expand on previous research by exploring the role of parental cognitions in perinatal mental health problems, parent-infant relationship, and infant development. We wanted to do this from a transactional viewpoint, considering the dynamic interplay between parents and infants. Increased understanding of this interplay between characteristics in the parents, in the infant and in the relationship between them, and how they affect each other, is of high clinical relevance. Altogether, the main goal of the present thesis was to increase our understanding of how parental cognitions are important mechanisms in perinatal illness and transgenerational transmission of illness.

The aim of paper I was to investigate if early adversity and parental cognitions affected symptoms of depression and parenting stress postnatally.

The aim of paper II was to explore transactions between parents' cognitions, depressive symptoms, and parenting stress, and infant regulatory problems and social withdrawal, to uncover possible transmission of vulnerability.

The aim of paper III was to examine the effect of parental cognitions on the parent-infant relationship, specifically parental bonding, and parents' perception of infant temperament.

Methods

Design and participants

The Northern Babies Longitudinal Study (NorBaby) is a longitudinal observational study with an intervention, located in Tromso, Norway. The study had a prospective cohort design with six assessments. Pregnant women and their partners were recruited and followed through the pregnancy (T1-T3) and after birth until the baby was 7 months old (T4-T6). The NBO intervention took place after birth between T3 and T4 and had a non-randomized cluster-controlled design, as randomization was not possible in the routine practice setting. The intervention group consisted of families affiliated to two of the well-baby clinics in Tromsø municipality, while the control group belonged to the remaining four clinics and received care as usual.

Altogether we recruited 220 pregnant women and 130 partners (one female and 129 male). Like population-based studies in general (Enzenbach et al., 2019), also the NorBaby study suffers from participation bias. Those who volunteer to participate in a population-based study might have certain characteristics that are not present throughout the general population (Fowler, 2009). Indeed, the families included are mostly resourceful families with above average income, higher education, and low levels of psychiatric symptoms, see Table 1 for participant characteristics. The majority stated that the pregnancy was wanted and were living together with their partner. There was some attrition during the study, and the drop out was higher among partners. Attrition analyses were done for the separate articles.

Procedure

Participants were recruited through midwife-services both in the communal health care services (FHT) and at the University Hospital of Northern Norway (UNN). All pregnant women and expecting partners living in the commune of Tromso who spoke Norwegian were eligible to participate. Midwives asked the expecting mothers if they were interested in knowing more about the study and if they were they received a pamphlet to fill out. Pamphlets were collected by the research team, and interested women were phoned to give more information about the study and invite them and their partner to participate. If they agreed to participate, they were invited to the first assessment (T1) either at the UiT the Arctic University of Tromso (UiT) or somewhere more convenient to them.

Assessments during pregnancy (T1-T3)

At the first assessment (T1) participants met with a member of the research group and were given information about the study before they signed their informed consent. They then completed two cognitive tasks and answered demographic information and a survey (see flowchart of data collection, figure 1, for details on which questionnaires were completed at what timepoint). T1 was completed between week 13-39 of gestation (*mean* 23.0, *median* 23, *SD* 3.62). The wide range is due to late recruitment of some participants. When they were

recruited late, we prioritized the T1 assessment as this contained all demographic information and skipped T2 (and T3) when there was not enough time. Standard routine was to answer T1 at recruitment, T2 between week 24-30 of gestation, and T3 after week 31 of gestation, preferably with at least 4 weeks between assessments.

The second (T2) and the third assessment (T3) were sent to participants by email, and their ID was sent by SMS. T2 was completed between week 24-37 (*mean* 28.7, *median* 28, *SD* 2.48) and T3 between week 31-41 of gestation (*mean* 34.6, *median* 34, *SD* 2.26). Participants informed the research group when they had given birth. If they did not inform the group, a SMS was sent to them about two weeks after term asking if they had delivered.

The Newborn Behavior Observation Intervention (NBO)

The maternity ward at the UNN received monthly term lists over the participating women. Participants belonging to the intervention group were highlighted so that the maternity ward knew who to conduct the NBO with. The intervention group received the NBO consultation three times. The first during the first 48 hours after birth, completed at the maternity ward or the patient hotel. The second during a routine home visit 7-10 days postdelivery from the public health nurses, and the third at the well-baby clinic when the infant was 4 weeks old. The control group received care as usual.

Assessments after birth (T4-T6)

Participants received a gratulation-card and present for the baby by post. They also received diurnal clock-forms to be filled out 6 weeks after birth. The T4 survey was sent by email 6 weeks postdelivery and completed week 6-15 after birth (*mean* 8.17, *median* 7.71, *SD* = 1.96). For the T5 assessment participants were phoned and invited to a session either at the Department of Psychology (DP), UiT or in their home to film the parent-infant interaction. The survey was sent by email and completed between week 16-39 (4-9 months) after birth (*mean week* 21.25, *median week* 20.43, *SD* 3.49).

For the T6 assessment, participants were phoned and invited to a neuropsychological screening (Bayley) of the baby at the DP, UiT. This session was also filmed for the scoring of the Alarm Distress Baby Scale (ADBB) and heart rate variability (ECG) of both the infant and one of the parents was measured during the screening. The T6 survey was sent by email and completed between week 25-42 (6-10 months) after birth (*mean week* 30.69, *median week* 29.57, *SD* = 3.18).

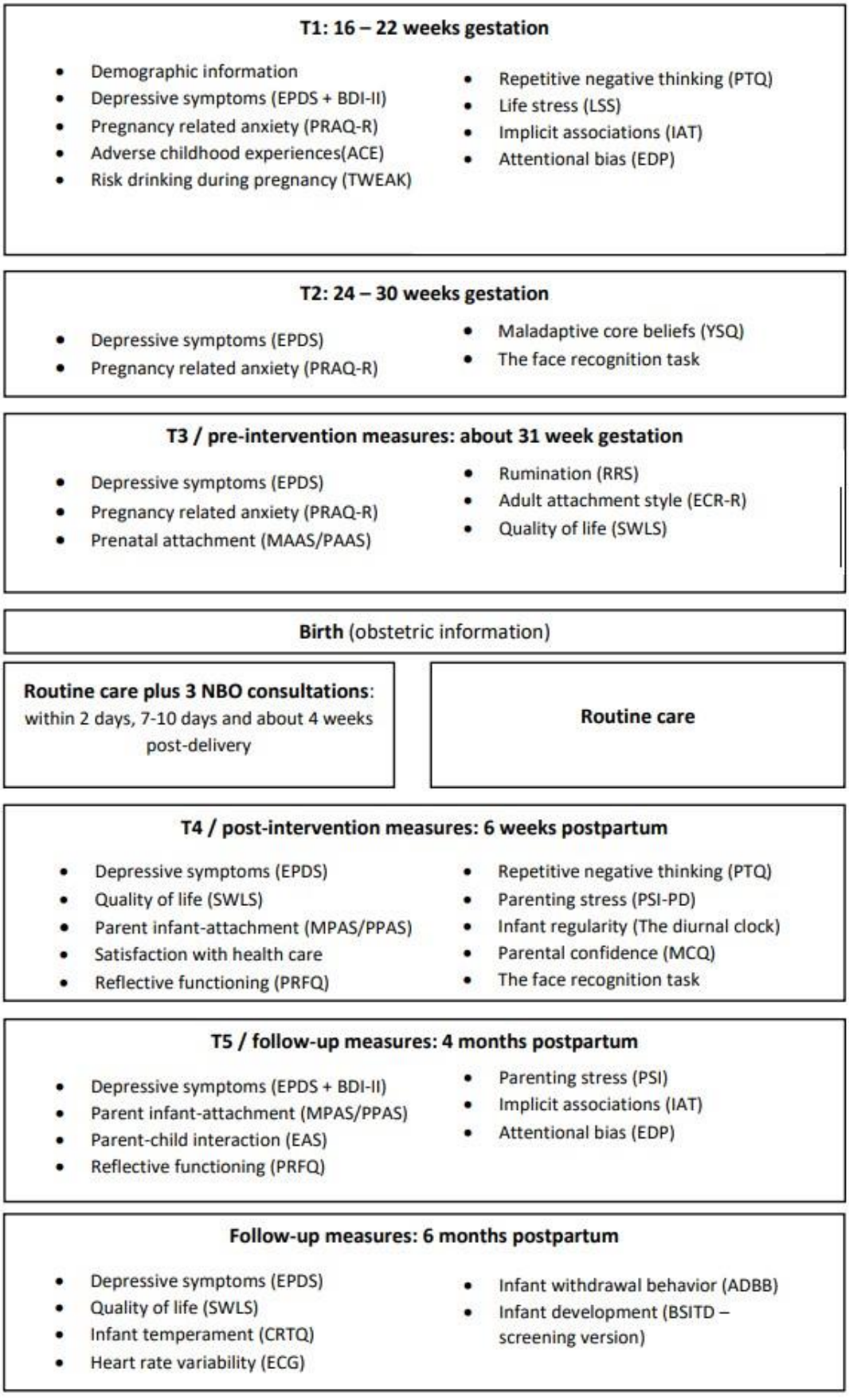

Figure 1. Flowchart of data collection

Measures

Only measures relevant for the present thesis will be described. For a description of all measures applied in the study, see Figure 1 and the protocol article of the NorBaby-study (Høifødt et al., 2017). We applied Norwegian translations of all measures.

Demographic information

As we did expect socioeconomic status to affect perinatal mental health and development, certain demographic factors were essential. Demographic information included gender, age, number of children, education, income, history of depression, and support from family and friends. Education was measured on an ordinal scale from low (no high school) to high (4 years or more from university/college). Income was measured ordinally for the household, from very low (below 150,000 NOK/ $17,550) to high (above 1,000,000 NOK/117,000 USD). The average yearly income for females in Norway in 2015 (when data collection begun) was 477,600 NOK/55,878 USD (SSB, 2016). To measure history of depression participants answered the question "Have you ever been depressed or sad almost every day, for a period of at least two weeks?". Support from family and friends were assessed with "Do you have enough friends/family to help and support you?", with answer options yes or no.

Edinburgh Postnatal Depression Scale (EPDS)

The scale was developed to screen for depressive symptoms postnatally (Cox et al., 1987). Cox et al. (1987) saw a need for a scale that specifically targeted postnatal depression, and not depression in general. This is because most physiological symptoms, like the lack of energy, loss or gain of appetite, weight loss or gain, and less sexual interest, are normal in the postnatal period, and therefore not suited to detect depression in this period. Today, the scale is widely used throughout the perinatal period, and validated for prenatal use as well (Field, 2017; Lydsdottir et al., 2019). Although developed for women, the EPDS has also commonly been applied to investigate perinatal depression in men (Goodman, 2004; Massoudi et al., 2013). However, although the scale is found sensitive to major depression in men, it might measure more of general psychological distress in men than in women (Massoudi et al., 2013).

The EPDS consists of 10 items assessing common depressive symptoms, e.g., "In the past 7 days, I have been so unhappy that I have had difficulty sleeping". The scale also includes two items assessing anxiety symptoms ("I have been anxious or worried for no good reason" and "I have felt scared or panicky for no very good reason"). Each item is scored from 0-3 points and total scores range from 0-30 points. A cutoff of a score ≥10 indicates possible depression, and has been the recommended cutoff score in both Norwegian samples (Eberhard-Gran et al., 2001; Glavin et al., 2009) and for men (Carlberg et al., 2018). We applied the Norwegian translation of the scale, which has also been validated in Norwegian samples previously (Eberhard-Gran et al., 2001). In NorBaby, participants completed the EPDS at all time points,

allowing us to examine depressive symptoms both pre- and postnatally. For the present thesis, EPDS from T1 and T4-T6 were applied. Internal consistency was good at all assessments (McDonald's ω at T1 = .80, T4 = .79, T5 = .83, and T6 = .84).

Adverse Childhood Experiences Questionnaire (ACE)

To assess early adverse experiences that might be involved in the development of vulnerability, we included the Adverse Childhood Experiences Questionnaire (ACE). The ACE is a 10-item questionnaire to assess the number of adverse childhood experiences one could have experienced. The 10 items are examples of different adverse experiences, like abuse, neglect or household dysfunction. Participants answered yes or no to the ten items, and total scores range from 0-10. Felitti et al. (1998) found a strong association between ACE scores and health. The risk for a range of mental and somatic illnesses increases with each adverse childhood experience, and the cumulative risk can be substantial. As the total score reflects a count of how many ACEs one has been through, internal consistency is less relevant, however the McDonald's ω was acceptable (.74).

Parenting Stress Index (PSI)

Parenting stress is associated with both parental and infant health. The Parenting Stress Index (PSI; Abidin, 1995) consists of 101 items that assess the level of stress parents experience in their parental role. The index has two subdomains, the parent domain (PD) and the child domain (CD). The PSI-PD consists of 54 items and measures experienced stress in the parental role, for example "I feel overwhelmed by the responsibility of being a parent". Items are scored on a 5-point Likert scale, and higher scores indicate higher stress levels. Participants answered the parent domain at both T4 and T5, and internal consistency was excellent at both timepoints (McDonald's ω at T4 = .92, T5 = .93).

The PCI-CD consists of 47 items and measures child characteristics that might contribute to stress, for example "My child appears disorganized and is easily distracted". Items are scored on a Likert scale from 1-5 where a higher score on the child domain reflects more negative perceptions of their child's characteristics and behavior, meaning the infant is perceived as having a more difficult temperament. Although not designed as a measure of temperament, the PSI-CD measures characteristics typically described as infant temperament (adaptability, mood, demandingness, distractability/hyperactivity, acceptability and reinforces parent; Olafsen et al., 2018). While other questionnaires designed to specifically measure infant temperament have struggled with poor or questionable internal consistency (Landsem et al., 2020; Olafsen et al., 2018), the PSI-CD in the present sample had excellent internal consistency (MacDonald's ω = .91). The scale was completed at T5.

Maternal/Paternal Postnatal Attachment Scale (MPAS/PPAS)

The Maternal/Paternal Postnatal Attachment scale (Condon & Corkindale, 1998) is a measure of parental bonding. It consists of 19 items concerning parents' thoughts and feelings towards their infant. Items are rated either on 2-, 3-, 4- or 5-point scales, and all items are therefore

recoded to scores from 1 (poor bonding) to 5 (strong bonding) to ensure equal weighting of the items. This gives a total range from 19-95. The measure uses the term "attachment" in its name, however this is a synonym to bonding, and previous research has used both terms when discussing the emotional tie from a parent to their infant (see Bicking Kinsey & Hupcey, 2013 for details). The present thesis will apply the term "bonding" to not confuse it with the infant's attachment to their parents. Both the MPAS and the PPAS had good internal consistency (McDonald's ω MPAS = .85, PPAS = . 82).

Perseverative Thinking Questionnaire (PTQ)

The Perseverative Thinking Questionnaire (PTQ; Ehring et al., 2011) is a transdiagnostic questionnaire that measures repetitive negative thoughts. As opposed to more diagnosis specific measurements that assess depressive rumination or anxious worry, the PTQ is not content specific. It measures if thoughts are repetitive, intrusive, and difficult to disengage from, if they are perceived unproductive and capture mental capacity, without regarding the content of the thoughts. The questionnaire consists of 15 items that are statements about one's thoughts, e.g., "The same thoughts keep going through my mind again and again". Answer options range from 0 (never) to 4 (almost always), giving a total range of 0-60 where higher scores indicate higher degrees of repetitive negative thinking. The internal consistency of the scale was excellent (McDonald's ω = .95).

Implicit Association Test – Single Category (SC-IAT)

Explicit attitudes or what we report when asked directly, are distinguished from implicit attitudes. This is because implicit aspects of attitudes often do not concur with self-report, especially in socially sensitive topics (Greenwald et al., 2009). When we desire to appear in a certain way, open-minded and tolerant for example, we would report positive attitudes to other cultures or religions, while at the same time we might have negative automatic associations to these cultures. Therefore, our implicit attitudes are examined through implicit associations, i.e., how quickly one associates a stimulus with another one or a category (Greenwald et al., 2009).

The Single Category Implicit Association Test (SC-IAT; Karpinski & Steinman, 2006) is a modified version of the Implicit Association Test (Greenwald et al., 1998). The test was applied as a measure of implicit associations to neutral infant faces (image stimuli). The faces were taken from the Tromso infant face database (Maack et al., 2017). In the test, participants were asked to categorize words as either positive or negative. This was done by sorting them either to the left or the right side of the screen using the "E" and "I" key. In addition, they were to sort the infant faces either to the same side as the positive or the negative words.

Stimuli (words or infant faces) were presented in random order on the screen, one at a time. Order of conditions (infants to the positive or negative side) were randomized. Response time was measured, and the difference between conditions is seen as a measure of implicit associations. There is a positive association toward infants when the response times are

shorter for sorting the infant faces to the same side as the positive words. There is a negative association toward infants when the response times are shorter for sorting the infant faces to the same side as the negative words.

Emotional Dot-Probe Task (EDP)

This is a modified version of the dot-probe task (MacLeod et al., 1986). We applied it to measure attentional bias to infant faces. The task presents participants with images of sad, happy, and neutral infant faces one at a time, on either the right or left side of the screen. Images are followed by an x on either the same or the opposite side of the screen. Participants have then to press a key (either "E" for left side or "I" for right side) to indicate where the x appeared.

Response time is recorded. If participants respond faster on congruent trials (x appears on the same side of the screen as the stimulus image) than on incongruent trials (x appears on the opposite side), then the stimulus image caught their attention and they disengaged more slowly. Reaction times are calculated for each emotion (happy, sad, neutral infants), and compared. Images were taken from the Tromsø infant face database (Maack et al., 2017). Reliability was not calculated for the whole sample, however it was analyzed for a subsample of NorBaby in a previous study, see Bohne et al. (2021) for details.

Diurnal Clock

To assess infant regularity, we decided to use a measure that was not so dependent on the parents' interpretation or description of the infant's behavior, and so we applied a parental observation of their infant's behavioral state. The diurnal clock (DC; Sarfi et al., 2009) is a diary to register the infant's daily rhythm and behavioral state for one day and night. Each hour in the DC is divided into quarters, and parents color each quarter according to the state the infant was in at the time. There were four states to record; sleep, awake and alert/pleased, awake and uneased/fuzzy, and crying. In the NorBaby study parents filled out the DC over to consecutive days.

Alarm Distress Baby Scale (ADBB)

The ADBB was developed to screen for social withdrawal in infants (Guedeney & Fermanian, 2001). While social withdrawal to some extent is part of the normal infant behavior to regulate the flow of social interaction, sustained withdrawal might be a warning sign of suboptimal development (Guedeney et al., 2013). Sustained social withdrawal can be caused by a range of conditions, e.g. autism, attachment disorders, infant depression, somatic disease (Guedeney & Fermanian, 2001). Parents' mental health problems are also found related to withdrawal behavior in the infant (e.g. Braarud et al., 2013; Burtchen et al., 2013).

The ADBB scale scores signs of sustained social withdrawal in the infant on eight categories; eye contact, facial expressions, vocalization, general activity, self-stimulation, response to stimulation, attraction, and relationship. Each category is rated from 0-4, giving a total range

of 0-32. A total score of 5 is found to be the cutoff score that ensures highest specificity and sensitivity (Guedeney & Fermanian, 2001), where scores at or above 5 are of clinical concern.

In NorBaby, videos of the infants during neuropsychological assessment were scored according to the ADBB by two independent coders. The primary coder was trained and certified before the scoring started, whereas the secondary coder was an experienced ADBB-trainer and had coded ADBB-videos for research purposes before. The primary coder scored all videotapes, while the secondary coder scored 20% of the videos, to allow for reliability checks along the way. Videos were randomized into nine blocks, and reliability was checked after completing each block. Whenever the two scorers disagreed (difference in sum score >2), they would be notified and then discuss and agree on what the correct score would be before proceeding to the next block. The interrater reliability for the original scores was acceptable (Kendall's $\tau = .59$). Disagreement only occurred twice and was easily solved by discussion. A third experienced ADBB-trainer served as a supervisor for the newly certified primary coder, to allow her to calibrate regularly and discuss ambiguous videos.

Data analysis

Power calculations

Power calculations were done for the NorBaby-study as a whole, and not to the specific articles of the present thesis. The sample size was calculated based on differences between the NBO-intervention group and the standard care group on the Edinburgh Postnatal Depression Scale (EPDS) maternal score, the Parenting Stress Index (PSI), the Parental Reflective Functioning Scale (PRFQ) and the Maternal Postnatal Attachment Scale (MPAS) 6 weeks postdelivery. Based on the pilot study by Nugent et al. (2014) and some regression to the mean, we expected a small to medium effect size ($f2=0.07$). A MANOVA with the four outcome variables can detect a difference between the groups with a power of 0.80 given a group size of $n=176$. With an estimated dropout of 10%, we aimed at recruiting 200 women, and ended up with 220. Sample size was not based on the number of men recruited, as their allocation to the two groups was less predictable than for mothers. The estimation was based on an α-level of 0.05.

Preregistration

All studies in the present thesis were preregistered prior to data analyses. Preregistration was done at the Open Science Framework (OSF), see links in each paper. Anonymized datasets are also available at each paper's OSF-page.

Data Analyses

Data analyses were done using R (R Core Team, 2020), Jamovi (jamovi, 2020), and Jasp (JASP, 2020).

Paper I

First, analyses of attrition were performed to investigate participation bias and possible differences between groups that might affect results. Differences between the intervention group and group who got standard care was also tested. Second, descriptive data was inspected to check assumptions, and where assumptions were violated, we decided to apply robust regression. However, this did not change the main results. To investigate predictors of pre- and postnatal depressive symptoms (EPDS) and parenting stress (PSI-PD), we therefore applied hierarchical bootstrapped regression. To investigate gender differences, we also ran the regression analyses separately for men and women. Third, mediation analyses were performed to investigate mediating effects of prenatal and postnatal depressive symptoms. Post-hoc we decided to compare a group with 3 or more ACEs to a matched control group (applying the MachIt package in R Ho et al., 2011), and ran t-tests for independent samples on measures of depression, parenting stress, RNT and attentional bias.

Paper II

Descriptives and reliability checks of the measures were first ran in Jamovi (jamovi, 2020). To build our specified transactional model, the lavaan package for structural equation models in R (Rosseel, 2012) was applied. We first tested a model with all hypothesized paths, we then performed reduction of insignificant paths and variables to yield a better fit of the model. We also ran the model separate for mothers and fathers.

The hypothesized model included paths from measures at T1 (repetitive negative thinking, implicit associations, parity, and social support) to the T4 measures (depressive symptoms, parenting stress and regulatory problems). As depressive symptoms and parenting stress were measured at three and two timepoints respectively, autoregressive paths of the EPDS and the PSI-PD were specified. There were also cross-lagged paths between these measures. Further, paths from T4 measures to T5 measures (depressive symptoms, parent, and child domain of parenting stress), and from T5 measures to T6 measures (depressive symptoms and signs of social withdrawal) were specified. Covariation between measures at the same timepoint was also entered. Goodness of fit was evaluated based on a comparative fit index (CFI), and standardized root mean square residual (SRMR). The combination of CFI and SRMR is recommended for samples < 250 (Hu & Bentler, 1999), and the SRMR is recommended for data based on Likert scales and chosen here (Hooper et al., 2008).

Paper III

Descriptives and reliability checks were performed. We then conducted robust regressions to investigate parental cognitions during pregnancy as predictors of bonding after birth (MPAS/PPAS). We investigated bonding along with prenatal RNT as predictors of the child domain of the parenting stress index (PSI-CD) at T5, while controlling for depressive symptoms and infant regulatory problems. Analyses were run separately for mothers and fathers. Finally, we conducted a regression model to examine predictors of discrepancy in bonding within couples. Analyses were performed in Jasp (JASP, 2020) and R (R Core Team, 2020).

Ethical considerations

The NorBaby-study followed the standards of the WMA Declaration of Helsinki – Ethical Principles for Medical Research Involving Human Subjects and was approved by the Regional Committee for Medical and Health Research Ethics in Northern Norway (2015/614). All participants received both oral and written information about the project. Parents gave informed consent for themselves and their infant's participation. Participants received unique IDs, which they used for questionnaires, cognitive tests, and observations. The sheet connecting IDs with names was securely stored separately from the data. Only authorized personnel from the project group had access to this sheet. We used a university survey system to ensure secure data storage. The survey is now closed, and data sets are password protected and stored according to UiT guidelines.

During the data collection, it was emphasized that the participants were free to decline the researcher´s involvement. They could at any time withdraw from the study or skip an assessment. None of the assessments or interventions involved any health risks.

Summary of papers

Paper I

Bohne, A., Høifødt, R. S., Nordahl, D., Landsem, I. P., Moe, V., Wang, C. E. A., & Pfuhl, G. (2022). The role of early adversity and cognitive vulnerability in postnatal stress and depression. *Current Psychology*. https://doi.org/10.1007/s12144-021-02651-1

The purpose of this paper was to establish if adverse childhood experiences and parental cognitions served as vulnerability factors for parental mental health among the participating parents. As we expected cognitive vulnerability in the parents to affect the parent-infant relationship and the infant development, it was a necessary first step to examine if we could observe cognitive vulnerability in some of the parents of our sample. Paper I therefore investigated adverse childhood experiences, repetitive negative thoughts, and attentional bias as predictors of parenting stress and pre- and postnatal depression.

Results showed that repetitive negative thoughts was a significant predictor of both depressive symptoms and parenting stress, while attentional bias and adverse childhood experiences were not. Some demographic factors turned out to be significant protective factors, namely education, social support, and parity, especially in mothers. Although not significant in the regression analyses, parental early adversity had an indirect effect on postnatal depressive symptoms and parenting stress, mediated by prenatal and postnatal depressive symptoms, respectively. However, post hoc we decided to compare a group of parents with several ACEs with a matched group with no ACEs and found no differences in stress or depressive symptoms.

In conclusion, this paper established prenatal repetitive negative thoughts as a significant vulnerability factor for postnatal stress and depression, independent of the presence of prenatal depressive symptoms or ACEs. This indicates that RNT has a significant effect on parents' mental health postnatally, regardless of their mental health during pregnancy or early adversity.

Paper II

Bohne, A., Høifødt, R. S., Nordahl, D., Landsem, I. P., Vannebo, U. T., Holstad, S. L., Moe, V., Wang, C. E. A., & Pfuhl, G. (under review). Transaction of parental cognition, stress and depressive symptoms, and infant regulatory problems.

The purpose of this paper was to investigate transactions between parents and their infant during the first 7 months after birth. We posed that infant regulatory problems, parental cognitions, stress, and depression might reinforce each other in vicious cycles in the early

parent-infant relationship. Paper II therefore tested a transactional model for understanding and disentangling these relationships.

From pregnancy, four variables were entered as predictors: repetitive negative thoughts, implicit associations to infants, parity, and social support. Postnatally, relations between measures of parental stress and depressive symptoms, infant regulatory problems, and social withdrawal were investigated.

Results demonstrated that parents' repetitive negative thoughts during pregnancy predicted their stress and depressive symptoms in the postnatal period. Infants' regulatory problems did not predict parental well-being. Repetitive negative thoughts also affected how parents perceived their infant's behavior at five months, while the infants' regulatory problems at two months did not. For mothers, parity was protective of stress and depressive symptoms, and infant regulatory problems. Social withdrawal in infants was not significantly associated with any of the predictors.

Interestingly, we could not demonstrate any transactions from the infant to the parents. Infant regulatory problems had no significant effect on any of the parental variables, and neither did parents' report of infant behavior. Parents' well-being and experience of their child was affected by their own negative thinking, and not by their infant's actual behavior. Accordingly, parental cognition and mental health should be considered when families struggle to adapt in the perinatal period.

Paper III

Bohne, A., Nordahl, D., Høifødt, R.S., Moe, V., Landsem, I.P., Wang, C.E.A., Pfuhl, G. (in press). Do parental cognitions during pregnancy predict bonding after birth in a low-risk sample? *Frontiers in Psychology.*

The purpose of the third paper was to investigate how cognitive vulnerability in the parents affected their relationship with their infant, namely parental bonding, and perception of infant temperament. We were also interested in differences between mothers and fathers in their parent-infant bonding.

To assess the influence of cognitive factors on bonding, demographics, repetitive negative thinking, attentional bias, and implicit attitudes to infants during pregnancy were entered as predictors of bonding after birth in a regression analysis. Further, bonding, infant regulatory problems, and depressive symptoms at two months postnatally were investigated as predictors of parents' perception of infant temperament 4 months postnatally. A mediation analysis was performed to examine the indirect effect of maternal RNT on perception of infant temperament through bonding.

Results showed that mothers and fathers differed on several variables. Parity was beneficial for bonding in mothers but not for fathers. Higher levels of mothers' repetitive negative thinking during pregnancy predicted weaker bonding, which was a non-significant trend in fathers. For fathers, higher education predicted weaker bonding, but not for mothers. Mothers' perception of their infant temperament was significantly affected by bonding, but for fathers, their depressive symptoms were the only significant predictor of perceived infant temperament.

In conclusion, for mothers, their relationship with their infant (bonding) is essential for how they experience their infant's temperament, while for fathers their own wellbeing might be the most important factor. Health care providers should screen parents' thoughts and emotions during pregnancy to help facilitate optimal bonding.

Discussion

The results of the three articles have several interesting aspects worth discussing. Firstly, I will discuss cognitive vulnerability for parental mental health, the parent-infant relationship and infant socioemotional development in the perinatal period. Then, I will discuss gender differences that have emerged. Briefly, I will discuss results considering the transactional model. I will go through methodological reflections regarding the sample and measurements. Finally, implications for health care services will be discussed before reaching conclusion.

Main findings

The present thesis has established repetitive negative thoughts (RNT) as an important cognitive vulnerability in the perinatal period. RNT during pregnancy predict both parental stress and depressive symptoms, and the parent-infant relationship after birth. It is positively associated with symptoms of depression and parenting stress in the parents, and it is associated with weaker maternal bonding and more negative perception of infant temperament. Further, we found that sociodemographic factors play an important part for the parents own mental health and well-being and affects infant regularity and parental bonding. Specifically, social support was confirmed as protective of parental well-being for both mothers and fathers. Maternal parity benefitted infant regularity, maternal bonding, and maternal mental health, while paternal parity and education was negatively related to paternal bonding.

The present results were based on a population study, where the sample was a resourceful one with high socioeconomic status (SES) and low levels of depressive symptoms. This is important to keep in mind when interpreting results. Results could differ in a sample with higher psychosocial risk.

Cognitive vulnerability in the perinatal period

Parents' stress and depressive symptoms in the perinatal period is predicted by RNT. This is in line with research of non-perinatal depression that has established RNT as an important precursor and vulnerability factor for depressive episodes (Joormann & Gotlib, 2010; Koster et al., 2011; Nolen-Hoeksema et al., 2008). Regarding perinatal depression, both Barnum et al. (2013) and Schmidt et al. (2017) also found RNT related to depression throughout the perinatal period.

Regarding the parent-infant relationship, RNT were predictive of both bonding and the parents' perception of infant temperament, at least for mothers. This indicates that parents who are caught up in negative thoughts to a higher degree, might have less cognitive resources or "room" for positive experiences or thoughts of their infant. This finding is in line with Stein et al. (2009) who proposed that maternal "preoccupation" might be the mechanism that leads to transgenerational transmission of vulnerability, and the model by DeJong et al. (2016) that illustrates how being caught up in negative material can lower parental sensitivity.

Parents whose cognitive capacity is occupied by negative thoughts are probably not as available, sensitive, and responsive as parents who have lower levels of RNT. Unfortunately, such a preoccupation can cause parents to miss out on social initiation and joyful expressions from their infant, which could have strengthened the bonding and given a more positive perception of the infant's temperament.

The present thesis cannot answer how RNT develop as a stable trait in the individual in the first place, but we did find that adverse childhood experiences had an indirect effect on both postnatal depressive symptoms and parenting stress, mediated by pre- and postnatal depressive symptoms respectively. Also, our previous research showing an association between early maladaptive schemas and prenatal bonding suggests that early adverse experiences play a part in forming vulnerability in the perinatal period (Nordahl et al., 2019), because maladaptive schemas is thought to be the concequense of early adversity. A possible latent vulnerability factor is also the personality trait of neuroticism, as this is related to emotional disorders, parenting stress and RNT (Deater-Deckard, 2004; Nolan et al., 1998; Roberts et al., 1998).

The other proposed cognitive vulnerability factors, attentional bias and implicit attitudes, turned out not to be significant predictors for mothers' depressive symptoms or parenting stress, or fathers' parenting stress. An attentional bias for happy faces was however a significant predictor of fathers' depressive symptoms, suggesting that fathers who disengaged faster from happy faces had higher levels of depressive symptoms. Implicit attitudes came close to significance for maternal bonding, with an effect size like that of parity, suggesting that negative implicit attitudes to infants might affect the bonding process.

However, these results are vague and difficult to conclude. As seen in our previous research (Bohne et al., 2021), there might be some differences in attentional bias between depressed and non-depressed groups in the perinatal period, and we cannot rule out the possibility that this is a vulnerability trait based on the present results. However, these cognitive factors, as measured by cognitive tasks, might not be suited for predicting individual differences (Dang et al., 2020). I will elaborate on methodology in its own section below.

Parental report of infant behavior

As the articles in the present thesis demonstrate, parental report can be affected by the parents' own mental health to a higher degree than actual problems in the infant. Infant regularity was not related to parents' perception of infant behavior, while depressive symptoms for fathers and bonding and RNT for mothers were. Parents' experience of their infant is colored by how they themselves are doing. This is important knowledge for health professionals meeting parents who report difficult infant behavior.

In fact, many of the well-known findings of how illness transfers from parents to children are based on findings where parents report both their own emotional state and the child's (see for example Tester-Jones et al., 2015). However, there is good reason to question the validity of

measuring children's internalized and externalized problems by parental report. A depressed mother will naturally experience her child's temper tantrums more exhausting and challenging than a mother who is healthy and well. Their report of their child will look different, even though the tantrums may objectively look alike. Therefore, we have been careful to explicitly state that the PSI-CD is the parents' perception of infant behavior or temperament, and not treat this measure as "true" or objective measure of infant temperament.

However, concerned parents should always be listened to, because the concerns might come from problems in the infant, the parents themselves, the family relationships, or a combination, and they might need intervention. No matter the cause, their worry itself can potentially harm the parent-infant relationship, as the worry might take up cognitive capacity or color how they perceive their infant, leading to a self-fulfilling prophecy, where parents are preoccupied, and the infant's needs are not met.

Gender differences

In line with emotional disorders in the general population, women in NorBaby reported higher levels of depressive symptoms and repetitive negative thoughts as compared to the men. Mothers also reported stronger bonding, which is not so surprising based on the mothers' role during the first months. However, both mothers and fathers reported high levels of bonding in general.

Interestingly, parity was the source of several gender differences. It had different effects on mothers and fathers regarding their mental health, infant regularity, and the parent-infant relationship. For mothers, parity was protective of both mental health (depressive symptoms and parenting stress) and the infant's regulatory problems. This was not the case for fathers. This indicates that fathers might benefit less from their previous experience with child rearing. Other factors might affect fathers' mental health to a larger degree, than their experience with having children. Fathers' depressive symptoms might be more dependent on their partner's depressive symptoms and the marital relationship (Bergström, 2013; Goodman, 2004), rather than how experienced they are in their parental role. Perhaps the fathers' role during the early months is more characterized by supporting the mother, taking care of previous children, arranging daily life, while the mother is occupied with the newborn. Goodman (2004) also suggests that fathers' postnatal depression might develop later during the first year than in mothers, possibly dependent on how the entire family is coping during the first months.

Further, parity predicted stronger maternal bonding, but weaker paternal bonding. This is in line with previous research (de Cock et al., 2016) that has found mothers to bond more strongly when it was not their first child, while the reverse applied for fathers. The roles of the mother and father during the early months might be essential, as the mother typically spends more time with the newborn.

Transactions in the perinatal period

Opposed to what we had expected, we were not able to identify transactions between parental depressive symptoms and infant development. Regulatory problems in the infant did not predict parents' mental health, and parents' mental health did not predict signs of social withdrawal in the infant. From this, there are several indications. Parents' mental health seems to be affected by their own RNT to a larger degree than the infant's behavior, at least during the early months. This indicates that mild symptoms of depression and parenting stress are not so detrimental to infant development in the early months after birth, which intuitively makes sense, especially since our sample is a resourceful one. This is encouraging to parents struggling in the perinatal period, and an important message to health professionals to care for the parents and not just the infant in this period.

One can imagine that infants with a neurodevelopmental vulnerability, for example premature infants, where regulation problems might be more persistent beyond the early months, could have a stronger effect on parental stress and depression. Transient regulation problems are normal (Cierpka, 2016) and mostly, parents and infants adapt accordingly. Even though such periods can be exhausting, it might not be so detrimental to parental mental health as more longlasting regulation difficulties. As we only measured regularity at one timepoint in NorBaby, we cannot investigate more persistent regulation problems in the present sample.

Further, parental stress and depressive symptoms were not related to signs of social withdrawal in the infants. Possibly, this can be explained by the resourceful sample, where levels of depressive symptoms were not severe. The number of infants with heightened scores of social withdrawals was also low. Therefore, it is difficult to conclude. We might have seen an effect of parental illness on infants in a less resourceful sample with more severe levels of depression and withdrawal. However, we must not let the encouraging result slip; it seems parents with depressive symptoms and high stress levels can be fully capable of sensitive parenting in support of their infant's development.

Despite the lack of expected transactions between parental illness and infant development, maternal parity did predict regulatory problems in the infant. This is in line with previous research (Kaley et al., 2012; Kurth et al., 2010; Petzoldt et al., 2016), and suggests there might be an underlying transaction where mothers' behavior is affected by previous experience, and further affects their infant's behavior. It is probable that experienced mothers are better, or at least more confident, in reading infant cues and providing effective soothing and solutions. This in turn, may support the infant in successful regulation and transmission between behavioral states, and the infant may not have to signal distress for prolonged periods.

Of note, social support was an important protective factor for parents, highlighting transactions between the inner family and their social network.

Unfortunately, the interaction data was not ready in time for the present thesis. It will be interesting to examine if parental cognitions, stress, and depressive symptoms affect parenting and the parent-infant interaction.

The NorBaby sample

The present study is a population study, and as with all population studies, it suffers from a participation bias where mostly resourceful families have participated (Enzenbach et al., 2019). This reduces generalizability of the results. The sample mostly had high socioeconomic status, with good income, higher education, and a social network (see Table 1). There were few participants belonging to cultural minorities, most reported the pregnancy as wanted and were in a relationship. Despite an a priori power calculation, results should therefore not be overinterpreted. There were few participants with depressive symptoms, at least with severe levels of symptoms. Similarly, there were few infants above cutoff for social withdrawal.

Further, analyses might be underpowered, especially the ones with men only. We had fewer male participants to begin with, and larger attrition among partners. Therefore, some effects might not have reached significance. Possibly, the attrition among partners is caused by most partners working full time and thereby not finding the time to participate, while the mother was on maternity leave during data collection. As our results highlight several gender differences, and we know that fathers have a unique effect on infant development (Fredriksen et al., 2018), further research should make sure to recruit large samples of men to investigate perinatal questions.

Other than the gender difference, where attrition was higher among fathers, the missing group at T4 was also significantly less educated. However, there was no significant difference in the level of income between the groups. Perhaps more importantly, the groups did not differ in their level of depressive symptoms at T1, their history of depression, or amount of adverse childhood experiences. Thereby, there was no indication that we lost a more vulnerable part of our sample.

In line with the transactional model, the social context is important when studying development (Sameroff, 2009b). Speaking from an international perspective, the welfare system in Norway is one of the best. Maternity/paternity leave is generous and funded by the state. Parents can stay home with their infant with full salary for 49 weeks, or 59 weeks with 80 % payment (Arbeids- og inluderingsdepartementet, 1997). After this year, all children are entitled to a place in a kindergarten, where there is at least one adult per 3 children under 3 years old (Kunnskapsdepartementet, 2006). Health care during pregnancy is free, and so is health care for children. The sample of NorBaby is thereby a privileged one, not just based on their SES, but because they live in a country where even the less resourced families have a minimum of economic security. This might affect the levels of depressive symptoms and parenting stress, and infant development, as there are few external stressors in the society. It is

also important to note that participants were mainly people living in the city of Tromso. Situated in the Arctic, the culture in Tromso might differ from other parts of Norway. Tromso might be more rural than other parts of the country, and at the same time more urban than most of Northern Norway. Altogether, there are characteristics of the present sample that might reduce generalizability to other samples. However, findings regarding levels of depression and infant withdrawal are like findings from other parts of the Nordic countries (Braarud et al., 2013; Puura et al., 2010).

Finally, I will note that the present study only recruited one same-sex couple. Therefore, we could not investigate if the gender differences that emerged were actual gender differences or differences related to being the birthparent or not. This is however an interesting question that further research can address.

Methodological reflections

NorBaby relies on several types of measurements. We believe this range of measurements is a strength of the study, however they all come with certain challenges. I will in the following reflect on methodological issues.

Self-report and common method variance

Self-report measures are always potentially affected by response bias due to social desirability. Participants might want to appear aligned with social norms, perhaps more well-functioning or with less controversial attitudes than they actually have, and thereby might answer accordingly (Brenner, 2020). However, one would expect anonymity to reduce this effect, but findings indicate that participants do not answer differently on web-based questionnaires (Gnambs & Kaspar, 2017), indicating that any social desirability-bias would be the same.

Response bias may not only be a result of impression management, but also a result of one's own self-view or identity (Brenner, 2020). Participants may not answer to control how they are perceived by others, but answer according to how they perceive themselves. Their answers can thereby be true reflections of how they experience their own behavior, thoughts, and emotions. This can explain why answers are similar in an anonymous setting.

Another issue with self-report is common method variance. An association between two constructs that are measured with the same method might be a result of the common method rather than an actual association between the constructs (Podsakoff et al., 2003). In NorBaby we applied several self-report measures, and of course the respondent was the same on all parental measures (in the present thesis), this could give the impression of stronger associations than there are. However, some conditions reduce this issue. Firstly, participants answered questionnaires on several timepoints. This time lag between assessments reduces the effect of previous answers, as they should be less salient, available or relevant (Podsakoff et al., 2003). In the papers of the present thesis, predictors are retrieved from pregnancy (T1

data), and outcome from after birth (T4 and T5), which is both a substantial time lag and situational shift in the life of the participants. We also apply T4 data to predict T5 data, however the time lag between these measures are still more than two months. Secondly, participants completed assessments on different locations, at least T1 which was with a member from the research group, and the rest of the assessments which were answered online. This change of location is also supposed to reduce common method variance-issues (Podsakoff et al., 2003).

The cognitive tasks in NorBaby

The application of cognitive tasks in research can be challenging. Even though we know there is a group difference in attentional bias in our dataset (Bohne et al., 2021), the cognitive tasks do not predict individual differences. This might not be surprising, considering the nature of cognitive tasks. Cognitive tasks are designed to provoke a certain response, based on known cognitive mechanisms, and have their roots in an experimental approach (Hedge et al., 2018). Such tasks may thereby produce homogenous results, as they provoke similar responses in individuals, and therefore do not effectively distinguish between individuals (Hedge et al., 2018). Low variability between individuals on a cognitive task may indicate that the task produces robust experimental effects, and is suited for investigating group differences, but low variability is disadvantageous for investigating individual differences (Hedge et al., 2018). For that we want high variability. Further, the cognitive tasks we applied in NorBaby, the EDP and the SC-IAT have both been criticized for poor reliability, but as described, this might be less crucial when comparing groups (Hedge et al., 2018; Staugaard, 2009).

Despite challenges in detecting individual differences, research applying cognitive tasks has provided valuable knowledge. This includes the tasks we applied in NorBaby. The SC-IAT has provided knowledge on how our automatic associations become predictive of behavior when we do not have resources to elaborately process a situation (Friese et al., 2008; Greenwald et al., 2009). In the present study, results indicate that implicit associations to infants might be involved in maternal bonding. Perhaps, if mothers have a negative schema related to infants, this schema might be activated when the infant is distressed or challenging to read and regulate, thereby reinforcing a negative association to infants. This could delay and challenge the bonding process. However, the relation between implicit associations to infants and bonding did not reach statistical significance, and we are left with the feeling that there might be something there, but larger and more diverse samples are needed to investigate further.

The emotional dot-probe task has provided knowledge of attentional bias in both depressed and anxious groups, both regarding at what level of processing the bias appears and to what kind of stimuli (LeMoult & Gotlib, 2019; Ouimet et al., 2009). In NorBaby, we know there is a group difference in attentional bias between the group with highest depressive symptoms and a matched control group (Bohne et al., 2021), but when applying regression models to predict individual differences, we get no statistically significant results.

The nature of cognitive tasks makes it challenging to test the proposed model by DeJong et al. (2016). The model proposes that the combination of cognitive biases and cognitive control deficits captures cognitive capacity in that it increases repetitive negative thoughts, and thereby keeps the parent preoccupied. This further reduces parental sensitivity and responsiveness to infant cues. When this pattern is persistent, it can affect parenting and further the child outcome. To see the interplay between RNT (self-report), cognitive biases and control deficits (cognitive tasks), parenting behavior and parent-infant relationship (self-report or observation), and infant behavior (parental report or observation), one must rely on different sorts of measures, and may thereby not get results that concur with reality, as the measures rarely correlate because of their different nature (Hedge et al., 2018).

Even though the different measures come with different challenges, we still believe it is a strength in NorBaby that we tried to broaden the range of measurements. We included self-report (from both mother and father), observation by researchers (ADBB), observation by parents (diurnal clock) and cognitive tasks (EDP and SC-IAT), and investigated data in a transactional paradigm, to increase knowledge of the complex perinatal period.

Transactional research

I wanted to examine the parent-infant relationship and interaction in a transactional paradigm. However, it is very complicated to empirically test the transactional model, as it involves measuring internal processes in a human (e.g., mother) and how these interact with internal processes in other humans (partner, infant, social network), and how they continuously change internal processes and behavior in each other. It is not possible to demonstrate the continuous changes that can appear within seconds in a parent-infant interplay, and so we are left with static measures of different variables at different timepoints. Hopefully, the relations between them will still give us some insight in the transactions that are continuously unfolding.

In paper II, we built a transactional model based on recommendations for transactional research (Bollen & Curran, 2004; Sameroff, 2009a). This paper is probably the one that is closest to illustrating the transactional interplay. However, we found that the posed transactions between parental illness and infant behavior and development were not present, but the parents' own cognitions affected their mental health and their perception of infant behavior. We do note however, that parity and social support had a significant effect on both parental and infant measures after birth, indicating ongoing transactions between the parents and their environment (social support) and parents and infant (parity).

In paper III, although we did not apply a transactional model, but ran regression analyses, the longitudinal data helps the transactional perspective. Seeing that variables affect another from one timepoint to the next could indicate a transactional interplay. Especially looking at the mediation analysis, where bonding mediates the relationship between RNT and perception of infant temperament, indicates that the mothers' cognition affects her relationship to the infant, which further affects how she perceive the infant's behavior. However, it would have been

optimal to include the interaction-data, to see the infant's contribution to the relationship, and how the parents' internal processes affect their parenting behavior. Unfortunately, scoring of the interaction videos were not ready in time. I look forward to analyzing this data, and examining if cognitive vulnerability, bonding, parental mental health and infant regularity is associated with the actual parent-infant interaction.

We only followed the families until the infant was 7 months old. Based on our results, the infants seem to be in good development regardless of parental symptoms of depression, stress, or cognitions. It is possible that results would have been different over time. As with adverse childhood experiences, there might be a dose-response relationship. Infants of parents with more persistent depressive symptoms (although mild) during the first year might be affected to a higher degree than during the early months. In a comparable Norwegian sample, Fredriksen et al. (2018) measured depressive symptoms at three timepoints during the first year, and parenting stress at 12 months, and found that it was related to infant development at 18 months. Although it is a strength that the present study is longitudinal, it would of course be preferable to follow the families even longer to detect transactions over time. Similarly, infants of parents with more severe levels of symptoms might also be more affected.

Infant measures

A methodological challenge in the perinatal field is that infants cannot answer verbally, and so we heavily rely on parental report. Reports of the infant's behavior are from the parents' viewpoint, and as our research demonstrates, parental report of their children's behavior is affected by factors in the parents themselves. Observational measures, or several responders, are therefore essential for future research. In NorBaby, we tried to meet this challenge by including observational data both from the parents (diurnal clock) and from the research team (interaction data and the ADBB). For the present thesis, the observation done by the research team was the ADBB. Although the scale is of high clinical value, we realize that it is less useful for research in population-based studies as the present, where the sample is resourceful and prevalence is low. In a more vulnerable sample, with higher prevalence of parental mental illness and psychosocial difficulties, we would expect higher prevalence and variety in the ADBB scores.

The other observation adopted in the present thesis was done by the parents, namely the diurnal clock. Chronological measures of behavior, like the diurnal clock which is a form of time diary, is proposed to produce unbiased measurements (Brenner, 2020). Although we believe that even registration of behavior is affected by interpretation on some level, we do agree that a time diary results in a more objective description of behavior than questionnaires. This is illustrated by the non-association between the registration of infant regularity (diurnal clock) and the parental report of infant temperament (PSI-CD). However, it should be mentioned that the diurnal clock was quite tasking to complete, and we could not control how thorough the participants filled out the form. The reliability of the measure is therefore debatable. However, based on feedback from participants we believe most have done their

best in keeping track. We think also the scoring criteria for regulation problems is set at a level where the details of reporting is not too demanding.

Including measures of infant behavior from other respondents than the parents, for example from well-baby clinics, would have been an advantage. However, this was not feasible due to lack of recourses and standardized assessments and routines at the well-baby clinics to collect such data.

Postpartum anxiety

Recent research indicates that anxiety is more prevalent in the perinatal period than depression (Dennis et al., 2017; Fawcett et al., 2019). Come to think of it, in daily talks about becoming a parent, becoming more worried and anxious is often mentioned. It is likely that most parents experience a heightened level of vigilance and risk assessment as the instinct to protect their child is so strong. Therefore, it is only reasonable that this can turn into disabling anxiousness for some parents. As worry and RNT are such an important part of anxiety disorders, the NorBaby study should have included an anxiety outcome measure, that tapped into obsessive thoughts and catastrophic thinking. We did include a prenatal anxiety measure (Pregnancy Related Anxiety Questionnaire), however this concerns anxiety specifically linked to the pregnancy and upcoming birth.

Traditionally, in the literature on perinatal mental health, it is perinatal depression that is being measured. Notably, the EPDS includes two items regarding anxiety symptoms, and as comorbidity is high, it is not always possible to distinguish between depression and anxiety. Some studies discuss postpartum distress (e.g. Kingston et al., 2012), and thereby do not differentiate between emotional symptoms. Even so, the new wave of research that specify and differentiate between the emotional disorders is important and promising. This will allow for more targeted interventions when needed, and knowledge about possible differential effects of the disorders. It is probable that the different disorders might be associated with different parenting behavior. Overprotection for example, might be more prevalent among anxious parents than depressed parents.

Implications for health care services

The present thesis has important implications for health care services during the perinatal period. I will in the following discuss this considering the present standard care, and then make recommendations in line with results from the articles in the present thesis.

Perinatal mental health care in Norway

In Norway, during pregnancy, standard care consists of regular visits to the midwife or general practitioner (GP). The usual number of consultations during pregnancy is nine, with frequency increasing in the second half of the pregnancy, and especially during third trimester. After birth, guidelines recommend a home visit by a midwife during the first few days after returning home from the hospital (Helsedirektoratet, 2014). A public health nurse

should pay a home visit 7-10 days after returning home. After this, women are recommended to see their midwife or GP 6 weeks postnatally. Public health nurses at well-baby clinics see the infant regularly throughout the postnatal period to follow up on weight gain, give vaccines, and discuss the infant's development, health, and safety. Overall, the family (or at least the mother and infant) is seen regularly throughout the perinatal period.

Despite this, guidelines on how to identify and help families struggling with mental health issues are diffuse (Høivik et al., 2021). During pregnancy, guidelines state that visits to health care services should enable women to talk about any psychosocial difficulties she might be experiencing and recommend health care workers to have routines to identify mental health problems (Helsedirektoratet, 2018). However, they do not specify what those routines should be or how to enable these conversations. Regarding mental health in the postnatal period, recommendations are to tailor the interventions individually to each family's (or mother's) needs (Helsedirektoratet, 2014). However, the same guidelines do not recommend screening for mental illness. It remains unclear how the public health nurses should identify parents with mental health issues, and how the tailoring of interventions should happen.

Asking mothers, they highlight the importance of their partner being involved, listened to, instructed, and cared for by the health professionals throughout the labor and postnatal period (Vedeler et al., 2022; Wiklund et al., 2018). In Norway, partners are not allowed to sleep over at the maternity ward after birth, and this is experienced very difficult for the families (Vedeler et al., 2022). National guidelines for prenatal care barely mention the partner, except for when recommending to screen for partner violence (Helsedirektoratet, 2018).

Summarized, even with wealthy welfare services, the mental health of the family is only vaguely part of the standard care program in the perinatal period. National guidelines do not recommend screening parents for perinatal mental health issues (Helsedirektoratet, 2014), and there is no clear care program for those who do get identified. The lack of national guidelines makes it up to the separate municipalities, who vary according to resources and specialists, to make their own guidelines and routines. Therefore, local differences are significant (Høivik et al., 2021).

Struggling in the perinatal period often includes feelings of shame and stigma, which complicates help-seeking from family, friends, and health care services (Dunford & Granger, 2017). Therefore, it may be unlikely that struggling parents themselves ask for the help they need. Routines to identify them, and a stepped care program to follow for those in need, should be in place. The socioeconomic cost of perinatal illness is substantial (Bauer et al., 2014), as well as the personal cost, and so improving services should be a clear aim. Although there are many passionate and competent health professionals meeting families in the perinatal period, recommendations should be more clearly specified in guidelines, to reduce local differences and dependence on specific persons.

Identify vulnerable families

As present results indicate, repetitive negative thoughts during pregnancy can affect both the mental health of the parents and the parent-infant relationship postnatally. This finding has a positive implication, namely that RNT can easily be detected during pregnancy health care, and thereby it is possible to facilitate helpful interventions prior to the infant's arrival. In addition to screening for symptoms of mental illness, asking about repetitive negative thoughts already during pregnancy can be fruitful in regards of preventing postnatal struggles. There are of course questionnaires one can adopt, as the PTQ applied in the present study. Alternatively, explaining how unwanted or unproductive thoughts might be repetitive and take up cognitive capacity, and ask if they have such thoughts, might be sufficient. This can at least enable women to talk about difficult thoughts they are having, as the guidelines recommend.

Based on the present results, health care providers should be especially aware of the needs and well-being of first-time parents. Present results indicate that first-time parents are the ones most likely to need extra support. This is especially true regarding mothers, where results indicated that parity was protective of mothers' mental illness, infant regulatory problems, and weaker bonding. Families expecting their second or third child might benefit from information that fathers often bond more easily to their first child, so that families can be aware and facilitate paternal bonding to a higher degree.

Further, parents often seek out help because of regulatory problems in the infant, like colic, difficulties to soothe the infant, or sleeping problems. In these situations, health professionals must keep in mind that the parents' mental health is equally important to screen, even though that is not the problem they are presented with. Based on previous and present results, when parents report difficult infant temperament, this could be caused by difficulties in the parents, the infant or the parent-infant relationship (Cierpka, 2016). Screening of infants with ADBB is also a feasible way to identify infants and families that might be in need of intervention (Smith-Nielsen et al., 2018), that is not dependent on parental report, and should be considered part of the care program at well-baby clinics postnatally.

Care program

If one is to screen for mental illness during the perinatal period, there must be a functioning care program for those who do get identified. I would recommend national guidelines to be more specific in this area. Intervention can take place both in communal services and specialist health care, based on the condition and severity of symptoms. Some families might benefit from extra consultations with the midwife or GP, which might be sufficient to reduce mild symptoms and negative thoughts, or to activate a social network around the family. First line services could also offer consultations with a communal psychologist, individually or in a group. When problems are of a more severe degree, families should be referred to specialist health care, where there should be specialists in perinatal mental health.

Regarding intervention for repetitive negative thoughts, several known therapeutic methods target such thoughts. Treatments like mindfulness-based cognitive therapy, concreteness training, cognitive control training, metacognitive therapy, rumination-focused cognitive behavioral therapy, and traditional cognitive behavioral therapy are all effective in reducing both symptoms of mental illness and repetitive negative thoughts (Monteregge et al., 2020; Spinhoven et al., 2018). In the context of the perinatal period, a mindful parenting approach has shown encouraging results (Moreira & Canavarro, 2018; Potharst et al., 2017). Helping parents to be less preoccupied could get the parent-infant relationship off to a good start, and thereby securing positive infant development and healthy parents.

When asked about perinatal health care, mothers highlight the importance of continuity of care, both in regards of getting continuous and consistent advice, but also that seeing the same person throughout the perinatal period gave a sense of security (Wiklund et al., 2018). Feeling safe is important to enable conversations about sensitive subjects, like negative thoughts and emotions. One should be aware that changes in who follows the family throughout the perinatal period can be a hindrance to uncover mental health issues in the parents, especially after birth, as the parents do not have an established relation to the public health nurse. Possibly, families in risk (for example with heightened levels of RNT during pregnancy, low social support, severe levels of symptoms) should be able to see the same person across the perinatal period. Another possibility is that the midwife who follows the family during pregnancy, makes sure the public health nurse who is to follow the family postnatally get introduced and involved before birth. This could be particularly important for vulnerable families.

Facilitate social network

In line with previous research (Racine et al., 2020), the present study found that social support is protective of depressive symptoms (at least in mothers) and parenting stress (both parents). Health professionals can ask about social network already during pregnancy, to explore with the family if they have sufficient support around them. Identifying those with little support from friends and family and aiding in activating or building a sufficient social support network, could make a real difference for those who seem to lack it. Health professionals can inform about communal services, like maternity (or paternity?) groups and other social platforms, and perhaps plan with the becoming parents who they can engage in their network if the network is sparse. Especially for first-time parents, information about different social platforms can be useful, as they probably do not know them from before, being new to parenting. Health care services and policy makers need to prioritize support for expecting families.

Conclusion

The present thesis investigated cognitive vulnerability in parents, and the effect on their mental health, their infant's socioemotional development and their bonding to and perception of their infant.

Repetitive negative thoughts during pregnancy were predictive of parenting stress and depressive symptoms after birth. Such thoughts also predicted maternal bonding and perception of infant temperament. Except for a few trends, we did not find significant effects of attentional bias and implicit associations on parental mental health, bonding, or infant regularity. Possibly, this is caused by the nature of cognitive tasks, that does not make them suited for research on individual differences. However, repetitive negative thoughts seem to be an important vulnerability factor to consider in the perinatal period. Further, several sociodemographic factors were identified as significant predictors. For both parents, social support from family and friends was protective of mental health problems. For mothers, parity was protective of their own mental health, and for infant regulatory problems. It was also associated with stronger bonding in mothers. For fathers on the other hand, parity did not significantly predict their own mental health or infant regularity and was negatively related to bonding. Education was also negatively associated with paternal bonding. This highlights gender differences in the perinatal period that are important to be aware of.

Of note, present results are based on a resourceful sample, and generalizability is therefore limited. Results might have differed in a sample with lower socioeconomic status, and higher prevalence and levels of depressive symptoms and infant withdrawal. Further research is needed to target those groups.

The results have implications for perinatal health care services. Repetitive negative thoughts should be identified during pregnancy, and intervention should be considered. Reducing such thoughts could prevent symptoms of mental illness in the parents and strengthen the parents' bonding process. Health professionals should be aware that first-time mothers may be in higher risk of illness than those with previous children, and that a social network is essential for the mental health of both mothers and fathers. Families struggling in the perinatal period should be met with a holistic approach where one considers the parents' cognitions and mental health, the infant's temperament and behavior, the nature of the parent-infant relationship, and the family's experiences and support network.

Together, we can tighten the net.

Tables

Table 1. Participant characteristics at T1

Variable	
Men / Women	129/221
Age	*M* = 32.19 (*SD* = 4.9, range 20-49)
Primiparous	52.1 %
Higher education	82.1 %
High income	68.7 %
Married or cohabitant	97.5 %
Ethnic minority	4.2 %
History of depression	26.9 %
EPDS T1	*M* = 3.89 (*SD* = 3.4, range 0-16)

Note. Higher education = university or college degree, bachelor level or higher. High income = average or higher, per household >750 000 NOK. Ethnic minority = "Do you belong to an ethnic minority?". History of depression = "Have you ever been depressed or sad almost every day, for a period of at least two weeks?"

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Paper I-III

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The role of early adversity and cognitive vulnerability in postnatal stress and depression

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Abstract

The purpose of the present study was to examine vulnerability factors in expecting parents that might lead to mental illness in the perinatal period. Specifically, we studied how parental early adversity, attentional bias to infant faces, repetitive negative thinking, and demographic factors, were associated with pre- and postnatal depressive symptoms and parenting stress. Participants were expecting parents taking part in the Northern Babies Longitudinal Study, where assessments were made both pre- and postnatally. Assessments included both questionnaires and cognitive tasks. About half of the participants received the Newborn Behavior Observation (NBO)-intervention after birth, between pre- and postnatal assessments. Results show that repetitive negative thinking was a significant predictor of both depressive symptoms and parenting stress, while education, social support, and parity came out as protective factors, especially in mothers. Parental early adversity had an indirect effect on postnatal depressive symptoms and parenting stress, mediated by prenatal and postnatal depressive symptoms, respectively. The NBO intervention did not affect the results, signifying the importance of early childhood adverse events and negative thinking on parents' postnatal adjustment and mood, even when an intervention is provided. In conclusion, repetitive negative thinking is a significant vulnerability factor independent of the presence of depressive symptoms, and health professionals must be aware of parents' thinking style both during pregnancy and after birth.

Keywords Perinatal depression · Parental stress · Repetitive negative thinking · Adverse childhood experience · Attentional bias · Cognitive thinking style

Introduction

Becoming a parent is among the greatest transitions in life, and a vulnerable period. The perinatal period is associated with increased risk of depression and symptoms of mental illness in parents (Bauer et al., 2014). Mental illness and psychosocial difficulties in parents are not only distressing for the parents themselves, but also a risk factor for infant development, as they may affect the quality of parenting (Goodman et al., 2011). To develop effective interventions for struggling families, it is essential to identify the factors contributing to parental stress and mental illness in the perinatal period. The purpose of the present study was to examine the role of parental early adversity and cognitive vulnerability factors in this period, as previous research regarding those factors is sparse.

Influences of Early Adversity

The Adverse Childhood Experiences-study (ACE-study) demonstrated how adverse experiences like abuse, neglect, and dysfunctional home-situations during childhood increased the risk of a whole range of mental and somatic illnesses in adult life (Felitti et al., 1998). Among them, the relationship between experiencing childhood maltreatment and later symptoms and diagnosis of depression is well established (Alloy et al., 2006). In the perinatal period,

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maternal ACE is found to be a risk factor for both perinatal depression (Racine et al., 2020) and parenting stress (Moe et al., 2018). In fathers, ACE is related to prenatal anxiety and depression (Skjothaug et al., 2014). Maternal ACE can not only affect the mother's own health, but also their infant's health (Esteves et al., 2020). This highlights how risk can transfer across generations, creating a vicious cycle that can be hard to break.

Influences of Negative Cognitions

Cognitive processing biases are considered an important factor in the onset and maintenance of depression (reviewed in LeMoult & Gotlib, 2019). Cognitive theories of depression posit that negative cognitions, like repetitive negative thinking or selective attention to negative stimuli, may represent psychological vulnerability (Joormann, 2010). Vulnerability can be defined as a stable underlying factor in the individual that makes them less resistant to stress (Ingram & Luxton, 2005). In interaction with a stressor (e.g., an adverse experience or a transitional period like the perinatal period) depression may be triggered (Ingram & Luxton, 2005). Furthermore, there are indications that attentional bias is related to perinatal depression and parenting. For example, expecting mothers who were more attentive to distressed infant faces during pregnancy reported more successful mother-infant bonding (Pearson et al., 2011). Expecting mothers with depressive symptoms were less attentive to emotional infant faces (Pearson et al., 2010, 2013). Thompson-Booth et al. (2014) found aberrant attention to emotional infant faces in parents with higher levels of parenting stress.

In addition, rumination and repetitive negative thinking prenatally is related to higher levels of postnatal depressive symptoms (Barnum et al., 2013; Schmidt et al., 2017). Rumination is traditionally referred to as a characteristic of depression, while repetitive negative thinking is considered transdiagnostic (Ehring et al., 2011). However, several authors refer to them interchangeably in the literature (e.g. DeJong et al., 2016). Repetitive negative thinking during pregnancy is also negatively associated with mother-infant bonding after birth (Müller et al., 2013; Schmidt et al., 2017). Interestingly, Müller et al. (2013) found no association between repetitive negative thinking during pregnancy and postnatal depressive symptoms. In their review, DeJong et al. (2016) concluded that the evidence of rumination predicting later postnatal depression is mixed, and rumination might not be predictive when controlling for concurrent and previous depressive episodes. To avoid possible confounding of measuring both depression and rumination, the present study applied a measure of repetitive negative thinking. However, rumination and repetitive negative thinking are highly related; accordingly, the literature on rumination is relevant too.

Postnatal Depression and Parenting Stress

Postnatal depression is prevalent in about 10—15% of mothers (Bauer et al., 2014; Ramchandani et al., 2005). Postnatal depression serves as a risk factor for insecure infant attachment, and could negatively affect mother-infant interactions (Tronick & Reck, 2009) and infant development (Goodman et al., 2011). Most research in this area has focused on mothers, but postnatal depression is a significant problem for fathers as well, and is associated with adverse child outcomes (Ramchandani et al., 2005). Fathers' mental health in the perinatal period is undeniably important and accordingly the present study recruited both expecting mothers and their partners.

Parenting stress arises when parents perceive that the demands of parenting exceeds their resources (Abidin, 1992). In mothers, anxiety and prenatal and postnatal depression are associated with parenting stress after birth (Leigh & Milgrom, 2008; Mazzeschi et al., 2015). In fathers, prenatal mental health predicted paternal stress 6 months after birth (Skjothaug et al., 2018). Parenting stress is associated with both the externalizing and internalizing of problems in the child (Barroso et al., 2018; Fredriksen et al., 2018), but also with relational problems between the parents (Mazzeschi et al., 2015). Thus, higher levels of parenting stress have adverse effects on the parents' mental health, the parent–child relationship and the child's development. Therefore, it is paramount to understand what leads to experiencing high levels of parenting stress.

Protective Factors

For most couples, pregnancy and childbirth are a positive experience where expecting parents experience social support, which in turn is protective against prenatal depressive symptoms (Leigh & Milgrom, 2008; Racine et al., 2020), parenting stress (Chich-Hsiu et al., 2011; Östberg & Hagekull, 2000; Racine et al., 2019) and postnatal depressive symptoms (Racine et al., 2020). Age is another possible protective factor. Bergström (2013) found that fathers of higher age had less risk of postnatal depressive symptoms than younger fathers, even when sociodemographic factors had been accounted for. The data are mixed for mothers, where some studies reported a protective effect while others reported no effect or an adverse effect of higher age on depression (Norhayati et al., 2015). Similarly, the association between postnatal depressive symptoms and education level varies between studies (Norhayati et al., 2015).

The Newborn Behavioral Observation (NBO) Intervention

The struggles experienced by many families in the postnatal period call for health care services to empower new parents and reduce stress and symptoms of mental illness. The Newborn Behavioral Observation (NBO) is a consultation where the parents together with a health professional observe the infant's competencies, behavioral repertoire, and communication cues. The goal is to sensitize the parents to their infant's communication and provide tailored supervision, and in this way increase parental competence and confidence (Nugent, 2007). There are a few studies yielding encouraging results, where the NBO is found to increase maternal engagement (Sanders & Buckner, 2006) and sensitivity (Nugent et al., 2017). However, in the Northern Babies Longitudinal Study (NorBaby; Høifødt et al., 2017), which the present study was part of, no effect of the NBO was found on maternal depressive symptoms or stress (Høifødt et al., 2020). In line with these findings, we did not expect the NBO to affect the results in 8. However, the current study may shed light on how interventions like NBO can be changed in order to make them more effective.

The Present Study

The present study aimed to add more knowledge about which parental vulnerability factors predict postnatal depression and parenting stress. Previous research on cognitive vulnerability factors has focused on mothers. Thus, to our knowledge, our study was the first to investigate not only the role of mothers', but also fathers' early adversity and cognitive styles on postnatal depression and parenting stress. The present study hypothesized that adverse childhood experiences, attentional bias and repetitive negative thinking during pregnancy would serve as vulnerability factors for perinatal depressive symptoms and parenting stress in both mothers and fathers. We also explored gender differences.

Specifically, our hypotheses were that:

a. Repetitive negative thinking and attentional bias during pregnancy, and adverse childhood experiences, would be predictive of both parenting stress and depressive symptoms.
b. Social support, education and age would serve as protective factors for parenting stress and depressive symptoms.

As prenatal and postnatal depressive symptoms and parenting stress are related, we hypothesized that

c. Prenatal depressive symptoms would mediate effects in the relations between predictors and postnatal depressive symptoms.
d. Postnatal depressive symptoms would mediate effects in the relations between predictors and parenting stress.

In a post hoc analysis between parents, with and without elevated ACE-scores, we hypothesized that

e. The elevated ACE-group would have significantly higher levels of depressive symptoms and parenting stress than the non-elevated ACE group.

Method

The present study was part of a larger study, the Northern Babies Longitudinal Study (NorBaby; Høifødt et al., 2017), that investigated pre- and postnatal risk factors for parental outcomes, parent-infant interaction and infant development.

Participants

Altogether, 220 expecting mothers and 130 of their partners were recruited as part of the NorBaby-study (Høifødt et al., 2017), totaling 350 participants. Families were followed longitudinally throughout pregnancy and after birth until the child was 6 months old. There were three measurement points during pregnancy (T1-T3) and three after birth (T4-T6). In 8, data from T1 and T4 are analyzed.

Analyses of Attrition

Data from 274 participants were included in 8. The attrition was a result of participants resigning from the study before the T4 measurement (n = 43), or omission of the T4 measurement (n = 33). The missing group was significantly different from participants in 8 when it came to gender ($\chi^2(349) = 9.659$, $p = 0.002$, Cramer's V = 0.166), because of a larger percentage of males in the missing group (52%), than in the participating group (32%). The missing group was significantly less educated ($t(346) = 5.200$, $p < 0.001$, Cohen's d = 0.681), but there was no significant difference in the level of income between the groups ($t(345) = 1.820$, $p = 0.070$, $d = 0.238$). Thus, attrition did not reflect resources and socioeconomic status. The groups did not differ in their level of depressive symptoms at T1, their history of depression, or amount of adverse childhood experiences (all p's > 0.300).

Procedure and Measures

The first assessment (T1) in 8 was performed during pregnancy between gestational week 13 to 39 (mean week 23, median 23, SD 3.62). 93% answered between week 18–29. The first postnatal assessment (T4) was performed 6–15 weeks after birth (mean week 8.1, median 7.7, SD 1.94). The T1 assessment was performed with a member

of the research team present, whereas T4 was performed with an online survey that participants received via email 6 weeks after birth.

Prenatal Assessment (T1)

This was the first meeting between participants and a member of the research group (for details, see Høifødt et al., 2017). The relevant measures for the present study are described in detail below.

Demographics

Demographic information included gender, age, number of children, education, income, history of depression, and support from family and friends. Education was measured on an ordinal scale from low (no high school) to high (4 years or more from university/college). Income was measured ordinal for the household, from very low (below 150,000 NOK/ $17,550) to high (above 1,000,000 NOK/117,000 USD). The average yearly income for females in Norway in 2015 (when data collection begun) was 477,600 NOK/55,878 USD (SSB, 2016). To measure history of depression participants answered the question "Have you ever been depressed or sad almost every day, for a period of at least two weeks?". Support from family and friends were assessed with "Do you have enough friends/family to help and support you?", with answer options yes or no.

Edinburgh Postnatal Depression Scale (EPDS)

The EPDS was developed to screen for depressive symptoms in the perinatal period (Cox et al., 1987). It consists of 10 items assessing common depressive symptoms, where each item (e.g., "In the past 7 days, I have been so unhappy that I have had difficulty sleeping") is scored from 0–3 points, with total scores ranging from 0–30 points. Scores ≥ 10 are commonly applied as a cutoff, indicating possible depression. In the present sample, the EPDS measured at T1 had a Cronbach's α of 0.81, indicating good internal consistency.

Adverse Childhood Experience Questionnaire (ACE)

The ACE is a 10-item questionnaire that assesses whether abuse, neglect or household dysfunction were experienced during childhood. Participants answered yes or no to the ten items, and total scores range from 0–10. Felitti et al. (1998) found a strong association between ACE scores and health. They write that since the risk for a range of mental and somatic illnesses increases with each adverse childhood experience, the cumulative risk can be substantial.

Perseverative Thinking Questionnaire (PTQ)

The PTQ is a 15-item questionnaire assessing repetitive negative thinking (Ehring et al., 2011). It is a transdiagnostic questionnaire that focuses on the thought process, or how the thoughts occur, rather than the specific content of the thoughts (e.g., "The same thoughts keep going through my mind again and again"). Participants rated each item on a scale from 0 (never) to 4 (almost always), with total scores ranging from 0–60. The scale had a Cronbach's α of 0.95 in the present sample, indicating high internal consistency.

Emotional Dot Probe-task (EDP)

The EDP was employed to assess attentional bias to emotional infant faces. We have described the task in previous work (Bohne et al., 2021) and the following description is similar to that. The task is based on the original dot-probe task (MacLeod, Mathews, & Tata, 1986). Happy, sad and neutral infant faces from the Tromso Infant Faces database (Maack et al., 2017) served as stimuli. A fixation cross was presented for 500 ms (ms) in the middle of the screen, followed by a single stimulus image, presented for 1000 ms. The stimulus was presented on either the left or the right side of the screen. After stimulus presentation, a dot-probe appeared on the same or the opposite side of the screen. To indicate the location of the dot-probe, participants pressed a key. The intertrial interval was 100 ms. The stimulus (happy, sad, or neutral infant faces) and the dot-probe appeared in the left or right position with equal probability. Participants first completed 10 rehearsal trials while supervised by a member of the research group, and then 144 trials on their own. The task was programmed using Inquisit (Millisecond software), which recorded response accuracy and latency. Reliability was poor, for neutral images: $r = 0.61$, for sad images: $r = 0.52$ and for happy images: $r = 0.59$. Note, low reliability is not seen as a hindrance to investigate differences at the group-level (Price et al., 2015; Staugaard, 2009).

Postnatal Assessment (T4)

This assessment was sent to participants by email 6 weeks after birth. The following two questionnaires were relevant for the present study.

Edinburgh Postnatal Depression Scale (EPDS)

As described above. Cronbach's α was 0.78 at T4, which is considered acceptable.

Parenting Stress Index – Parent Domain (PSI-PD)

The parenting stress index (PSI; Abidin, 1983) consists of 101 items and is used to measure stress in the parent–child relation. The parent domain reflects stress in the parental role, while the child domain reflects stress associated with characteristics in the child. Together, the two domains give a total stress score. At T4, participants only answered the parent domain (54 items). Items are scored on a 5-point Likert scale, where higher scores indicate more stress. In the present sample Cronbach's α was 0.91.

Intervention – The Newborn Behavioral Observation (NBO)

The intervention took place between the two measurement points in 8. After birth, 91 of the participating families were in the intervention group and received three NBO-consultations. The first consultation was at the maternity ward during the first few days after birth. The next two were provided by the well-baby clinics at a home visit 1–2 weeks after birth and at the clinic 4 weeks after birth, respectively. As Høifødt et al. (2020) found no group difference between those who received NBO and those who did not on measures included in 8, we therefore pooled the data.

Pre-Registration and Primary Data Analyses

Analyses were planned and pre-registered on the Open Science Framework before completion of data collection (osf.io/h8379). In accordance with the pre-registered plan for analyses, we conducted regression analyses to examine significant predictors of prenatal and postnatal depression and parenting stress. When there was a violation of assumptions, we performed robust regression analysis, however the main results did not substantially change. Mediation analyses were then performed to investigate mediating effects of prenatal and postnatal depressive symptoms. Analyses were run in Jasp (JASP, 2020) and Jamovi (jamovi, 2020).

Results

Sample

A total of 274 participants (185 female) participated in both assessments (T1 and T4). The age range was from 20 to 49. Most participants had high socioeconomic status (Table 1). At T1, 9.3% experienced depressive symptoms indicating a possible depression (EPDS ≥ 10). Regarding adverse childhood experiences, 15 persons (5.5%) had 4 or more and 27 (9.9%) had 3 or more ACE's.

The group who received the NBO-intervention differed from the group who got care as usual regarding education ($t(270) = 2.516$, $p = 0.012$, Cohen's d = 0.306), and support from family (χ^2 (274) = 5.960, $p = 0.015$, Cramer's V = 0.147) and friends (χ^2 (274) = 4.880, $p = 0.027$, Cramer's V = 0.134). The NBO group had slightly lower education and less support. The two groups did not differ from each other with respect to age, gender, parity, income, history of depression or adverse childhood experiences. Further exploration revealed that mothers in the two groups did not significantly differ on any of the demographic variables (all $p > 0.050$).

Table 1 Descriptives

Variable		*N*
Men / Women	89/185	274
Age	*M* = 31.95 (*SD* = 4.9, range 20–49)	274
Primiparous	52.2%	274
Higher education	87.2%	274
High income	71.4%	273
History of depression	28.5%	274
EPDS T1	*M* = 3.82 (*SD* = 3.5, range 0–16)	273
ACE	*M* = .80, median = 0 (range 0–9)	271

Higher education = university or college degree, bachelor level or higher. High income = average or higher, per household > 750 000 NOK. History of depression = "Have you ever been depressed or sad almost every day, for a period of at least two weeks?"

Prenatal Depression

Five participants misunderstood the EDP-task, so the error rates were too high to include them. Another eight participants did not complete the EDP-task. Three participants did not complete the PTQ and ACE. This left 258 participants for the regression analysis.

A hierarchical bootstrapped regression model predicting prenatal depression (as measured by EPDS) was applied (Table 2). In model 1 demographic variables and ACE were entered as predictors, and in model 2 the cognitive variables (PTQ and EDP) were added. Model 1 was significant ($F(9, 247) = 6.378$, $p < 0.001$; see Table 2) and explained 18.9% of the variance. Five significant predictors emerged: gender (1 = female), age, parity, family support, and history of depression. Adding the cognitive variables explained 22.4% more of the variance (model 2; $F(12, 244) = 14.308$, $\Delta R^2 = 0.224$, $p < 0.001$), a significant change. Significant predictors in model 2 were gender, age, education, and repetitive negative thinking, where higher age and higher education were protective against prenatal depressive symptoms.

Postnatal Depression

Three participants did not complete the PSI, leaving 255 participants for analysis. A hierarchical regression model

Table 2 Results of hierarchical regression for predictors of prenatal depression (EPDS T1)

Predictor variables	B	β	sr^2	t	p
Model 1					
Gender	1.613	.223	.207	3.608	**<.001**
Age	-.100	-.144	-.116	-2.023	**.044**
Parity	-.762	-.155	-.143	-2.493	**.013**
Education	-.386	-.082	-.072	-1.248	.213
Income	.105	.043	.038	.671	.503
History of depression	1.047	.139	.131	2.289	**.023**
ACE	.188	.071	.067	1.171	.243
Family support	-1.900	-.151	-.140	-2.446	**.015**
Friend support	-1.091	-.091	-.088	-1.532	.127
Model 2					
Gender	.893	.124	.112	2.291	**.023**
Age	-.100	-.144	-.116	-2.365	**.019**
Parity	-.441	-.090	-.082	-1.673	.096
Education	-.548	-.116	-.101	-2.064	**.040**
Income	.195	.080	.071	1.458	.146
History of depression	-.215	-.028	-.025	-.518	.605
ACE	-.009	-.004	-.003	-.067	.946
Family support	-.786	-.063	-.057	-1.154	.250
Friend support	-.990	-.082	-.079	-1.615	.108
PTQ	.192	.551	.470	9.589	**<.001**
Bias Happy	-.003	-.033	-.027	-.560	.576
Bias Sad	-.003	-.029	-.024	-.486	.627

Significant *p*-values (<.05) are in bold

B = Unstandardized beta, β = Standardized beta, sr^2 = semipartial correlation, History of depression = "Have you ever been depressed or sad almost every day, for a period of at least two weeks?", ACE = Adverse childhood experiences questionnaire, PTQ = Perseverative thinking questionnaire, bias happy/sad as measured by the EDP. Model 1: $R = .434$, $R^2 = .189$, Adjusted $R^2 = .159$, Standard error = 3.093. Model 2: $R = .643$, $R^2 = .413$, Adjusted $R^2 = .384$, Standard error = 2.647

predicting postnatal depression (as measured by EPDS) was applied (Table 3). Prenatal depressive symptoms was entered in model 1, as it is a strong predictor of postnatal depressive symptoms. The intervention variable was also entered in model 1. In model 2, demographic and cognitive variables were entered, and finally parenting stress was entered in model 3. Results are presented in Table 3. Prenatal depressive symptoms were confirmed as a significant predictor, and model 1 ($F(2, 251) = 58.430$, $p < 0.001$) explained 31.8% of the variance. Model 2 ($F(14, 239) = 11.354$, $p < 0.001$) explained an additional 8.2% of the variance, a significant change ($\Delta R^2 = 0.082$, $p = 0.002$), and education and repetitive negative thinking were significant predictors in addition to prenatal depressive symptoms. Adding parenting stress improved the model significantly, increasing explained

Table 3 Results of hierarchical regression for predictors of postnatal depression (EPDS T4)

Predictor variables	B	β	sr^2	t	p
Model 1					
Prenatal depression	.510	.557	.557	10.676	**<.001**
NBO-intervention	.512	.082	.082	1.565	.119
Model 2					
Prenatal depression	.331	.362	.277	5.526	**<.001**
NBO-intervention	.414	.066	.063	1.257	.210
Gender	.277	.042	.037	.744	.457
Age	-.014	-.022	-.018	-.350	.727
Parity	-.424	-.094	-.085	-1.700	.091
Education	-.624	-.143	-.122	-2.429	**.016**
Income	.117	.052	.046	.915	.361
History of depression	.527	.076	.068	1.348	.179
ACE	.182	.075	.068	1.395	.164
Family support	.065	.006	.005	.100	.920
Friend support	-.072	-.007	-.006	-.125	.901
PTQ	.071	.222	.161	3.220	**.001**
Bias Happy	.006	.057	.048	.954	.341
Bias Sad	-.006	-.064	-.052	-1.040	.299
Model 3					
Prenatal depression	.249	.272	.205	4.613	**<.001**
NBO-intervention	.149	.024	.022	.506	.614
Gender	.349	.052	.047	1.056	.292
Age	-.016	-.024	-.019	-.436	.663
Parity	-.138	-.031	-.027	-.616	.539
Education	-.666	-.153	-.130	-2.926	**.004**
Income	.087	.039	.034	.772	.441
History of depression	.227	.033	.029	.654	.514
ACE	.111	.046	.042	.953	.342
Family support	-.107	-.009	-.008	-.186	.852
Friend support	.638	.058	.054	1.223	.223
PTQ	.031	.098	.069	1.557	.121
Bias Happy	.003	.028	.024	.532	.595
Bias Sad	-.004	-.045	-.037	-.825	.410
Parenting stress	.065	.439	.363	8.170	**<.001**

Significant *p*-values (<.05) are in bold

B = Unstandardized beta, β = Standardized beta, sr^2 = semipartial correlation, History of depression = "Have you ever been depressed or sad almost every day, for a period of at least two weeks?", prenatal depression = EPDS at T1, NBO = Newborn behavioral observation, ACE = Adverse childhood experiences questionnaire, PTQ = Perseverative thinking questionnaire, bias happy/sad as measured by the EDP. Model 1: $R = .564$, $R^2 = .318$, Adjusted $R^2 = .312$, Standard error = 2.576. Model 2: $R = .632$, $R^2 = .399$, Adjusted $R^2 = .364$, Standard error = 2.476. Model 3: $R = .729$, $R^2 = .531$, Adjusted $R^2 = .501$, Standard error = 2.193

variance from 40% to 53.1% (model 3: $F(15, 238) = 17.963$, $p < 0.001$). With this addition, repetitive negative thinking was no longer significant, while prenatal depressive

symptoms and education remained significant. There was no multicollinearity (all VIFs < 2).

The assumed mediational effect of prenatal depressive symptoms on the relationship between the predicted vulnerability and risk factors (repetitive negative thinking, attentional bias, adverse childhood experiences and history of depression) and postnatal depressive symptoms was investigated. First, associations between postnatal depressive symptoms and the predictors were analyzed. There was no significant association between attentional bias (as measured by the EDP-task) and postnatal depressive symptoms, and this variable was excluded from further mediation analysis. Separate bootstrapped mediation analyses for adverse childhood experiences, history of depression and repetitive negative thinking were performed. The effect of ACEs on postnatal depressive symptoms was fully mediated by prenatal depressive symptoms, while history of depression and repetitive negative thinking were only partially mediated (Fig. 1).

Parenting Stress

A hierarchical regression for predictors of parenting stress was performed (Table 4). In accordance with the chronology of assessments, demographics and cognitive factors were entered in model 1 (Model 1: $F(9, 244) = 5.709$, $p < 0.001$, $R^2 = 0.174$). Prenatal depressive symptoms were also measured at T1, but since it was established as a mediator of postnatal depressive symptoms it was entered in model 2 along with the NBO-intervention (Model 2: $F(14, 239) = 7.987$, $p < 0.001$, $R^2 = 0.319$). This yielded a significant change in explained variance ($\Delta R^2 = 0.145$, $p < 0.001$). Postnatal depressive symptoms was added in model 3, both because of its simultaneous assessment with the outcome and the expected suppressing effect on other variables (Model 3: $F(15, 238) = 13.956$, $p < 0.001$). Results can be seen in Table 4. The final model found support from friends being protective for parental stress whereas repetitive negative thinking and postnatal depressive symptoms had adverse effects on parental stress.

As postnatal depressive symptoms and parenting stress were highly related, we investigated the mediational effect of postnatal depressive symptoms between the assumed vulnerability factors, and parenting stress. As there was no significant association between parenting stress and attentional bias, this was left out of further mediation analysis. Three predictors were run in separate bootstrapped mediation analyses: history of depression, adverse childhood experience and repetitive negative thinking. The effect of adverse childhood experiences on parenting stress was fully mediated by postnatal depressive symptoms. The effect of history of depression and repetitive negative thinking was only partially mediated by postnatal depressive symptoms (Fig. 2).

Gender Differences

There were some important differences in demographics and cognitive factors between mothers and fathers. Mothers were significantly younger ($t(138) = 3.460$, $p < 0.001$), and expressed higher levels of repetitive negative thinking ($t(178) = -3.400$, $p < 0.001$) and adverse childhood experiences ($t(245) = -2.130$, $p = 0.034$). Mothers were also more depressed, both according to present symptoms at T1 (EPDS; $t(214) = -4.710$, $p < 0.001$) and history of depression ($\chi^2 = 5.680$, $p = 0.017$).

To address these differences, we ran all regression analyses again, separate for mothers and fathers. Results for the regression analyses of predictors of prenatal depressive symptoms demonstrated that repetitive negative thinking was a highly significant predictor for both genders. For mothers, higher age, parity, and support from friends served as protective factors. For fathers, the only other significant predictor was an attentional bias for happy faces from the EDP, which was negatively related to prenatal depressive symptoms. This suggests that a tendency to disengage from happy faces is associated with higher levels of depressive symptoms in fathers.

Both prenatal depressive symptoms and parenting stress were highly significant and positively related to postnatal depressive symptoms in both mothers and fathers. History of depression was also a significant predictor in fathers, and education served as a protective factor for mothers.

Regarding predictors of parenting stress, postnatal depressive symptoms was highly significant in both mothers and fathers. Repetitive negative thinking was a significant predictor of parenting stress as well, in both genders. For mothers, these were the only significant predictors when all variables were entered. However, in fathers, support from friends was protective. See Supplementary material Tables 1–6 for full regression tables for mothers and fathers separately.

Explorative Data Analyses

To further investigate the effect of ACE on depressive symptoms, parenting stress and cognitions, we explored differences in a group comprised of participants with elevated ACE-scores (≥ 3), and a matched control group. There were 27 participants scoring 3 or more on ACE. This group was matched on age, gender, education, income, number of children and support from family and friends to 27 participants (MatchIt package in R; Ho et al., 2011). T-tests for independent samples were performed to investigate group differences. There were no differences between

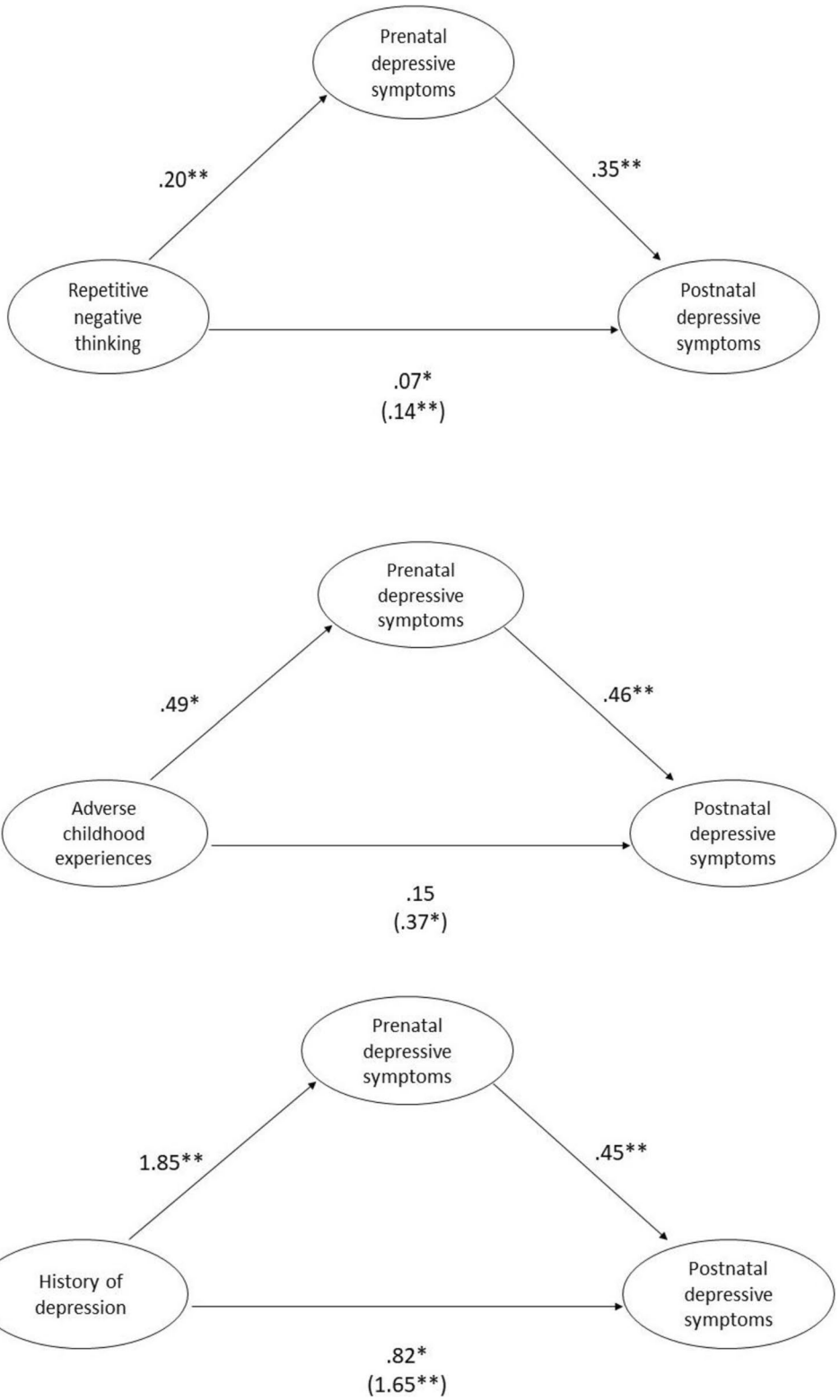

Fig. 1 Mediation models with prenatal depressive symptoms as mediator between repetitive negative thinking, adverse childhood experiences and self-reported history of depression and postnatal depressive symptoms. Coefficients are unstandardized. Total effects in brackets. * = $p < 0.05$, ** = $p < 0.001$

the ACE-group and the no ACE group on either variable, all p's > 0.160. For details, see Supplementary Material, Table 7.

Discussion

The present study investigated predictors of parenting stress and perinatal depressive symptoms. Our results partly

Table 4 Results of hierarchical regression for predictors of parenting stress (PSI T4)

Predictor variables	B	β	sr^2	t	p
Model 1					
Gender	3.503	.078	.072	1.235	.218
Age	-.089	-.021	-.017	-.284	.776
Parity	-.6.215	-.203	-.187	-3.219	**.001**
Education	-.066	-.002	-.002	-.034	.973
Income	.463	.030	.027	.466	.642
History of depression	10.224	.217	.206	3.539	**<.001**
ACE	1.795	.109	.103	1.773	.077
Family support	-4.922	-.063	-.059	-1.006	.315
Friend support	-13.365	-.179	-.173	-2.982	**.003**
Model 2					
Gender	-1.098	-.024	-.022	-.408	.683
Age	.023	.005	.004	.077	.938
Parity	-4.408	-.144	-.131	-2.452	**.015**
Education	.644	.022	.019	.348	.728
Income	.456	.030	.026	.495	.621
History of depression	4.608	.098	.087	1.637	.103
ACE	1.104	.067	.063	1.172	.243
Family support	2.643	.034	.030	.567	.571
Friend support	-10.946	-.147	-.140	-2.614	**.010**
PTQ	.610	.282	.205	3.844	**<.001**
Bias Happy	.043	.066	.055	1.031	.303
Bias Sad	-.029	-.043	-.035	-.660	.510
NBO-intervention	4.097	.096	.092	1.724	.086
Prenatal depression	1.265	.204	.156	2.925	**.004**
Model 3					
Gender	-2.034	-.045	-.040	-.854	.394
Age	.070	.016	.013	.272	.786
Parity	-2.978	-.098	-.088	-1.859	.064
Education	2.749	.093	.078	1.656	.099
Income	.061	.004	.004	.075	.940
History of depression	2.831	.060	.053	1.131	.259
ACE	.489	.030	.028	.583	.560
Family support	2.424	.031	.028	.587	.558
Friend support	-10.701	-.143	-.136	-2.885	**.004**
PTQ	.371	.172	.122	2.584	**.010**
Bias Happy	.025	.037	.031	.659	.511
Bias Sad	-.007	-.011	-.009	-.195	.846
NBO-intervention	2.699	.063	.060	1.278	.203
Prenatal depression	.146	.024	.017	.360	.719
Postnatal depression	3.375	.498	.386	8.170	**<.001**

Significant *p*-values (<.05) are in bold

B = Unstandardized beta, β = Standardized beta, sr^2 = semipartial correlation, prenatal depression = EPDS at T1, postnatal depression = EPDS at T4, NBO = Newborn behavior observation, ACE = Adverse childhood experiences questionnaire, PTQ = Perseverative thinking questionnaire, bias happy/sad as measured by the EDP. Model 1: $R = .417$, $R^2 = .174$, Adjusted $R^2 = .143$, Standard error = 19.460. Model 2: $R = .565$, $R^2 = .319$, Adjusted $R^2 = .279$, Standard error = 17.856. Model 3: $R = .684$, $R^2 = .468$, Adjusted $R^2 = .434$, Standard error = 15.813

confirmed hypothesis a): repetitive negative thinking makes parents more vulnerable to experiencing perinatal depressive symptoms and parenting stress. However, we did not find support that attentional bias was predictive of this. Adverse childhood experiences had an indirect effect on postnatal depressive symptoms and parenting stress, fully mediated by pre- and postnatal depressive symptoms respectively. The effect of repetitive negative thinking on postnatal depressive symptoms and parenting stress was also mediated by pre- and postnatal depressive symptoms, although only partly, and hypothesis c) and d) were confirmed. When matched with participants without adverse childhood experiences, the group with more ACE's did equally well, thus refuting hypothesis e). Finally, results also indicated important protective factors, especially the experience of social support from friends, thus partially confirming hypothesis b).

Cognitive Vulnerability

The present and previous studies (Barnum et al., 2013; Leigh & Milgrom, 2008) indicate that parental cognitive thinking style is important in understanding why some parents develop mental illness during the perinatal period.

It is understandable that repetitive negative thinking affects parents in the perinatal period, as DeJong et al. (2016) illustrate in their model. Minor concerns about the infant's behavior and communication, or doubt about one's own parenting, can grow into greater concerns than necessary when negative thoughts are repetitive, partly intrusive, and difficult to disengage from. Naturally, this thinking style might interfere with parents' sensitivity to their newborn child, as one of the main features of repetitive negative thinking is that it occupies mental capacity. Further, this could affect the parent-infant interaction, maybe leading to even more negative thoughts. In turn, this could predict both depressive symptoms and the experience of stress after birth. In their model, DeJong et al. (2016) also illustrate how cognitive biases, like a negative attention bias, affects what material undergoes rumination. An attentional bias can affect what you notice about your infant. Together with cognitive control deficits, such as how the thoughts are intrusive and difficult to disengage from, this pattern may be persevering. This study investigated attentional bias to baby faces. Biased attention to faces (LeMoult & Gotlib, 2019) and baby faces (Bohne et al., 2021; Pearson et al., 2013) has been found in depressed groups, where either sad or mood-congruent faces seem to take precedence, or an emotional expression does not engage the depressed group as much as the healthy control group. This is also proposed as a possible vulnerability factor in perinatal mental illness, as in the model of DeJong et al. (2016). In 8 we did not find support for any attentional bias predicting stress or depressive symptoms in mothers. In the male group however, disengaging from happy faces

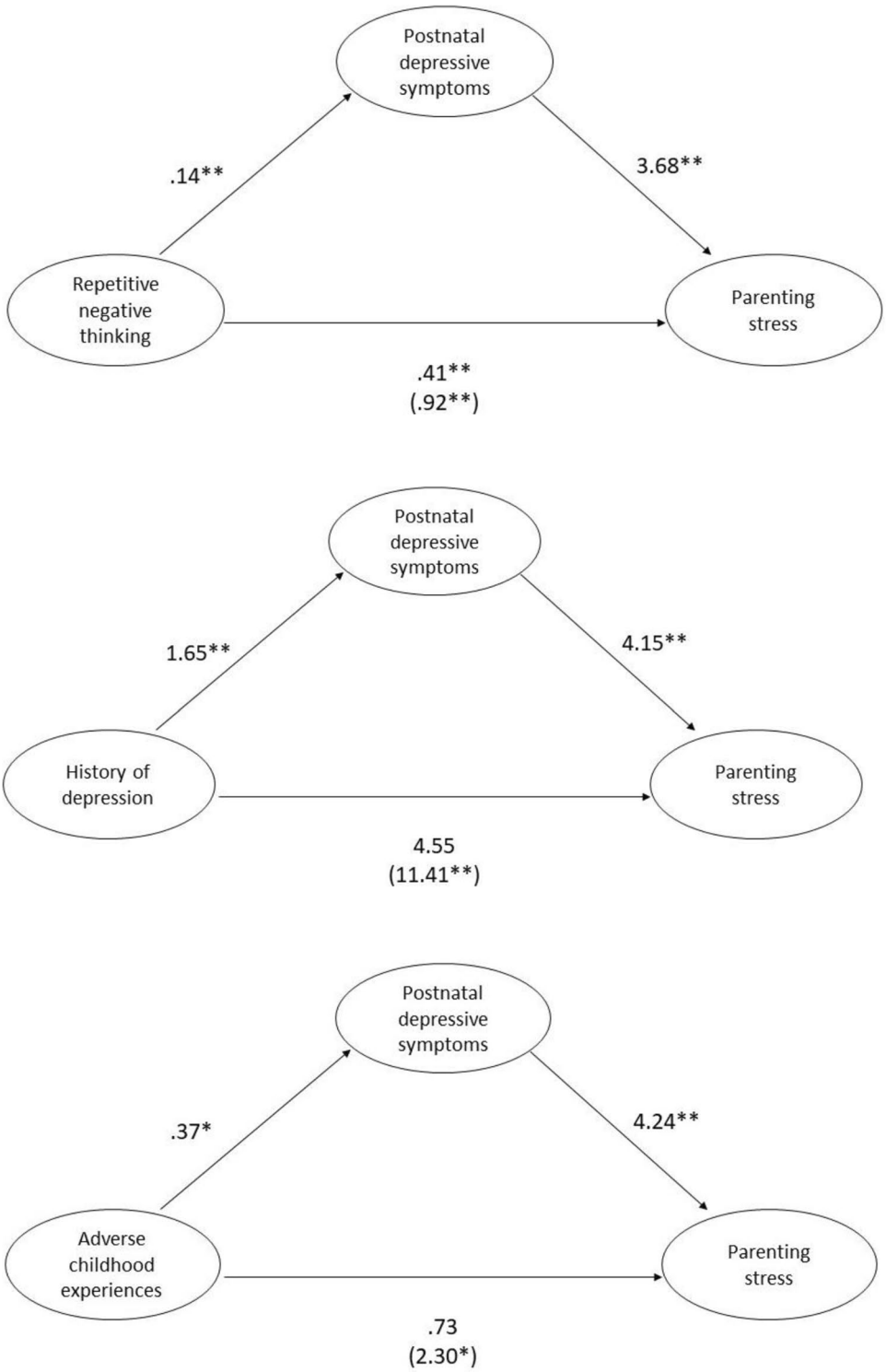

Fig. 2 Mediation models with postnatal depressive symptoms as mediator between repetitive negative thinking, adverse childhood experiences and self-reported history of depression, and parenting stress. Coefficients are unstandardized. Total effects in brackets. *=$p<0.050$, **=$p<0.001$

was related to prenatal depressive symptoms. This indicates a "protective bias", where engaging with happy infant faces might be protective of depressive symptoms.

The tendency to be caught up in negative thoughts is targeted by several treatment programs. Treatments like mindfulness-based cognitive therapy, concreteness training, cognitive control training, metacognitive therapy, rumination-focused cognitive behavioral therapy, and traditional cognitive behavioral therapy are all effective in reducing both symptoms of mental illness and repetitive negative thinking (Monteregge et al., 2020; Spinhoven et al., 2018). Offering expecting parents with high levels of repetitive

negative thinking one of these treatment options could be preventive of further postnatal illness and parenting stress, which would also benefit the infant, and potentially break the vicious cycle.

Our results deviated from what Müller et al. (2013) found in their study, where repetitive negative thinking was predictive of mother-infant bonding, but not depressive symptoms. This inconsistency might be caused by different instruments, as Müller et al. (2013) used the Beck Depression Inventory-II (Beck et al., 1996), while we used the EPDS. The EPDS is specifically designed for depressive symptoms in the perinatal period, and therefore is less confounded by overlapping symptoms of childbirth and depression such as tiredness, lacking energy, or sexual appetite. Different instruments might be an important consideration when examining the effect of cognition on depression in the perinatal period (Fried, 2017).

Protective Experience

In line with our hypothesis d) and previous research (Norhayati et al., 2015; Racine et al., 2019, 2020), experiencing support from friends and family emerged as protective factors. While other cultures and earlier Western societies traditionally assisted and supported families in the early postnatal period, the western society today promotes an individualistic and independent lifestyle (Eckersley, 2005). This seems not to be beneficial in the perinatal period and should be noted by health care services and policy makers in their shaping of perinatal care.

The other significant protective factors in 8 have a connection with life experience: higher age, parity, and education. This might reflect how a stable life situation makes us more robust when facing challenges. Also, experience and knowledge might prepare us to meet challenging or novel situations without being overwhelmed. In their review of depression following life transitions, Moustafa et al. (2020) argue that the role change one undergoes in such a transition can cause distress if one finds it hard to accept the new role or struggles to find out what that role is. A stable life situation, often reflected in higher education and age, may make the parenting role easier to accept and adapt to in today's society. Having previous children makes the parenting role a familiar role, and one might therefore not experience a great role change.

Gender Differences

Overall, there were few differences in vulnerability between mothers and fathers. Repetitive negative thinking was a significant predictor for both genders on prenatal depressive symptoms and parenting stress. Mothers were protected by demographic factors to a higher degree than fathers, as age, parity, and social support were protective of prenatal depression, and education was protective of postnatal depression. However, this was not the case in fathers. The only demographic protective factor that was significant in fathers was support from friends on parenting stress.

Resilient ACE-Group

Contrary to what we expected, there were no group differences between those who had ≥ 3 adverse childhood experiences and those who had none. This indicates resilience in the ACE-group and is not consistent with findings in an older ACE-study (Felitti et al., 1998). Of course, this might be caused by a participation bias, where only resilient expecting parents chose to participate. Even so, results are encouraging and underline that risk factors are not inescapable.

Implications

The current results suggest that for the sake of the parents' well-being in this transition period, prenatal care is of essence. Depressive symptoms and repetitive negative thinking during pregnancy are predictive of both postnatal parenting stress and depressive symptoms, and these postnatal conditions might affect child outcomes in a negative way (Tronick & Reck, 2009). Both prenatal depressive symptoms and repetitive negative thinking could be addressed by effective interventions during pregnancy. To do so, early screening is needed. Identifying those with little support from friends and family and aiding in activating or building a sufficient social support network, could make a real difference for those who seem to lack it. Social support is essential for good mental health during the perinatal period (Racine et al., 2020). Health care services and policy makers need to prioritize support for expecting families, instead of downsizing. Minor, but meaningful actions in the prenatal care could make all the difference for the family facing a new life situation and the responsibility of parenting.

Limitations

As with all open population studies, the present one has an issue with participation bias. The parents that chose to participate are typically resourceful and low-risk families, with a high educational level and income, and low levels of depressive symptoms. Generalizability is limited to resourceful families. Effects might be larger in more vulnerable families, as mental illness prevalence is higher in those groups (Freeman et al., 2016). Future studies should investigate this further. 78.3% of the participants in the study completed both T1 and T4. Attrition was high among fathers and those with lower education, which might have affected our results.

Regarding the Emotional Dot Probe-task, our version with only a single stimulus image differs from previous research where emotional faces are shown coupled with neutral faces. This limits the comparability of the results. However, in the original version any bias towards or away from emotional images is relative to the neutral image, and therefore might have other explanations than preference or avoidance of the stimulus image. We therefore think the present version is preferable. Reliability of the task is debatable though.

Even though the EPDS is widely used as a measure of depressive symptoms in the perinatal period, it is still a short, self-report screening questionnaire, and so we cannot be certain that any of our participants experienced clinical depression. Results might differ in a clinically depressed group. This applies to our measure of previous depressive episodes as well, as this was also self-report and not based on diagnosed episodes.

Conclusion

The present study adds valuable knowledge of cognitive vulnerability factors in parents – both mothers and fathers—that is of essence in predicting perinatal depressive symptoms and parenting stress. Repetitive negative thinking is found to be a cognitive vulnerability trait in both mothers and fathers. This could be identified and targeted already during pregnancy, and thereby reduce the chance of parenting stress, worry and depressed mood in the postnatal period. Our results support vulnerability-stress models, which serve as frameworks in understanding the mechanisms involved in perinatal mental health (Ingram & Luxton, 2005). In line with previous research, the results also highlight the importance of social support in ensuring good mental health in expecting parents. These factors seem to be of greater significance than parents' early adversity when screening for risk in the perinatal period, at least in resourceful families. The present study implicates that health and welfare services should be aware of different parental thinking styles and inquire about the social network of expecting parents. This knowledge can potentially prevent postnatal depression and parenting stress. Given the current results, interventions for expecting and new parents may be improved by enhancing social support and by adding therapeutic techniques that have been shown to reduce rumination (e.g., Spinhoven et al., 2018).

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All datasets used for supporting conclusions of this article are available at the open science framework: https://osf.io/h8379/?view_only=b5317085db074679bbf38f1f7f639777

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Declarations

Ethics Approval The study is approved by the Regional Committees for Medical and Health Research Ethics, ref. 2015/614. We confirm that the present study complies with the 1964 Declaration of Helsinki and later addenda.

Consent to Participate Informed consent was obtained from all individual participants in the study.

Conflict of Interest On behalf of all authors, the corresponding author states that there is no conflict of interest.

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Transaction of parental cognition, stress and depressive symptoms, and infant regulatory problems

Abstract

Infant regulatory problems, parental cognitions, stress, and depression might reinforce each other in vicious cycles in the early parent-infant relationship. A transactional model was used as a framework for understanding and disentangling these relationships. 220 pregnant women and their partners were recruited during pregnancy and followed seven months postnatally in the NorBaby study. From pregnancy, four variables were entered as predictors: repetitive negative thinking, implicit associations to infants, parity, and social support. Postnatally, relations between measures of parental stress and depressive symptoms, infant regulatory problems, and social withdrawal were investigated. Results demonstrate that parents' repetitive negative thinking predicts their stress and depressive symptoms, while the infants' regulatory problems do not. Repetitive negative thinking also affects how parents perceive their infant at five months. For mothers, parity is protective of stress and depressive symptoms, and infant regulatory problems. First-time parents are at higher risk for aberrant cognitions. Implicit associations during pregnancy and social withdrawal at seven months were not related to the other variables included. In sum, how parents experience their child is affected by their cognitions, and not by their infant's actual behavior. Accordingly, parental cognitions and well-being should be considered when families struggle to adapt in the perinatal period.

Keywords: parenting stress, perinatal depression, regulatory problems, social withdrawal, repetitive negative thinking, implicit attitudes

Key findings:

1. Prenatal repetitive negative thinking predicts parenting stress and depressive symptoms postnatally, and how parents experience their child 5 months after birth.
2. For mothers, parity is protective of parenting stress, depressive symptoms, and regulatory problems in the infant.
3. Infant regulatory problems 2 months after birth is not related to parenting stress, depressive symptoms, or the parents' experience of their child.

Statement of relevance: The present study demonstrates how parental cognitions can affect parents' well-being and experience of their child in the postnatal period, while the infant's regulatory problems do not. Parental cognitions are therefore important to consider when intervening to support a healthy development for the infant and its parents.

After birth, a newborn and its parents start a life-long interactive relationship. To understand parental and infant health and development during the perinatal period, this reciprocal and dynamic relationship must be considered. A deeper understanding of the interplay can inform interventions for those struggling during the perinatal period. The present study adds to our knowledge of this complex dynamic relationship in the perinatal period by examining a transactional model (Sameroff, 2010) of parental cognitions, stress, depressive symptoms, infant regulatory problems and social withdrawal, as well as controlling for parity. We apply the model to the NorBaby data (Høifødt et al., 2017) and investigate it for mothers and fathers.

Parental cognitions, depression, and stress during the perinatal period

The perinatal period is a major transitional period for parents where some parents experience mental health issues. Postnatal depression affects about 10-15% of mothers (Bauer et al., 2014; Leigh & Milgrom, 2008), and 4-10% of fathers (Bergström, 2013; Ramchandani et al., 2005). Perinatal depression in the parents can have a negative impact on the quality of parenting (Stein et al., 2014), maternal-infant bonding (Reck et al., 2016) and the child's development (Kingston et al., 2012; Stein et al., 2014). Several factors have been identified as predictors of postnatal depression, including previous psychopathology and adversity (Fredriksen et al., 2017), low social support (Leigh & Milgrom, 2008; Racine et al., 2020), lower education and age (Norhayati et al., 2015), low self-esteem and a negative cognitive style (Leigh & Milgrom, 2008).

Certain thinking styles, like rumination and repetitive negative thinking are related to both the onset and maintenance of major depression (Koster et al., 2011; Nolen-Hoeksema et al., 2008). Rumination is traditionally referred to as a characteristic of depression, while repetitive negative thinking is considered transdiagnostic (Ehring et al., 2011). However, several authors refer to them interchangeably in the literature (e.g. DeJong et al., 2016). These thinking styles have been linked to perinatal depression and parenting stress (Barnum et al., 2013; Bohne et al., submitted; Schmidt et al., 2017). They might also affect parent-infant interactions and mother-infant bonding (DeJong et al., 2016; Müller et al., 2013; Schmidt et al., 2017).

DeJong et al. (2016) proposed a model to explain how repetitive negative thinking disturbs the parent-infant interaction. They argue that repetitive negative thinking reciprocally interacts with cognitive control and cognitive biases, and that this affects how the infant cues

are processed. Being caught up in one's thoughts might reduce sensitivity and responsiveness to infant cues. Together with a negative bias, parents might miss positive or neutral signals from the infant, and thereby reinforce negative thoughts. This can cause a vicious cycle where the parent feels less capable of parenting and the infant does not receive appropriate responses.

Recently, repetitive negative thinking was recently also found related to parenting stress (Bohne et al., submitted). Parenting stress occurs when experiencing that the demands of parenting exceeds one's resources (Deater-Deckard, 2004). Although circumstances like income, social support and education play a part in the experience of resources, parenting stress is a subjective experience of childrearing, regardless of the absolute and concrete resources that surrounds the family (Deater-Deckard, 2004). Parenting stress can affect the quality of parenting (Crnic et al., 2005) and maternal sensitivity (Dau et al., 2019), and is linked to symptoms of mental illness in the parents (Bohne et al., submitted; Leigh & Milgrom, 2008), and externalizing behavior problems in the child (Barroso et al., 2018).

Attitudes towards infants may also influence parenting (Keller et al., 2003). Implicit aspects of attitudes that might not concur with self-report are examined through implicit associations, i.e., how quickly one associates a stimulus with another one or a category (Greenwald et al., 2009). Implicit associations are found predictive of behavior, over and above what we explicitly report (Greenwald et al., 2009). This is especially the case when we are under stress, or low on cognitive capacity or self-regulatory resources (Friese et al., 2008). Becoming a parent can put you under stress, and therefore implicit associations might affect behavior in the perinatal period. Senese et al. (2013) applied a Single Category-Implicit Association Test (SC-IAT) to examine associations to infant faces, adult faces, and animal faces. They found that participants had implicit positive reactions to infant faces, more than to adult and non-human faces. However, there were individual differences ranging from a large positive reaction to infant faces to a medium negative association. To our knowledge, no study investigated the effect of implicit associations about infants by parents in the perinatal period.

Regulatory problems in infants

Infants' regulatory capacity often affects how they are perceived. Infants who are predictable and display less negative emotionality are often described as "easy", while less predictable infants who express more negative emotions, might be perceived as more difficult.

Infant regularity, like how they sleep, eat, how much they cry, and how easy they are to soothe, can be measured through observation and registration of the infant's daily rhythm and behavior (e.g. Hiscock et al., 2014; Öztürk Dönmez & Bayik Temel, 2019). To some extent, regulatory problems during infancy are normal and transient. As infants are in rapid development, their needs, signals, and reactions change continuously during the early months, and parents must adapt accordingly to meet the infant's demands (Cierpka, 2016). These changes give rise to periods where parents struggle to regulate their infant before they have adapted to the new needs of the infant.

However, when the regulatory problems are more stable over time, this could indicate difficulties in the parent-infant interaction, the parents' mental health, or the infant's general regulatory capacity or neurodevelopmental vulnerability (Cierpka, 2016). For example, Bilgin and Wolke (2017) argue that the infants' innate neurodevelopmental vulnerability might explain regulatory problems in infancy to a higher degree than parenting. Petzoldt et al. (2016) found that maternal anxiety predicted excessive crying in the infant, however, only in primiparous women. Also, sleep problems in the infant were predicted by maternal depression.

Further, regulatory problems in infancy are predictive of both dysregulation and behavioral problems in later childhood (Hemmi et al., 2011; Hyde et al., 2012; Winsper & Wolke, 2014). These associations are stronger when there is more than one regulatory problem, for instance both sleeping and crying problems (Winsper & Wolke, 2014).

Being the parent of a child with regulatory problems is likely to be more stressful than parenting children that are easily regulated, regardless of the parents' own mental health. Sheinkopf et al. (2005) found an interaction effect between mothers' levels of parenting stress and neonatal reactivity at 1 month, when predicting infant temperament (mothers' report) at 4 months. This suggests that infants who cry a lot or are difficult to soothe benefit from parents with low stress levels. Parents of infants expressing more distress and fuss have higher levels of parenting stress, but not psychiatric symptoms (Calkins et al., 2004). Parenting stress seems to decline during the preschool years but is still higher among parents of children with externalizing behaviors (Williford et al., 2007).

Social withdrawal in infants

Infants are born with the capacity to communicate and engage in social interactions (Feldman, 2007; Pascalis et al., 2011). Signs of social withdrawal can therefore serve as a

signal that the infant is not developing normally. This led Guedeney and Fermanian (2001) to develop the Alarm Distress Baby Scale (ADBB) to systematically measure the infant's withdrawal behavior. Withdrawal over time or across situations might be a warning signal of persistent distress. Possible causes could be biological risk factors in the infant, or developmental disorders like autism spectrum disorder (Guedeney et al., 2008; Guedeney et al., 2012). Distress could also emerge because of risk factors in the infants' environment, like parents' mental health problems (Burtchen et al., 2013; Guedeney et al., 2012; Mäntymaa et al., 2008). Braarud et al. (2013) demonstrated that mothers' depressive symptoms at 3 and 6 months postpartum was related to infants' withdrawal behavior at 9 months. Seemingly, infants might develop sustained social withdrawal to cope with aberrant parenting. If the parent is unresponsive or passive in the interaction with the infant, the infant might imitate this behavior, or engage less in the interaction as there is minimal response. In fact, Dollberg et al. (2006) demonstrated how infant withdrawal was not related to mothers' depressive symptoms, but to mothers' depressive behavior when interacting with the child, e.g. unresponsiveness and/or emotional flatness. Dollberg et al. (2006) also found that unpredictability in the infant behavior, which might suggest regulatory problems, was positively related to withdrawal behavior.

Transactional parent-infant relationship

The transactional model is a framework where not only the infant is affected by the parents, but the infant's behavior affects the parents as well (Sameroff, 2010). Parental mental health and wellbeing and infant regulatory problems are related (Bayer et al., 2007; Wake et al., 2006), and reducing infant regulatory problems benefits parents' mental health (Hiscock et al., 2014). Moe et al. (2018) found that perceived infant temperament was predictive of concurrent parental stress. Although, as the transactional model infers, it might not be possible to identify causation as the interplay is continuous.

Importantly, parents' report of their infant's behavior is *their* subjective experience, and therefore might be colored by the parents' wellbeing and cognitions. MacKenzie and McDonough (2009) describe how caregivers' perception of infant crying as problematic was not related to the actual amount of crying. Instead, they found that several other factors, such as parenting stress, relationship representation and maternal anxiety were related to negative caregiver perceptions of infant crying and behavior. In another study, van der Wal et al. (1998) also found that the amount of crying was not necessarily related to experiencing the crying as troublesome.

Parity might be an important factor to consider in the early interactions between infants and parents. Parity benefits sleep duration in the infant (Kaley et al., 2012) and is protective of crying problems (Kurth et al., 2010). In a qualitative study by Kurth et al. (2014) they describe how primiparous women gain confidence and broaden their range of soothing techniques during the first months, while multiparous women are calmer, and display a larger variety of techniques from the start. However, Kaitz et al. (2000) found no difference in effective soothing of their infants between primiparous and multiparous mothers the first days after birth.

The present study

In sum, when considering the early relationship between parents and infants, one must examine the interplay between infant behavior and parents' thoughts, perceptions, and behavior. Efforts to disentangle these dynamic relationships can produce helpful knowledge for future prevention and interventions for families struggling in the perinatal period.

The present study examines the relationship between parental cognitions, stress and depressive symptoms, and infant regulatory problems and signs of social withdrawal. Specifically, our hypotheses are that repetitive negative thinking during pregnancy predicts parenting stress, parental depressive symptoms, and regulatory problems in the infant 2 months after birth. Further, these variables are expected to reciprocally predict later measurements of parenting stress and depressive symptoms, the parents' experience of child characteristics, and signs of social withdrawal in the infant. We also expect negative implicit associations to infants during pregnancy to be associated with parenting stress and regulatory problems after birth. Lastly, we expect that parity and social support will be protective of difficulties in both the parents and the infants.

Method

The present study is part of the Northern Babies Longitudinal Study (NorBaby), where 220 pregnant women and 130 of their partners were recruited (for details, see Høifødt et al., 2017). All participants gave written consent to participate after receiving information about the study from the research group. The families were followed throughout pregnancy and until the baby was about 7 months old. There were six measurement points (T1-T6) and the present study uses data from T1, T4, T5 and T6. T1 was completed during pregnancy, between week 13-39 of gestation (*mean* 23.0, *median* 23, *SD* 3.62), T4 was completed

between week 6-15 after birth (*mean* 8.17, *median* 7.71, *SD* = 1.96), T5 between week 16-39 (4-9 months) after birth (*mean week* 21.25, *median week* 20.43, *SD* 3.49) and T6 between week 25-42 (6-10 months) after birth (*mean week* 30.69, *median week* 29.57, *SD* = 3.18).

The NorBaby-study also included an intervention, a consultation named the Newborn Behavioral Observation (NBO; Nugent, 2007). After birth, families belonging to three different well-baby clinics received this consultation three times, at the maternity ward the first days after birth and by the well-baby clinics 1-2 weeks and 4 weeks after birth. Results of the intervention is presented in Høifødt et al. (2020). As there was no difference between the intervention group and the control group on any of the included measures, we pooled the data in the present article.

Participants

Of the 350 participants who completed T1, 274 completed the surveys on T4 and 157 filled out diurnal clocks to register infant regularity, whereby two of the parents had twins, resulting in 159 infants with diurnal clock data. 234 participants completed surveys on T5, and 266 completed surveys on T6. 171 infants participated in the filming part of T6, which was the basis for ADBB-scores. Participant characteristics are reported in Table 1.

[Table 1 near here]

Procedure and measures

Prenatal assessment (T1). This assessment was completed with a member of the research team present. The assessment consisted of demographics, questionnaires and two cognitive tasks (for details, see Høifødt et al., 2017). The relevant measures for the present study are presented below.

Demographics. All participants answered demographic questions about their age, gender, education, number of children, their household income, and social support. Education was measured ordinally from low (no high school) to high (4 years or more in university/college). Household income was measured ordinally from very low (less than 150.000 NOK/17.000 USD a year) to high (more than 1.000.000 NOK/117.000 USD a year). Social support was measured by asking “Do you have enough friends/family to help and support you?”, with answer options yes/no.

Perseverative thinking questionnaire (PTQ). The questionnaire was developed by Ehring et al. (2011) as a transdiagnostic measure of repetitive negative thinking. It consists of

15 items, answer options ranged from 0 (never) to 4 (almost always). Items are statements about one's thoughts, for example "The same thoughts keep going through my mind again and again" or "My thoughts prevent me from focusing on other things". The score can be divided into three subscales, but we applied it as a whole. In the present sample, MacDonald's ω = .948.

Single Category Implicit Association Test (SC-IAT). A Single Category Implicit Association Test (SC-IAT; Karpinski & Steinman, 2006) was applied as a measure of implicit associations to neutral facial expressions of infant faces (seven image stimuli). Images are taken from the Tromsø infant face database (Maack et al., 2017). In brief, participants are presented with words or images in random order on the screen, one at a time. Participants are asked to categorize the stimuli as either a positive or a negative word, or a neutral facial expression of an infant face, by sorting them either to the left or the right side of the screen using the "e" and "i" key. In one condition, infant faces are sorted to the same side as positive words, and in the other condition they are sorted with the negative words. The difference in response time between each condition is seen as a measure of implicit associations. Sorting the infant faces faster to the positive side than the negative indicates a positive association, and vice versa.

Postnatal assessment (T4, T5, T6). The postnatal assessments were sent to the participants at 6 weeks (T4), 4 months (T5) and 6.5 months (T6) after birth. In addition to questionnaires and cognitive tasks that were sent digitally, participants received two diurnal clocks per mail that were to be filled out at the same time point as T4. When the infant turned 6 months, participants were per phone contacted by a member of the research team to invite them to a filmed observation that occurred at 6.5 months and was ADBB-scored. The relevant measures for the present study are presented below.

Edinburgh Postnatal Depression Scale (EPDS; measured at T4, T5 and T6). This is a 10-item questionnaire measuring depressive symptoms. It was developed to assess depressive symptoms in the perinatal period (Cox et al., 1987). Items (e.g., "In the last 7 days, I have blamed myself unnecessarily when things went wrong") are rated from 0 to 3, and a score above 10 indicates depression. MacDonald's ω at T4 = .79, T5 = .83, T6 = .84.

Parenting Stress Index (PSI, measured at T4 and T5). The Parenting Stress Index (Abidin, 1983) consists of 101 items and we used both the parent domain and the child domain. The parent domain consists of 54 items and measures experienced stress in the parental role, for example "I feel overwhelmed by the responsibility of being a parent". The

child domain consists of 47 items and measures child characteristics that might contribute to stress, for example "my child appears disorganized and is easily distracted". Items are scored on a 5-point Likert scale, and higher scores indicate higher stress levels. At T4 only the parent domain was assessed, while at T5 both the parent and the child domain were assessed. MacDonald's ω for the parent domain was .92 at T4 and .93 at T5, while MacDonald's ω for the child domain was .91.

Diurnal clock (T4). The diurnal clock (DC) is a diary to register the infant's state for one day and night. Parents were asked to observe and register their infant's state for two days and two nights, and record this in two DCs. Each hour in the DC is divided into quarters, and parents were asked to color each quarter according to the state the infant was in at the time. There were four states to record; sleep, awake and alert/pleased, awake and uneased/fuzzy, and crying. See figure 1 for an example of a completed DC.

[Figure 1 near here]

To identify possible regulatory problems in the infant, each DC was coded on four criteria similar to previous research (Bilgin & Wolke, 2016; Hemmi et al., 2011; Kaley et al., 2012). Criteria were total amount of sleep, continuous night sleep, excessive amount of crying, and difficult to soothe (see Table 2 for details). As parents filled out two DCs, the range was 0-8 (0-4 for each DC) on the total scale of regulatory problems. As many infants struggle with continuous night sleep at this age, a total score of 1 or 2 does not necessarily represent a pattern, hence the cutoff for a regulatory problem to be present was set to a total score of ≥ 3, to estimate prevalence. The two twin pairs scored the same, no regulatory problems, and so data from only one of the twins in each pair was applied.

[Table 2 near here]

Alarm Distress Baby Scale (ADBB; T6). The ADBB (Guedeney & Fermanian, 2001) scores signs of sustained social withdrawal in the infant on eight categories; eye contact, facial expressions, vocalization, general activity, self-stimulation, response to stimulation, attraction, and relationship. Each category is rated from 0-4, giving a total range of 0-32. The score of 5 is found to be the cutoff score that ensures highest specificity and sensitivity (Guedeney & Fermanian, 2001), where scores at or above 5 are of clinical concern.

In the present study, infants were videotaped during a neuropsychological assessment at T6, where the infant was seated on their parent's lap, while engaging in the assessment with a member of the research team. The duration of the assessment was usually about 30 minutes,

however scoring of the ADBB-scale only demands a brief observation of about 10 minutes. Here we used the first 10 minutes. Videos were scored by two independent coders. The primary coder was trained and certified before the scoring started, whereas the secondary coder was an experienced ADBB-trainer and has coded ADBB-videos for research purposes before. The primary coder scored all videotapes, while the secondary coder scored 20% of the videos, to allow for reliability checks along the way. Videos were randomized into nine blocks, and reliability was checked after completing each block. Whenever the two scorers disagreed (difference in sum score >2), they would be notified and then discuss and agree on what the correct score would be before proceeding to the next block. The interrater-reliability for the original scores was acceptable (Kendall's $\tau = .59$). Disagreement only occurred twice and was easily solved by discussion. A third experienced ADBB-trainer served as a supervisor for the newly certified primary coder, to allow her to calibrate regularly and discuss ambiguous videos.

Primary Data Analyses

The study and planned analyses were preregistered at the Open Science Framework (OSF; osf.io/4zra9) before data analysis began. Descriptives and reliability checks were performed in Jamovi (jamovi, 2020), while the tests of models were performed in R (R Core Team, 2020). To explore how parents' thinking style, stress and depressive symptoms, and the infants' regulatory problems, characteristics and signs of social withdrawal were interconnected over time, a model with all hypothesized paths (see Figure 2) was tested. Reduction of insignificant paths and variables to yield a model with better fit was then performed. To test the models, the lavaan package in R was applied (Rosseel, 2012).

Results

Analyses of attrition.

Since data were collected at different timepoints, there was some attrition. At T4, 274 of the original 350 participants answered. At this point 43 participants had resigned from the study, while 33 participants missed the T4 step. Comparing the missing group at T4 to those who answered T4 revealed a significant difference when it came to gender ($\chi^2(349) = 9.659$, $p = .002$, Cramer's $V = .166$) and education ($t(346)$, $p < .001$, Cohen's $d = .681$). There was a larger percentage of men in the missing group (52%), than in the participating group (32%), and the missing group was significantly less educated. However, there was no significant difference in the level of income between the groups ($t(345) = 1.82$, $p = .07$, $d = .24$).

Importantly, the groups did not differ in their level of depressive symptoms at T1 ($t(343) = .716$, $p = .474$, Cohen's $d = .094$).

Descriptives and correlations

Of the infants, 5.3 % of the 171 with ADBB-data were scored above cutoff for signs of social withdrawal, and 17.6% of the 159 infants with diurnal clock data were above cutoff for regulatory problems. Of the parents, 5.5% of the 274 that answered EPDS at T4 scored above the cutoff indicating depression. At T6, 5.2% scored above cutoff. To check whether the parents who were depressed at T6 had a larger portion of infants with social withdrawal symptoms, a chi square test was run, but this was not significant (χ^2=.432, $p = .511$). Table 3 displays descriptive statistics and correlation coefficients of all measures. There were many statistically significant correlations, however, the ADBB and the SC-IAT were unrelated to any of the other variables.

[Table 3 near here]

Autoregressive and cross-lagged effects

The model was built in R applying the lavaan package (Rosseel, 2012) and using the PML estimator. The hypothesized model included paths from measures at T1 (repetitive negative thinking, implicit associations, parity, and social support) to the T4 measures (depressive symptoms, parenting stress and regulatory problems). As depressive symptoms and parenting stress were measured at three and two timepoints respectively, autoregressive paths of the EPDS and the PSI-PD were specified. There were also cross-lagged paths between these measures. Further, paths from T4 measures to T5 measures (depressive symptoms, parent, and child domain of parenting stress), and from T5 measures to T6 measures (depressive symptoms and signs of social withdrawal) were specified. Covariation between measures at the same timepoint was also entered. To check for collinearity we performed linear regressions for each of the T5 variables as outcome and the T1 and T4 variables as predictor. No collinearity was detected, see SOM for details.

Goodness of fit was evaluated based on a comparative fit index (CFI), and standardized root mean square residual (SRMR). The SRMR is recommended for data based on Likert scales and chosen here. However, the fit of the hypothesized model was not acceptable. We therefore decided to remove the T6 variables, as the ADBB was not related to other variables and the EPDS already was included at T4 and T5. Reducing the model would

also allow for running separate analyses for men and women, as the sample of men was limited. The final model had a good fit (CFI = .961, SRMR = .058), see Figure 2.

[Figure 2 near here]

Both autoregressive paths of depressive symptoms and parenting stress had significant positive estimates. As expected, parenting stress and depressive symptoms were related, and both were predicted by repetitive negative thinking during pregnancy. Parity was a significant protective factor of both parenting stress and depressive symptoms, in addition to regulatory problems in the infant. Parity was also negatively related to the child domain of parenting stress at T5, along with social support, while repetitive negative thinking was positively related. All significant paths can be seen in figure 2, estimates are reported in Table 4.

[Table 4 near here]

Gender differences

To explore possible gender differences, the model was run for mothers and fathers separately. We removed the implicit association variable, as this was not related to other variables in the model with all participants. This increased the number of free parameters. The female model had a good fit (CFI = .96, SRMR = .064). The significant paths did not change from the full model, except that social support no longer was a significant predictor of the child domain of parenting stress. Because only 53 fathers had answered all measures, the male model had less power. It still had a good fit (CFI = .98, SRMR = .067). For fathers, parity was not predictive of either depressive symptoms, parenting stress or regulatory problems. Depressive symptoms at T4 did not predict later parenting stress in fathers, as opposed to mothers. Only repetitive negative thinking was a significant predictor for the child domain of parenting stress in fathers, where higher levels led to more stress.

Discussion

The present study examined the dynamic relationship between parental cognitions, stress and depressive symptoms, and infant regulatory problems and signs of social withdrawal. Social support and parity were also included and investigated as protective factors. Using a transactional model, we found that repetitive negative thinking during pregnancy predicted parental stress and depressive symptoms after birth (T4), but not regulatory problems in the infant. Repetitive negative thinking also predicted how the parents perceived their infant at T5 (PSI-CD). Infant regulatory problems (T4) were not related to

concurrent parental stress or depressive symptoms, nor did it predict these factors at T5. Parity played an important role as a protective factor for parental stress and depressive symptoms. For mothers, parity yielded a positive association with less infant regulatory problems, which was not true for fathers.

Parental cognitions and infant regulatory problems

Results show that repetitive negative thinking during pregnancy significantly predicted both parental stress and depressive symptoms after birth, but not regulatory problems in the infant. Interestingly, infant regulatory problems at T4 was not significantly related to how the parents perceived their infant at T5 (PSI-CD), while repetitive negative thinking during pregnancy was. This is in line with previous research where the infants' actual behavior was not related to the parents' subjective experience (MacKenzie & McDonough, 2009). Parental experience of their infant might not depend on the infant's actual behavior, but rather on their own interpretations. What is experienced as exhausting or frustrating for one parent, might not be considered problematic for another (Deater-Deckard, 2004). Overall, infant regulatory problems did not have a significant effect on any parental variables.

The tendency to be caught up in negative thoughts represents a clear vulnerability for experiencing stress and depressive symptoms during the perinatal period. However, opposed to our prediction, the parents' implicit association to infants did not have a significant effect on either parental stress or infant regulatory problems.

Parity

For mothers, parity came out as an important factor to consider, as it was protective of parental stress and depressive symptoms, and infant regulatory problems after birth. Accordingly, previous experience with childbirth and care makes mothers less vulnerable for experiencing stress and symptoms of depression. Regarding regulatory problems, parity can be protective of crying problems (Kurth et al., 2010; Petzoldt et al., 2016), and benefit sleep duration (Kaley et al., 2012), as in our sample as well. Experience in reading the infant's signs and knowing effective strategies for soothing can build parents' confidence and provide well known solutions (Kurth et al., 2014). This, in turn can affect the regularity of the infant.

Infant social withdrawal

Contradictory to our hypothesis, infants' signs of social withdrawal was not significantly related to depressive symptoms in the parents in our sample. This is opposed to

previous research indicating an association between parental mental health and infant social withdrawal (Burtchen et al., 2013; Mäntymaa et al., 2008). The low prevalence of social withdrawal in our sample might conceal any association though. Previous studies in the Nordic countries have also demonstrated a low prevalence of withdrawal behavior, for instance Mäntymaa et al. (2008) had only a 4% prevalence on ADBB in their sample, and Braarud et al. (2013) had 2.18% above cutoff in their full-term infant group at 6 months post birth. In a more vulnerable sample, where parents would have higher levels of relational challenges, we would expect higher prevalence of social withdrawal in the infants (Burtchen et al., 2013; Guedeney et al., 2012) and possibly significant relations with parental functioning. Regardless, it is encouraging that infants in the present sample do not seem to take harm of parental depressive symptoms. This supports research that illustrates that parenting behavior, and not only symptoms of depression or parental stress, affects the infant's development (Stein et al., 2014). One must be careful to draw conclusions though, as our sample had a low prevalence of depression, and severity of symptoms were low too.

Parental stress and depressive symptoms

Unsurprisingly, parental stress and depressive symptoms were closely related. However, parenting stress two months after birth did not significantly predict depressive symptoms 5 months after birth, while depressive symptoms at two months after birth did significantly predict parenting stress at 5 months. This provides evidence that depressive symptoms might increase parenting stress, but stress might not necessarily lead to depression. Some parents might find their new role and life situation stressful and overwhelming, but do not experience symptoms of depression.

Gender differences

When running the model separately for mothers and fathers, some interesting differences emerged. Parity in fathers had no significant effect on either parental stress or depressive symptoms, or infant regulatory problems. Fathers might benefit less from their previous experience with child rearing. It might also suggest that other factors are more important for fathers' mental health. Previous research found that fathers' depressive symptoms are affected by their partner's depressive symptoms and the partner relationship quality (Bergström, 2013; Goodman, 2004). Goodman (2004) also suggests that fathers' postnatal depression might develop later during the first year than in mothers. Possibly their mental health is more dependent on how the family and the partner relationship is coping during the first months. However, paternal repetitive negative thinking was still a significant

predictor of their stress and depressive symptoms, and it was also predictive of how they experienced their child at 5 months. For both mothers and fathers, being caught up in negative thoughts play an important role in their experience and wellbeing during the postnatal period.

Limitations and strengths

Participants in the present study were resourceful families, where most have higher education, a good income, and experienced social support. Generalizability is therefore limited. Results might have differed in a sample of less resourceful families, where one might have expected higher levels of parental stress and depressive symptoms, and possibly more infants with signs of social withdrawal. A larger sample size would also be preferable, considering the low numbers of parents with depressive symptoms and infants with signs of social withdrawal. It is a strength however, that the study recruited both mothers and fathers, as research on fathers in the perinatal period traditionally is lacking.

The regulatory problems were only measured at one timepoint. It is possible that we would have seen an effect of regulatory problems on parents' well-being if we had data on persistent regulatory problems. For example, if the infant still had regulatory problems at 5 months or 7 months, this might be more detrimental to the parents´ mental health. Similarly, parents' persistent stress or depressive symptoms might affect regulatory problems on a later time point. As we do not have data on regulatory problems after T4, we cannot examine this. However, based on the present results, we can assume that at least early transient regulatory problems, in the first few weeks after birth, do not seem to affect parents' well-being.

The reliability of the diurnal clock as a measure of regulation problems is also debatable. Keeping track of the infant's state throughout two full days and nights is quite tasking and we could not control how thorough the participants filled out the form. However, based on feedback from participants and the amount of details and extra information many had given (e.g. feeding of the infant), we believe most have done their best in keeping track. We think also the scoring criteria for regulation problems is set at level where the details of reporting is not too demanding. Measuring the daily rhythm of the infant is complicated, but a diary such as the diurnal clock might be the closest we get in a population study. It is a strength that the present study not only included parental report of how they experience the infant's behavior, but observation and registration of actual behavior states.

The data in the present study is mostly based on self-reports, but also includes observational data and an implicit measure of attitudes towards infants. Ideally, more

observational data is desirable, as one could have examined if and how parental cognition, stress and depressive symptoms affected parental behavior. However, observations can feel intrusive and rarely reflect entire behavior. Regarding the measure of implicit attitudes, it was not significantly related to any of the other variables. Behavioral tasks are often only weakly correlated to questionnaires and may not be suited to measure individual differences (Dang et al., 2020). In addition, the SC-IAT has been criticized for low reliability (Chevance et al., 2017), and should perhaps be reserved for investigating group differences.

Finally, there was some attrition between measurements, especially among fathers, that might affect the results. It is possible that the group of fathers who dropped out could have experienced more stress or depressive symptoms, and therefore did not find the time to prioritize participation. However, attrition analyses showed that there was no difference in depressive symptoms between the missing and the participating group at the initial assessment. We think it likely that fathers dropped out because most fathers were working while the mothers were at home with their infant during the study. Despite some attrition, this study contributes to important knowledge about fathers in the perinatal period. Still, more studies that examined fathers' cognitions in relation to their postnatal health should be conducted.

Implications

Based on the present results, health care providers should be especially aware of the needs and well-being of first-time parents. First-time parents are the ones most likely to need extra support, at least in resourceful families as in the present sample. This is especially true regarding mothers. For fathers, other factors like their own cognitions might be more important. Health professionals should make sure they ask how the parents are doing, if they worry much, if they are feeling unable to cope, or how their mood is. Parents often seek out help because of colic, difficulties to soothe the infant, or sleeping problems, but if these parents only get advice on how to plan their infant's sleep routine, one might overlook that the parents might need help for their own thoughts and feelings. Giving a stressed mother more advice or techniques on how to soothe her baby, instead of calming her and building her confidence, might only add to her stress and decrease her chances of successfully soothing her baby. Nowadays, with so much information online, parents seeking help will often already have read up on tips and tricks, and so the perinatal health care should strive to offer the time to listen, understand what and why the family is struggling. They should meet them with a holistic approach where one considers the parents' cognitions, functioning and well-being, the

infant's temperament and behavior, the nature of the parent-infant interactions, and the family's experiences and support network.

Conclusion

The present study indicates that parents' own cognitions, especially repetitive negative thinking affects their experience of parental stress and depressive symptoms, while their child's regulatory problems few weeks after birth might not. Parents' cognitions also significantly predict their self-reported experience of their own child, as opposed to the actual regulatory problems of the child. Accordingly, parents who experience their child as difficult during the first months after birth might need interventions targeting their own cognitions and mental health. Mothers of more than one child have a decreased risk of experiencing difficulties with both their own mental health and regulatory problems in the infant.

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Figures

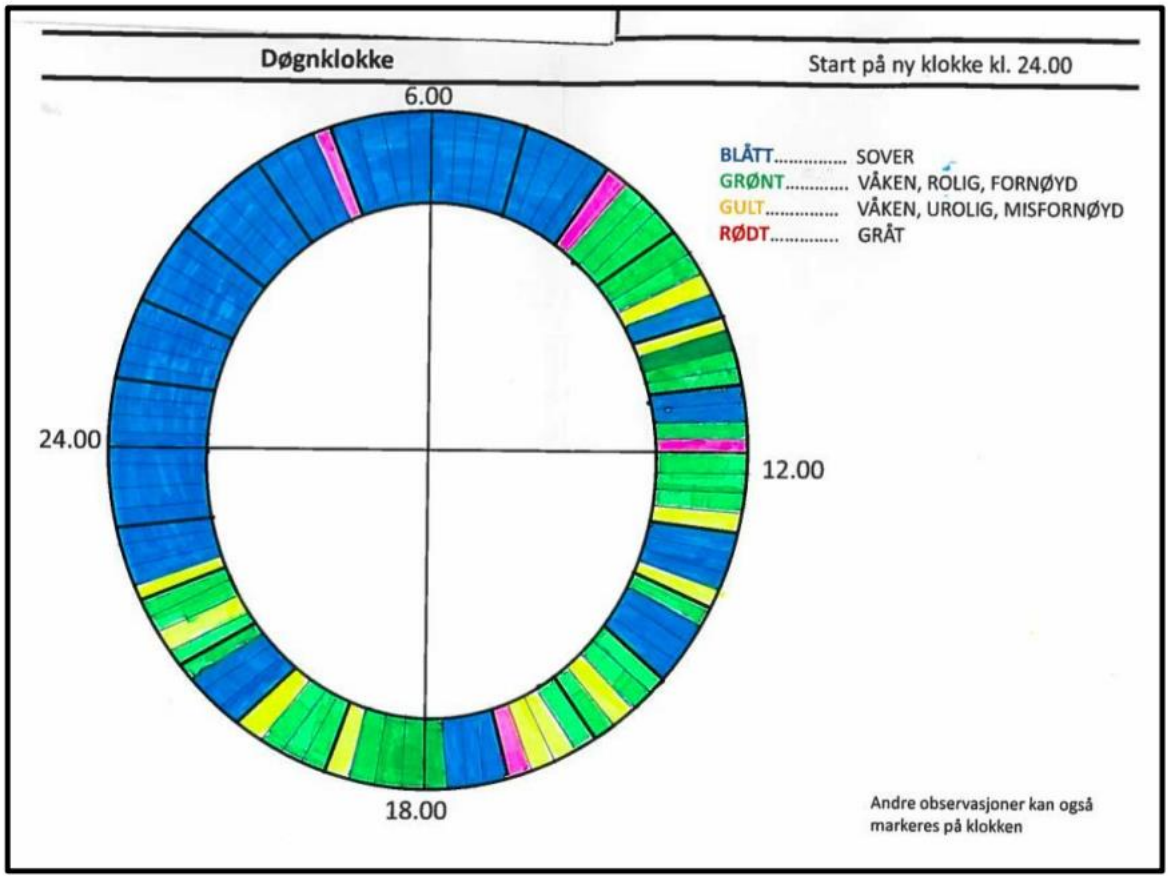

Figure 1. Example of a diurnal clock. The text is in Norwegian. The translated instructions are to start recording at 12 a.m. and use the following colors to record the different behavior:
Blue = sleeping
Green = awake, calm, pleased
Yellow = awake, fussy, uneased
Red = crying
Other observations can also be noted.

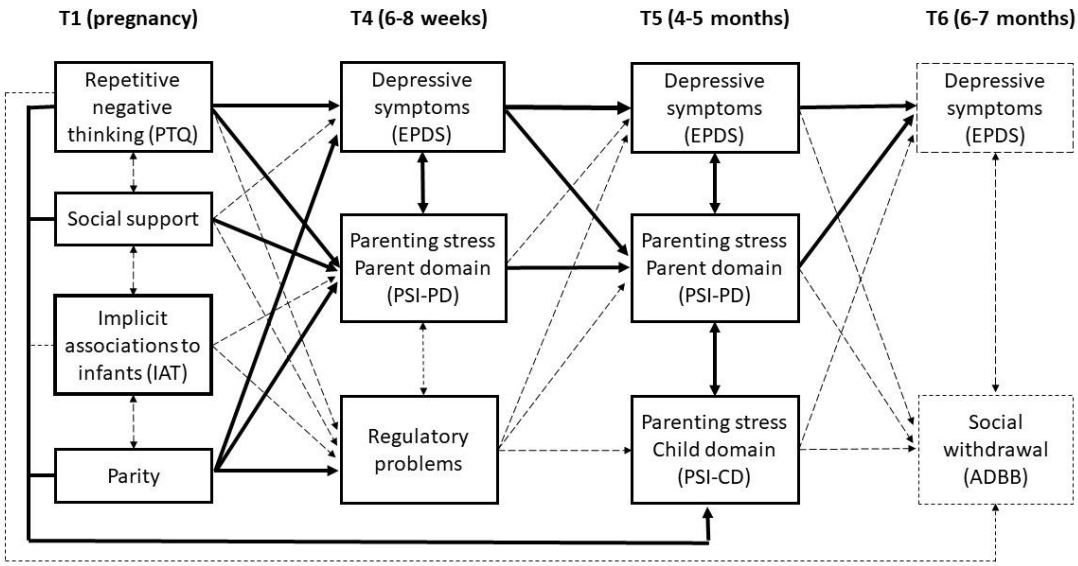

Figure 2. The final model. Bold arrows are significant. T6 measures were excluded from the final model, illustrated by their boxes being dotted.

Tables

Table 1

Participant characteristics at T1.

Variable		*N*
Men / Women	129/221	350
Age	*M* = 32.19 (*SD* = 5.0, range 20-49)	348
Primiparous	51.8 %	350
Higher education	82.6 %	350
High income	68.9%	350

Note. Higher education = university or college degree, bachelor level or higher. High income = average (750 000 NOK - 1 000 000 NOK) or high (> 1 000 000 NOK) per household.

Table 2.

Criteria for coding of the Diurnal Clocks.

	Definition of when a regulatory problem is present
Total sleep	< 12 h during the 24 h
Night sleep	< 5 h continuous sleep between 23-06. Awakenings of 15 minutes or less is not counted since discontinued sleep for feeding during the night is considered normal.
Difficult to soothe	≥ 2 h of continuous fuzziness and/or crying
Excessive crying	≥ 3 h of crying during the 24 h

Table 3

Means, standard deviation, sample size and correlation matrix of all measures

Measure	N	Mean	SD	1	2	3	4	5	6	7	8	9	10
1 PTQ T1	349	16.1	9.91										
2 IAT T1	239	.029	.28	-.05									
3 Parity	353	.59	.69	-.09	-.02								
4 EPDS T4	274	3.15	3.07	.45**	-.04	-.16**							
5 PSI-PD T4	273	2.08	.39	.44**	-.05	-.18**	.64**						
6 Reg. prob.	158	2.08	.39	.09	-.13	-.23**	.23**	.21**					
7 EPDS T5	246	3.05	3.35	.49**	-.09	-.10	.62**	.48**	.18*				
8 PSI-PD T5	241	2.10	.42	.42**	-.08	-.10	.65**	.82**	.18*	.60**			
9 PSI-CD T5	240	1.86	.34	.19**	.04	-.18**	.42**	.58**	.17*	.30**	.67**		
10 EPDS T6	270	2.86	3.40	.43**	-.06	-.16**	.53**	.49**	.19*	.55**	.51**	.26**	
11 ADBB T6	169	1.33	1.78	-.08	-.11	.01	.04	-.02	.12	-.05	-.05	-.00	-.08

Note. PTQ = Perseverative thinking questionnaire. IAT = Implicit Association Task. Parity is measured by number of children. EPDS = Edinburgh Postnatal Depression Scale. PSI = Parenting Stress Index, PD = Parent Domain, CD = Child Domain. The PSI has been transformed from total score to mean score to account for missing items. Reg. Prob = Regulatory problems, total score, scored according to table 2. ADBB = Alarm Distress Baby Scale, total score, measure of social withdrawal. Correlation coefficients are Pearson's *r*, * = $p < .05$, ** = $p < .01$.

Table 4.

Coefficients of the model

	Standardized estimate	*p*
Depressive symptoms T4 regressed on		
Repetitive negative thinking (T1)	.48	**<.001**
Social support (T1)	-.41	.234
Parity (T1)	-.47	**.005**
Depressive symptoms T5 regressed on		
Depressive symptoms (T4)	.60	**<.001**
Parenting stress – parent domain (T4)	.23	.360
Regulatory problems (T4)	.03	.645
Parenting stress – parent domain T4 regressed on		
Repetitive negative thinking (T1)	.19	**<.001**
Social support (T1)	-.45	**.001**
Parity (T1)	-.19	**.022**
Implicit associations (T1)	.07	.585
Parenting stress – parent domain T5 regressed on		
Depressive symptoms (T4)	.07	**.010**
Parenting stress – parent domain (T4)	.77	**<.001**
Regulatory problems (T4)	-.01	.500
Infant regulatory problems T4 regressed on		
Repetitive negative thinking (T1)	-.02	.864
Social support (T1)	-.34	.279
Parity (T1)	-.86	**<.001**
Implicit associations (T1)	-.14	.683
Parenting stress – child domain T5 regressed on		
Repetitive negative thinking (T1)	.11	**<.001**

Social support (T1)	-.35	**.014**
Parity (T1)	-.20	**.005**
Implicit associations (T1)	.11	.357
Covariances		
T4 Depressive symptoms – Parenting stress PD	.13	**<.001**
T4 Parenting stress PD – Infant regulatory problems	.01	.686
T5 Depressive symptoms – Parenting stress PD	.07	**<.001**
T5 Parenting stress PD – Parenting stress CD	.05	**<.001**
T5 Depressive symptoms – Parenting stress CD	.04	**.050**

Note. Covariances between T1 measures not included in table, all *p*'s > .07

Supplementary table 1.

Coefficients of the model with mothers only

	Standardized estimate	*p*
Depressive symptoms T4 regressed on		
Repetitive negative thinking (T1)	.48	**<.001**
Social support (T1)	-.43	.343
Parity (T1)	-.57	**.001**
Depressive symptoms T5 regressed on		
Depressive symptoms (T4)	.56	**<.001**
Parenting stress – parent domain (T4)	.24	.421
Regulatory problems (T4)	.04	.627
Parenting stress – parent domain T4 regressed on		
Repetitive negative thinking (T1)	.19	**<.001**
Social support (T1)	-.35	**.030**
Parity (T1)	-.21	**.012**
Parenting stress – parent domain T5 regressed on		
Depressive symptoms (T4)	.08	**.023**
Parenting stress – parent domain (T4)	.76	**<.001**
Regulatory problems (T4)	-.01	.522
Infant regulatory problems T4 regressed on		
Repetitive negative thinking (T1)	.14	.391
Social support (T1)	-.28	.573
Parity (T1)	-.86	**.001**
Parenting stress – child domain T5 regressed on		
Repetitive negative thinking (T1)	.12	**<.001**

Social support (T1)	-.27	.180
Parity (T1)	-.22	**.005**
Covariances		
T4 Depressive symptoms – Parenting stress PD	.12	**.001**
T4 Parenting stress PD – Infant regulatory problems	.05	.126
T5 Depressive symptoms – Parenting stress PD	.09	**.001**
T5 Parenting stress PD – Parenting stress CD	.06	**<.001**
T5 Depressive symptoms – Parenting stress CD	.05	**.025**

Note. Covariances between T1 measures not included in table, all *p*'s > .30

Supplementary table 2.

Coefficients of the model with fathers only

	Standardized estimate	*p*
Depressive symptoms T4 regressed on		
Repetitive negative thinking (T1)	.49	**.007**
Social support (T1)	-.50	.540
Parity (T1)	-.19	.780
Depressive symptoms T5 regressed on		
Depressive symptoms (T4)	.67	**.018**
Parenting stress – parent domain (T4)	.20	.758
Regulatory problems (T4)	-.00	1.00
Parenting stress – parent domain T4 regressed on		
Repetitive negative thinking (T1)	.18	**.009**
Social support (T1)	-.56	**.051**
Parity (T1)	-.07	.813

Parenting stress – parent domain T5 regressed on		
Depressive symptoms (T4)	.00	.954
Parenting stress – parent domain (T4)	.88	**<.001**
Regulatory problems (T4)	.00	.929
Infant regulatory problems T4 regressed on		
Repetitive negative thinking (T1)	-.24	.204
Social support (T1)	-.26	.561
Parity (T1)	-.80	.081
Parenting stress – child domain T5 regressed on		
Repetitive negative thinking (T1)	.10	**.011**
Social support (T1)	-.35	.133
Parity (T1)	-.11	.659
Covariances		
T4 Depressive symptoms – Parenting stress PD	.19	**.001**
T4 Parenting stress PD – Infant regulatory problems	-.07	.288
T5 Depressive symptoms – Parenting stress PD	.05	**.033**
T5 Parenting stress PD – Parenting stress CD	.03	**.036**
T5 Depressive symptoms – Parenting stress CD	.01	.661

Note. Covariances between T1 measures not included in table, all *p*'s > .20

Do parental cognitions during pregnancy predict bonding after birth in a low-risk sample?

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Abstract

Parental bonding to their infant is important for healthy parent-infant interaction and infant development. Characteristics in the parents affect how they bond to their newborn. Parental cognitions such as repetitive negative thinking, a thinking style associated with mental health issues, and cognitive dispositions, e.g., mood-congruent attentional bias or negative implicit attitudes to infants, might affect bonding.

To assess the influence of cognitive factors on bonding, 350 participants (220 pregnant women and their partners) were recruited over two years by midwives at the hospital and in the communal health care services. Participants were followed throughout the pregnancy and until the infant was seven months old as a part of the Northern Babies Longitudinal Study. Both mothers and fathers took part. First, we measured demographics, repetitive negative thinking, attentional bias, and implicit attitudes to infants during pregnancy, as predictors of bonding two months postnatally. Second, we also measured infant regulatory problems, and depressive symptoms at two months postnatally as predictors of parents' perception of infant temperament at five months. Robust regression analyses were performed to test hypotheses.

Results showed that mothers and fathers differed on several variables. Parity was beneficial for bonding in mothers but not for fathers. Higher levels of mothers' repetitive negative thinking during pregnancy predicted weaker bonding, which was a non-significant trend in fathers. For fathers, higher education predicted weaker bonding, but not for mothers. Mothers' perception of their infant temperament at five months was significantly affected by bonding at

two months, but for fathers, their depressive symptoms were the only significant predictor of perceived infant temperament.

In conclusion, for mothers, their relationship with their infant is essential for how they experience their infant, while for fathers their own wellbeing might be the most important factor. Health care providers should screen parents' thoughts and emotions already during pregnancy to help facilitate optimal bonding.

1 Introduction

Bonding is defined as the emotional tie from a parent to the infant (Bicking Kinsey and Hupcey, 2013). It refers to the affective component of the parent's relationship to the infant, the emotions, and feelings towards the infant. Low quality of bonding may negatively affect parenting behavior, as it could lead to less positive maternal feelings and more irritability and hostility towards the infant (Brockington, 2004; Bicking Kinsey and Hupcey, 2013). Poor bonding is also related to parents' well-being, as it predicts parenting stress (de Cock et al., 2017), and parenting stress affects child development (Barroso et al., 2018; Fredriksen et al., 2018). Overall, bonding quality is positively related to the infant's developmental outcomes (Mason et al., 2011; Alhusen et al., 2013; de Cock et al., 2017; Le Bas et al., 2020). Identifying potential precursors of bonding quality can inform how to mitigate poor bonding and parenting stress.

1.1 Predictors of maternal bonding

Previous research has investigated both demographic factors and parental mental health as possible predictors of bonding, with varying results. Kinsey et al. (2014) found a negative effect of socioeconomic status on the quality of bonding, where mothers who were less educated, had lower income, and were less likely to be married reported higher levels of bonding. Cuijlits et al. (2019) also reported a negative effect of education on prenatal bonding in mothers, but not on postnatal bonding. Prenatal maternal depressive symptoms are negatively associated with bonding after birth (Dubber et al., 2015; Rossen et al., 2016; Cuijlits et al., 2019), while prenatal anxiety is not (Dubber et al., 2015; Rossen et al., 2016). As bonding includes forming a relationship to one's infant, maternal relational experiences have been examined. Mothers' own attachment style is related to both prenatal (Alhusen et al., 2013) and postnatal maternal-infant bonding (Nordahl et al., 2020). Similarly, Nordahl et al. (2019) also investigated mothers' early maladaptive schemas, which are negative and stable self-assumptions about oneself and one's relationships, and found they were negatively associated with prenatal maternal bonding. This indicates that parents' predispositions in the form of cognitive and relational styles can affect bonding to their child, maybe even to a higher degree than mental health in general.

1.1.1 Bonding and parental cognitions

The adverse effects of maternal mental illness on infant development is well established (Goodman et al., 2011; Kingston et al., 2012; Stein et al., 2014). Maternal cognitions or preoccupations might explain this relation (Stein et al., 2009; 2012). Indeed, the tendency to be caught up in negative thoughts during pregnancy is associated with mother-infant bonding after birth (Müller et al., 2013; Schmidt et al., 2017). Emotional availability in the parent is important in the formation of the parent-infant bond (Bicking Kinsey and Hupcey, 2013), accordingly, preoccupied parents might struggle more with bonding. In a model by DeJong et al. (2016) repetitive negative thinking, combined with reduced cognitive control and cognitive biases, occupies mental capacity and leads to less parental sensitivity. In turn, this can cause

parents to miss out on positive infant cues, interpret cues more negatively, and cause the infant to either become more passive from the lack of response or express more negative emotionality to get attention. This might facilitate difficulties in parent-infant bonding, parent-infant interaction, and how the parents perceive their infant's temperament.

Although there is some evidence of a negative effect of repetitive negative thinking on maternal bonding, less is known about other cognitions. Attentional bias has received a considerable amount of attention in depression research. Depressed individuals tend to engage more with sad stimuli than healthy controls, a mood-congruent attentional bias (Gotlib and Joormann, 2010). This tendency was also found in expecting parents with depressive symptoms when looking at emotional infant faces (Bohne et al., 2021). Parents who are caught up in their infant's sad expressions might experience their child as having more negative emotionality than other parents. Attentional bias towards sad faces may thereby interfere with an optimal bonding process.

Implicit attitudes are predictive of behavior (Greenwald et al., 2009), particularly when under stress and being low on self-regulatory resources. Negative implicit attitudes to infants could thus affect parenting behavior and possibly parents' emotions towards their infant. For example, Sun et al. (2021) demonstrated that pregnant women's reported attitudes towards infant crying were not related to their implicit attitudes to the sounds of infant crying. Less is known whether these implicit attitudes affect bonding.

1.2 Parental perception of infant temperament

The infants' emotionality and regularity, and if they are experienced as easy or difficult, are often referred to as infant temperament (Rothbart and Putnam, 2002). Parents' report of infant temperament is their subjective experience and, therefore, might be colored by the parents' cognitions and well-being (Davies et al., 2021). Accordingly, studies found that caregivers' perception of infant crying as problematic was not related to the actual amount of crying (van der Wal et al., 1998; MacKenzie and McDonough, 2009). However, the infant itself is an active part in every parent-infant relationship, and actual infant behavior might also affect both bonding and parental perception of their infant (Bicking Kinsey and Hupcey, 2013; de Cock et al., 2016). It may be harder to connect to an infant that cries a lot, or has sleep difficulties, as this might be experienced as exhausting and challenging for the parents. Therefore, when parents report difficulty with their infant's emotional regulation, this could be an expression of both actual regulatory problems in the infant and parental perception of the infant.

1.3 Differences between paternal and maternal bonding

Traditionally, research on parent-infant bonding has focused on mothers, though recent studies investigated father-infant bonding (de Cock et al., 2016; de Cock et al., 2017; Scism and Cobb, 2017; Bieleninik et al., 2021). As maternal bonding, paternal bonding is associated with child development (Ramchandani et al., 2013; de Cock et al., 2017) and bonding patterns are similar between mothers and fathers. However, fathers are more likely to have high levels of bonding to their firstborn child than to later-born children, which is not the case in mothers (de Cock et al., 2016). Like mothers, fathers' mental health affects bonding, where paternal anxiety and parenting stress is related to bonding (Bieleninik et al., 2021). As mental health and parental cognitions affect bonding, parents within a couple might differ in their bonding to their infant, not least of their individual differences in mental health and cognitions.

1.4 The present study

Summarized, bonding can be affected by repetitive negative thinking during pregnancy (Müller et al., 2013; Schmidt et al., 2017) in mothers. We do not know if this holds true for fathers too. We do not know if parents' own cognitions and mental health can explain differences in bonding within couples, even though they are bonding to the same infant. Further, parental perception of their own infant's temperament can be affected by difficulties in the parent themselves or the parent-infant relationship (MacKenzie and McDonough, 2009; Davies et al., 2021). Thus, a closer look at the effect of bonding and parents' cognitions is warranted.

The sample was a resourceful one with high socioeconomic status and low levels of depressive symptoms. We asked; do repetitive negative thinking, attentional bias, and implicit attitudes during pregnancy predict bonding after birth? Do mothers and fathers differ in this regard? If so, would cognitions and depressive symptoms in one parent cause differences in bonding within a couple? Are parents' perception of their infant's temperament affected by bonding, depressive symptoms, cognitions, or the infants' actual regularity?

Specifically, we hypothesized that a) higher levels of repetitive negative thinking, bias towards sad infant faces, and negative implicit associations to infants would lead to lower levels of bonding. We expected that b) parity would have a positive effect on bonding for mothers but not for fathers, and that c) education would not be a significant predictor for either, especially because of the low variance in the sample. Further, we expected that d) disparity in depressive symptoms or cognitions within a couple would predict disparity in bonding to their infant. Regarding the parental perception of infant temperament, we hypothesized that e) higher levels of bonding would lead to perceiving the infant as less difficult, while f) depressive symptoms and negative cognitions would have the opposite effect.

2 Method

The present study was part of the Northern Babies Longitudinal Study (NorBaby; Høifødt et al., 2017), taking place in Northern Norway. Participants in this study were followed throughout the pregnancy until the infant was about 7 months old (last assessment was sent 6.5 months postnatally). There were six assessments, three during pregnancy (T1-T3) and three after birth (T4-T6). The present study applied data from T1, T4 and T5. T1 was completed between week 13-39 of gestation (*mean* 23.0, *median* 23, *SD* 3.62). The wide range is due to late recruitment of some participants. When they were recruited late, we prioritized the T1 assessment as this contained all demographic information and skipped T2 (and T3) when there was not enough time. Standard routine was to answer T1 at recruitment, T2 between week 24-30 of gestation, and T3 after week 31 of gestation, preferably with at least 4 weeks between assessments. T4 was sent to participants at week 6 after birth and completed between week 6-15 after birth (*mean* 8.17, *median* 7.71, *SD* = 1.96), and T5 was sent at week 16 after birth and completed between week 16-39 (4-9 months) after birth (*mean week* 21.25, *median week* 20.43, *SD* 3.49).

2.1 Power calculations

Sample size was a priori estimated for the NorBaby study, see Høifødt et al. (2017) for details. Given feasibility and available resources, we aimed to recruit at least 200 families. We did not perform an a priori power calculation for the specifics of this analysis.

2.2 Participants

350 participants were recruited to the NorBaby-study, 220 pregnant women and 130 partners (one female). The sample was a resourceful one, where the majority had higher education, good incomes, and experienced social support from family and friends (see Table 1 for details).

2.3 Procedure and measures

Participants were recruited through midwife-services both in the commune and at the University Hospital. All pregnant women and expecting partners living in the commune of Tromso who spoke Norwegian were eligible to participate. All who volunteered were included. Midwives asked the expecting mothers if they were interested in knowing more about the study and they were given a pamphlet to fill out if they were. Pamphlets were collected by the research team, and interested women were phoned to give more information about the study and invite them to participate. If they agreed to participate, they were invited to the first assessment either at the university or somewhere more convenient to them. Recruitment took place from September 2015 to October 2017.

The first assessment was completed in person with a member of the research group present. After that T2-T4 were sent to participants via e-mail. T5 and T6 was also sent by e-mail, but they also met in person as these assessments included filming and neuropsychological testing (not relevant for the present article). Measures relevant for the present article will be presented below.

2.3.1 Prenatal assessments (T1)

2.3.1.1 Demographics

Participants answered demographic questions at T1, including if they already had children and their level of education. Education was measured ordinally, from low (did not finish high school) to very high (more than 5 years at university/college). Previous depressive episodes were also reported, however this variable was not included in present analyses (please see Bohne et al., 2022 for analyses including history of depression).

2.3.1.2 The perseverative thinking questionnaire (PTQ)

To measure repetitive negative thinking we administered the Perseverative Thinking Questionnaire (PTQ; Ehring et al., 2011). This is a transdiagnostic questionnaire that measures if thoughts are repetitive, intrusive, and difficult to disengage from, if they are perceived unproductive and capture mental capacity. The questionnaire consists of 15 items that are statements about one's thoughts, e.g., "The same thoughts keep going through my mind again and again". Answer options range from 0 (never) to 4 (almost always), giving a total range of 0-60 where higher scores indicate higher degrees of repetitive negative thinking. Internal consistency was excellent both in the original version (α = .95) and in the present sample (MacDonald's ω = .948).

2.3.1.3 Emotional Dot-Probe task (EDP)

This is a modified version of the dot-probe task (MacLeod et al., 1986). We applied it to measure attentional bias to infant faces. The task presents participants with images of sad, happy, and neutral infant faces one at a time, on either the right or left side of the screen.

Images are followed by an x on either the same or the opposite side of the screen. Participants have then to press a key (either "E" for left side or "I" for right side) to indicate where the x appeared. Response time is recorded. If participants respond faster on congruent trials (x appears on the same side of the screen as the stimulus image) than on incongruent trials (x appears on the opposite side), then the stimulus image caught their attention and they disengaged more slowly. Reaction times are calculated for each emotion (happy, sad, neutral infants), and compared. The task was completed at T1. Images were taken from the Tromso infant face database (Maack et al., 2017). Previous research demonstrated that a depressed group of expecting mothers differed from a non-depressed group of expecting mothers mainly on bias to sad faces (Bohne et al., 2021), and therefore we included only bias to sad faces in our analyses.

2.3.1.4 Single Category Implicit Association Test (SC-IAT)

The Single Category Implicit Association Test (SC-IAT; Karpinski and Steinman, 2006) is a modified version of the Implicit Association Test (Greenwald et al., 1998), here applied as a measure of implicit associations to neutral infant faces (image stimuli). The faces are taken from the Tromsø infant face database (Maack et al., 2017). In the test, participants were asked to categorize words or infant faces as either positive or negative. This was done by sorting them either to the left or the right side of the screen using the "E" and "I" key. Stimuli (words or infant faces) were presented in random order on the screen, one at a time. There were two conditions, one where infants were sorted to the same side as positive words, and one where they were sorted with the negative words. Order of conditions were randomized. Response time was measured, and the difference between conditions is seen as a measure of implicit associations. There is a positive association toward infants when the response times are shorter for sorting the infant faces to the same side as the positive words. There is a negative association toward infants when the response times are shorter for sorting the infant faces to the same side as the negative words. The task was completed at T1.

2.3.1.5 Edinburgh Postnatal Depression Scale (EPDS)

The scale was developed to screen for depressive symptoms in the perinatal period (Cox et al., 1987). It consists of 10 items assessing common depressive symptoms, e.g., "In the past 7 days, I have been so unhappy that I have had difficulty sleeping". Each item is scored from 0-3 points and total scores range from 0-30 points. According to Norwegian validation and prevalence studies, a cutoff score ≥10 indicates possible depression and provides high sensitivity (Eberhard-Gran et al., 2001; Glavin et al., 2009). Even though it was originally developed to measure postnatal depression, it is widely used throughout the perinatal period, and validated for prenatal use as well (Field, 2017; Lydsdottir et al., 2019). Originally, the internal consistency of the scale was good ($\alpha = .87$) and this was also the case in the present sample (MacDonald's $\omega = .802$).

2.3.2 Postnatal assessments (T4 and T5)

2.3.2.1 Edinburgh Postnatal Depression Scale (EPDS)

As described above. Internal consistency at T4 was acceptable (MacDonald's $\omega = .790$).

2.3.2.2 Diurnal clock

To measure infant regulatory problems, we extracted data from diurnal clocks filled out by the parents at T4. The Diurnal Clock is a diary where participants registered their infants' daily rhythm and behavioral state for two days and two nights. Diurnal clocks were coded according to criteria presented in Table 2. As many infants struggle with their night sleep at

this age, a regulatory problem was not considered present unless they had a score of three or more.

2.3.2.3 Maternal/Paternal Postnatal Attachment Scale (MPAS/PPAS)

The scale is a measure of parental bonding (Condon and Corkindale, 1998; Condon et al., 2008). It consists of 19 items concerning parents' thoughts and feelings towards their infant. Items are rated either on 2-, 3-, 4- or 5-point scales, and all items are therefore recoded to scores from 1 (poor bonding) to 5 (strong bonding) to ensure equal weighting of the items. This gives a total range from 19-95. Originally, internal consistency of both the MPAS and the PPAS was good, with Cronbach's α varying from .78-.81 depending on infant age (Condon and Corkindale, 1998; Condon et al., 2008). In the present sample, MacDonald's ω_{MPAS} = .854, ω_{PPAS} = .842 indicating good consistency. The scale was answered at both T4 and T5, of interest here is the T4 score.

2.3.2.4 Parenting stress index – Child Domain (PSI-CD)

The parenting stress index (PSI; Abidin, 1983) measures the level of stress parents experience in their parental role. The index has two subdomains, the parent domain (PD) and the child domain (CD). While the PD measures the stress experienced related to being a parent, the CD measures the stress related to child behavior. The present study included the CD only. A higher score on the child domain reflects more negative perceptions of their child's characteristics and behavior, meaning the infant is perceived as having a more difficult temperament. Although not designed as a measure of temperament, the PSI-CD measures characteristics typically described as infant temperament (adaptability, mood, demandingness, distractability/hyperactivity, acceptability and reinforces parent; Olafsen et al., 2018). The PSI-CD consists of 47 items scored on a Likert scale from 1-5, giving a total range of 47-235. While other questionnaires designed to specifically measure infant temperament have struggled with poor or questionable internal consistency (Olafsen et al., 2018; Landsem et al., 2020), the PSI-CD in the present sample had excellent internal consistency (MacDonald's ω = .91), as it also did originally (Cronbach's α = .90 Abidin, 1995). The scale was completed at T5.

2.4 Primary data analyses

Analyses were planned and pre-registered on the Open Science Framework before cleaning and analyses of the data begun (https://osf.io/dw3zs). In accordance with the plan, we conducted regressions to investigate parental cognitions during pregnancy as predictors of bonding after birth (MPAS/PPAS). We investigated bonding along with prenatal cognitions as predictors of the child domain of the parenting stress index (PSI-CD) at T5, while controlling for depressive symptoms and infant regulatory problems. The measure of bonding (MPAS and PPAS) is not the same questionnaire for mothers and fathers, although comparable. We ran analyses separately for mothers and fathers. Finally, we conducted a regression model to examine predictors of discrepancy in bonding within couples. Analyses were performed in Jasp (JASP, 2020) and R (R Core Team, 2020).

3 Results

3.1 Sample

There was some attrition during the study. At T4, 43 participants had resigned, while 33 participants missed this assessment. At T5, another 19 had resigned and 44 participants missed the assessment. This left us with 274 participants at T4 and 244 at T5. Comparing the

missing group at T4 with the participating group revealed that fathers were more likely than mothers to drop out of the study ($\chi^2(349) = 9.659$, $p = .002$, Cramer's $V = .166$). The missing group had 52% fathers, while the participating group had 32%. The missing group at T4 was also less educated than the participating group ($t(346) = 5.200$, $p < .001$, Cohen's $d = .681$). The groups did not differ on the level of income ($t(345) = 1.820$, $p = .070$, $d = .238$).

Mothers and fathers differed significantly on several measures (see Table 3).

3.2 Predictors of bonding

A hierarchical regression model predicting parent-infant bonding (as measured by MPAS and PPAS at T4) was applied (Table 4). The demographic variables parity and education were entered in step 1. Cognitive variables and prenatal depressive symptoms were entered in step 2.

For mothers, model 1 was significant, explaining 3.9% of the variance ($F(2, 159) = 4.268$, $p = .016$). As predicted in hypothesis b) parity came out as a significant predictor, where having children from before was positively associated with bonding. Model 2 explained 16.2% of the variance ($F(6,155) = 6.203$, $p < .001$), and in addition to parity, repetitive negative thinking was a significant predictor. Implicit associations came close to statistical significance ($p = .052$) and had an effect size like that for parity (ß = .146 vs ß = .166, see Table 4). Attentional bias was not a significant predictor. Hypothesis a) was partly supported in mothers.

For fathers, model 1 explained 7.7% of the variance ($F(2, 76) = 4.239$, $p = .018$) and education was significantly and negatively predicting bonding. Less educated fathers had higher levels of father-infant bonding, refuting hypothesis c). Model 2 explained 21.5% of the variance ($F(6, 72) = 4.569$, $p < .001$) and both education and parity were significant. In line with hypothesis b) the effect of parity was opposite from mothers, as it was negatively associated with bonding for fathers (see Figure 1). Repetitive negative thinking was not significant for fathers ($p = .069$), although there was a trend in the same direction as for mothers, and the effect size (ß = -.249) was similar to that for parity and education (Table 4).

3.2.1 Difference in bonding within couples.

Parents can differ in their amount of bonding to their infant, so we looked at whether this difference was due to differences in their cognitions and depressive symptoms. To investigate what predicted higher discrepancy in bonding within couples, we extracted participants where both mother and father had answered both T1 and T4. This left us with 79 couples. We calculated the difference in scores within each couple, subtracting mothers' scores from fathers' scores. The variables included as predictors were education, prenatal assessed implicit associations and repetitive negative thinking, and postnatal depressive symptoms. Due to power, we excluded attentional bias as this was not significant for bonding in either mothers or fathers, and parity as only 12 couples differed within themselves on number of children. We ran a regression analysis with the difference in bonding as outcome (see SOM Table 6). The model was significant ($F(4,74) = 8.062$, $p < .001$) and explained 26.6% of the variance. Within couples, difference in repetitive negative thinking and postnatal depressive symptoms were significant predictors for the difference in bonding, supporting hypothesis d). Higher discrepancy in bonding within a couple is in part explained by higher levels of prenatal repetitive negative thinking or postnatal depressive symptoms in one of the parents, as can be seen in Figure 2. Differences in education or implicit associations within a couple did not explain differences in bonding.

3.3 Predictors of parents' perception of infant behavior

A hierarchical regression model predicting parents' perception and experience of their infant temperament (measured by the child domain of the parenting stress index (PSI-CD) at T5) was applied for mothers and fathers separately (see Table 5). Due to power and the results for bonding, attentional bias and implicit associations were excluded from this analysis. The only prenatal cognitive factor repetitive negative thinking was entered in step 1 (see SOM for a model including the implicit association, and a model including education and parity, only for mothers). In step 2, variables from T4 were entered: bonding, postnatal depressive symptoms, and infant regulatory problems.

For mothers, model 1 was not significant ($F(1, 123) = 2.802$, $p = .097$), but model 2 was ($F(4, 120) = 9.663$, $p < .001$). Model 2 explained 21.8% of the variance, and bonding was the only significant predictor. The more bonding, the less stressful the infant was experienced. This supported hypothesis e), however as depressive symptoms and negative thinking were not significant, hypothesis f) was not supported for mothers.

For fathers, hypothesis f) was confirmed, with postnatal depressive symptoms being the only significant predictor in model 2 ($F(4,48) = 4.244$, $p = .005$), explaining 20% of the variance. Higher levels of depressive symptoms predicted more stressful experience of the infant. Bonding was not significant for fathers, not supporting hypothesis e) for fathers.

3.3.1 Indirect effect of repetitive negative thinking.

As repetitive negative thinking during pregnancy was a strong predictor of bonding after birth for mothers, but not for the mothers' perception and experience of infant behavior, we decided to examine if repetitive negative thinking had an indirect effect on the perception of the infant through bonding. The mediation analysis confirmed our assumption: the effect of repetitive negative thinking on mothers' perception of their infant's behavior, was fully mediated by mother-infant bonding (see figure 3). Repetitive negative thinking affects bonding, and then bonding affects the perception of the infant's behavior.

4 Discussion

The present study investigated if parental cognitions during pregnancy predicted bonding after birth in a resourceful and low depression sample. The findings partly support the role of cognitions on bonding. Repetitive negative thinking during pregnancy was a significant predictor of bonding after birth in mothers, and there was a similar trend for fathers. However, attentional bias and implicit associations to infant faces were not related to bonding, thereby only partly confirming hypothesis a). Notably, there were differences between mothers and fathers in the predictors of bonding. As hypothesized, b) parity was a significant predictor for both mothers and fathers, and in opposite directions. For mothers, parity was positively related to bonding, suggesting that experience with mothering had a positive effect. For fathers, parity was negatively related to bonding, which was in line with previous findings where fathers bond more strongly to their firstborn (de Cock et al., 2016). Further, hypothesis c) was partly confirmed, education had no significant effect on mothers' bonding, whereas fathers' education level was negatively related to bonding.

Regarding parents' perception of their infant's temperament (PSI-CD at T5), we found partly support for our hypotheses. After controlling for infant regulatory problems, for mothers, bonding (T4) was the only significant predictor, and for fathers, depressive symptoms (T4) were the only significant predictor. We found that there was an effect of repetitive negative

thinking on mothers' perception of their infant's temperament that was fully mediated by bonding, meaning that repetitive negative thinking affects bonding, which further affects mothers' perception of infant temperament.

4.1 Parental cognitions

4.1.1 Repetitive negative thinking

In line with the model of DeJong et al. (2016), the present study illustrated that repetitive negative thinking in mothers can have a negative effect on maternal bonding. One can easily imagine how the pregnancy itself can fuel repetitive negative thoughts, worrying about both the infant and how the parental role and the new life will be. Having a baby can be overwhelming for anyone, and if you are prone to a repetitive negative thinking style, this may increase the burden. As the baby can be the source of many stressful thoughts, this may challenge the bonding process. As Stein and colleagues (2009; 2014) stated, being preoccupied with negative thoughts challenges the parents' ability to be present, sensitive, responsive, and focused on the infant's cues, and may thereby also preclude the bonding process. Although not statistically significant, there was a trend in the same direction for fathers and changing this thinking style is likely to be beneficial for new fathers too.

4.1.2 Implicit associations and attentional bias to infant faces

Although the implicit association score was not a statistically significant predictor for bonding in mothers, its effect size was comparable to that for parity and thus implicit associations might play a role. Further research is needed to understand what leads to negative associations to infants, and if this can affect parenting. The attentional bias to sad faces was not significant and had negligible effect sizes in the model for mothers and the model for fathers. Behavioral tasks may not be suited to predict individual differences (Dang et al., 2020). In addition, both the SC-IAT and the emotional dot probe task have been criticized for low reliability (Staugaard, 2009; Chevance et al., 2017), and may be better suited for comparing groups (Staugaard, 2009; Bohne et al., 2021). Further, behavioral tasks and self-report measures are often only weakly correlated (Dang et al., 2020). Thus, questionnaires that measure cognitive styles might be more potent than experimental tests when looking into the effect of parental cognitions on their parenting experiences.

4.2 Differences between mothers and fathers

The present study revealed some interesting differences between mothers' and fathers' cognitions in the perinatal period. While mothers had more repetitive negative thinking during pregnancy and more depressive symptoms after birth, they still experienced stronger bonding to their infant than fathers. This may of course be explained by biological factors, breast feeding, and the amount of time the mother spends with her newborn. Even so, this tells us that fathers might need to put a larger effort in the bonding process to reach the same level as the mothers. In Norway, fathers have a mandatory paternity leave (it was 10-15 weeks at the time of data collection). It would be interesting to measure bonding after this period to see if the difference would be equalized. Schaber et al. (2021) found an unstable effect of duration of paternity leave on bonding though, leaving the question open. The authors suggest other factors like partner satisfaction might be more important for paternal bonding, as it indicates the ability to form good relationships (Schaber et al., 2021).

In line with previous research (de Cock et al., 2016), mothers bonded more strongly when it was not their first child, while the reverse applied for fathers. Again, the time spent with the

newborn may be of essence. When it is their first child, both parents can fully attend to the newborn, while when it is the second (or third, or fourth), other children present also demand attention. As the mother is the primary caregiver during the first months after birth, naturally the father attends more to the other children. One could imagine the father even bonding more strongly to the older siblings in this transition, while the mother cares for the newborn. We did not assess this but recommend future studies to investigate the dynamics of the entire family.

4.2.1 Education

Interestingly, education was a significant predictor of bonding in fathers, where lower educated fathers had stronger bonding to their infant. This was in line with previous studies on mothers' bonding (Kinsey et al., 2014; Cuijlits et al., 2019). One explanation for this could be as Kinsey et al. (2014) suggested, that higher educated fathers are less biased by social desirability and therefore, more honest about their feelings towards the infant. However, we find it likely that higher educated fathers are more likely to have demanding jobs, and therefore might have less capacity for bonding. Just as repetitive negative thoughts can keep you occupied, worry, planning, or problems solving related to work can keep you occupied as well.

4.3 Infant temperament

Bonding was predictive of mothers' perceived infant temperament, which is in line with the cross-sectional findings of Davies et al. (2021). de Cock et al. (2016) also found that both mothers and fathers with low levels of bonding reported more difficult temperament in their infant at 6 months.In the present study, depressive symptoms, but not bonding, were predictive of perceived infant temperament for fathers. It seems their own well-being colors how they see their infant, while for mothers, the relationship to their infant is essential for how they experience their infant's temperament. As there might be a discrepancy between actual infant behavior and perceived infant temperament (MacKenzie and McDonough, 2009), we encourage more research that measures both. In the present study, regulation problems in the infant were not significantly related to later perception of infant temperament.

4.4 Discrepancy within couples

As mothers and fathers within a couple bond to the same infant, the difference in bonding between mother and father must be caused by something else than infant behavior. To our knowledge, our study is the first to investigate discrepancies in bonding levels within couples. Perhaps this is because previous findings indicate that couples mostly display comparable levels of bonding (de Cock et al., 2016). Our analysis suggests that when the difference in bonding within a couple was large, one of the parents experienced higher levels of either repetitive negative thinking or depressive symptoms than the other parent. However, the amount of time spent with the child and other probable factors were not measured, and so one must be careful to conclude. Even so, if one parent is struggling on a personal level with depressive symptoms or negative thoughts, and the other one is bonding strongly to their infant, the healthy parent will likely spend the most time with the infant. This could turn into a vicious cycle, where the struggling parent is prevented from building a stronger bond to the infant, thereby delaying both the recovery and the bonding.

4.5 Implications for health care services

Bonding is predictive of child outcome (Alhusen et al., 2013; Le Bas et al., 2020), parenting stress (de Cock et al., 2017), and, as the present study has shown; parents' perceived infant temperament. Therefore, bonding is an important aspect to be aware of when providing health care during the perinatal period. Already during pregnancy, cognitive thinking styles like repetitive negative thinking, shown here to have a negative effect on bonding, can be identified. This gives the opportunity to intervene before birth, and thereby enhance bonding and a good start for the new family. There is a range of therapeutic interventions that target such thinking styles (see Monteregge et al., 2020 for a meta-analysis), and also interventions more specific for this group, e.g., mindful parenting interventions (Potharst et al., 2017).

Health professionals should strive to screen parents' thoughts and emotions during pregnancy and offer intervention when applicable. When parents seek help because of regulatory problems in the infant, health professionals must keep in mind that the parents' mental health is equally important to screen as is the infant's behavior.

Families expecting their second or third child might benefit from information that fathers bond more easily to their first child, so that families can be aware and facilitate paternal bonding to a higher degree.

4.6 Limitations

There was some attrition between assessments. More fathers and less educated participants dropped out. This might have affected the results. However, education still came out as a significant predictor of bonding in fathers even though a large majority had higher education. In retrospect, it would have been beneficial to have kept fathers from dropping out, and future studies should apply a different data collection strategy to mitigate this. For example, instead of having mothers and their infant visit the university during work hours for their T5 assessment, home visits after work could be made to ensure father participation as well. Still, it was a clear strength that we included fathers, which allowed us to identify differences between mothers and fathers.

The present sample was a resourceful one, where most parents were mentally healthy, highly educated, and had a good income. We therefore cannot generalize to more vulnerable groups. Future research should target groups with lower socioeconomic status and examine how worries about economy and employment might affect bonding as it would easily occupy mental capacity. Such worries are related to increased distress in other contexts (e.g. Mækelæ et al., 2021), and so it is probable that it would affect bonding as well.

The present study did not consider partner satisfaction or adult attachment style, which previous studies have suggested as an important predictor of bonding (Nordahl et al., 2020; Schaber et al., 2021). The ability to form close relationships may be an individual characteristic affecting both parent-child relations and romantic relations. Repetitive negative thinking or rumination is negatively affecting bonding (this study), and romantic relations (Jostmann et al., 2011; Elphinston et al., 2013). This indicates that a negative thinking style may be a mechanism involved in relationship difficulties in general.

Due to our sample size, especially fathers, we did not investigate possible interaction effects. It would be interesting to examine e.g., if the effect of parity in fathers interact with the effect of education. Fathers with lower education might bond stronger to their first-born whereas fathers with higher education might experience a weaker effect of parity. Future research should address possible interaction effects.

5 Conclusion

The present study investigated parental cognitions during pregnancy and their effect on bonding after birth. What affected bonding differed between mothers and fathers. In fathers, bonding was strongest if it was their first child and if they had lower education. In mothers, repetitive negative thinking during pregnancy negatively affected bonding whereas parity affected bonding positively. Further, maternal bonding affected how the mother perceived her infant's temperament. Attentional bias and implicit attitudes did not affect bonding. Bonding quality is related to child development outcome. Beneficial factors for bonding quality should be strengthened and detrimental factors should be debilitated when possible. Identifying repetitive negative thoughts during pregnancy and helping reduce these thoughts might therefore facilitate stronger bonding and a better start for the family. Health care services should strive to screen parents' thoughts and feelings already during pregnancy and offer intervention where needed.

6 Conflict of Interest and Funding Details

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The present research received no external funding.

7 Author contributions

All authors were involved in the conception and design, AB, RSH, DN and IPL were involved in data acquisition, GP designed the cognitive task, GP and AB analyzed data, AB drafted the work and all authors critically revised and approved for publishing.

8 Ethics approval

The study was approved by the Regional Committees for Medical and Health Research Ethics, ref. 2015/614. We confirm that the present study complies with the 1964 Declaration of Helsinki and later addenda.

9 Data availability statement

Data is available at https://osf.io/dw3zs/?view_only=8a4961745d294904a29ce37e527a9932. Due to sensitive information, the dataset does not contain demographics.

552

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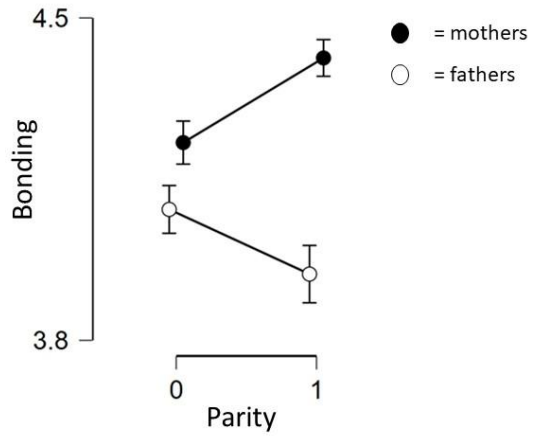
759

760

10 Figures

Figure 1

Different effect of parity on bonding for mothers and fathers



Note. Bonding as measured by Maternal/Paternal Postnatal Attachment Scale, mean scores. Parity is either yes or no.

768

769 **Figure 2**

770 Plots of associations between difference in bonding within couples and the difference in
771 repetitive negative thinking and depressive symptoms.

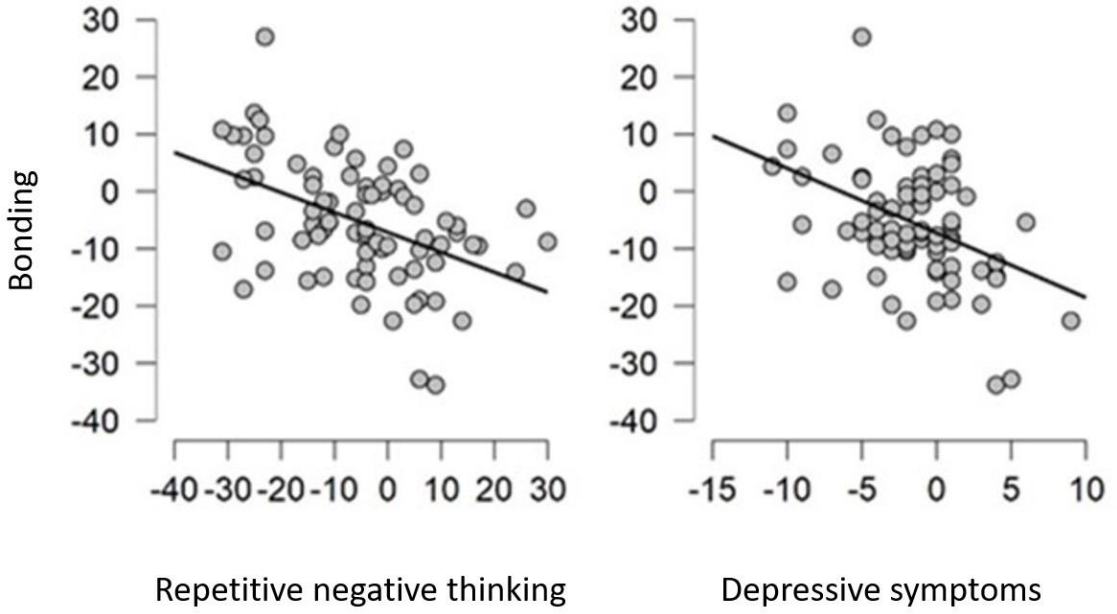


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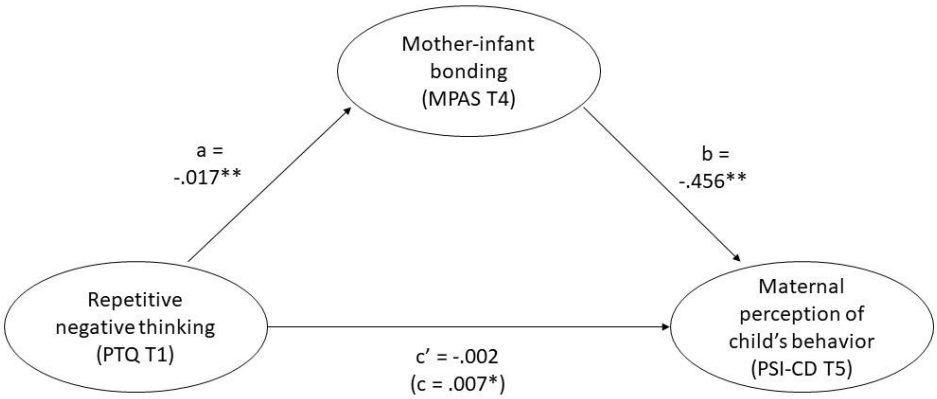
Figure 3

Indirect effect of repetitive negative thinking



Note. Coefficients are unstandardized. a and b are the indirect path, c' is the direct path. Total effect (c) in brackets. * = $p < 0.05$, ** = $p < 0.001$

11 Tables

Table 1

Descriptives for T4 and T5 participants

	T4		*T5*	
Variable		*N*		*N*
Men / Women	89/185	274	72/172	244
Age	*M* = 31.95 (*SD* = 4.9, range 20-49)	274	*M* = 31.91 (*SD* = 4.8, range 20-49)	244
Primiparous	52.2 %	274	52.0%	244
Higher education	87.2 %	274	86.9 %	243
High income	71.4%	273	69.2 %	242
Family support	91.6 %	274	91.4 %	244
Friend support	90.5 %	274	90.2 %	244

Note. Higher education = university or college degree, bachelor level or higher. High income = average (750 000 NOK - 1 000 000 NOK) or high (> 1 000 000 NOK) per household. Family/Friend support = yes or no to the questions “Do you have enough family/friends to support you?”

Table 2.

Criteria for coding of the Diurnal Clocks.

	Definition of when a regulatory problem is present
Total sleep	< 12 h during the 24 h
Night sleep	< 5 h continuous sleep between 23-06. Awakenings of 15 minutes or less is not counted since discontinued sleep for feeding during the night is considered normal.
Difficult to soothe	≥ 2 h of continuous fuzziness and/or crying
Excessive crying	≥ 3 h of crying during the 24 h

Table 3.

Difference between mothers and fathers.

Measures	Mothers Mean (SD)	*N*	Fathers Mean (SD)	*N*	*t*	*p*	*d*
T1 measures							
Repetitive negative thinking	17.246 (10.280)	179	12.791 (9.624)	84	3.450	< **.001**	.447
Attentional bias	-7.249 (15.645)	171	-9.301 (15.490)	84	.991	.323	.132
Implicit associations	.066 (.295)	171	.032 (.248)	84	.965	.336	.125
T4 measures							
Bonding	4.323 (.419)	180	4.025 (.378)	88	5.839	< **.001**	.746
Prenatal depressive symptoms	4.475 (3.597)	185	2.534 (2.840)	89	3.042	**.003**	.392
T5 measures							
Infant temperament	1.831 (.359)	169	1.919 (.293)	71	1.816	.071	.257

Note. T-tests on T1 measures is run with participants from T4. Repetitive negative thinking = PTQ at T1, Implicit associations as measured by the Single Category Implicit Association Task, Attentional bias = bias to sad infant faces as measured by Emotional Dot-Probe Task, Prenatal depressive symptoms = EPDS at T1, Bonding = MPAS or PPAS at T4, Infant temperament = PSI-CD at T5.

798 **Table 4**

799 *Results of hierarchical regression predicting bonding in mothers and fathers.*

	Mothers				Fathers			
Predictor variables	B	*β (95% CI)*	*t*	*p*	B	*β (95% CI)*	*t*	*p*
Model 1								
Parity	.186	.222 (.068, .376)	2.842	**.005**	-.140	-.181 (-.399, .036)	-1.659	.101
Education	-.052	-.086 (-.240, .068)	-1.100	.273	-.139	-.278 (-.494, -.060)	-2.539	**.013**
Model 2								
Parity	.139	.166 (.017, .314)	2.195	**.030**	-.162	-.210 (-.412, -.008)	-2.067	**.042**
Education	-.056	-.093 (-.245, .060)	-1.207	.229	-.145	-.289 (-.494, -.084)	-2.818	**.006**
Repetitive negative thinking	-.010	-.244 (-.406, -.072)	-2.808	**.006**	-.010	-.249 (-.514, -.001)	-1.846	.069
Implicit associations	.206	.146 (-.001, .293)	1.960	.052	-.274	-.173 (-.378, .033)	-1.671	.099

Attentional bias	.000	.006 (-.144, .144)	.078	.938	-.001	-.044 (-.245, .163)	-.424	.673
Prenatal depressive symptoms	-.017	-.139 (-.320, .042)	-1.507	.134	-.024	-.182 (-.451, .090)	-1.341	.184

Note. B = Unstandardized beta, β = Standardized beta. Repetitive negative thinking = PTQ at T1, Implicit associations as measured by the Single Category Implicit Association Task, Attentional bias = bias to sad infant faces as measured by Emotional Dot-Probe Task, Prenatal depressive symptoms = EPDS at T1. Model 1 (mothers): R = .226, R^2 = .051, Adjusted R^2 = .039, Standard error = .412. Model 2 (mothers): R = .440, R^2 = .194, Adjusted R^2 = .162, Standard error = .385. Model 1 (fathers): R = .317, R^2 = .100, Adjusted R^2 = .077, Standard error = .371. Model 2 (fathers): R = .525, R^2 = .276, Adjusted R^2 = .215, Standard error = .342.

Table 5.

Results of hierarchical regression predicting parents' perception of infant temperament (PSI-CD T5.)

	Mothers				Fathers			
Predictor variables	B	*β (95% CI)*	*t*	*p*	B	*β (95% CI)*	*t*	*p*
Model 1								
Repetitive negative thinking	.006	.149 (-.027, .320)	1.674	.097	.006	.248 (-.002, .502)	1.826	.074
Model 2								
Repetitive negative thinking	-.001	-.039 (-.213, .133)	-.448	.655	.000	.007 (-.270, .309)	.046	.963
Bonding	-.301	-.384 (-.568, -.199)	-4.118	< **.001**	-.163	-.230 (-.509, .048)	-1.662	.103
Infant regularity	.078	.089 (-.072, .249)	1.095	.276	-.030	-.042 (-.306, .222)	-.320	.751
Postnatal depressive symptoms	.017	.167 (-.029, .358)	1.723	.087	.040	.387 (.107, .663)	2.821	**.007**

Note. B = Unstandardized beta, β = Standardized beta. Repetitive negative thinking = PTQ at T1, Bonding = MPAS/PPAS at T4, Infant regularity as measured with diurnal clocks at T4, Postnatal depressive symptoms = EPDS at T4. Model 1 (mothers): $R = .149$, $R^2 = .022$, Adjusted $R^2 = .014$, Standard error = .319.

Model 2 (mothers): R = .494, R^2 = .244, Adjusted R^2 = .218, Standard error = .284. Model 1 (fathers): R = .248, R^2 = .061, Adjusted R^2 = .043, Standard error = .279. Model 2 (fathers): R = .511, R^2 = .261, Adjusted R^2 = .200, Standard error = .255.

Table 6

Results of regression predicting difference in bonding (MPAS/PPAS at T4) within couples

Predictor variables	B	*β (95% CI)*	*t*	*p*
Education (diff)	-1.734	-.146 (-.349, .057)	-1.431	.157
Repetitive negative thinking (diff)	-.272	-.358 (-.565, -.150)	-3.434	<.001
Implicit associations (diff)	-1.848	-.071 (-.273, .132)	-.694	.490
Postnatal depressive symptoms (diff)	-.846	-.305 (-.513, -.097)	-2.917	.005

Note. B = Unstandardized beta, β = Standardized beta. All differentials are calculated subtracting mothers' values from fathers' values. Education (diff) = difference in education within couples, Repetitive negative thinking (diff) = difference within couples on PTQ at T1, Implicit associations (diff) = difference within couples on the SC-IAT, Postnatal depressive symptoms (diff) = difference within couples on EPDS at T4. Model summary: $R = .551$, $R^2 = .304$, Adjusted $R^2 = .266$, Standard error = 8.933.

Linear Regression_PSI-CD mothers (version incl sc-IAT)

Model Summary

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
0	0.154	0.024	0.007	0.324	0.024	1.439	2	118	0.241
1	0.524	0.275	0.243	0.283	0.251	13.270	3	115	< .001

Note. Null model includes PTQ_T1, T1_IAT_d

ANOVA

Model		Sum of Squares	df	Mean Square	F	p
0	Regression	0.303	2	0.151	1.439	0.241
	Residual	12.416	118	0.105		
	Total	12.719	120			
1	Regression	3.496	5	0.699	8.717	< .001
	Residual	9.223	115	0.080		
	Total	12.719	120			

Note. Null model includes PTQ_T1, T1_IAT_d

Coefficients

Model		Unstandardized	Standard Error	Standardized	t	p	95% CI Lower	95% CI Upper
0	(Intercept)	1.728	0.064		27.023	< .001	1.602	1.855
	PTQ_T1	0.006	0.003	0.151	1.656	0.100	-0.001	0.012
	T1_IAT_d	0.048	0.100	0.043	0.477	0.634	-0.150	0.245
1	(Intercept)	3.194	0.348		9.185	< .001	2.505	3.883
	T4_MPAS_mean	-0.331	0.074	**-0.417**	-4.443	**< .001**	-0.478	-0.183
	T4_reg_prob_yes_no	0.089	0.074	0.100	1.206	0.230	-0.057	0.235
	EPDS_T4	0.018	0.010	0.173	1.769	0.079	-0.002	0.038
	PTQ_T1	-0.002	0.003	-0.052	-0.598	0.551	-0.008	0.005
	T1_IAT_d	0.096	0.089	0.088	1.084	0.281	-0.079	0.271

Descriptives

	N	Mean	SD	SE
PSI_CD_T5_mean	121	1.824	0.326	0.030

Coefficients

Model			Unstandardized	Standard Error	Standardized	t	p	95% CI Lower	95% CI Upper
T4_MPAS_mean		121	4.299	0.410	0.037				
T4_reg_prob_yes_no		121	0.157	0.365	0.033				
EPDS_T4		121	3.562	3.141	0.286				
PTQ_T1		121	16.364	8.674	0.789				
T1_IAT_d		121	0.063	0.298	0.027				

Linear Regression_PSI-CD mothers (incl IAT, education and parity)

Model Summary

Model	R	R^2	Adjusted R^2	RMSE	R^2 Change	F Change	df1	df2	p
0	0.154	0.024	0.007	0.324	0.024	1.439	2	118	0.241
1	0.524	0.275	0.230	0.286	0.251	7.827	5	113	< .001

Note. Null model includes PTQ_T1, T1_IAT_d

ANOVA

Model		Sum of Squares	df	Mean Square	F	p
0	Regression	0.303	2	0.151	1.439	0.241
	Residual	12.416	118	0.105		
	Total	12.719	120			
1	Regression	3.497	7	0.500	6.121	< .001
	Residual	9.222	113	0.082		
	Total	12.719	120			

Note. Null model includes PTQ_T1, T1_IAT_d

Coefficients

Model			Unstandardized	Standard Error	Standardized	t	p	95% CI Lower	95% CI Upper
0	(Intercept)		1.728	0.064		27.023	< .001	1.602	1.855
	PTQ_T1		0.006	0.003	0.151	1.656	0.100	-0.001	0.012
	T1_IAT_d		0.048	0.100	0.043	0.477	0.634	-0.150	0.245

Coefficients

Model		Unstandardized	Standard Error	Standardized	t	p	95% CI Lower	95% CI Upper
1	(Intercept)	3.217	0.419		7.668	< .001	2.386	4.048
	T4_MPAS_mean	-0.332	0.077	**-0.418**	-4.332	**< .001**	-0.484	-0.180
	T4_reg_prob_yes_no	0.089	0.076	0.100	1.170	0.244	-0.062	0.240
	EPDS_T4	0.017	0.011	0.168	1.518	0.132	-0.005	0.040
	PTQ_T1	-0.002	0.003	-0.052	-0.583	0.561	-0.009	0.005
	T1_IAT_d	0.094	0.091	0.086	1.037	0.302	-0.086	0.275
	Education	-0.004	0.044	-0.008	-0.091	0.928	-0.091	0.083
	NotFirstChild	-0.004	0.055	-0.006	-0.071	0.943	-0.114	0.106

Descriptives

	N	Mean	SD	SE
PSI_CD_T5_mean	121	1.824	0.326	0.030
T4_MPAS_mean	121	4.299	0.410	0.037
T4_reg_prob_yes_no	121	0.157	0.365	0.033
EPDS_T4	121	3.562	3.141	0.286
PTQ_T1	121	16.364	8.674	0.789
T1_IAT_d	121	0.063	0.298	0.027
Education	121	3.545	0.671	0.061
NotFirstChild	121	0.504	0.502	0.046