Mother-Infant Relationship, Dyadic Interaction, and Child Development:

The Role of Maternal Mental Health

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List of Abbreviations

AIC Akaike information criterion. 57–59, 61, 65

CBCL Child Behavior Checklist. 81

CFI comparative fit index. 26, 38, 57, 58, 61, 66

CIB Coding Interactive Behavior manual. 81

CLPM cross-lagged panel model. 57, 59, 74–76, 86

DFG German Research Foundation. 19

EA Emotional Availability Scales. 12

EMA ecological momentary assessment. 75

EPDS Edinburgh Postnatal Depression Scale. 22, 26, 56–60

ESM experience sampling method. 75, 76

FDR False Discovery Rate. 39, 57, 69

FFSF Face-to-Face Still-Face Paradigm. xix, 3, 4, 10, 18, 22, 24, 26, 82, 93

FIML full information maximum likelihood. 26, 57, 69

HPA hypothalamic-pituitary-adrenocortical. 80

ICEP-R Infant and Caregiver Engagement Phases. 24, 82, 88, 93

IRSS Infant and Caregiver Engagement Phases. 24

MFAS Maternal-Fetal Attachment Scale. 23, 26, 47

MLR maximum-likelihood estimation with robust estimators of model fit. 57

MRSS Maternal Regulatory Scoring Systems. 24

PBQ Postpartum Bonding Questionnaire. 23, 47

PBQ-16 Postpartum Bonding Questionnaire - 16. 23, 26

PCDI Parent-Child Dysfunctional Interaction. 12

PSS Perceived Stress Scale. 56–60

RI-CLPM random-intercept cross-lagged panel model. 74–76, 86

RI-CLPM Random Intercept Cross-Lagged Panel Model. 86

RMSEA root-mean-square error of approximation. 26, 38, 57, 58, 61, 66

SCID Structured Clinical Interview for DSM-IV. 21, 22

SRMR standardized root-mean-square residual. 26, 38, 57, 58, 61, 66

STAI State and Trait Anxiety Inventory. 22, 23, 44

STAI-S State and Trait Anxiety Inventory - State. 23, 26

STAI-T State and Trait Anxiety Inventory - Trait. 23, 45

TLI Tucker-Lewis index. 26, 38, 57, 58, 61, 66

WEIRD (1) western, (2) educated, (3) industrialized, (4) rich, and (5) democratic. 73, 86

Abstract

Peripartum maternal depressive and anxiety disorders may adversely affect child development (J. H. Goodman et al., 2016; Kingston & Tough, 2014). Mother-infant interaction and mother-infant relationship/bonding have been shown to be involved in the transmission of these adverse effects (Edwards & Hans, 2015; Mason et al., 2011; Reck, Nonnenmacher, et al., 2016). It is therefore crucial to further investigate how dyadic interaction, mother-infant bonding, and child development are associated in the context of peripartum maternal mental health. Only if we get a better understanding of this complex, multicausal, and dynamic process, we may further improve specific prevention and intervention programs for caregivers and their children (Downing et al., 2014). The COVID-19 pandemic has created a very particular context which may have contributed to an exacerbation of maternal mental health issues, in particular depressive symptoms and perceived stress (Achterberg et al., 2021; Q. Chen et al., 2022; Suárez-Rico et al., 2021). In two empirical studies and one summary of an ongoing study, this work investigated the aforementioned domains in order to inform and guide policy-makers as well as further prevention and intervention research.

Study 1 investigated the mediating role of maternal pre- and postpartum bonding in the relationship between maternal psychopathology and the quality of the dyadic interaction. Further exploratory analyses assessed the relationship between maternal bonding and the severity of (1) depressive symptoms as well as (2) anxiety symptoms across three different time points in the peripartum period. 59 mother-infant dyads were assessed applying diagnostic interviews, self-reports, and microanalytic coding of mother-infant interaction during the Face-to-Face Still-Face Paradigm (FFSF). The quality of mother-infant interaction was quantified as the latency to interactive reparation, i.e. the average time a dyad needs to transform an affective-behavioral uncoordinated state (mismatching state) into a coordinated one (matching state). The results did not provide evidence for a mediating effect of maternal pre- and postpartum bonding in the relationship between maternal psychopathology and the quality of mother-infant interaction, probably due to our small sample size. Additional exploratory analyses revealed that bonding, as well as the severity of depressive and anxiety symptoms, at earlier stages of the peripartum period predicted their respective subsequent level at a later peripartum stage. Both symptom measures were also negatively associated with bonding quality 4-8 weeks postpartum. In addition, anxiety symptoms were negatively associated with the bonding quality at the second trimester.

These findings are in line with a number of studies showing a connection between the pre- and postpartum level of depressive and anxiety symptoms, as well as bonding, respectively (Dubber et al., 2015; Ohara et al., 2017; Rossen et al., 2016). Thus, the findings additionally support previous research asserting that the administration of screenings to identify women at risk of bonding issues, depression, and anxiety should start *during pregnancy* and become universal practice to foster the long-term well-being of mothers and children (Biaggi et al., 2016).

Study 2 focused on maternal mental health during the COVID-19 pandemic, targeting the severity of depressive symptoms and perceived stress. The aims of this study were threefold: We (1) assessed the overall severity of maternal depressive symptoms and perceived stress at two time points during the pandemic and reported prevalence rates, (2) compared the respective overall severity of depressive symptoms and perceived stress between the two time points, and (3) examined the reciprocal relation between these two constructs. 666 mothers with children aged 0-3 years were assessed via an online survey at two measurement points during the pandemic (T1: May-November 2020; T2: February/March 2021). The overall severity of maternal depressive symptoms and perceived stress appears to have increased in the course of the COVID-19 pandemic, which is in line with current meta-analyses (Q. Chen et al., 2022; Safi-Keykaleh et al., 2022). Given that even subclinical maternal depressive symptoms may adversely affect child development (Ramchandani et al., 2005), at least 33.8% of children were at risk of developmentally suffering under the depressive symptoms of their mothers in Germany between May and November 2020, whereas a disturbingly high percentage of 55.1% were at risk in February/March 2021. 15.2% of mothers between May and November 2020, and 26.0% in February/March 2021 additionally suffered from high perceived stress levels, which, according to Calvano et al. (2021) and Freisthler, Wolf, et al. (2021), put children at risk for abuse, neglect, and domestic violence. As depressive symptoms and perceived stress seem to linearly depend on their own prior values (i.e., significant auto-regressive effects), and to reciprocally predict each other (i.e., significant cross-lagged effects), prevention and intervention programs should (1) screen and treat mothers as early as possible to mitigate the risk for subsequent depressive symptoms and perceived stress, and (2) focus on both depressive symptom reduction and perceived stress relief to most effectively decrease mothers' levels of suffering in both areas. These latter results should be regarded as preliminary and interpreted very cautiously as we faced some methodological shortcomings (i.e., only two assessment points not allowing to account for between-person associations). Nevertheless, in light of very high and increasing prevalence rates across both time points, high correlations of both constructs within time points, and a potential bidirectional link between the severity of depressive symptoms and perceived stress, we may conclude that mothers should be supported as early as possible, targeting both types of adversities.

Finally, the ongoing COMPARE-Interaction study was outlined to provide future perspectives, especially for the assessment of how maternal comorbid depressive and anxiety disorders may impact child cognitive and socio-emotional development, compared to solely

depressive disorders and a healthy control group. As far as we are aware, the COMPARE-Interaction study is the first study to longitudinally assess the influence of comorbid maternal mood disorders on child development on a behavioral, relational, hormonal, developmental, and clinical psychological level. We focused on children's internalizing and externalizing behavior problems and their cognitive development at 24 months of age. The focus of mediating effects was set to maternal sensitivity and infant cortisol reactivity at 12 months of age.

The findings of this work provide evidentiary support that mothers should be supported as early as possible when peripartum maternal mental health issues, such as depressive or anxiety symptomatology, impaired bonding, or perceived stress, occur. This applies to the vulnerable peripartum period in general, and to the peripartum period during the exceptional state of a global pandemic in particular in order to prevent these issues during the ongoing pregnancy and in the long run. Only thus may intergenerational transmission processes be countered at early stages in order to mitigate and prevent potential detrimental effects on child development.

Chapter 1

Introduction: Associations between the Mother-Infant Relationship, Dyadic Interaction, and Child Development in the Context of Maternal Mental Health

The peripartum period is a changeable time for caregivers as parturition is regarded as a critical life event which demands major adjustment and adaptive behavior (Emmanuel & St John, 2010). Especially for mothers, emotions during pregnancy, parturition, and lying-in may often be rather extreme or very variable within a short period of time and might reach high intensities (Pięta et al., 2014). Due to the high physical and psychological demands of the peripartum period mothers may quite often experience less joy, which contradicts cultural expectancies (O'Hara, 2009). This may increase the mothers' vulnerability to develop a mental disorder (Banti et al., 2011). Particularly, maternal depressive and anxiety disorders are the most common peripartum disorders (Howard et al., 2017; Martini et al., 2015; Woody et al., 2017). Fathers may also experience increased levels of depression and anxiety (Glasser & Lerner-Geva, 2019; Leiferman et al., 2021), which may detrimentally affect children's development (Barker et al., 2017). Even though there has been a steady increase in research focusing on the potential effects of fathers on their children's development, the primary focus in developmental research has been on mothers (Reck et al., 2022). The relationship between mother and fetus/infant starts earlier than every other social relationship and is marked by the exceptional physicality during pregnancy, parturition, and, commonly, the breastfeeding phase (Fuchs, 2018; Geuter, 2015). Hence, whilst treasuring the broadening focus on fathers and wider social networks in developmental research (Barker et al., 2017; Fonagy et al., 2021), the focus of this work lies on mothers. More specifically, this work aims at shedding more light on the associations between the mother-infant relationship, dyadic interaction, and child development in the context of maternal mental health. First, this chapter gives an overview summarizing the theoretical and empirical foundation of these associations. Chapter 2 presents an empirical investigation of the mediating role of maternal bonding in the relationship between maternal psychopathology and mother-infant interaction. Chapter 3 empirically captures the maternal health status during the ongoing COVID-19 pandemic. In chapter 4, the study protocol of an ongoing, cutting-edge developmental study is summarized. Chapter 5 integrates the findings and provides future perspectives for research and clinical practice. Before presenting the empirical findings, we[1] first present the theoretical and empirical framework we operate in and define the aforementioned terms. This framework has been well reviewed in Reck et al. (2022).

1.1 The Process of Interactive Regulation

In a considerable amount of prior research, early infant development - in particular infant affect regulation - has been associated with distinct interactive patterns in the mother-infant dyad during the first months of life (Montirosso et al., 2020; Provenzi et al., 2018). Self-regulatory as well as interactive capacities of both mother and infant co-constitute these patterns (Tronick & Beeghly, 2011). Infant researchers have been asserting for a few decades now that infants as early as three to four months of age initiate a great deal of their interactions by themselves (Beebe & Lachmann, 2020; Beebe & Stern, 1977). The early co-creation of communication between the two subjects, i.e. intersubjectivity, seems neurobiologically anchored (Fuchs, 2018). Intersubjectivity is constituted by the infant's inherent abilities for communication which encounter the caregiver's ubiquitous skills to intuitively adapt and simplify their way of communicating (e.g., motherese; Colwyn and Kenneth, 2001; Fonagy, 2015). Thus, both parties may experience a mutual engagement which continuously reinforces them.

1.1.1 The Mutual Regulation Model and the Still-Face Paradigm

Edward Tronick's research team has provided a comprehensive description of the reciprocal, mutual regulation when mother and infant interact, i.e. the Mutual Regulation Model (Tronick, 1989, 2007). Both participants in a face-to-face interaction coordinate their behavior in a way which keeps engagement, arousal, and affective regulation at optimum degrees. For the most part, both infant and mothers operate on unconscious levels when mutually adapting their behaviors. These experiences are supposedly internalized by the infant and the mother, creating, or in the mother's case expanding, the implicit relational understanding of how to interact with others. In essence, the infant expects the mother to act in a contingent manner and gets upset when his or her expectation is not met. Beebe and Lachmann (2020) described infants as "contingency-detectors from birth" [p. 314].

[1] The pronouns "we/us/our" instead of "I/me/my" will be used throughout the entire work as research is a greatly collaborative process which relies on feedback and prior work of supervisors and colleagues. I, hereby, would like to emphasize, however, that the written thesis presented here is the product of the author alone.

The so-called Face-to-Face Still-Face Paradigm (FFSF; Tronick et al., 1978) provides an impressive illustration of this idea. The FFSF is an experimental paradigm which is typically practiced with infants between the ages of 3 and 9 months. During three subsequent episodes, lasting two minutes each, the infant is placed in front of the mother in a reachable distance in a baby-chair so that they look at each other and play with one another. During the first episode, i.e. the play episode/phase, the mother should play and interact with her infant as she would usually do. For the second episode, i.e. the still-face episode/phase, the mother has been told to glance above the infant's head while maintaining a neutral facial expression and refraining from responding to her child. During the still-face episode, infants commonly exhibit less positive affect and a variety of behaviors, ranging from attempts to reengage the mother and fussing to gazing away and alternative forms of withdrawal (Mesman et al., 2009; Tronick & Beeghly, 2011). These behaviors are regarded as indicators that the infant perceives the interruption of maternal engagement as a stressor. During the third and final episode, i.e. the reunion episode/phase, the mother recommences to interact with her infant. DiCorcia and Tronick (2011) consider the return to a positive exchange as a marker for (1) the interactive skills of affect regulation in the mother-infant dyad, (2) the general quality of mother-infant relationship, and (3) the level of maternal sensitivity.

The Mutual Regulation Model states that the interaction partners constantly change between coordinated affective and behavioral states, i.e. so-called matches or matching states, and uncoordinated affective and behavioral states, i.e. so called mismatches or mismatching states. Oscillating between matches and mismatches during interactions is the norm with a commonly higher proportion of mismatching states (DiCorcia & Tronick, 2011). Most failures in coordination, however, are rapidly repaired (Tronick, 1989). This specific process of *interactive reparation*, involving the capacities of both parties to recoordinate the affect, behavior, gaze, vocalization, etc. from an asynchronous mismatching state into a synchronous matching state, is accompanied by a sense of self-efficacy and of agency that acquired interactive coping skills are effective (Fonagy, 2015; Tronick, 2007). This deep sense of self-efficacy and agency, which Tronick (1989) termed the *positive affective core*, is fostered by interactive reparation. Interactive repair, thus, scaffolds infants' and children's affect regulation and attachment formation (Beebe et al., 2010; Tronick, 2007). Noe et al. (2015) corroborated this conjecture as they could demonstrate that affective behavioral matching during face-to-face interaction fostered the progression from mutual regulation to infant self-regulation. The more matching states during FFSF play episode could be identified, the less negative and the more positive affect the infants demonstrated in the FFSF still-face and reunion episode, respectively. Müller et al. (2015) provided further evidence that children's affect regulation and attachment security are scaffolded by interactive reparation. In their study, a shorter latency to interactive reparation, meaning that microtemporal mismatches were on average resolved more rapidly, related to a lower infant cortisol reactivity. These three-to-eight-month-old infants were, thus, assumed to be less distressed and better regulated during the still-face episode of the FFSF experiment. Maternal diagnostic status in this sample of healthy controls vs. mothers suffering from one or more maternal anxiety disorders was not significantly associated with infant cortisol reactivity. The authors concluded that infants react to what they experience and not to the maternal diagnostic classification. The infants of this study were followed up (Müller et al., 2022), so that at 12 to 24 months of age, their attachment style could be assessed via the Strange Situation paradigm (Ainsworth et al., 1978). Maternal diagnostic status at three to eight months postpartum best predicted ensuing child attachment style: children of mothers having suffered from an anxiety disorder were five times more likely to be insecurely attached. Insecure attachment style was also predicted by a longer latency to interactive reparation during the FFSF experiment at three to eight months postpartum. Quite notably, children who had developed an insecure attachment style at 12 to 24 months of age showed an increased cortisol reactivity during free play at a second follow up at five to six years of age (Müller et al., 2022).

To sum up, the quality of interactive regulation in mother-infant dyads affects the infant's socio-emotional development. Thus, it is crucial to investigate which maternal qualities promote favorable interactive regulation (Reck et al., 2022).

1.1.2 Central Maternal Qualities: Sensitivity, Mentalizing and Bonding

Intuitive skills when interacting with an infant or child comprise a behavioral repertoire which is biologically anchored and to a certain degree universal across cultures (H. Papoušek & Papoušek, 1987). A caregiver commonly spontaneously draws on this repertoire consisting of distinct adaptations of facial expressions and body language, i.e. more simplistic, prototypical forms of behavior, such as raising the eyebrows or other exaggerated greeting responses when the infant is looking (M. Papoušek, 2011). Making eye contact, applying motherese, i.e. specifically changing pace and pitch of speech, and calling infants by their name are also part of this repertoire (Csibra & Gergely, 2011; "Natural pedagogy," 2009). According to the infant's receptive capacity, a caregiver may intuitively adapt their behaviors (M. Papoušek, 2011). Thus, an optimal support for the infant's development is provided. However, this reciprocal process is, of course, not flawless as it demands a particular degree of responsiveness by the caregiver, which is determined by individual and environmental factors (Feldman, 2012; M. Papoušek & von Hofacker, 1995). Thinking of a depressed caregiver with reduced facial expressions may provide an example of a diminished responsiveness (Tronick & Reck, 2009), which will be further elaborated below.

To regulate their distress and negative emotions, infants only possess a limited repertoire of self-regulatory behaviors during their first few months of life, e.g. head turning, non-nutritive sucking, or hand-to-mouth movement (Kopp, 1989). Since this repertoire does not suffice to downregulate intense affective states, infants need caregivers as an external source of assistance for emotion regulation (Diener & Mangelsdorf, 1999). If the caregiver is not able to adequately respond to the infant's affect, and therefore, the dyadic regulation is impaired, children may develop a reduced tolerance of negative emotions and dysfunctional capacities to regulate stress (Gianino & Tronick, 1988). This is the reason why *responsiveness*, i.e. promptly responding to an infant's cues, or, even more optimal, *sensitivity*, i.e. promptly responding to an infant's cues in an appropriate and contingent manner, are such important maternal qualities (Ainsworth et al., 1978). Ainsworth et al. (1978) regarded a mother's sensitivity as an important component for child development as children whose mothers sensitively meet their needs are more likely to become securely attached. Subsequent attachment research has examined maternal sensitivity as one pathway through which the mother's attachment representation is transgenerationally transmitted to the offspring (De Wolff & van Ijzendoorn, 1997). Fonagy et al. (2007) went one step further and described *parental mentalizing* as a prerequisite for sensitivity. That is, caregivers need to be able to view their children's behavior as motivated by mental states, i.e. thoughts, feelings, and desires; and then appropriately interpret the behavior. Notably, this interpretation process operates on an conscious/explicit and unconscious/implicit level. According to meta-analytic findings (Zeegers et al., 2017), parental mentalizing seems to have both direct and indirect influences on attachment security. The indirect influence was mediated via parental sensitivity, thus corroborating Fonagy et al.'s (2007) conjecture of parental mentalizing being a precondition of sensitivity. First conceptualized and operationalized via an analysis of parents' verbal expressions, parental mentalizing has since been also elaborated and described on the body level (Shai & Belsky, 2011). The term parental embodied mentalizing alludes to a parent's ability to (1) implicitly conceive, understand, and extrapolate the infant's mental states from his or her whole-body movement, and (2) adapt and adjust their own body movements and kinesthetic patterns correspondingly. Shai and Meins (2018) showed that both verbal and nonverbal indices of parental mentalizing independently contributed to the prediction of attachment security. Also, besides predicting attachment security, maternal embodied mentalizing assessed at the infants' age of 6 months predicted language abilities, academic skills, behavior problems, and social competence, even after accounting for traditional measures, such as maternal sensitivity (Shai & Belsky, 2017).

According to Reck et al. (2022), another very important factor affecting infants' socio-emotional development is maternal bonding. Since bonding and attachment are often applied synonymously, we follow Dubber et al. (2015) by distinguishing between bonding as referring to feelings the mother has towards her fetus or infant and attachment as describing the relationship a child has developed to its mother and other caregivers. Maternal bonding starts to develop during pregnancy and has been defined as "the extent to which women engage in behaviors that represent an affiliation and interaction with their unborn child" (Cranley, 1981, p. 282). For instance, a mother watches her belly when the baby moves or kicks, or she anticipates her role as a mother by picturing herself feeding the baby. As the pregnancy progresses, the mother-to-fetus bond usually increases (Cannella, 2005). Maternal prepartum bonding predicts a number of other important factors, such as health practices during pregnancy and adverse neonatal outcomes (J. L. Alhusen et al., 2012), the bonding quality in the subsequent postpartum period (J. Alhusen et al., 2013; Dubber et al., 2015), and maternal sensitivity (Maas et al., 2016; Shin et al., 2006). Brockington (2004) underlines the central role of building a relationship between a caregiver and an infant in the postpartum period. From a biological point of view, maternal postpartum bonding ensures the survival of the child by securing its nurturing and protection even though the price paid may be quite high (e.g., lack of sleep, lowered couple relationship satisfaction; Carter and Keverne, 2002; Schwenck et al., 2022). According to a recent meta-analysis, stronger pre- and postpartum bonding relates to more advantageous socio-emotional development in children, such as easier temperament and better attachment security (Le Bas et al., 2020).

As already mentioned above, these central qualities of maternal sensitivity, mentalizing and bonding are shaped by individual and environmental factors (Feldman, 2012; M. Papoušek & von Hofacker, 1995) and might therefore not always develop or operate smoothly. Especially in light of maternal psychopathology with the most common diagnoses of depressive and anxiety disorders, the complex process of interactive regulation may be impaired (Reck et al., 2022; Tronick, 2007). Thus, the following section focuses on maternal peripartum depression and anxiety disorders, and impaired bonding.

1.2 Peripartum Depression, Anxiety Disorders, and Impaired Bonding

1.2.1 Prevalences of Peripartum Depressive and Anxiety Disorders

The peripartum period may be a time of increased vulnerability for a mother to develop a mental disorder, in particular a depressive or anxiety disorder (Biaggi et al., 2016; Howard et al., 2017; Martini et al., 2015). However, compared to other women of child-bearing age, not all studies find higher risks for depressive and anxiety disorders for pregnant women or for those who have recently given birth, except for a slightly higher increased risk for a major depressive episode (Vesga-López et al., 2008). Prevalence rates for depressive disorders range from 3-23 % for the prepartum period (Andersson et al., 2003; Andersson et al., 2006; Banti et al., 2011; Bennett et al., 2004; Melville et al., 2010) and from 6-10 % for the postpartum period (Banti et al., 2011; Reck et al., 2008; Vesga-López et al., 2008). As about 50 % of postpartum depressive disorders start in the prepartum period, the current diagnostic manual DSM-5 speaks of depressive disorders *with peripartum onset* (American Psychiatric Association, 2013). For peripartum depressive disorders, Woody et al. (2017) estimated an overall adjusted pooled prevalence of 11.9 %, with higher prevalences for women from low- and middle-income countries compared to women from high-income countries. Specifically focusing on a comparison between low- and middle-income countries, Dadi et al. (2020) found a higher prevalence for postpartum depression in low-income countries, i.e. 25.8%, than in middle-income countries, i.e. 20.8 %. Notably, these rates were estimated based on primary studies which mainly applied screening tools instead of diagnostic interviews, partly explaining the much higher rates compared to the other rates presented.

Regarding anxiety disorders, Martini et al. (2015) report incident rates of 7.3 % during pregnancy which increase up to 15.6 % until 16 months postpartum, whereas Andersson et al. (2003) found a point prevalence of 6.6 % in the second trimester. The meta-analysis by J. H. Goodman et al. (2016) revealed that 8.5 % of postpartum mothers experience one or more anxiety disorders. Another meta-analysis, applying a different, i.e. Bayesian, statistical approach, estimated the prevalence of having at least one or more anxiety disorders to be 20.7 % (Fawcett et al., 2019). Reck et al. (2008) estimated a prevalence rate of 11.1 % in a German community sample for postpartum anxiety disorders. The researchers also demonstrated a high comorbidity in this sample. 18.3 % of participants who suffered from an anxiety disorder were also diagnosed with a depressive depressive disorder and 33.9 % of the mothers diagnosed with a depressive disorder also suffered from an anxiety disorder.

1.2.2 Effects on Mothers and Their Children

Depressive and anxiety disorders may have adverse consequences for affected mothers, meaning that, for example, depressed mothers seem to have difficulties connecting and building a relationship with their newborn, i.e. maternal bonding (Edhborg et al., 2011; Nonnenmacher et al., 2016). Besides typical symptoms of the respective disorders, mothers suffering from depressive and anxiety disorders may experience specific dysfunctional anxieties and cognitions concerning their infant or their role as a mother. These include overwhelming sensations and fears of being alone with the infant, excessive worries about the infant's health or even compulsive thoughts of harming the child, etc. (J. H. Goodman, 2019; Martini et al., 2008). This might affect their parenting behaviors and their capacity to build a bond to their infant (Reck et al., 2022).

That is why, on the children's side, a wide range of studies assert the detrimental long-term effects of maternal mental illness in the peripartum period on child development, concerning higher risks to develop a mental disorder, comprised cognitive and socio-emotional development as well as behavior problems (Kingston & Tough, 2014; Rasic et al., 2013). The risk for a child to develop a depressive or anxiety disorder will become two to five times higher compared to healthy controls if at least one parent suffers from a depression (Apter-Levy et al., 2013; Lieb et al., 2002; Pawlby et al., 2009). Micco et al. (2009) suggest that parental anxiety disorders also confer significantly greater risk for anxiety and depression in offspring. The risk seems to be two to nine times higher, compared to offspring of non-psychiatric controls and offspring of psychiatric controls with other disorders. Regarding developmental parameters, a wide range of systematic reviews and meta-analyses reveal detrimental effects of maternal depressive disorders on child development (Atkinson et al., 2000; S. H. Goodman et al., 2011; Kingston & Tough, 2014; Wan & Green, 2009). Among others, adverse effects could be shown for cognitive and fine motor development (Koutra et al., 2013), language skills (Quevedo et al., 2012), attachment (Martins

& Gaffan, 2000; Righetti–Veltema et al., 2003), as well as executive functions and memory tasks (Vänskä et al., 2011b). Peripartum anxiety disorders also yield a risk for child development (J. H. Goodman et al., 2016). Cognitive (Ibanez et al., 2015), behavioral, and emotional (O'Connor et al., 2003) development as well as language performance (Reck, Van den Bergh, et al., 2018) may be impaired. Furthermore, Kraft et al. (2017) found out that children of mothers suffering from a social phobia showed a higher rate of insecure attachment at 16 months of age.

1.2.3 Transmission Pathways

Given this wide range of adverse effects, it is crucial to examine the specific transmission pathways of how early adversities, such as maternal depressive and anxiety symptoms, may influence infant and child development (Montirosso et al., 2020; Starr et al., 2014). Only if we get a better understanding of this complex, multicausal, and dynamic process, we may further improve specific prevention and intervention programs for caregivers and their children (Downing et al., 2014). Based on the research findings presented above, Müller (2017) presented a transmission model with three levels of mediating variables (see figure 1.1). The effects of maternal depressive and anxiety disorders on child development may be mediated via (1) an emotional level, in particular the mother-to-infant bond (Branjerdporn et al., 2017; Mason et al., 2011), (2) a dyadic behavioral level, in particular the mother-infant interaction (Edwards & Hans, 2015; Stanley et al., 2004), and (3) a regulatory level, in particular infant stress reactivity and the infants capacities to regulate stress (Gunnar & Quevedo, 2007; Ladd et al., 1998; Müller et al., 2016). All three levels are not independent of each other, but interact (Müller, 2017).

1.2.4 Effects on Mother-Infant Interaction

As multiple studies have shown that the quality of mother-infant interaction is substantially involved in the intergenerational transmission of mental disorders (Edwards & Hans, 2015; Mäntymaa et al., 2009; Reck, Nonnenmacher, et al., 2016; Stanley et al., 2004), it is crucial to further examine how mother-infant interaction is affected. A greater number of studies have already investigated the effects of peripartum depression on mother-infant interaction. Depressed mothers show more intrusive behavior, less positive affect, and more negative affect while interacting with their children (Crugnola et al., 2016; Reck et al., 2004; Tronick & Reck, 2009; Weinberg & Tronick, 1998). Kluczniok et al. (2016) revealed that mothers suffering from depression were less emotionally available, less sensitive, less structuring, and more hostile during mother-infant interaction. Furthermore, infants of depressed mothers look away from their mothers more than infants of nondepressed mothers, and they express more anger and negative affect (Tronick & Reck, 2009). It could be shown that these infant behaviors were specific, that is, infants of mothers who were emotionally unavailable and withdrawn seemed disturbed and sad and cried more frequently, whereas infants of intrusively acting mothers, more often gazed away, cried less, but demonstrated

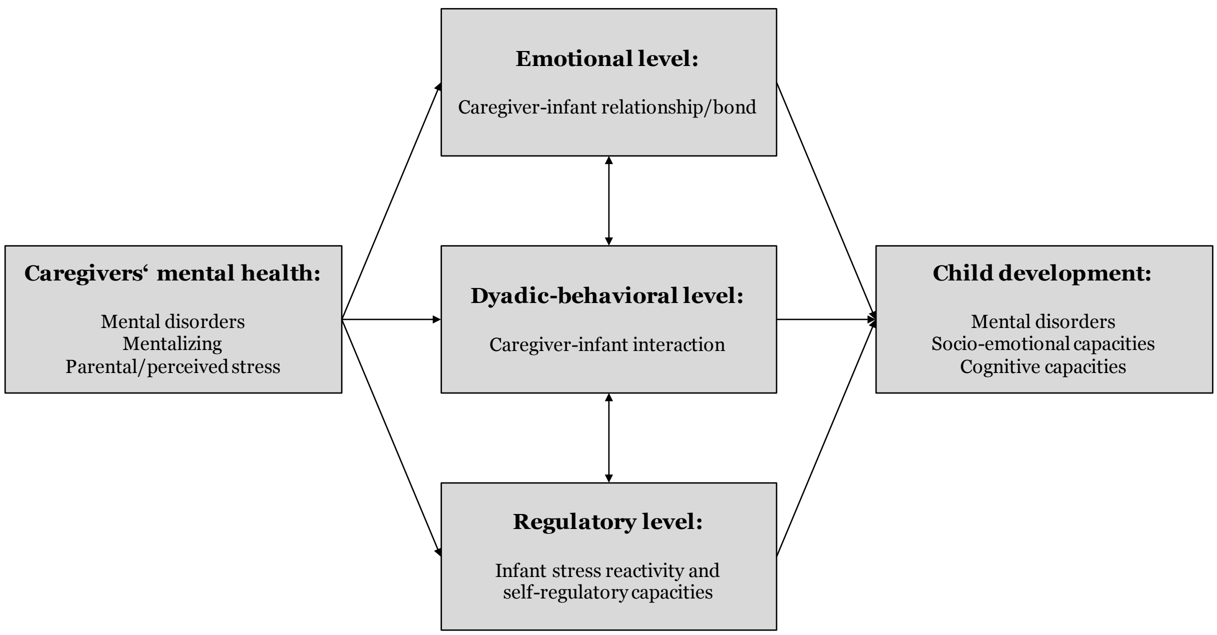

Figure 1.1: Central mediating levels of the relationship between caregivers' mental health and child development (adapted from Müller, 2017, p. 22). Notably, this is a simplified model of a complex, multicausal, and dynamic process. Other potentially influencing variables as well as reciprocal effects between the single domains are neglected. Figure available at https://osf.io/7xdy3/, under a CC-BY4.0 license.

angrier affect. Generally, infants of depressed mothers also demonstrated less effort to activate their mothers during the still-face episode of the the FFSF. Regarding dyadic measures, Reck et al. (2011) could show that for depressed mothers, the dyadic regulation is characterized by fewer positive matched states and longer latencies to reparation of mismatching states, i.e. impaired interactive reparation, during the FFSF.

Fewer studies examined anxious mothers and the effects on mother-infant interaction (J. H. Goodman et al., 2016). Besides, their results are not as consistent as for depressed mothers. Anxious mothers also seem to show less sensitive, more intrusive (Feldman et al., 2009) and less responsive behavior (Parfitt et al., 2013; Stein et al., 2012), but Kaitz et al. (2010) found no difference in sensitivity and intrusiveness. Infants of anxious mothers spent more time during the interaction showing signs of distress, gaze aversion, and crying, and less time smiling, vocalizing, and showing motor activity or imitation (Field et al., 2005; Murray et al., 2008; Stein et al., 2012). Furthermore, Reck, Tietz, et al. (2018) found an infant sex-specific characteristic when comparing a clinical and healthy control group. Male infants of anxious mothers demonstrated significantly less positive interactions than male infants of healthy controls, whereas female infants did not differ in their positive interactions. In a recent study, both maternal anxiety and depressive symptoms directly affected maternal sensitivity and indirectly affected controlling style mediated by parental embodied mentalizing (Ierardi et al., 2022)

1.2.5 Maternal Prepartum Bonding in the Context of Depression and Anxiety

Branjerdporn et al. (2017) emphasized the importance of the prepartum bonding process because lower prepartum maternal bonding seems to lead to suboptimal developmental outcomes. In turn, prepartum bonding may be negatively associated with both depression and anxiety (J. L. Alhusen, 2008). According to Lindgren (2001) and McFarland et al. (2011), higher depression scores related to lower maternal-fetal bonding, whereas Barone et al. (2014) and Seimyr et al. (2009) found no or ambiguous results for a correlation between depressive symptoms and maternal-fetal bonding. For anxiety disorders, McFarland et al. (2011) and Rubertsson et al. (2015) found little or no relation to maternal-fetal bonding. To sum up, only few quantitative studies have investigated the effect of depressive and anxiety disorders on maternal-fetal bonding. There is some evidence for a link, more so for depressive than anxiety disorders.

Effects of prepartum bonding on mother-infant interaction

A poorer or impaired maternal-fetal bond may affect mother-infant interaction. Lower prepartum bonding quality was associated with less maternal involvement when mothers interacted with their babies 12 weeks postpartum (Siddiqui & Hägglöf, 2000). Furthermore, the quality of the maternal-fetal relationship at 26 weeks of gestation predicted maternal sensitivity towards their 6-month-old infant during caregiving and free play situations (Maas et al., 2016).

1.2.6 Maternal Postpartum Bonding in the Context of Depression and Anxiety

In the study by Nonnenmacher et al. (2016), mothers with a current or life-time diagnosis of depression showed a poorer bonding quality on average than healthy mothers. A wide range of studies revealed similar negative associations between postpartum depressive symptoms and postpartum bonding (Busonera et al., 2017; Lehnig et al., 2019; Park et al., 2019; Reck, Zietlow, et al., 2016; Taylor et al., 2005). Perry et al. (2011) and Rossen et al. (2016) focused on the whole peripartum period and found out that prepartum depressive symptoms predicted postpartum bonding problems. Furthermore, measuring depressive symptoms and mother-infant bonding at four different time points during and after pregnancy, Ohoka et al. (2014) detected significant weak to moderate correlations ($r = 0.14 - 0.39$) between the severity of depressive symptoms and a lower bonding quality at each time point. Ohara et al. (2017) tested the relation of mother-infant bonding and depressive symptoms using structural equation modeling and revealed interesting results about the direction of the prediction. They assessed bonding and depressive symptoms at three different time points, i.e. in early pregnancy before week 25 (T 1), in late pregnancy around week 36 (T 2), and 5 days after delivery (T 3). Their findings indicate that bonding problems predict depressive mood in the prepartum period and 5 days after birth, thus concluding that not only depressive symptoms should be treated to mitigate bonding issues, but that at the same time bonding issues should be treated to mitigate depressive symptoms.

Fewer studies investigated postpartum bonding in the context of anxiety. Müller et al. (2016) revealed that anxious mothers of older female infants (over 5.5 months of age) showed a lower quality of maternal bonding compared to healthy controls. The study by Tietz et al. (2014) also associated postpartum anxiety disorders with lower maternal bonding. However, their linear regression analysis revealed that 27 % of the overall variance might be due to aspects of pronounced avoidance behavior and concurrent subclinical depressive symptoms. They highlighted the need to target even mild depressive symptoms when treating postpartum anxiety disorder and dealing with bonding issues. Nolvi et al. (2016) also reported an association of postpartum maternal bonding problems with both postpartum maternal depressive and anxiety symptoms. However, regarding anxiety disorders, findings are not as consistent as for depressive disorders because Edhborg et al. (2011) even found a positive correlation between the severity of postpartum maternal anxiety symptoms and postpartum bonding quality. Daglar and Nur (2018) contradict these findings, asserting that postpartum maternal anxiety symptoms were negatively associated with the postpartum bond. For prepartum anxiety symptoms, on the other hand, Daglar and Nur (2018) could not find an association with postpartum bonding.

To sum up, impaired bonding more often develops in the context of pre- and postpartum depression and it may continue even after maternal depressive symptoms are remitted (Reck, Zietlow, et al., 2016). Fewer studies have investigated impaired bonding in the context of anxiety disorders, but in this context, maternal bonding may also be impaired, in particular when concurrent depressive symptoms occur (Tietz et al., 2014).

Effects of postpartum bonding on mother-infant interaction

The effects of postpartum bonding on mother-infant interaction are not that well investigated either. Some studies, however, find significant associations between postpartum bonding and the quality of the mother-infant interaction. Mason et al. (2011) revealed that a higher maternal bonding quality two months postpartum is related to better results in the mother-infant interaction 6 months postpartum. Mother-infant interaction was, however, assessed by a self-report measure (i.e., Parent-Child Dysfunctional Interaction (P-CDI); Haskett et al., 2006). Their additional analysis also revealed that maternal bonding quality mediated, rather than moderated, the effect of peripartum depressive symptoms on mother-infant interaction. Moreover, Noorlander et al. (2008) found a significant correlation between the postpartum mother-infant bond and observations of mother-infant interaction by the nursing staff during hospitalization. Furthermore, for depressed mothers, impaired bonding seems to correlate with a lack of maternal reactivity, more pejorative behavior towards the child, and more breaking off of stimulation during a videographed interaction sequence (Hornstein et al., 2006). Muzik et al. (2013) showed that mothers with postpartum depression suffered from greater impaired bonding which in turn was significantly associated with a loss in maternal sensitivity, warmth, engagement, and flexibility during a dyadic play interaction. On the other hand, Behrendt et al. (2016) and Rossen et al. (2019) found no association between maternal bonding and the dyadic interaction assessed with the Emotional Availability Scales (EA; Biringen, 2000). Regarding anxiety disorders, lower maternal bonding seems to partially mediate between maternal anxiety and increased self-comforting behaviors but solely in female infants over 5.5 months of age (Müller et al., 2016).

In case of impaired bonding, mothers may perceive or exhibit less affection toward their infant or may even think that they are not capable of "properly" loving their child (Brockington et al., 2006). Impaired bonding can even eventuate in rejection, hostility, aggressive impulses towards the child (Da Costa et al., 2006; Kitamura et al., 2006), a heightened risk of abuse and neglect (Appleby et al., 1998), and infanticide (Feldman et al., 2009; Ohoka et al., 2014). Further research on impaired bonding, therefore, is of the utmost importance.

Before displaying the findings on bonding of the research project presented in chapter 2, the following section will give an overview of maternal mental health in the context of the COVID-19 pandemic. The peripartum period as a vulnerable period per se (Banti et al., 2011; O'Hara, 2009) has been even more of a challenge for mothers in light of a global pandemic.

1.3 Maternal Mental Health in the Context of the COVID-19 Pandemic

1.3.1 The COVID-19 Pandemic as a General Stressor

The COVID-19 pandemic has been an ongoing stressor for the worldwide population and public health care systems (French et al., 2022; Manchia et al., 2022). Next to the threatening somatic consequences of the coronavirus disease SARS-CoV-2 (COVID-19), the psychosocial effects of the virus itself or the associated confinement measures on the general population have been vast and well-documented in several studies and meta-analyses, suggesting higher rates of depression, generalized anxiety, depression, insomnia, and psychological distress (Bäuerle et al., 2020; Mahmud et al., 2022; Peters et al., 2021; Salari et al., 2020). A current systematic review asserted that the COVID-19 pandemic and its accompanying confinement measures may be conceptualized as traumatic events and that the COVID-19 pandemic may be associated with trauma sequelae (Kaubisch et al., 2022).

Especially for families, the confinement measures, such as social distancing and the closure of daycare centers and schools, have been challenging as parents had to meet multiple demands simultaneously, not only resulting in higher levels of stress, anxiety, depressive symptoms as well as poorer sleep and physical activities for parents (Brown et al., 2020; Freisthler, Gruenewald, et al., 2021; Kracht et al., 2021), but also putting children at a number of risks. Freisthler, Wolf, et al. (2021) saw children at risk for abuse and neglect since the daily assessment of parental stress and use of aggressive discipline from April to May 2020 demonstrated that for each higher level of stress, parents had 1.3 greater odds of aggressively disciplining their children, comprising corporal punishment and psychological aggression. Calvano et al. (2021) examined a subgroup of parents who reported adverse childhood experiences in their child's lifetime. 29.1% of these parents reported that their children witnessed increased domestic violence during the pandemic. Hence, investigating parents' mental health during the pandemic is of the utmost importance.

Parents of children aged 0-6 years, mothers compared to fathers, and parents with a higher level of education seem to be most affected by the pandemic situation (Hübener et al., 2020). Further risk factors comprise being single, staying with more children, and younger age (Kowal et al., 2020). As stated in the first part of this chapter, mothers in the peripartum period in general are particularly prone to developing a mental disorder, foremost a depressive disorder (Woody et al., 2017), and to be stressed by the various challenges connected to the demands of child-rearing (Reck, Zietlow, et al., 2016). In the context of the COVID-19 pandemic, this vulnerability may have increased.

1.3.2 Maternal Depressive Symptomatology and Perceived Stress

Recent meta-analyses indeed report an increase in maternal peripartum depressive symptomatology in the context of the pandemic (Q. Chen et al., 2022; Racine et al., 2022; Safi-Keykaleh et al., 2022; Yan et al., 2020). Notably, the more up-to-date the meta-analysis is, the higher the prevalence of scores above established cut-offs appears to be: (1) 22% (95% CI 15–29%) for a study inclusion up to September 2020 (Yan et al., 2020), (2) 26.9% (95% CI: 21.3-33.4%) up to March 2021 (Racine et al., 2022), (3) 28% (95% CI = 23-33%) up to August 2021 (Safi-Keykaleh et al., 2022), and (4) 34% (95% CI: 21–46%) up to November 2021 (Q. Chen et al., 2022). A pre-pandemic meta-analysis on postpartum depressive symptomatology yielded a pooled prevalence for low-income countries of 25.8% (95% CI: 17.9–33.8%) and for middle-income countries of 20.8% (95% CI: 18.4–23.1%). Considering the overlapping confidence intervals, this descriptive trend should be interpreted cautiously. However, studies comparing pre- to post-pandemic study means found statistically significant differences (Davenport et al., 2020; Fallon et al., 2021), corroborating the assumption that the ongoing pandemic of multiple waves increasingly affected the severity of maternal depressive symptoms (Q. Chen et al., 2022).

Regarding stress levels, mothers were not only distressed over childbirth under severe restrictions (Bertholdt et al., 2020; DeYoung & Mangum, 2021; Venta et al., 2021; Zanardo et al., 2020), but also perceived changes in children's routines, worries about COVID-19, as well as closures of school and child care facilities as highly stressful (Adams et al., 2021; Hiraoka & Tomoda, 2020). Other studies showed higher levels of perceived stress compared to pre-pandemic levels (Suárez-Rico et al., 2021) and a significant increase of stress levels during the pandemic (Calvano et al., 2021; Spinelli et al., 2020). Achterberg et al. (2021) more closely investigated the role of perceived stress for longitudinal effects of the COVID-19 lockdown on parents' and children's wellbeing. They found that parents' perceived stress during lockdown mediated the relationship between parents' negative feelings (i.e. feelings of anxiety, depression, hostility) before the lockdown and parents' negative feelings during lockdown. This result highlights the strong relation between perceived stress and depressive symptoms which is argued to be reciprocal (Hammen, 2005).

Perceived stress, defined as the extent to which a situation is appraised as unpredictable, uncontrollable, and overloading (S. Cohen et al., 1983), may be regarded as a symptom of depression, implying a certain overlap of these constructs and accounting, to some degree, for their strong correlation ranging from .63 to .76 (S. Cohen et al., 1983; Reis et al., 2019). Still, perceived stress has proven to be a valid, independent predictor of other constructs, such as anxiety, insomnia, or physical symptomatology (S. Cohen et al., 1983; Reis et al., 2019). Investigating the bidirectional link between stress and depression has been of particular interest for some time now (Brose et al., 2017; Hammen, 1991). Stress can increase the risk for depression, implying a stress exposure model of depression (Monroe & Reid, 2009). Depression, or depressogenic vulnerabilities can, in turn, enhance the susceptibility to stressful events which are at least partly influenced by the individual, implying a stress generation model (Hammen, 1991; Liu & Alloy, 2010). Several studies tested this bidirectional etiological model of stress and depression, providing evidence for either one or both directions. In a longitudinal experience sampling study, Brose et al. (2017) found that daily stressful experiences precede but do not succeed depressive symptoms. Another study yielded significant predictions for both pathways across two time points, that is, preceding levels of depressive symptoms predicted greater stress generation, and greater levels of stress also predicted higher levels of depressive symptoms (Calvete et al., 2013). Other results demonstrated that depression predicted stress, contrary to the researcher's primary assumption that stress predicts depression (Galaif et al., 2003). Another study detected predictions in both directions (Martinez & Bámaca-Colbert, 2019). Additionally, strong predictions for the auto-regressive paths were observed, meaning that prior depressive symptoms predicted subsequent depressive symptoms, and the same applied to the stress level (Calvete et al., 2013; Martinez & Bámaca-Colbert, 2019). Notably, these studies were conducted with adolescents or first year university students.

Regarding maternal depressive symptoms and perceived stress in the peripartum period, few longitudinal studies exist. They focused on assessing the interplay and different trajectories of perceived stress and depressive symptoms up to 2 years after delivery (Chow et al., 2019; Law et al., 2019; Leonard et al., 2020). Elevated levels of prepartum depressive symptoms put women at significant risk of higher stress up to two years after delivery (Chow et al., 2019). This result is pertinent as considerable research has already substantiated the robust role of stress as a precipitating factor for recurrent or persistent depressive episodes (Mora et al., 2008; Santos et al., 2017). Furthermore, perceived stress mediated the relationship between lower perceived social support and depressive symptoms (Leonard et al., 2020). Also, Law et al. (2019) consistently discovered significant and moderate-to-strong positive correlations within their multiple measurement points ($r = .58 - .81.$). These studies underscored the concurrent comorbidity of depressive symptoms and perceived stress during the process of pregnancy and early motherhood.

To the author's best knowledge, no studies have investigated the reciprocal relationship between the severity of depressive symptoms and perceived stress over the course of early motherhood during the COVID-19 pandemic. We, therefore, set out to further examine this relationship, which will be presented in chapter 3. First, however, we will go back to pre-COVID times and investigate maternal mental health and its associations with pre- and postpartum bonding as well as dyadic interaction in the next chapter.

Chapter 2

Study 1: Peripartum Maternal Depressive and Anxiety Disorders and Dyadic Interaction: Investigating the Mediating Role of Pre- and Postpartum Bonding

The goal of this first study was to shed more light on the associations between maternal depressive and anxiety disorders, pre- and postpartum bonding, as well as dyadic interaction. More specifically, we examined whether the interactive reparation, i.e. the latency to resolve an affective behavioral mismatching state and transform it into a matching state, was influenced by maternal depressive and/or anxiety disorders, and whether that effect was mediated by pre- and/or postpartum bonding. Since multiple studies have shown that the quality of mother-infant interaction is substantially involved in the intergenerational transmission of mental disorders (Edwards & Hans, 2015; Mäntymaa et al., 2009; Reck, Nonnenmacher, et al., 2016; Stanley et al., 2004), it is crucial to investigate how the interaction quality may be influenced. Before doing so, we shortly highlight and refresh some important theoretical and empirical background which has been presented in chapter 1.

2.1 Theoretical Background

Peripartum maternal depressive and anxiety disorders may adversely affect child development (J. H. Goodman et al., 2016; Kingston & Tough, 2014). Mother-infant interaction has been shown to be substantially involved in the transmission of these adverse effects (Edwards & Hans, 2015; Reck, Nonnenmacher, et al., 2016). Hence, it is crucial to further investigate which factors may potentially lead to a lower quality of mother-infant interaction (Müller, 2017; Reck et al., 2022). A wider range of studies have addressed the negative effects of peripartum depressive disorder on mother-infant interaction (Tronick

& Reck, 2009), whereas fewer studies have investigated the adverse effects of peripartum anxiety disorders (Feldman et al., 2009). Adjacent to maternal psychopathology, mother-infant interaction is also influenced by maternal prepartum (Maas et al., 2016; Siddiqui & Hägglöf, 2000) and postpartum (Mason et al., 2011; Muzik et al., 2013) bonding. In turn, prepartum and postpartum bonding may be negatively correlated with both depression and anxiety (J. L. Alhusen, 2008; Lehnig et al., 2019; Müller et al., 2016; Tietz et al., 2014). Only very few studies investigated the associations of both prepartum and postpartum bonding with depressive and anxiety symptoms in a longitudinal design (Dubber et al., 2015; Ohara et al., 2017; Rossen et al., 2016). So far, to our best knowledge no study prospectively examined the effects of both maternal psychopathology and bonding during and after pregnancy on mother-infant interaction. Mason et al. (2011) found out that postpartum maternal feelings of bonding mediated the relationship between postpartum maternal depression and mother-child interaction, which is why we aimed to further investigate the mediating role of maternal bonding in the course of both maternal depressive and anxiety disorders. Our goal was

1. to investigate the mediating role of maternal prepartum bonding and maternal impaired[1] postpartum bonding in the relationship between maternal psychopathology (depressive and/or anxiety disorders) and a lower quality of mother-infant interaction, meaning a longer latency to interactive reparation during the challenging reunion phase of the FFSF (hypothesis (H) 1),

2. to specify the mediating role of bonding in the relationship between the severity of depressive symptoms and a longer latency to repair (H2), and

3. to specify the same mediating role, but in the context of anxiety symptoms (H3).

Figure 2.1 depicts these associations in a serial mediation model.

Concerning the direction of relationships, we hypothesize that a maternal psychopathological diagnosis or higher symptom severity are associated with lower maternal prepartum bonding and higher impaired postpartum bonding as well as a longer latency to interactive reparation.

As an additional exploratory analysis, we took Ohara et al.'s (2017) findings for depressive symptoms into consideration by investigating the reciprocal relations between maternal bonding and depressive symptoms in a more complex model (see figure 2.2). Equally to Ohara et al. (2017), we examined bonding and symptoms across three measurement points. In addition to Ohara et al. (2017), we did not only investigate depressive symptom severity but also looked into the severity of anxiety symptoms.

[1]Notably, the constructs, maternal prepartum bonding and impaired postpartum bonding, are named according to what the values obtained from their scale represent (see Maternal-Fetal Attachment Scale and Postpartum Bonding Questionnaire in 2.2.3)

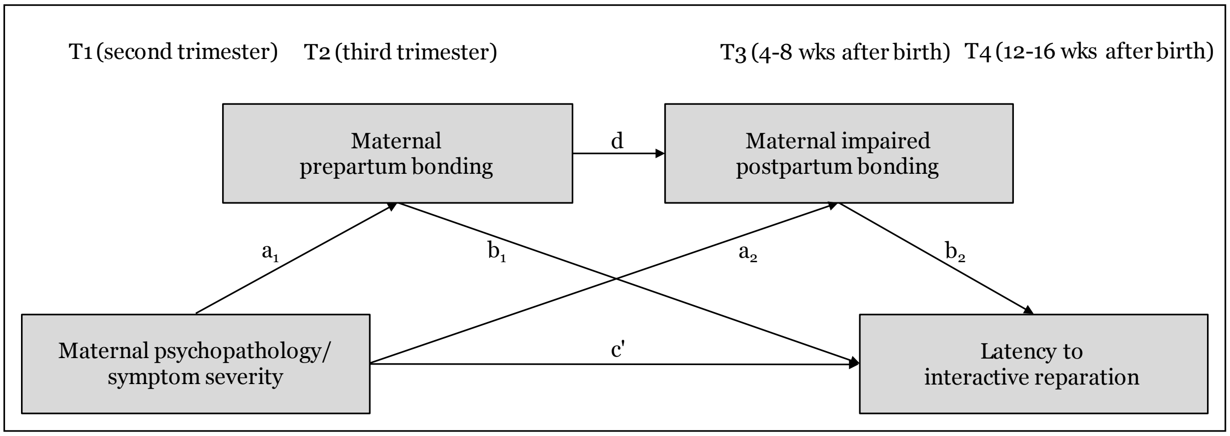

Figure 2.1: Mediation model with two potential serial mediators, i.e. maternal prepartum bonding and maternal impaired postpartum bonding. Path a_1*b_1: indirect effect of maternal psychopathology on interactive reparation through maternal prepartum bonding. Path a_2*b_2: indirect effect of maternal psychopathology on interactive reparation through maternal postpartum bonding. Path a_1*d*b_2: indirect effect of maternal psychopathology on interactive reparation through maternal prepartum and postpartum bonding in serial. Path c': direct effect of maternal psychopathology on interactive reparation.
Examining maternal psychopathology included testing a clinical group of mothers suffering from depressive and/or anxiety disorders against a healthy control group (model 1), investigating the severity of depressive symptoms across both groups (model 2), and investigating the severity of anxiety symptoms across both groups (model 3). Notably, the constructs, maternal prepartum bonding and *impaired* postpartum bonding, are named according to what the values obtained from their scale represent (see Maternal-Fetal Attachment Scale and Postpartum Bonding Questionnaire in 2.2.3). Figure available at https://osf.io/2rh8f/, under a CC-BY4.0 license.

2.2 Method

In order to ensure a thoroughly transparent and reproducible research process, this study was pre-registered and supplementary files were made publicly available (see section 2.5 for access to all documents and files). As the following data analyses were based on a data set which had been collected up to January 2015, access to the data was first granted after pre-registration. The STROBE guidelines (von Elm et al., 2014) were adhered to in order to provide a standardized way of presenting our observational study.

2.2.1 Participants

The sample is part of a larger longitudinal study funded by the German Research Foundation (DFG). Inclusion criteria for (1) the clinical group were at least one of the following depressive and/or anxiety disorders according to the DSM-IV (American Psychiatric As-

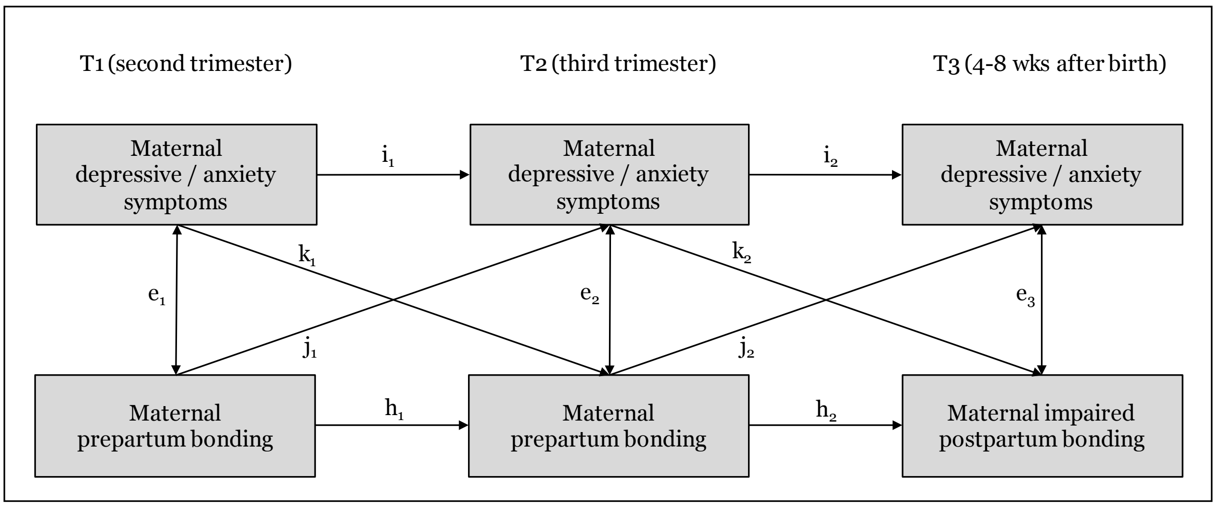

Figure 2.2: Exploratory structural equation model depicting the potential relationship between maternal depressive or anxiety symptoms and maternal bonding. This exploratory model follows the structure of a cross-lagged panel design with (1) auto-regressive effects, i.e. i_i and h_i, examining the stability within constructs across time, (2) cross-lagged effects, i.e. k_i and j_i, examining the relation between constructs across time, and (3) correlations, i.e. e_i, examining the relation between constructs within measurement points. Notably, the severity of depressive and anxiety symptoms were assessed in three separate exploratory models: exploratory model 1 examining depressive symptoms, exploratory model 2 examining state anxiety symptoms, and exploratory model 3 examining trait anxiety symptoms. Figure available at https://osf.io/2rh8f/, under a CC-BY4.0 license.

sociation, 2000) before and/or during the prepartum period: major depressive disorder, dysthymia, panic disorder with or without agoraphobia, agoraphobia without history of panic disorder, generalized anxiety disorder, social phobia, obsessive compulsive disorder, posttraumatic stress disorder, and anxiety disorder not otherwise specified. A specific phobia as the only diagnosis was not included. Further exclusion criteria for clinical mothers included: an acute or former psychosis, current or former bipolar disorder, current substance abuse, or acute suicidal tendency. Mothers of the (2) healthy control group needed to have no current or antecedent diagnosis according to the DSM-IV. Besides, participants of both groups and their infants did not suffer from any severe physical diseases.

99 mothers were recruited from maternity hospitals and gynecological clinics in Heidelberg and Mannheim, Germany, between March 2010 and January 2015. 23 mothers missed either missed their first appointment or needed to be excluded after the first diagnostic interview. All other assessments ($n = 76$) took place at the University Hospital of Heidelberg, Germany. 5 mothers dropped out before giving birth due to the following reasons: change of residence, lack of time, questionable psychotic disorder, or a severe gastrointestinal disease. From the remaining sample of 71 mothers who completed the study 12 mothers could not be part of our main analyses as mother-infant interaction could not be coded due to technical issues with the videos. Thus, our final study sample comprised 59 mothers.

Out of these 59 mothers, 21 mothers were healthy and thus assigned to the control group. 38 mothers either suffered from a current ($n = 21$) or lifetime ($n = 17$) depression or anxiety disorder and were therefore allocated to the clinical group. The clinical group comprised 6 mothers with an anxiety disorder, 15 mothers with a depressive disorder, and 17 mothers with a comorbid depressive and anxiety disorders. Initially, we intended to separately analyze two clinical groups with depressive disorders and anxiety disorders, which, however, was not feasible due to difficult recruitment and therefore small sample size.

2.2.2 Procedure

After a screening and interview via telephone, mothers in their first or second trimester were invited to the laboratory of the Heidelberg University Hospital where written informed consent was obtained. The study protocol was approved by the independent ethics committee of the Heidelberg University Medical Faculty. First, the Structured Clinical Interview for DSM-IV (SCID; (Wittchen et al., 1997)) was conducted. Subsequently, questionnaires assessing the mothers' sociodemographic status, symptom severity, and bonding were filled out at home. Diagnostic and sociodemographic status, symptom severity, and bonding were assessed between the 9th and 12th (T0), the 19th and 22nd (T1) and the 29th and 32nd (T2) week of pregnancy, as well as between the 4th and 8th week postpartum (T3), and between the 12th and 16th week postpartum (T4). Notably, recruitment at T0 was not feasible probably due to this very early stage of pregnancy, which is why the study protocol was changed to include mothers until the 22nd week of pregnancy. We, therefore, regarded T1 as the actual first measurement point of the study and did not include any of the very sparse data of T0 in our analyses.

In addition to the interviews and self-report measures, mother-infant interaction during the FFSF was videographed in the laboratory at T4. The infant was secured in a booster seat in front of the mother who was briefed applying a standard text. One camera each focused on the infant and on the mother. A single screen, simultaneously displaying the two different frontal views, was created by transmitting both recordings through a split-screen generator. The FFSF paradigm consists of three episodes each lasting 2 minutes. First, there is an initial face-to-face interaction in which the mothers are instructed to play with their infant as usual but without using any toys and pacifiers. In the following episode, the still-face episode, the mothers have to turn their heads aside while silently counting to 10 and then turn back to the infant but not engage in any gestures, facial expressions, or vocalizations, creating a prolonged state of interactional mismatch. Finally, the procedure ends with the reunion episode in which the mother is required to resume the face-to-face play with her infant. Each episode was ended by a tap from a research assistant from the adjoining room, which likewise served as the initiation of subsequent episodes.

2.2.3 Instruments

Structured Clinical Interview for DSM-IV (SCID)

Postpartum maternal depressive and anxiety disorders were assessed with the German version of the SCID-I (Wittchen et al., 1997). At the time of assessment, it had been a widely applied semistructured interview for the diagnosis of selected axis I disorders, which has been updated in the meantime.

Edinburgh Postnatal Depression Scale (EPDS)

Symptom severity of depressive symptoms was assessed by the German version (Bergant et al., 1998) of the Edinburgh Postpartum Depression Scale (Cox et al., 1987; see appendix A.1 for full questionnaire). As a ten-item self-rating scale, each item coded from 0 to 3, it has been validated for the detection of prepartum as well as postpartum depression in numerous studies (Matthey et al., 2006). A higher sum score indicates a higher severity of depressive symptoms during the last seven days. Matthey et al. (2001) demonstrated a high sensitivity and specificity of the EPDS in detecting depressive disorders in mothers. In our sample, EPDS data revealed good to excellent internal consistencies at all measurement points (Cronbach's $\alpha = 0.85 - 0.93$).

State and Trait Anxiety Inventory (STAI)

In order to assess the participants' severity of anxiety, we applied the German version (Laux et al., 1981) of the State and Trait Anxiety Inventory (STAI; Spielberger et al., 1970) as a reliable and valid measure for both clinical and nonclinical populations (see appendix A.2 for full questionnaire). The STAI is divided into two subscales: (1) the state scale (STAI-S) evaluates feelings of apprehension, tension, nervousness and worry as anxiety of a temporary condition, whereas (2) the trait scale (STAI-T) refers to anxiety as a temporally stable personality feature. Both subscales comprise 20 items. In order to assess the acute status of severity of anxiety, we only included the STAI-S into our main analyses. Mothers rated their symptoms on a 4-point scale from 1 (almost never/not at all) to 4 (almost always/very much). The sum score of the STAI-S, therefore, ranges from 20 to 80 points. A higher sum score represents greater severity of anxiety. We considered the STAI-S to be suitable for our study as it does not contain any somatic symptoms, which are very common during pregnancy due to other reasons than anxiety. Thus, we aimed to minimize a pregnancy-related bias in our assessment of anxiety. Besides, both subscales of the STAI were also validated to DSM-IV criteria for the prepartum period (Grant et al., 2008). The STAI-S data yielded excellent internal consistencies at all measurement points (Cronbach's $\alpha = 0.94 - 0.95$).

Maternal-Fetal Attachment Scale (MFAS)

Prepartum maternal bonding was assessed with the revised version (Van den Bergh, 1989) of the Maternal-Fetal Attachment Scale (MFAS; Cranley, 1981). We used the German translation by Dubber et al. (2015), validated by Doster et al. (2018; see appendix A.3 for full questionnaire). In contrast to the original version with five subscales, this validation revealed a three-factor solution, constituting the three independent dimensions "anticipation", "empathy", and "caring". The MFAS comprises a total of 24 items, assessing the relationship between mother and fetus. Participants score the items on a 7-point Likert-scale from 1 for "definitely no" to 7 for "definitely yes". Scores may be either added up for each subscale or for the total scale. As we were interested in the overall bond between mother and fetus, we did the latter. The total sum scores range from 24 to 168, with higher sum scores indicating greater bonding to the fetus. The MFAS total scale reached acceptable to good internal consistencies at all of the measurement points (Cronbach's $\alpha = 0.78 - 0.82$).

Postpartum Bonding Questionnaire - 16 (PBQ-16)

To assess maternal impaired postpartum bonding, we applied the abridged German version (PBQ-16; Reck et al., 2006) of the Postpartum Bonding Questionnaire, originally developed by Brockington et al. (2001; see appendix A.4 for full questionnaire). Reck et al. (2006) could not confirm the four factor structure of the original English version in a German validation study ($n = 862$), which is why nine of the 25 items were eliminated for a one factor structure solution. The remaining 16-items are scored on a 6-point Likert-scale (1 for "always" to 6 for "never"). The sum score ranges from 16 to 86. Higher values represent a poorer quality of bonding, which we refer to as impaired bonding. For the 16-item version of the PBQ, Reck et al. (2006) report a Cronbach's α of 0.85. In our data, the PBQ reached a good internal consistency of $\alpha = 0.80$.

Coding of Infant Behavior During the FFSF: Infant and Caregiver Engagement Phases-Revision.

The videotaped FFSF experiments were coded by a trained and reliable coder using the microanalytic coding system Infant and Caregiver Engagement Phases (ICEP-R; Reck et al., 2009). The ICEP-R is based on Tronick's Monadic Phases Scoring System (Tronick et al., 1980) and the Infant and Maternal Regulatory Scoring Systems (IRSS & MRSS; Tronick and Weinberg, 1990a, 1990b). The different ICEP-R phases combine information from the caregiver's and the infant's face, direction of gaze and vocalizations. First, the infant's engagement phases are coded, including (1) negative engagement (further divided into (2) protest and (3) withdrawn). (4) object/environment engagement, (5) social monitor, and (6) social positive engagement. Second, the caregiver's engagement phases are coded, comprising (1) negative engagement (further divided into (2) withdrawn, (3) intrusive, and (4) hostile), (5) non-infant focused engagement, (6) social monitor/no or neutral vocalizations, (7) social monitor/positive vocalizations, and (8) social positive engagement. Additional infant codes, which may co-occur with the engagement codes, include (1) oral and (2) manual self-comforting behaviors, (3) distancing, and (4) automatic stress indicators (see appendix B for full coding manual). Reliable coders need to achieve an interrater reliability of Cohen's $\kappa = 0.75$ and are blinded to the maternal psychiatric status as well as to the hypotheses of the study. Cohen's κ was determined for the categorical engagement phase codes on a second-by-second basis. The video tapes were coded using the Noldus Observer Video-Pro® coding system with 1-second time intervals by one reliable coder of our study team. 20 % of the the videos will be randomly selected and coded by a second independent coder before publishing our results in an academic journal.

We defined matching states as the mother and infant simultaneously exhibiting the same affective-behavioral state (Tronick, 2007). In order to describe the process of interactive reparation, we focused on positive social matches, assuming this coordinated state to be a sign of positive interaction (Beeghly et al., 2011). We defined a *positive social match* as follows: the infant is either in social monitor or positive engagement, while the mother is in social monitor/positive vocalizations or social positive engagement. More specifically, the following overlapping codes count as a positive social match:

1. Caregiver's social positive engagement (Cpos) + Infant's social positive engagement (Ipos)
2. Caregiver's social positive engagement (Cpos) + Infant's social monitor (Ineu)
3. Social monitor/positive vocalizations (Cpvc) + Infant's positive social engagement (Ipos)

Notably, an overlap of Cpvc and Ineu is not regarded as sufficient to count as a positive social match because the exhibition of a clear positive affect is not given on either side. As an illustration of the ICEP coding, the whole 360 s, i.e. 6 min, of one dyadic exemplary interaction during the FFSF experiment was plotted as a time series (see 2.3.

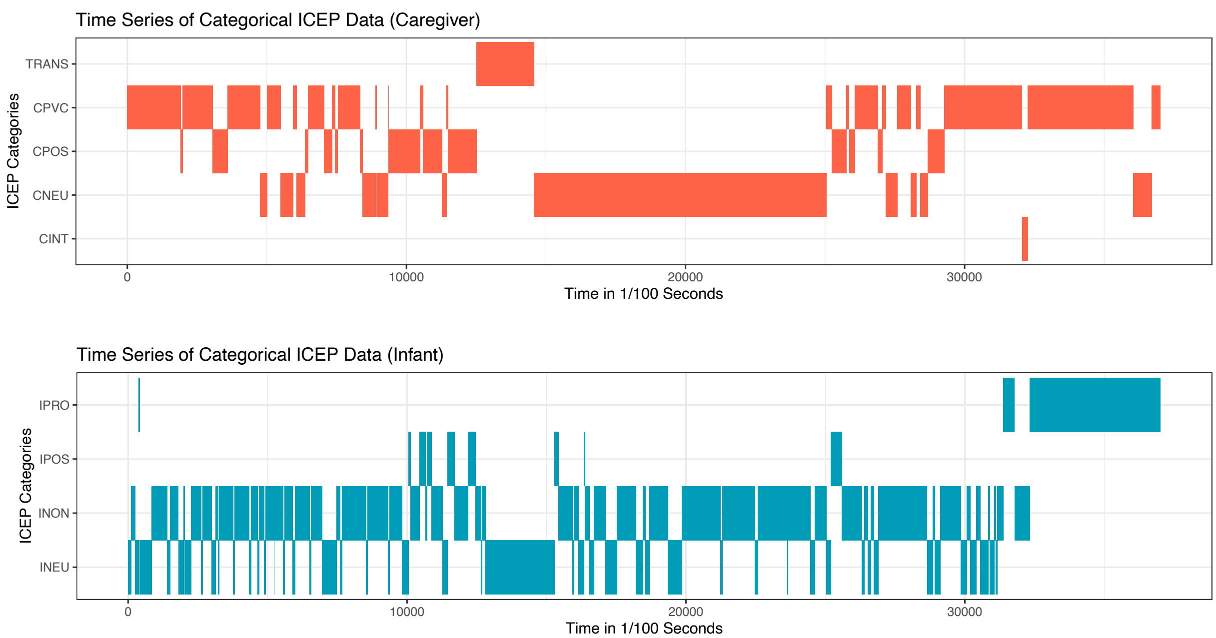

Figure 2.3: Exemplary time series of one dyadic interaction during the Face-to-Face Still-Face experiment. The mother's time series is presented at the top and the infant's time series at the bottom. ICEP = Infant and Caregiver Engagement Phases; TRANS = transition phase of 10 seconds before the still-face episode starts; CPVC = Caregiver's social monitor/positive vocalizations; CPOS = Caregiver's social positive engagement; CNEU = Caregiver's social monitor/no or neutral vocalizations; CINT = Caregiver's intrusive affect/behavior; IPRO = Infant's protesting; IPOS = Infant's social positive engagement; INON = Infant's object/environment engagement; INEU = Infant's social monitor. Notably, not all ICEP codes were observed within this dyad. Figure available at https://osf.io/2rh8f/, under a CC-BY4.0 license.

Our outcome measure, i.e. the latency to interactive reparation, was computed as the average mismatch duration in seconds, meaning the average time interval from positive social match offset to positive social match onset. As an additional exploratory measure we looked into relative time durations of positive social matching states, i.e. the sum of seconds the dyads spent in positive social matching states divided by the time of the reunion episode of the FFSF. We focused on the challenging reunion episode as it is particularly informative regarding the regulatory quality of the interaction (Weinberg & Tronick, 1996).

2.2.4 Statistical Analysis

Analyses were conducted using R, version 4.2.1 (R Core Team, 2021). Post-hoc power was estimated via G*Power 3.1 (Faul et al., 2007). We employed serial mediation analyses using the packages “lavaan” (Rosseel, 2012), “semPlot” (Epskamp et al., 2022), “mma” (Yu & Li, 2020), and “dplyr” (Wickham et al., 2021). Parameter estimates were obtained by a maximum-likelihood estimation with robust estimators of model fit (MLR) with robust (Huber-White) standard errors and a scaled test statistic that is (asymptotically) equal to the Yuan-Bentler test statistic as it is robust against the violation of normal distribution (Rosseel, 2020). A full information maximum likelihood (FIML) approach was be applied to compensate for missing data. To evaluate the quality of model fits, we inspected a range of fit indices, including the comparative fit index (CFI), the Tucker-Lewis index (TLI; also called the non-normed fit index), the root-mean-square error of approximation (RMSEA), and the standardized root-mean-square residual (SRMR). In line with Hu and Bentler (1999) and Kline (2016), cut-off values for good model fit were CFI $>$ .90, TLI $>$ .90, SRMR $<$ .09, and RMSEA $<$ .08. Cut-offs for excellent model fit were CFI $>$ .95, TLI $>$ .95, SRMR $<$ .08, and RMSEA $<$ .06.

As we focus on the links and overall scores of our variables rather than the measurement procedure, we tested three pathway models, each comprising four manifest variables (see figure 2.1). Model test 1 included (1) a binary independent variable, i.e. the assessment of maternal psychopathology revealed a maternal diagnosis of depression and/or anxiety (dummy coded as 1) or did not reveal any diagnosis (dummy coded as 0) taken from measurement point T1, (2) a continuous mediating variable, i.e. the sum score of the MFAS taken from T2, (3) a second continuous mediating variable in series, i.e. the sum score of the PBQ-16 taken from T3, and (4) a continuous dependent variable, i.e. the latency to interactive reparation taken from T4. Model test 2 and 3 only differed in including the sum scores of the EPDS and the STAI-S of T1 as the respective independent variable. We hypothesized significant indirect effects in mediation model 1:

$$a_{11} * b_{11} \text{ (H1a)},$$

$$a_{21} * b_{21} \text{ (H1b)},$$

$$a_{11} * d_1 * b_{21} \text{ (H1c)},$$

model 2:

$$a_{12} * b_{12} \text{ (H2a)},$$

$$a_{22} * b_{22} \text{ (H2b)},$$

$$a_{12} * d_2 * b_{22} \text{ (H2c)},$$

and model 3:

$$a_{13} * b_{13} \text{ (H3a)},$$

$$a_{23} * b_{23} \text{ (H3b)},$$

$$a_{13} * d_3 * b_{23} \text{ (H3c)}.$$

Our pathway signifiers are named according to the model they belong to, i.e. a_{11} represents a_1 in model 1, a_{12} represents a_1 in model 2, a_{13} represents a_1 in model 3, and so on. Empirical p values are two-tailed (critical $\alpha = .05$). It is noteworthy that all three mediation models are saturated models, inherently producing a perfect model fit which is of little statistical use. They may still be interpreted due to our strong theoretical foundation.

In case of non-significant initial direct effects (i.e., initial pathway c), no direct association between the independent and dependent variable can be assumed, which is why we would refrain from interpreting potential mediation effects in such cases. Further preconditions for mediation analysis are (Hayes, 2018):

1. Normal distribution of residuals, i.e. residuals follow a normal distribution, which is crucial for parametric analyses, can be investigated by visual examination of histograms and by a Shapiro-Wilk test. A significant result indicates non-normal distribution.

2. Linearity, i.e. a linear association between variables, can be assumed which can be examined by visual analysis of the data.

3. Homoscedasticity, i.e. homogeneity of variance, can be tested via a Breusch-Pagan test. A significant result indicates non-homogeneity of variances, i.e. heteroscedasticity.

4. Independence of residuals is secured via the study design and can be assumed in our case.

5. Temporal precedence is also secured via our study design as our independent variables, serial mediators, and outcome variable were assessed at consecutive time points. Thus, the serial mediators and outcome variable are each predicted by a temporally preceding variable.

Concerning outliers, we did not exclude cases based on deviations from the respective group means, in order not to further reduce the sample size and not to affect the representativeness of our sample. We screened for outliers and conducted sensitivity analyses where necessary to test the robustness of our main analyses. Outliers were defined as participants more than 1.5 interquartile ranges above the upper quartile (75 %) or below the lower quartile (25 %) of the respective variable.

Besides, we ensured comparability between the clinical group and the control group by exploring several sociodemographic as well as pregnancy- and birth-related variables, such as maternal and infant age, relationship status, gestational age etc., via two sample t tests, Wilcoxon rank sum tests, also known as Mann-Whitney U tests, and χ^2 tests. A full list of these variables is demonstrated in tables 2.1 and 2.2.

As additional exploratory analyses, we employed structural equation modelling to test the models presented in figure 2.2. Considering our sample size and the many pathways to be estimated, we meant to only very cautiously interpret the results of the exploratory models. Nevertheless, compared to other clinical studies (Behrendt et al., 2019; Juengst et al., 2017), our sample size may be considered sufficient to possibly draw some meaningful conclusions.

2.3 Results

2.3.1 Preliminary Analysis

Maternal and infant sociodemographic as well as pregnancy- and birth-related data are presented in tables 2.1 and 2.2, which also show tests of comparability between the control and clinical group. Groups were comparable except for the mothers' educational level. Mothers of the control group were more highly educated ($W = 497$, $p = .035$).

2.3.2 Model Assumptions

We tested the following preconditions of mediation analyses: (1) normal distribution of residuals, (2) linearity, and (3) homoscedasticity.

Normal Distribution of Residuals

For model 1, residuals followed a normal distribution according to a visual check of the Q-Q plot and a non-significant Shapiro-Wilk normality test ($p = .110$). Residuals of model 2 were not normally distributed ($p < .001$), nor were residuals of model 3 ($p < .001$).

Table 2.1: *Mothers' Descriptive Statistics of Sociodemographic Data and Tests of Comparability between the Control and Clinical Group.*

	Total *M (SD)*	Control *M (SD)*	Clinical *M (SD)*	*t (p)*
Maternal Age at T1 (yr.)	31.62 (4.49)	31.00 (4.29)	31.95 (4.61)	-0.76 (.450)
	Total *n*	Control *n*	Clinical *n*	*W (p)*
Number of children				34 (.083)
1	14	4	10	
2	9	1	8	
3	1	0	1	
4	1	0	1	
Educational level				497 (.035)
No school degree	0	0	0	
Low secondary education	0	0	0	
High secondary education	10	2	8	
University qualification	9	1	8	
University degree	39	18	21	
	Total *n*	Control *n*	Clinical *n*	χ^2 *(p)*
In a relationship				0.12 (.724)[a]
No	2	0	2	
Yes	55	21	34	
Parity				2.49 (.114)
Nulliparae	35	16	19	
Multiparae	23	5	18	
Breastfeeding after birth				3.40 (.639)[a]
No	4	0	4	
Immediately	27	9	18	
Within 30 min	9	4	5	
Within 1 h	5	1	4	
Within 1-6 h	9	4	5	
$>$ 6 h	3	1	2	
Holding child after birth				4.09 (.394)[a]
No	0	0	0	
Immediately	47	15	32	
Within 30 min	3	2	1	
Within 1 h	2	1	1	
Within 1-6 h	5	1	4	
$>$ 6 h	1	1	0	

Note. M = arithmetic mean; SD = standard deviation; t = t value of the two sample t-test; p = p value; n = sample size; W = W value of the Wilcoxon rank sum test; χ^2 = Chi value of the Chi-squared test; T1 = first measurement point. Parity is the number of times a woman gave birth at a viable gestational age, comprising live births and stillbirths.
If the sum of the total sample size does not add up to the complete sample size of 59, the remainder indicates the number of missing values for this variable.
[a] Additional Fisher's exact test due to low cell counts: In a relationship: p = .526; Breastfeeding after birth: p = .684; Holding child after birth: p = .383

Table 2.2: *Infants' Descriptive Statistics of Sociodemographic Data and Tests of Comparability between the Control and Clinical Group.*

	Total *M (SD)*	Control *M (SD)*	Clinical *M (SD)*	*t (p)*
Infant Age at T4 (yr.)	4.03 (0.35)	4.12 (0.32)	3.99 (0.36)	1.41 (.163)
Gestational age (wks.)	39.74 (1.26)	39.73 (1.23)	39.74 (1.29)	-0.04 (.967)
Birth weight (g)	3469.48 (430.67)	3558.00 (441.49)	3422.89 (423.29)	1.14 (.260)
APGAR 10 min.	9.96 (0.20)	10.00 (0.00)	9.94 (0.24)	1.03 (.310)
	Total n	Control n	Clinical n	χ^2 (p)
Infant gender				0.73 (.394)
female	26	11	15	
male	32	9	23	
Birth mode				3.09 (.214)[a]
Spontaneous	46	14	32	
Primary section	6	2	4	
Secondary section	6	4	2	

Note. M = arithmetic mean; SD = standard deviation; t = t value of the two sample t-test; p = p value; n = sample size; χ^2 = Chi value of the Chi-squared test; T4 = fourth measurement point. The APGAR value is a score assessed directly after birth, evaluating the newborn's muscle tone, pulse, respiration, grimace, and appearance. It ranges from 0 to 10 with healthy children receiving values of 8 to 10.
If the sum of the total sample size does not add up to the complete sample size of 59, the remainder indicates the number of missing values for this variable.
[a] Additional Fisher's exact test due to low cell counts: Birth mode: $p = .307$

Linearity

A visual examination of the three scatter plots of the latency to interactive repair on each the diagnostic grouping variable, the severity of depressive symptoms, and the severity of anxiety symptoms revealed no linear association between the severity of depressive and anxiety symptoms and the latency to interactive repair. For the binary diagnostic variable, a linear trend could be seen, which, however, pointed in the opposite direction as assumed, i.e. a shorter latency to interactive reparation in the clinical group instead of the postulated longer latency in the clinical group. This trend, however, did not reach significance according to linear regression analysis ($\beta = -0.568$, $p = 0.0501$) even though the same linear association reached significance in model 1 of the main analyses (see below and 2.4), which will be elaborated in the discussion. In order to further corroborate our visual check of scatter plots and correlation analysis, we also tested the association between the severity of depressive and anxiety symptoms and the latency to interactive repair via linear regression analysis, revealing insignificant results (depressive symptoms: $\beta = -0.039$, $p = 0.783$; anxiety symptoms: $\beta = -0.018$, $p = 0.896$). When removing a detected outlier with a relatively high latency to interactive repair, there was still no linear association between the three independent variables and latency to interactive reparation. The beta weights of this paragraph represent the initial c_1, c_2, and c_3 pathways of mediation model 1, 2, and 3; describing the solitary influence of the independent variable on the dependent variable without considering potential mediators or moderators.

Homoscedasticity

For model 1, the Breusch-Pagan test revealed a significant result ($p = .003$), and thus, indicated non-homogeneity of variances, i.e. heteroscedasticity. For model 2 and 3, the Breusch-Pagan test yielded an insignificant result, thus indicating homoscedasticity ($p_2 = .715$, $p_3 = .886$).

2.3.3 Main Analysis

Testing our three main mediation models yielded the following results. As a reminder, models only differed in their independent variable: Model 1 examined the diagnostic group, model 2 the severity of depressive symptoms, and model 3 the severity of state anxiety symptoms as the independent variable (see again figure 2.1 to be reminded of the following parameter indices).

Regarding model 1, we could not support hypotheses H1a, meaning the indirect effect of the diagnostic group on the latency to interactive repair via maternal prepartum bonding did not reach significance (standardized indirect effect: $a_{11} * b_{11} = 0.002$, $p = .842$). The indirect effect of the diagnostic group on the latency to interactive repair via maternal impaired postpartum bonding (H1b) did not reach significance either (standardized indirect effect: $a_{21} * b_{21} = 0.018$, $p = .573$), nor did the serial indirect effect via both maternal prepartum and impaired postpartum bonding yield a significant result (standardized indirect effect: $a_{11} * d_1 * b_{21} = 0.001$, $p = .834$).

Testing model 2 did not yield any significant mediation effects either. Hence, we could not provide evidence for H2a, i.e. an indirect effect of the severity of depressive symptoms on the latency to interactive repair mediated via maternal prepartum bonding (standardized indirect effect: $a_{12} * b_{12} = 0.015$, $p = .561$), nor could we support H2b (standardized indirect effect: $a_{22} * b_{22} = 0.031$, $p = .542$), nor H2c (standardized indirect effect: $a_{12} * d_2 * b_{22} = 0.005$, $p = .589$).

Estimates of model 3 revealed no significant results either. According to these results, we could not find a mediating effect of maternal prepartum bonding in the relationship between the severity of state anxiety symptoms and the latency to interactive reparation (H3a; standardized indirect effect: $a_{13} * b_{13} = 0.026$, $p = .489$). Mediating effects postulated in H3b and H3c could not be confirmed either (standardized indirect effects: $a_{23} * b_{23} = 0.039$, $p = .496$; $a_{13} * d_3 * b_{23} = 0.007$, $p = .569$, respectively).

Parameter estimates for the standardized partial regression weights of all the pathways are depicted in figures 2.4, 2.5, and 2.6. Testing model 1 yielded a significant prediction of maternal impaired postpartum bonding by maternal prepartum bonding in the expected direction ($d_1 = -0.264$, $p = .045$) and a significant prediction of the latency to interactive reparation by the maternal diagnostic status in the opposite direction than expected ($c'_1 = -0.314$, $p = .047$). Notably, screening for outliers revealed one outlier with a relatively high latency to interactive repair (38.98 s). No outliers were detected for the other main measures. When removing the outlier, the latter effect did not reach significance anymore ($c'_1 = -0.244$, $p = .096$). Testing model 2 revealed a significant prediction of maternal impaired postpartum bonding by the severity of depressive symptoms in the expected direction ($a_{22} = 0.259$, $p = .049$). In model 3, the severity of anxiety symptoms significantly predicted maternal prepartum bonding in the expected direction ($a_{13} = -0.281$, $p = .041$) and maternal impaired postpartum bonding in the expected direction ($a_{23} = 0.308$, $p = .026$). Removing the outlier when testing model 2 and 3 did not majorly change estimates.

To sum up, neither of our postulated mediation effects reached significance. We, however, found some single significant pathways which will be further investigated in the exploratory analysis section.

2.3.4 Diagnostics

Table 2.3 demonstrates the descriptive statistics of our main and exploratory measures in the total, control, and clinical sample. In order to get an impression of differences between the control and clinical group, we conducted exploratory two sample t-tests, more specif-

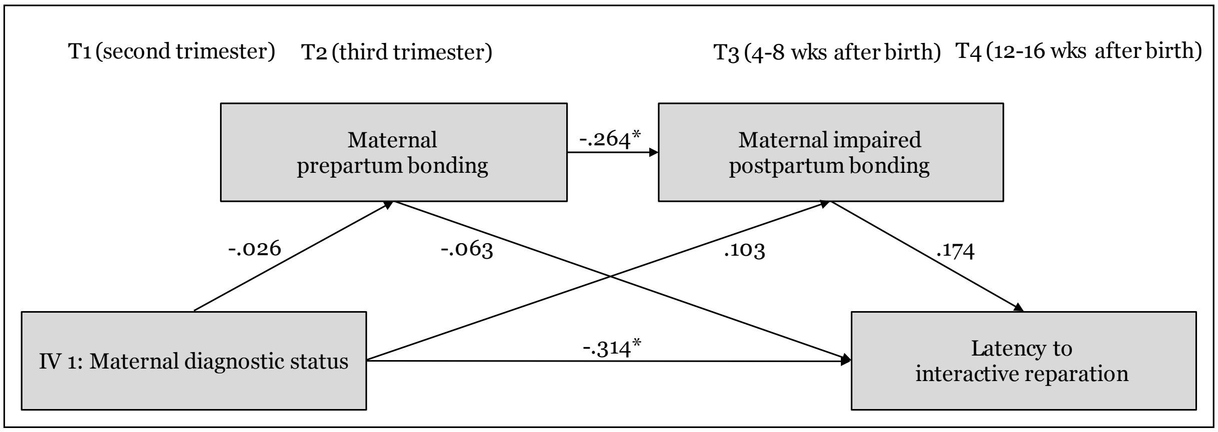

Figure 2.4: Mediation model 1 with the maternal diagnostic status as the independent binary variable. Pathway coefficients represent standardized partial regression weights. Figure available at https://osf.io/2rh8f/, under a CC-BY4.0 license. $*p < .05$

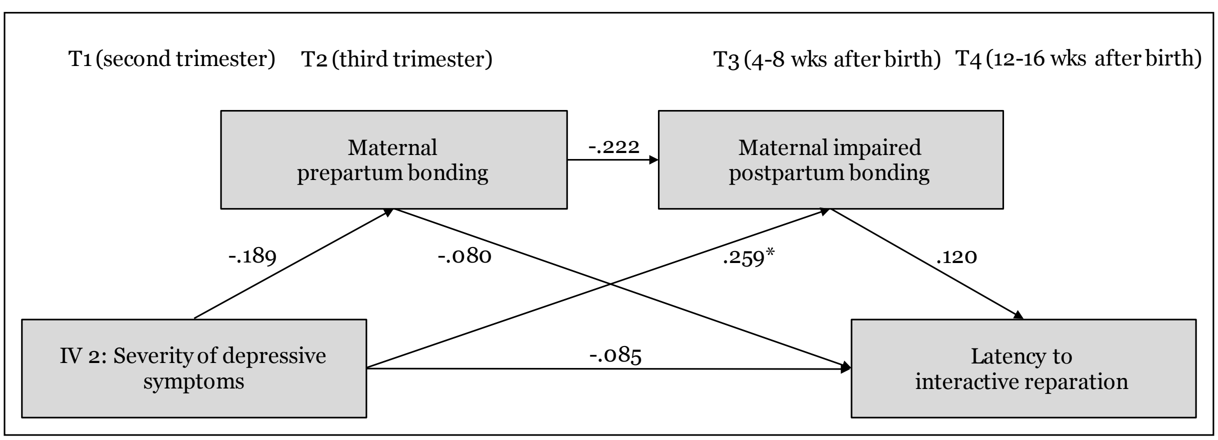

Figure 2.5: Mediation model 2 with the severity of depressive symptoms as the independent continuous variable. Path coefficients represent standardized partial regression weights. Figure available at https://osf.io/2rh8f/, under a CC-BY4.0 license. $*p < .05$

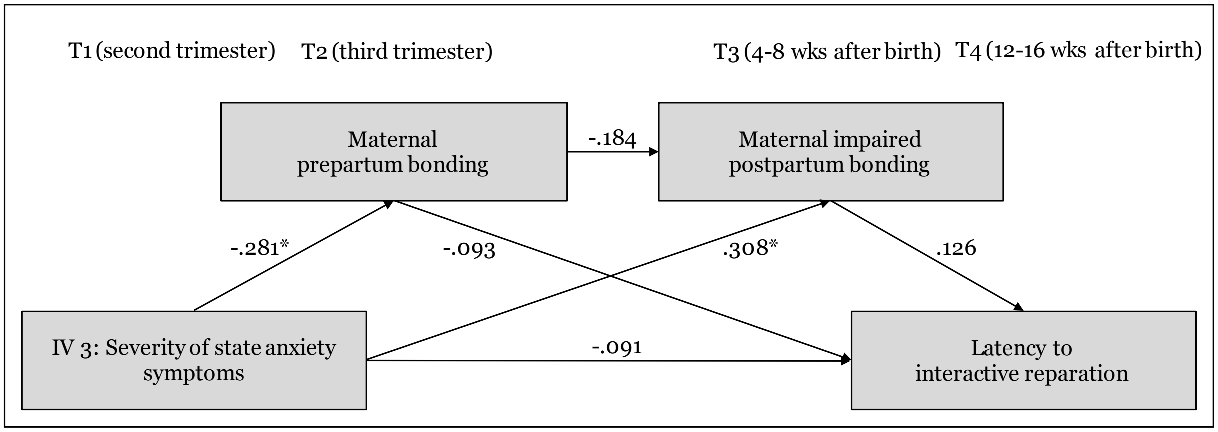

Figure 2.6: Mediation model 3 with the severity of state anxiety symptoms as the independent continuous variable. Path coefficients represent standardized partial regression weights. Figure available at https://osf.io/2rh8f/, under a CC-BY4.0 license. $^{*}p < .05$

ically, Welch tests, due to non-homogeneity of variances. Groups did not differ in (1) the severity of depressive symptoms (EPDS) at T3, i.e. 4-8 weeks postpartum, in (2) prepartum bonding at T1, (3) prepartum bonding at T2, (4) impaired postpartum bonding at T3, (5) relative time durations of positive social matches at T4, and (6) latency to interactive reparation at T4. Notably, (3) prepartum bonding at T2, (4) impaired postpartum bonding at T3, and (6) latency to interactive reparation are the two serial mediators and the dependent variable of our mediation model 1. The diagnostic group as the independent variable of model 1 might, therefore, be not able to explain differences in the mediating and outcome variables. It is also noteworthy that the post-hoc power of our t-tests to detect differences for a small effect by the group was .11, for a medium effect .44, and for a large effect .82 ($n_1 = 21$, $n_2 = 38$, $\alpha = .05$ (two-tailed)).

Visually examining the distributions of our main and exploratory measures revealed that almost all measures have right-skewed distributions with higher frequencies on the left side of the distribution. The distributions of the MFAS at T1 and T2 look rather left-skewed, however, did not significantly deviate from the normality distribution ($p = .321$ and $p = .105$, respectively). All other distributions significantly differed from the normality distribution (ps $< .01$). This may have eventuated in biased results of our further exploratory analyses, which should therefore be interpreted cautiously. We, however, applied estimators in our structural equation modeling approach which are robust against the violation of normal distribution.

Furthermore, we examined the association of our main and exploratory measures via correlation analysis. Pearson's correlations for all measures are demonstrated in table 2.4. Notably, neither our binary group variable, nor any measure of symptoms or bonding correlated with our main outcome, i.e. the latency to interactive reparation during the

Table 2.3: *Descriptive Statistics of Main and Exploratory Measures in the Total, Control, and Clinical Sample as well as a Comparison of the Control and Clinical Means.*

	Total *M (SD)*	Control *M (SD)*	Clinical *M (SD)*	*t (p)*
EPDS T1	6.03 (5.11)	3.05 (3.19)	7.68 (5.26)	-4.21 (< .001)
EPDS T2	6.32 (6.30)	3.20 (2.53)	8.00 (7.07)	-3.71 (< .001)
EPDS T3	6.05 (4.33)	5.26 (3.96)	6.45 (4.50)	-1.02 (.315)
STAIS T1	35.59 (11.95)	28.62 (5.27)	39.45 (12.89)	-4.54 (< .001)
STAIS T2	35.32 (12.31)	29.45 (5.61)	38.49 (13.78)	-3.49 (< .001)
STAIS T3	33.63 (11.33)	28.79 (7.06)	36.05 (12.33)	-2.82 (.007)
STAIT T1	36.59 (12.48)	29.19 (6.51)	40.68 (13.15)	-4.48 (< .001)
STAIT T2	35.37 (11.86)	29.95 (7.77)	38.30 (12.71)	-3.07 (.003)
STAIT T3	33.72 (10.77)	28.16 (4.74)	36.50 (11.87)	-3.77 (< .001)
MFAS T1	105.39 (18.95)	112.11 (18.79)	101.55 (18.19)	2.03 (.050)
MFAS T2	119.79 (18.80)	120.16 (14.78)	119.60 (20.76)	0.12 (.907)
PBQ-16 T3	8.62 (6.67)	7.60 (6.26)	9.16 (6.90)	-0.87 (.390)
RTD T4	0.12 (0.12)	0.13 (0.14)	0.11 (0.11)	0.65 (.520)
IAR (s) T4	9.90 (7.55)	12.71 (9.31)	8.42 (6.08)	1.77 (.089)

Note. M = arithmetic mean; SD = standard deviation; t = t value of the Welch two sample t-test; p = p value; T1, T2, T3, T4 = first, second, third, and fourth measurement point; EPDS = Edinburgh Postnatal Depression Scale; STAIS = Stait and Trait Anxiety Inventory - State; STAIT = Stait and Trait Anxiety Inventory - Trait; MFAS = Maternal-Fetal Attachment Scale; PBQ-16 = Postpartum Bonding Questionnaire - 16-item version; RTD = relative time durations of positive social matching states during the reunion episode of the Face-to-Face Still-Face paradigm, i.e. the sum of seconds the dyads spent in positive social matching states divided by the time of the reunion episode; IAR = latency to interactive reparation in seconds, i.e. the average mismatch duration or the average time interval from positive social match offset to positive social match onset.
In bold print: Measures of the main mediation models.

reunion phase of the FFSF, or exploratory outcome, i.e. the relative time durations of positive social matching states during the reunion phase of the FFSF. Moreover, it is noteworthy that correlations between the EPDS and the STAIS as well as the STAIT are mostly quite large, ranging from .46 as the smallest correlation, however, across two time points, to .84 as the highest correlation within the same time point. This raises the question if the EPDS and STAI really measure distinct constructs, which will be elaborated in the discussion section. Furthermore, our correlation analyses revealed small to large correlations between symptom severity and bonding, with the smallest significant correlation of -.28 between the STAIS at T1 and the MFAS at T1 and at T2, and the largest significant correlation of .53 between the EPDS at T3 and the PBQ at T3. These relations will be further examined in our exploratory analysis. Notably, as none of our measures correlated with the latency to interactive reparation and the relative time durations of positive social matching states during the *reunion* phase of the FFSF, we additionally tested these two measures of the *play* phase of the FFSF. They did not correlate with any of the symptom and bonding measures either. Additionally, they followed a similar right-skewed distribution with little variation as the two respective measures of the reunion phase did. The Shapiro-Wilk normality test revealed a significant result, indicating non-normality (ps $< .01$). This did not encourage us to conduct further exploratory mediation analyses for the play phase.

Table 2.4: *Pearson's Correlations of the Main and Exploratory Measures.*

	Group	**EPDS T1**	EPDS T2	EPDS T3	**STAIS T1**	STAIS T2	STAIS T3	STAIT T1	STAIT T2	STAIT T3	MFAS T1	**MFAS T2**	**PBQ T3**	RTD T4
EPDS T1	.44***													
EPDS T2	.37**	.56***												
EPDS T3	.13	.51***	.54***											
STAIS T1	.44***	.69***	.59***	.46***										
STAIS T2	.35**	.64***	.84***	.54***	.64***									
STAIS T3	.30*	.51***	.50***	.70***	.57***	.63***								
STAIT T1	.44***	.73***	.57***	.51***	.80***	.68***	.59***							
STAIT T2	.34**	.66***	.66***	.59***	.78***	.76***	.69***	.83***						
STAIT T3	.37**	.62***	.57***	.69***	.72***	.64***	.78***	.82***	.85***					
MFAS T1	−.27*	−.25	−.08	−.16	−.28*	−.13	−.30*	−.29*	−.24	−.33*				
MFAS T2	−.01	−.18	−.24	−.25	−.28*	−.25	−.33*	−.24	−.30*	−.31*	.75***			
PBQ T3	.11	.30*	.20	.53***	.36**	.31*	.47***	.37**	.31*	.45***	−.27	−.28*		
RTD T4	−.09	−.15	−.04	−.02	−.09	.06	.06	−.07	.02	−.02	−.01	.03	−.10	
IAR T4	−.27	−.04	−.24	−.01	−.02	−.19	.10	−.05	−.02	−.02	.07	−.10	.12	−.34*

Note. Group = Grouping of participants in either the control (0) or clinical group (1); EPDS = Edinburgh Postnatal Depression Scale; STAIS = Stait and Trait Anxiety Inventory - State; STAIT = Stait and Trait Anxiety Inventory - Trait; MFAS = Maternal-Fetal Attachment Scale; PBQ-16 = Postpartum Bonding Questionnaire - 16-item version; RTD = relative time durations of positive social matching states during the reunion episode of the Face-to-Face Still-Face paradigm, i.e. the sum of seconds the dyads spent in positive social matching states divided by the time of the reunion episode; IAR = latency to interactive reparation in seconds, i.e. the average mismatch duration or the average time interval from positive social match offset to positive social match onset; T1, T2, T3, T4 = first, second, third, and fourth measurement point.
In bold print: Measures of the main mediation models.
$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

Table 2.5: Fit Indices of Tested Exploratory Models.

Model	χ^2	df	CFI	TLI	RMSEA [90% CI]	SRMR
(1) Exploratory model 1	5.75	4	.983	.935	.088 [.000, .235]	.054
(2) Exploratory model 2	6.45	4	.982	.931	.095 [.000, .225]	.045
(3) Exploratory model 3	14.31**	4	.959	.847	.188 [.089, .297]	.036

Note. χ^2 = Chi-squared test statistic; *df* = Degrees of freedom; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root mean square error of approximation; 90% CI = Upper and lower 90% confidence interval; SRMR = Standardized root mean square residual.
$^{**}p < .01$; $^{***}p < .001$.

2.3.5 Exploratory Analysis

We did not conduct further exploratory mediation analyses with the severity of *trait* anxiety symptoms nor with the relative time durations of positive social matching states as initially intended because our correlation analysis did not provide a reasonable basis for it 2.4. Based on our theoretical considerations and the results of our correlation and mediation analysis we further investigated the relationship of maternal depressive and anxiety symptoms with maternal bonding. We tested three exploratory cross-lagged panel models assessing the relationship between maternal bonding and each (1) the severity of depressive symptoms, (2) the severity of state anxiety symptoms, and (3) the severity of trait anxiety symptoms. Model fit indices are presented in table 2.5. Model fit of exploratory model 3 was unacceptable with the TLI, RMSEA, and SRMR yielding values below an acceptable cut-off. Additionally, the chi-square test indicated a significant difference between the model-implied and empirical covariance matrix, implying that this model does not fit well to our data. Exploratory model 1 and 2 can be regarded as acceptable and interpretable models as only the RMSEA lay slighlty above cut-off. The TLIs lay in an acceptable range, the CFIs and SRMRs even in an excellent range.

The two acceptable exploratory models with their respective estimates are presented in figures 2.7 and 2.8. Exploratory model 1 shows strong, significant auto-regressive effects of the severity of depressive symptoms, implying a certain stability of the severity over time. The severity of depressive symptoms of the subsequent time point seems to be influenced by the severity of the respective preceding time point. We see a similar pattern for maternal bonding with a strong prediction of maternal prepartum bonding at T2 by maternal prepartum bonding at T1. The prediction of maternal impaired postpartum bonding by maternal prepartum bonding at T2 did not reach significance ($h_2 = -0.250$, $p = .097$). Furthermore, the severity of depressive symptoms and maternal impaired postpartum bonding moderately correlated. The correlations between the two measures did

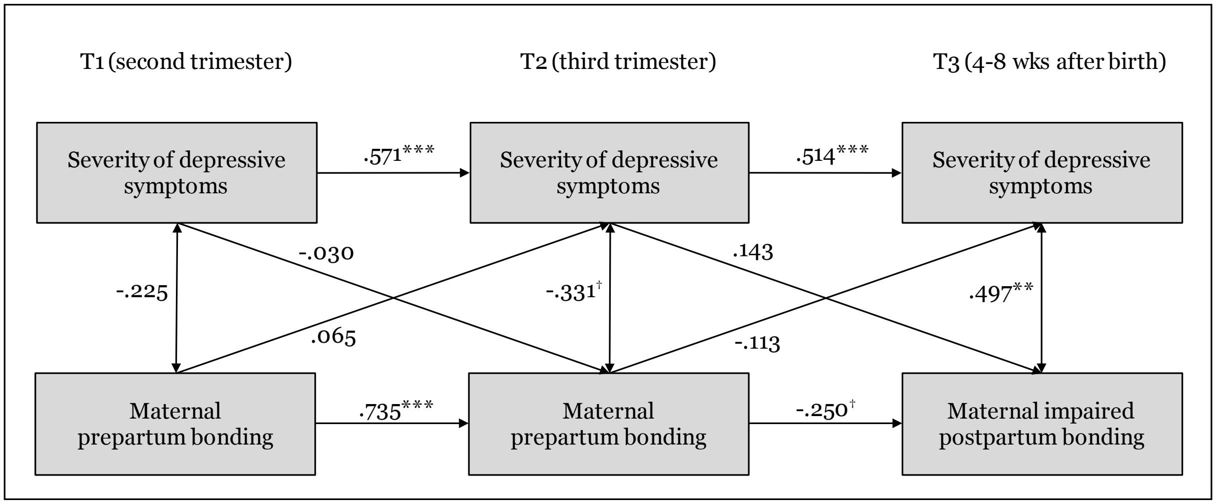

Figure 2.7: Exploratory cross-lagged pathway model 1 including the severity of depressive symptoms (EPDS) and maternal prepartum (MFAS) and impaired postpartum (PBQ-16) bonding. Path coefficients represent standardized partial regression weights. Figure available at https://osf.io/2rh8f/, under a CC-BY4.0 license.
$^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

not get significant at T1 and at T2, though. The size of the correlation, however, lay in a small to moderate range. Cross-lagged effects assessing the reciprocal relationship between measures across time were of a negligible to small size and did not reach significance.

Testing exploratory model 2 also revealed strong, significant auto-regressive effects of the severity of state anxiety symptoms and a strong, significant prediction of maternal prepartum bonding at T2 by maternal prepartum bonding at T1. Additionally, measures correlated significantly within time points. At T2, however, the correlation did not reach significance ($e_2 = -.241$, $p = .089$).

To sum up, the severity of both depressive and state anxiety symptoms showed a certain stability across the three measurement points. The same pattern applied for maternal bonding in the prepartum period. Also, the severity of depressive and state anxiety symptoms consistently correlated with maternal impaired postpartum bonding at T3, i.e. 4-8 weeks after birth.

2.3.6 Changes to the Pre-Registration

We did not deviate from the pre-registered analysis plan in any major way. We did not need to apply Benjamini-Hochberg's False Discovery Rate (FDR) correction (Benjamini & Hochberg, 1995) for significant p-values as the analyses of our main models did not yield any significant mediation effects. Additionally, we meant to include the latency to interactive repair in our exploratory model analyses. However, since neither the latency to

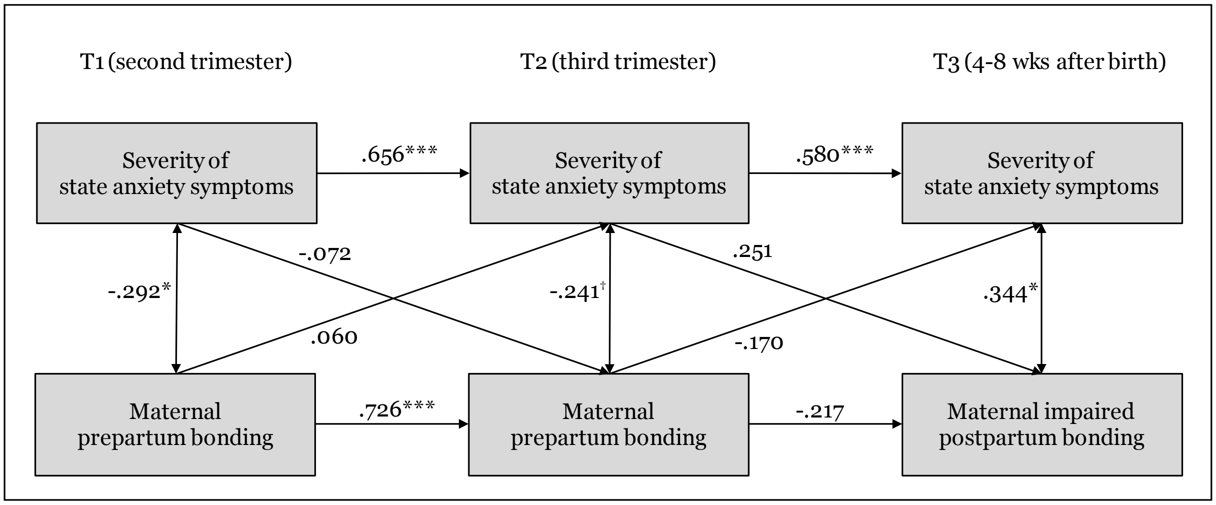

Figure 2.8: Exploratory cross-lagged pathway model 2 including the severity of state anxiety symptoms (STAIS) and maternal prepartum (MFAS) and impaired postpartum (PBQ-16) bonding. Path coefficients represent standardized partial regression weights. Figure available at https://osf.io/2rh8f/, under a CC-BY4.0 license.
$^{\dagger}p < .1$; $^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$

interactive nor the relative time durations of positive social matching states revealed any significant association with symptom severity or bonding, we decided to only focus on the relationships between the latter variables in our exploratory analysis.

2.4 Discussion

2.4.1 Summary and Comparison of Findings

This study aimed at, first, investigating the mediating role of maternal prepartum bonding and impaired postpartum bonding in the relationship between maternal depressive and/or anxiety disorders and latency to interactive reparation as our measure of interaction quality. Second, we tried to specify the mediating role of bonding in the relationship between the severity of depressive symptoms and the quality of mother-infant interaction. Third, this mediation role was examined in the context of anxiety symptoms. We applied structural equation modelling to test these three serial mediation models, exploring factors that may influence the coordination in mother-infant interaction. Regarding the direction of effects, we assumed that a maternal depressive and/or anxiety disorder are associated with lower maternal prepartum bonding and higher impaired postpartum bonding as well as a longer latency to interactive reparation. Finally, we tested two exploratory structural equation models assessing the relationship between maternal bonding and the severity of (1) depressive symptoms as well as (2) anxiety symptoms.

First, we could not detect any mediation effects regarding the relationship between maternal diagnostic status and the latency to interactive reparation mediated by maternal prepartum bonding, mediated by maternal impaired postpartum bonding, and serially mediated by both maternal prepartum bonding and impaired postpartum bonding. These findings are not in line with prior research that confirmed a mediating effect of postpartum maternal feelings of bonding in the relationship between postpartum maternal depression and mother-infant interaction (Mason et al., 2011). Notably, this study had a much larger sample size of 232 mother-infant dyads, only focused on the postpartum bond, and only administered self-report measures, even for assessing mother-infant interaction. We could only include 59 dyads which were, however, videotaped and micro-analytically coded. Before conducting mediation analyses, our preliminary analysis had already revealed that no group differences between the control and clinical group for the majority of our measures could be found. This could be due to a number of reasons. First, our sample size and thus power was too small to detect differences of a small and medium effect size. Second, due to our small sample size we combined mothers suffering from a depressive and/or anxiety disorder into one group. On the one hand, we argued that similar detrimental effects on mother-infant interaction and bonding were identified by some studies (Feldman et al., 2009; Lehnig et al., 2019; Müller et al., 2016; Tronick & Reck, 2009), justifying our combination into one clinical group. On the other hand, depressive and anxiety disorders may share variance (Nolvi et al., 2016), but are nevertheless distinct disorders for which effects on interaction and bonding might differ. Effects of anxiety disorders are not as consistent as the ones of depression (Daglar & Nur, 2018; J. H. Goodman et al., 2016; Kaitz et al., 2010). Markedly, Edhborg et al. (2011) found a positive correlation of postpartum maternal anxiety and postpartum bonding, explaining it by a possibly more heightened state of primary maternal preoccupation (Winnicott, 1956) for anxious mothers, i.e. a state following childbirth in which a mother becomes preoccupied with her infant to the exclusion of everything else. This state is regarded to be adaptive allowing the mother to sensitively meet her infant's needs. For anxious compared to depressed mothers this state might be heightened and more difficult to drop due to more worries or fears concerning the infant, which might be reflected in a supposedly stronger bond. In light of different impacts of depressive and anxiety symptoms on mother-infant interaction and bonding, it is crucial to differentiate between them (Edhborg et al., 2011). We had already acknowledged that while planning our analyses, which is why we ran separate mediation and exploratory models for depressive and anxiety symptoms across the whole sample in a next step. However, in our group comparisons and mediation model 1, which investigated the binary diagnostic status as a predicting variable, effects of depression and anxiety disorders within the one clinical group might have affected each other or even canceled each other out. The negative significant prediction of the latency to interactive repair by the maternal diagnostic status, which points in the opposite direction as hypothesized (see figure 2.4), should therefore be regarded very cautiously. In the next paragraph, we nevertheless present some explanations for a potential negative association.

The few studies that investigated the latency to interactive reparation found a longer latency to reparation of mismatching states to be associated with a maternal diagnosis of depression (Reck et al., 2011) and with a higher infant cortisol reactivity (Müller et al., 2015). It is noteworthy that Müller et al. (2015) found no association between interactive reparation and maternal anxiety disorders, which might be explained by the notion that the infants react to what they experience during the interaction and not to a maternal diagnostic category. One reason why a maternal diagnosis could lead to a potential shorter latency to repair could be that the association is not linear but rather U-shaped as suggested by Beebe et al. (2003), for example. In her optimum midrange model, she asserts that moderate degrees of dyadic matching foster infant socio-emotional development and lead to a secure attachment. Extremely high or low rates result in an insecure attachment. In a study with highly depressed mothers, maternal interactive coordination was either excessive or insufficient (Beebe et al., 2008). Notably, Noe et al. (2015) expected U-shaped functions for infant target behaviors in association with the degree of dyadic matching. Their results, however, yielded a monotonous trend: The more matching states during the FFSF play phase, the less negative and more positive affect the infant showed during each the FFSF still face and reunion phase. We also expected a linear trend for both of our outcomes, i.e. the main outcome latency to interactive reparation and the exploratory outcome relative time durations of positive social matching states. However, our visual data checks revealed no U-shaped trend, but only a slight linear trend which did not reach significance in our correlation and linear regression analysis of the association between maternal diagnostic status and these outcomes. The significant association between maternal diagnostic status and the latency to interactive reparation in our mediation model 1 might most likely be an artefact due to our skewed-right distribution with little variation. That is, the relative average percentage of time the mother-infant dyads of our sample spent in coordinated matched states was quite low throughout the whole sample with an average of 12% in the total, 13% in the control, and 11% in the clinical sample. Regarding the averages, other studies found matching rates of as low as 12% (Lester et al., 1985) to 30-40% (Moore & Calkins, 2004; Tronick & Cohn, 1989; Tronick & Reck, 2009) of the time. These rates, however, were reported for the play phase of the FFSF, whereas our rate was calculated for the more challenging reunion phase, which is generally characterized by more negative affect on the infant's side (Tronick, 2007). Thus, our relative time durations could be somewhat representative for the reunion phase. As the relative duration of matching states is quite short throughout the data set, our main measure, i.e. the latency to interactive repair as the average mismatch duration, rests on a weak footing: the fewer matches you detect, the sparser the data base to estimate the average mismatch duration is. It is, therefore, questionable whether our overall latency provides a reliable estimate of the interactive quality *in this data set*, especially since there is little variation across the dyads. Interactive repair should be further investigated in larger samples as it seems a very promising measure to predict attachment security (Müller et al., 2022). Nevertheless, our results underline DiCorcia and Tronick's (2011) conjecture that asynchronous/mismatched states, seem to be more the norm than the exception in face-to-face interactions of both healthy and clinical mother-infant samples.

Furthermore, the significant effect of the maternal diagnostic status on the latency to interactive repair in model 1 was not robust when removing an outlier. The significant association between maternal prepartum bonding and impaired postpartum bonding we detected in the first model test might, however, be more trustworthy as distributions of both prepartum and postpartum measures showed more variation and less skewness. Visual examination and ordinary linear regression of the association also showed a clear trend in the expected direction, i.e. the stronger the prepartum bond, the less impaired the postpartum bond. This finding is in line with a number of studies showing a clear connection between pre- and postpartum bonding (Dubber et al., 2015; Ohara et al., 2017; Rossen et al., 2016). It should, however, be interpreted cautiously due to some methodological shortcomings, such as non-homogeneity of variances. Summarizing our findings from our first model test, model diagnostics, and sensitivity analyses, we could not corroborate a mediating effect of pre- and postpartum bonding in the relationship between maternal diagnostic status and the latency to interactive repair, but could detect a significant association between pre- and postpartum bonding.

Second and third, we investigated the same overall relationships but in the context of the severity of depressive and anxiety symptoms, respectively. Contrary to what we hypothesized, we could not detect any mediation effects of pre- and postpartum bonding on the interaction quality either. Neither one of our symptom and bonding measures was significantly associated with the coordination in mother-infant interaction, i.e. the latency to interactive repair (nor the relative time durations of positive social matching states). These results are not in line with studies demonstrating that the quality of mother-infant interaction may be influenced by maternal prepartum (Maas et al., 2016; Siddiqui & Hägglöf, 2000) and postpartum (Mason et al., 2011; Muzik et al., 2013) bonding. Sample sizes of these studies were larger than ours and ranged from 100-273 mother-infant dyads. These studies, however, applied either self-report measures or more global coding schemes to assess the interaction quality, in contrast to our very fine-grained video analysis of the FFSF based on 1-s time intervals. Notably, Siddiqui and Hägglöf (2000) also used a quite detailed video analysis applying a continuous time sampling method on a 5-s basis. The better established influence of depressive symptoms on coordination in mother-infant interaction has already been discussed above (Beebe et al., 2008; Beebe et al., 2003; Reck et al., 2011). Regarding anxiety symptoms, Beebe et al. (2011) discovered interactive contingency patterns which were characterized by intermodal discrepancies, meaning confusing forms of communication. During mother-infant 4-month face-to-face play, they found that mothers vigilantly tracked infants visually, but withdrew from contingently coordinating with infants emotionally. On the infants' side, facial affect coordination was more vigilant, vocal affect coordination, however, was more dampened. The authors concluded a mutual ambivalence. These results highlight the fact that, when investigating mother-infant coordination in the context of anxiety symptoms, one should differentiate between different modes of coordination. Hence, by combining different modes of visually/socially monitoring and clearly emotionally matching states in our analysis, we might have lost some valuable differential information. In light of Beebe et al.'s (2011) findings of ambivalent patterns, this may have even led to a canceling out of conflicting effects in our analysis. Future studies should therefore focus on matches in different modalities and the respective latency to interactive repair, such as the positive *affect* match, i.e., the overlapping ICEP codes are Cpos and Ipos, in comparison to the positive *social* match which we applied (Weinberg et al., 2008). The latter includes the modality of visual monitoring in addition to the modality of affects, and therefore, represents a blend of two different modalities. Still, we believe the skewed distributions with little variation to be the main reason for insignificant effects of the severity of depressive and anxiety symptoms as well as pre- and postpartum bonding on the capacity to repair mismatches. When testing these effects, further violated assumptions included the non-normality of residuals, which is why the results of the following paragraph should also be interpreted with caution.

Single pathways of our mediation models 2 and 3 yielded significant results of a small to moderate size which are in line with prior research. First the severity of depressive symptoms in the second trimester predicted impaired bonding 4-8 weeks after birth. Thus, the higher the severity of depressive symptoms mid-pregnancy was, the poorer mother-infant bonding seemed to be. This corroborates previous research which has detected a relationship between prepartum depressive symptomatology and a lower postpartum bonding quality (Goecke et al., 2012). Rossen et al. (2016) also demonstrated in their large longitudinal study on 372 Australian women that maternal depressive symptoms in the second (and third) trimester as well as stress in the second trimester were related to a poorer mother-infant bond 8 weeks postpartum. Regarding the severity of anxiety symptoms, we found that symptom severity in the second trimester inversely predicted both maternal pre- and postpartum bonding quality in the third trimester and after birth, respectively. That is, the higher the severity of anxiety symptoms mid-pregnancy was, the weaker the bond from mother to the fetus/infant towards the end of pregnancy and after birth seemed to be. These findings are in line with most previous studies which found a negative association between postpartum anxiety levels and postpartum bonding quality (Daglar & Nur, 2018; Nolvi et al., 2016; Tietz et al., 2014), whereas Edhborg et al. (2011) as discussed above found that anxiety symptoms were positively associated with the postpartum bonding quality. Rossen et al. (2016) could not corroborate their conjecture that preceding anxiety symptoms predicted subsequent bonding quality. Notably, they conducted multiple regressions also including depressive symptoms for which they found predicting effects. It seems as if depressive symptomatology more clearly predicts impaired bonding, whereas anxiety disorders or anxiety symptoms might need to be accompanied by concurrent depressive symptoms to unfold their effect. This is what Tietz et al. (2014) concluded after having analyzed the bonding quality of mothers with anxiety disorders: the perceived lower bond between mother to infant might be attributable to aspects of a concurrent subclinical depressive symptomatology. It is noteworthy that Rossen et al. (2016) and Tietz et al. (2014) used self-report measures which more clearly assess actual anxiety symptoms, i.e. the anxiety subscale of the Depression and Anxiety Scales (Lovibond, 1995) and the Agoraphobic Cognitions Questionnaire, Body Sensations Questionnaire and Mobility Inventory (Ehlers et al., 2001), respectively. The STAI, which we used and many other international studies still use to assess anxiety symptoms, has been shown to actually assess general negative affect, comprising specific aspects of cognitive anxiety and depression together (Balsamo et al., 2013). In Balsamo et al.'s (2013) study, the STAI-T total score was more strongly associated with measures of depression than with a parallel measure of anxiety. We could, therefore, rather consider our analysis of anxiety symptoms as a second analysis of depressive symptoms with concurrent anxiety symptoms.

To summarize our findings from our second and third model test, we could not provide evidence for a mediating effect of pre- and postpartum bonding in the relationship between maternal depressive or anxiety symptoms and the capacity to transform uncoordinated into coordinated states of interaction. However, the severity of depressive symptoms mid-pregnancy seems to predict the degree of impaired bonding 4-8 weeks after birth. Additionally, the severity of state anxiety symptoms mid-pregnancy appears to be associated with a poorer mother-to-infant bond towards the end of pregnancy and after birth. Notably, the prediction of maternal postpartum bonding quality by the prepartum bonding quality did not reach significance when testing them in the context of depressive and anxiety symptoms. This, however, is likely due to our low power or estimation issues in light of some violated statistical assumptions.

Finally, we would like to present some additional findings on the longitudinal relationships between depressive and anxiety symptoms and mother-to-infant bonding quality. These results are based on a robust structural equation modeling approach. Both of our exploratory models provided an acceptable model fit allowing for - together with our strong theoretical foundation - a valid interpretation of the significant pathways. In accordance with Rossen et al. (2016) and Ohara et al. (2017), we found that (1) preceding depressive symptoms predicted subsequent depressive symptoms and (2) preceding anxiety symptoms predicted subsequent anxiety symptoms from the second trimester to 4-8 weeks after birth. Furthermore, (3) preceding bonding quality predicted subsequent bonding quality during pregnancy. A poorer postpartum bonding quality was also associated with the postpartum severity of both depressive and state anxiety symptoms. Moreover, in the second trimester, state anxiety symptoms were associated with a poorer bonding quality. The cross-lagged effects, i.e. the reciprocal relations between measures across time points, are mostly of a negligible size and need further investigation in future research with larger sample sizes. Some further associations, especially the one between maternal pre- and postpartum bonding, did not quite reach significance in our larger structural equation model, probably due to a low power. Ordinary correlation and linear regression analyses, however, showed that the quality of bonding after birth was associated with the one in the third trimester. These findings support previous research asserting that prepartum care has a crucial role to play at key points during both pregnancy and the postpartum period to foster both the mother-to-fetus/infant bond and to mitigate symptoms of depression and anxiety (Biaggi et al., 2016; Dubber et al., 2015; Ohara et al., 2017; Rossen et al., 2016). Rossen et al. (2019) even showed that early postpartum bonding is a more robust indicator of bonding quality at 12-months of age than maternal mental health, implying that the "predictive chain" of bonding continues throughout the first year of life. Our results may not answer the question if maternal depressive or anxiety symptoms eventuate in the occurrence of impaired bonding or whether, conversely, impaired bonding may result in the occurrence of these symptoms. An alternative explanation might be that both issues coexist, however, running rather independent time courses (Ohara et al., 2017). Regardless, our results highlight the notion that it is essential to pay more attention to the *prepartum* period, by screening for potential mother-to-fetus bonding issues as well as for mental health problems in order to counter detrimental effects on the postpartum period as early as possible.

2.4.2 Strengths, Limitations, and Future Directions

One major strength of this study is that we applied a dyadic measure of matching which equally acknowledges the mothers' and infants' contributions to the interactive process. Not many studies have used such a fine-grained approach to measure the mutual capacity to coordinate behavioral and affective states, thus, underlining the co-construction of interaction (e.g. Beebe et al., 2008; Crugnola et al., 2016; Müller et al., 2015; Noe et al., 2015; Reck et al., 2011). All of these investigations were inspired by the works of Tronick (1989) and meet the demands of conceptualizing development from a complex open systems point of view. Moreover, by using micro-analytically coded, observational data, we examined a process, i.e. interactive reparation, which appears to be relevant to the formation of attachment security (Müller et al., 2022). In Müller et al.'s (2022) study, a longer latency to interactive reparation during the reunion episode of the FFSF as well as a maternal diagnosis of anxiety disorder at the children's age of 3–8 months predicted insecure attachment in 12-24-month-old children. Thus, despite our null findings for mediating effects of bonding on the latency to interactive repair, both measures seem very promising for predicting future child developmental outcomes and should be further examined in future studies with larger sample sizes. Not only child attachment security might be shaped by bonding and interactive reparation, but also psychophysiological stress regulation in infants and children. Müller et al. (2015) found that quicker reparation of dyadic mismatching states during early mother-infant interaction fostered infants' psychophysiological stress regulation, measured by infant cortisol reactivity. Hence, future longitudinal studies focusing on the pre- and postpartum period should include psychophysiological stress measures, such as infant cortisol reactivity, in addition to measures of dyadic coordination, bonding, and psychiatric symptoms.

Given the small sample size as a limitation of this study, the validity of our null findings for mediating effects and some pathways of our models may not be entirely evaluated, in particular for small to medium effect sizes. Furthermore, the small sample size did not allow for subgroup analyses of depressive and anxiety disorders, not to speak of specific disorders of these supercategories. Also, the vast majority of included mothers hold a university degree and are in a relationship, which may decrease the external validity of our findings. However, another strength of the study is the longitudinal design assessing mothers at four measurement points during and after pregnancy. Hence, pre- and postpartum measures of bonding were, however, not directly comparable. The MFAS assesses the perceived bond towards the developing fetus, whereas the PBQ measures the perceived bond towards the infant. It remains questionable and requires further examination if a direct comparison between pre- and postpartum bonding is valid (Rossen et al., 2016). This might partly explain why we did not find a significant association between pre- and postpartum bonding in our structural equation models, although the low power might have been the main reason. We should also clarify that the associations between maternal psychopathology, bonding, and the quality of mother-infant interaction are much more complex than presented here in our simplified models. With larger sample sizes, several other factors, such as social support (Kitamura et al., 2004; Ohashi et al., 2014), the mother's personality (Kitamura et al., 2009; Ohashi et al., 2014), or characteristics and behaviors of the infant (Edhborg et al., 2005), need to be taken into consideration in further research. Another limitation is that we did not examine measurement invariance of the scales we applied. Future studies with larger sample sizes should include measurement models and check them for measurement invariance during pregnancy and the postpartum period. Furthermore, the ordinary cross-lagged panel design we used in our exploratory analysis should be superseded by a random-intercept cross-lagged panel design in future studies, in order to account for between-subject differences over time (Lucas, 2022). An extensive critique of this issue will be presented in the discussion of the next chapter (see 3.5.2).

One very promising direction future studies on dyadic interaction should take is the use of non-linear time series analyses to estimate the degree to which the caregiver or the infant is initiating reparations (Beebe et al., 2008; Beebe et al., 2011). Our rich, high-resolution data of categorical mother and infant codes creates an ideal base for such an analysis. It would, thus, even be possible to analyze our data with shorter time intervals than our current 1-second interval. This might render our analysis more accurate because currently, we could have overestimated the average mismatch duration if matches occurred below the 1-second time unit.

2.4.3 Conclusion

Our results do not provide evidence for a mediating effect of maternal pre- and postpartum bonding in the relationship between maternal psychopathology and the quality of mother-infant interaction, probably due to our small sample size and therefore low power. We still regard interactive reparation, i.e. our measure of the coordination in mother-infant interaction, as a promising marker of interactive quality according to recent research (Müller et al., 2015; Müller et al., 2022), which should, therefore, be investigated further. Additional exploratory analyses revealed that bonding as well as the severity of depressive and anxiety symptoms at earlier stages of the peripartum period predicted their respective subsequent level at a later peripartum stage. Both symptom measures were also negatively associated with the bonding quality 4-8 weeks postpartum. Our findings corroborate the notion that the administration of screenings to identify women at risk of bonding issues, depression and anxiety *during early pregnancy* should be universal practice to foster the long-term well-being of mothers and children in the long run (Biaggi et al., 2016). If necessary, prevention and intervention programs should be recommended.

2.5 Supplementary Files

As we embrace the values of openness and transparency in science (http://www.researchtransparency.org/), the pre-registration, data sets, analysis code, and supplementary material concerning this chapter were published online and may be accessed via the provided URL or DOI.

2.5.1 Pre-Registration

The study was pre-registered on the Open Science Framework (OSF). The pre-registration may be accessed via https://osf.io/nrbmu.

2.5.2 Data

The data set was published on PsychArchives (Woll, Reck, Küçükakyüz, et al., 2022) and may be accessed via http://dx.doi.org/10.23668/psycharchives.8224. A codebook is provided to list information such as names and labels of all variables.

2.5.3 Analysis Code

The analysis code was published on PsychArchives (Woll, 2022a) as a R Markdown file and may be accessed via http://dx.doi.org/10.23668/psycharchives.8225. The code is comprehensively commented to enable traceability and reproducibility of the analysis.

2.5.4 Supplementary Material

The supplementary material was published on PsychArchives (Woll, 2022c) and comprises the analysis code as a knitted PDF file based on the R Markdown file to provide an easily accessible way to retrace the analysis. It may be accessed via http://dx.doi.org/10.23668/psycharchives.8226.

Chapter 3

Study 2: How are German Mothers Feeling During the COVID-19 Pandemic? Assessing Depressive Symptoms and Perceived Stress

The goal of this second study was to assess the prevalences of depressive symptoms and perceived stress levels during the COVID-19 pandemic. We also assessed the relationship between both aspects of maternal mental health to get a better sense of how and when to support mothers. Notably, we focused on maternal perceived stress rather than anxiety symptoms because we could not identify a short self-report measure of anxiety symptoms which actually assesses anxiety symptoms rather than general negative affect, i.e. cognitive anxiety and depression together (Balsamo et al., 2013). Before presenting the study in more detail, we shortly highlight and refresh some important theoretical and empirical background which has been reviewed in chapter 1.

3.1 Theoretical Background

Parents of younger children aged 0-6 years and especially mothers seem to be most affected by the pandemic situation (Hübener et al., 2020). The peripartum period per se is a particularly vulnerable time for a woman to develop mental health issues (Reck, Zietlow, et al., 2016; Woody et al., 2017). This vulnerability may have even increased in the context of the COVID-19 pandemic, especially for depressive symptomatology and perceived stress (Achterberg et al., 2021; Kaubisch et al., 2022). Recent meta-analyses indeed reported an increase in maternal peripartum depressive symptomatology in the context of the pandemic (Q. Chen et al., 2022; Racine et al., 2022; Safi-Keykaleh et al., 2022; Yan et al., 2020). Regarding perceived stress, studies also showed higher levels of perceived stress than before the pandemic (Suárez-Rico et al., 2021) and even a significant increase of stress levels during the pandemic (Calvano et al., 2021; Spinelli et al., 2020).

As both of these aspects of mental health seem closely associated with each other (S. Cohen et al., 1983), investigating the bidirectional link between stress and depression has been of particular interest for some time now (Brose et al., 2017; Hammen, 1991). Stress not only increases the risk for depression, that is, a stress exposure model of depression (Monroe & Reid, 2009), but depression, or depressogenic vulnerabilities, in turn, enhances the susceptibility to stressful events which are at least partly influenced by the individual, that is, a stress generation model (Hammen, 1991; Liu & Alloy, 2010). Only few studies exist which examine the interplay and different trajectories of perceived stress and depressive symptoms in the peripartum period (Chow et al., 2019; Law et al., 2019; Leonard et al., 2020). These studies emphasized the concurrent comorbidity of depressive symptoms and perceived stress during the process of pregnancy and early motherhood.

As far as we are aware, no studies have investigated the reciprocal relationship between the severity of depressive symptoms and perceived stress over the course of early motherhood during the COVID-19 pandemic. This study, therefore, aimed at (1) assessing the overall severity of depressive symptoms and perceived stress at two time points during the pandemic and reporting prevalence rates, (2) comparing the respective overall severity of depressive symptoms and perceived stress between the two time points, and (3) examining the reciprocal relation between these two constructs. Based on the aforementioned empirical evidence, we assumed the following hypotheses:

We hypothesized an increase in the overall severity of depressive symptoms as well as the overall level of perceived stress of mothers with children aged 0-3 years across two measurement points during the COVID-19 pandemic (T1: time of more lenient confinement measures; T2: time of stricter confinement measures).

H 1: The overall severity of depressive symptoms at T1 is significantly lower than the overall severity of depressive symptoms at T2.

H 2: The overall level of perceived stress at T1 is significantly lower than the overall level of perceived stress at T2.

We also expected the severity of depressive symptoms and perceived stress to be positively and reciprocally related to each other (see figure 3.6 for the model):

H 3: A higher severity of depressive symptoms at T1 predict a higher level of perceived stress at T2 ($\beta_1 > 0$).

H 4: a higher level of perceived stress at T1 predict a higher severity of depressive symptoms at T2 ($\beta_2 > 0$).

H 5: The severity of depressive symptoms at T1 positively predicts the severity of depressive symptoms at T2 ($\beta_3 > 0$).

H 6: Perceived stress at T1 positively predicts perceived stress at T2 ($\beta_4 > 0$).

H 7: The severity of depressive symptoms and perceived stress correlate positively at T1 ($r_1 > 0$).

H 8: The severity of depressive symptoms and perceived stress correlate positively at T2 ($r_2 > 0$).

3.2 Method

To guarantee a transparent and reproducible research process, this study was pre-registered before data cleaning and preparation began and supplementary files were made publicly available (see section 3.6 for access to all documents and files). The STROBE guidelines (von Elm et al., 2014) were adhered to in order to provide a standardized way of presenting our observational study.

3.2.1 Sampling Procedures and Participants

The study sample is part of a larger longitudinal online survey, the CoviFam-study, conducted in German-speaking countries (Austria, Germany, and Switzerland) between mid-July and mid-November 2020 for T1 and between mid-February and mid-March 2021 for T2. T1 represents a time of more lenient confinement measures due to a lower infection rate after the first wave of the pandemic in spring 2020 (e.g. reopening of day care facilities and public spaces as well as more relaxed social distancing measures), whereas T2 represents a time of stricter confinement measures due to a higher infection rate (e.g., closures of day care facilities and public spaces as well as stricter social distancing measures). The CoviFam-study assessed the psychosocial well-being of parents with infants and toddlers aged 0 to 3 years of age and their children's behavioural problems in the course of the COVID-19 pandemic. Parents were recruited via medical institutions (e.g. birth clinics, pediatricians, gynecologists), and professional regional and national networks (e.g. midwifes, nurses) which were asked to share information on this study, including an online link to our online survey tool *Unipark*. Additionally, we used different social media channels (e.g. Instagram, Twitter, Facebook) to either inform about this study via an account that had been specifically created for this study or to convince suitable other accounts to share and or post our call for participation among their followers or subscribers.

The study had been approved by the independent ethics committee of the medical faculty, Ruprecht-Karls-University, Heidelberg, in agreement with the Ludwig Maximilian University, Munich (vote: S-446/2017). Participants were asked for consent to participate at the beginning of the survey and, at the end of the survey, for consent to be contacted again via e-mail for a possible follow-up. For the follow-up at T2, a randomized ID code was created which was sent to the participants in an invitation e-mail including the link to our follow-up survey. The whole sampling process is described in Figure 3.1. This study focused on the sub-sample of mothers living in Germany as restrictions were quite heterogeneous across countries and nesting due to couples in our data was to be avoided.

The mothers' and infants' sociodemographic data are presented in Table 3.1 and 3.2. Notably, 71 children were above 3 years of age, which is probably due to a misconception of the range 0 to 3 years which does not include the fourth year of life. Six children were even slightly above 4 years of age. As we focus on the dynamics of two maternal outcomes and not on any child specific outcomes, we decided not to exclude these mothers in order to not further reduce our sample size.

As attrition analyses, we conducted Welch two sample t-tests, Wilcoxon rank sum tests, or Pearson's Chi-squared tests depending on the level of measurement, comparing the longitudinal sample of mothers who completed the survey of T1 and T2 ($n = 666$) to the sample of mothers who only completed the survey of T1 ($n = 987$). Notably, only 67.09 %, i.e. 1109 out of 1653 mothers, consented at T1 to be contacted again for a follow-up. Thus, 60.05 %, i.e. 666 out of 1109 of mothers, who agreed to be followed up, actually took part at T2. Rather than relying on the p-values of the significance tests, we additionally calculated the respective effect sizes applying a cut-off for a negligible effect of 0.20 for Cohen's d (J. Cohen, 1988), 0.147 for Cliff's Delta (Romano et al., 2006), and 0.05 ($df = 4$) for Cramer's V (J. Cohen, 1988). The longitudinal T1 and T2 sample did not meaningfully differ from the sample of mothers who only completed the survey at T1 on any of the sociodemographic or outcome scales, except for mothers' age and the change in partners' job situation (e.g. home office or short-time working). However, these differences were small and close to a negligible effect size (i.e., for mothers' age: Cohen's $d = 0.24$, $95\%CI = [0.13, 0.34]$, $M_{T_1 and T_2} = 33.45$ years, $M_{only T_1} = 32.42$ years; for change in partner's job situation: Cramer's $V = 0.09$, $95\%CI = [0.06, 0.14]$, $df = 4$, reflecting that slightly more partners worked from home at T1 in the drop-out group than in the longitudinal sample). Every single test result may be seen in the provided R markdown file (see https://osf.io/5sb8q/).

3.2.2 Measures

Sociodemographic and COVID-related data

To assess the mothers' sociodemographic and COVID-related data, such as educational background, job and living situation, contact with the coronavirus, and child care situation, a self-developed questionnaire was employed (see https://osf.io/kg3s8/ for the full version of the questionnaire). At T1, some questions were additionally asked retrospectively to cover the period before the pandemic and the period of the greatest constraints.

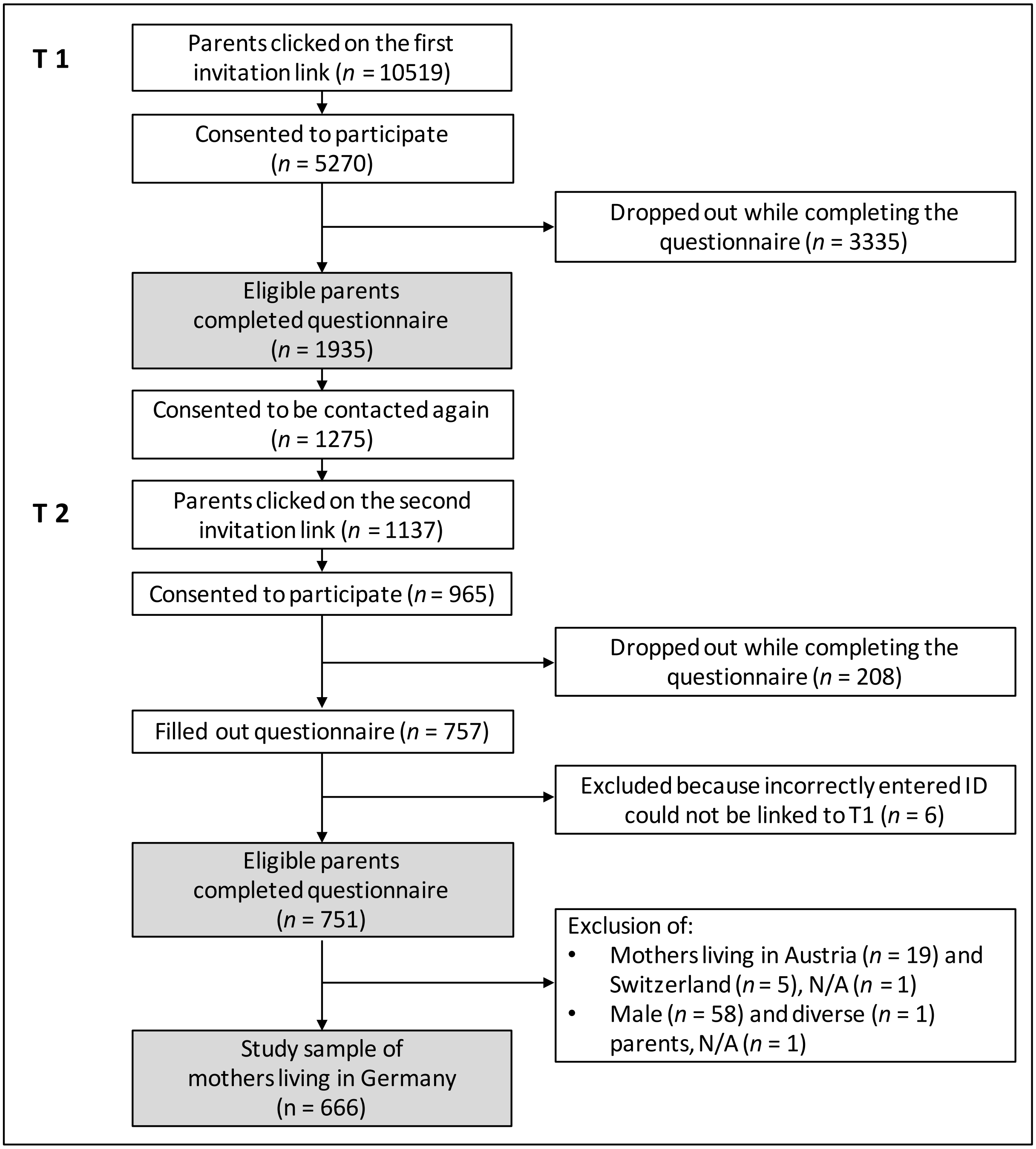

Figure 3.1: Flowchart of the sampling procedure. Figure available at https://osf.io/bg2fy/, under a CC-BY4.0 license.

Table 3.1: *Descriptive Statistics of Categorical Sociodemographic Variables.*

	n	%
Relationship status	666	
Married (living together)	512	76.87
Relationship (living together)	125	20.27
Relationship (not living together)	4	0.60
Single	7	1.05
Divorced	7	1.05
Widowed	1	0.15
School degree	666	
No diploma yet	0	0
Left school without diploma	1	0.15
German middle school diploma	5	0.75
German Realschule diploma	69	10.36
German Fachabitur	76	11.41
German Abitur	515	77.33
Monthly net income	663	
0 - 1000 €	8	1.20
1000 - 2000 €	44	6.64
2000 - 3000 €	141	21.27
3000 - 5000 €	318	47.96
> 5000 €	152	22.93
Change in job situation	666	
No change	356	53.45
Short-time working	20	3.00
Home office	160	24.02
Had to stay home and could not work	40	6.00
Other changes	90	13.51
Child's gender	666	
Male	340	51.05
Female	326	48.95

Note. n = sample size. These variables were assessed at the first measurement point.

Table 3.2: *Descriptive Statistics of Continuous Sociodemographic and Outcome Variables.*

Measure	n	M	SD	Min	Max
EPDS (T1)	666	7.73	5.51	0	27
PSS (T1)	666	18.21	7.24	0	39
EPDS (T2)	666	10.51	5.80	0	30
PSS (T2)	666	21.32	7.27	0	40
Children's age	663	20.38	11.27	0.30	50.57
Mothers' age	648	33.45	4.26	19	47
Living space	665	112.63	39.85	37	300
Caregiving by oneself	666	75.19	22.59	0	100
Caregiving by partner	666	21.25	19.76	0	100
Caregiving by grandparents	666	1.86	7.79	0	100
Caregiving by external caregiver	666	1.10	7.16	0	100
Number of children	663	1.61	0.81	1	6

Note. n = sample size; M = arithmetic mean; SD = standard deviation; Min = minimal value; Max = maximum value; EPDS = Edinburgh Postnatal Depression Scale; PSS = Perceived Stress Scale - 10-item version (PSS); T1 = Measurement point 1; T2 = Measurement point 2. Notably, the four percentages of caregiving time had to add up to 100% when mothers filled out the questionnaires. The sociodemographic variables were assessed at the first measurement point.

Edinburgh Postnatal Depression Scale (EPDS)

Symptom severity of depressive symptoms was assessed by the German version (Bergant et al., 1998) of the Edinburgh Postpartum Depression Scale (Cox et al., 1987; see appendix A.1 for full questionnaire). As a ten-item self-rating scale, each item coded from 0 to 3, it has been validated for the detection of prenatal as well as postnatal depression in numerous studies (Matthey et al., 2006). A higher sum score indicates a higher severity of depressive symptoms during the last seven days. Matthey et al. (2001) demonstrated a high sensitivity and specificity of the EPDS in detecting depressive disorders in mothers. In the German version, a sum-score of at least 10 or higher is regarded as an indicator for a depressive disorder (Bergant et al., 1998), additionally distinguishable between a minor (≥ 10) and a major depressive disorder (≥ 13) according to the outdated Diagnostic and statistical manual of mental disorders (4th ed., Text revision; DSM-IV-TR; American Psychiatric Association, 2000). In other words, participants carry a low or high risk for depression according to their sum score. The EPDS data of this study revealed an internal consistency of Cronbach's $\alpha = 0.86$ at T1, $\alpha = 0.87$ at T2, McDonald's $\omega = .87$ at T1, and McDonald's $\omega = .87$ at T2.

Perceived Stress Scale (PSS)

To assess individuals' self-reported stress levels, the German version, as published by Reis et al. (2019) and translated by Büssing and Recchia (2016), of the Perceived Stress Scale (PSS; S. Cohen et al., 1983) in its 10-item version was administered (see appendix A.5 for full questionnaire). Each item is answered on a 5-point Likert scale and coded from 0 to 4 ("never" to "very often"). The PSS is a popular, well-validated instrument to measure the degree to which situations in life are appraised as unpredictable, uncontrollable, and overloading (S. Cohen et al., 1983; Reis et al., 2019). Reis et al. (2019) could confirm a bifactor structure with one general and two specific factors for the German version, as proposed for the English and Spanish versions of the PSS (Perera et al., 2017). In this study, only the general factor, implying an overall sum score with higher values indicating higher levels of stress, is of relevance. In order to compare our findings to several other studies (Adams et al., 2021; Islam et al., 2020; D. S. Kim et al., 2017; Swaminathan et al., 2015), we applied their categorization of sum scores to both only two categories of low (0-26) and high (27-40) and to three categories of low (0-13), moderate (14-26), and high (27-40) levels of stress. The PSS data of this study revealed an internal consistency of Cronbach's $\alpha = 0.90$ at T1, $\alpha = 0.90$ at T2, McDonald's $\omega = .91$ at T1, and McDonald's $\omega = .91$ at T2.

3.2.3 Statistical Analysis

All analyses were conducted using R, version 4.2.1 (R Core Team, 2021), applying the following main packages: "lavaan" (Rosseel, 2012), "semPlot" (Epskamp et al., 2022), "tidyverse" (Wickham et al., 2019), "ggplot2" (Wickham, 2016), and "raincloudplots" (Allen et al., 2019).

To test the hypotheses H 1 and H 2, paired t-tests were performed, examining the mean difference between the observations of our two time points. As additional analyses, we (1) calculated prevalences of a risk for depression as well as of low, moderate and high levels of perceived stress as percentages of mothers in the respective categories, complemented by their 95% confidence intervals (CI). (2) Cohen's d (J. Cohen, 1988) was calculated to measure the effect size between both measurement points for both of our outcome measures. (3) In order to measure if mothers changed from being at a low risk for depression to being at a high risk for depression across the two time points, i.e. changing from an EPDS sum score of below 10 to a sum score of equal or above 10, a McNemar's Chi-squared test was performed. Before, we created additional variables coding the EPDS sumscores in a binary format, i.e. being at a low risk for depression or being at a high risk for depression. The same procedure was applied to the maternal perceived stress levels, analyzing a change from a low/moderate (PSS sumscore: 0-26) to a high stress level (PSS sumscore: 27-40).

Hypotheses H 3 to H 8 were tested by structural equation modelling in a cross-lagged panel design. Parameter estimates of the cross-lagged panel model (CLPM) were obtained by a maximum-likelihood estimation with robust estimators of model fit (MLR) with robust (Huber-White) standard errors and a scaled test statistic that is (asymptotically) equal to the Yuan-Bentler test statistic as it is robust against the violation of normal distribution (Rosseel, 2020). We did not need to compensate for missing data via the pre-registered full information maximum likelihood (FIML) approach as no missing data occurred in our data set.

To evaluate the quality of model fits, a range of fit indices were inspected, including the comparative fit index (CFI), the Tucker-Lewis index (TLI; also called the non-normed fit index), the root-mean-square error of approximation (RMSEA), and the standardized root-mean-square residual (SRMR). In line with Hu and Bentler (1999) and Kline (2016), cut-off values for good model fit were CFI $>$ .90, TLI $>$ .90, SRMR $<$ .09, and RMSEA $<$ .08. Cut-offs for excellent model fit were CFI $>$ .95, TLI $>$ .95, SRMR $<$ .08, and RMSEA $<$ .06.

Our global alpha level was .05. We did not need to correct p-values for multiple testing using the pre-registered Hochberg's False Discovery Rate (FDR) (Benjamini & Hochberg, 1995) as our p-values were close to zero.

First, two models were tested in order to analyze measurement invariance of constructs over time: (1) the model suggesting configural invariance, assuring the measurement/factor structure remains equal across time points and (2) the model suggesting metric invariance, assuring the same variable is tested across time points. Models were compared applying the "anova" function in the R package "lavaan", reporting the Akaike information criterion (AIC) values (Akaike, 1987). As the chi-squared test tends to be too conservative and too sensitive, models were regarded as considerably different with a difference of the AIC values between 4 and 7 and as essentially different with a difference of higher than 7, with the lower value model being accepted in such a case (Burnham & Anderson, 2002, p. 70). Testing the model implying configural invariance resulted in an acceptable fit to the data: χ^2 = 1610.36, *df* = 338, $p < .001$, CFI = .891, TLI = .882, RMSEA = .078 ($90\% CI = [.074, .082]$), SRMR = .047. Even though the χ^2 difference test was significant and the CFI as well as TLI did not quite hit the cut-off of .90 for a satisfactory fit, the RMSEA and the SRMR imply a moderate and excellent model fit, respectively. Additionally, constraining factor loadings to be equal across both time points, assuring metric invariance, yielded the following fit of the model: χ^2 = 1639.02, *df* = 356, $p < .001$, CFI = .894, TLI = .887, RMSEA = .076 ($90\% CI = [.072, .080]$), SRMR = .051. Overall, both model fits yielded a moderate and excellent fit on two indices and an unacceptable to borderline satisfactory fit on the other two fit indices. Model comparison revealed a ΔAIC = $\text{AIC}_{\text{configural}}$ - $\text{AIC}_{\text{metric}}$ = 58347 - 58341 = 6, implying a considerable difference between models and accepting the model with the lower AIC value, i.e. the model assuming metric invariance. Besides, the ΔCFI = .003 and the Δ RMSEA = .002 between the two models also indicate a sufficient amount of metric invariance as recommended by the cut-off values of Δ CFI < .01 and Δ RMSEA < .015 for a total $N > 300$ (F. F. Chen, 2007). The χ^2 difference test was not significant, though ($\chi^2_{diff} = 28.73$, $p = 0.052$). To conclude, we very cautiously assumed a certain extent of metric invariance and further address this issue in the discussion.

As the focus of this study lay on the relation and overall scores of our two constructs rather than the measurement procedure, pathway models were tested, comprising four continuous manifest variables: (1) the sum scores of the EPDS at T1 and T2, as well as (2) the sum scores of the PSS at T1 and T2. These four sum scores represent the severity of depressive symptoms and levels of perceived stress, respectively (see figure 3.6 for a model overview). As main analysis, a cross-lagged panel design was employed. Following Burić et al. (2019), four competing models to assess unidirectional and/or bidirectional relations among the severity of depressive symptoms and perceived stress were tested and compared (Selig & Little, 2012):

(1) stability model, including auto-regressive effects (β_3 and β_4),

(2) pathway model, including auto-regressive effects and the cross-lagged effect from the severity of depressive symptoms to perceived stress (β_1, β_3, and β_4),

(3) reverse-pathway model, including auto-regressive effects and the cross-lagged effect from perceived stress to the severity of depressive symptoms (β_2, β_3, and β_4), and

(4) reciprocal model, including auto-regressive and all cross-lagged effects ($\beta_{1\text{-}4}$).

Notably, the correlations of the two manifest variables assessed at the same time point (r_1 and r_2) were specified in model (2) - (4). It is also noteworthy that the reciprocal model is a saturated model, inherently producing a perfect model fit which is of little statistical use. It may still be interpreted due to our strong theoretical foundation and be compared to the other models. In order to determine the best-fitting model, models (2) - (4) were compared to the baseline model (1) by applying the AIC. Here again, models were regarded as considerably different with a difference of the AIC values between 4 and 7 and as essentially different with a difference of higher than 7, with the lower value model among models 2, 3 and 4 being accepted in such a case (Burnham & Anderson, 2002, p. 70). The first model was merely considered as a baseline model for comparisons to be based on. The "anova" function only allows to compare nested models which is why we compared models (1), (2), and (4) in a first step, and models (1), (3), and (4) in a second step.

In order to explore general and COVID-specific covariates or control variables and check the robustness of our model, we examined the following variables: (1) the continuous variables children's age, mothers' age, living space, number of children, percentages of taking care of the children by the mothers, partners, grandparents, and external caretakers, (2) the ordinal scaled variables school degree and income, and (3) the categorical dichotomous variables children's gender and access to a balcony. In order to calculate a point-biserial correlation, three nominal scaled variables ((1) relationship status and (2) change in job situation for oneself or (3) for the partner) were meaningfully dichotomized, that is, (1) being in a relationship: yes [1] vs. no [0], (2) and (3) having experienced a change in job situation: yes [1] vs. no [0]. According to Stavrova and Ehlebracht (2019), we included control variables in our CLPM which had a significant association with our outcomes at T2, more specifically, a significant Pearson's, Spearman's or point-biserial correlation with the EPDS or PSS sum score at T2 which was equal or above a meaningful value of .10. For the original, non-dichotomized nominal scaled variables, we additionally calculated a χ^2 test to explore their association with the outcomes.

3.3 Results

3.3.1 Foundational Analysis

Figure 3.2 demonstrates how many mothers carried a high or low risk for depression at T1 and T2, respectively, according to the established cut-off sum score of 10 on the EPDS. At T1, roughly a third of mothers were at a high risk, whereas at T2, more than half of mothers were at a high risk for depression ($\chi^2 = 60.449$, $df = 1$, $p < .001$). Moreover, 19.5% (95% CI 16.7-22.7%) of mothers even reached or exceeded the cut-off of 13 at T1, whereas 36.5% (95% CI 32.9-40.2%) did so at T2.
Assessing the numbers of mothers who changed their risk status across the two measurement points, we found that a much higher percentage changed from the non-risk to the risk group, i.e. 27.0%, than from the risk to the non-risk group, i.e. 5.7%. 39.2% of mothers carried a low risk for depression at both measurement points, whereas 28.1% carried a high risk at both measurement points. This imbalance in the amount of changers is corroborated by a significant result of the McNemar's Chi-squared test (McNemar's $\chi^2 = 92.495$,

$df = 1$, $p < .001$).

Figure 3.3 illustrates how many mothers showed a low, moderate, or high level of perceived stress at T1 and T2, respectively, according to the established cut-off sum scores of 14 and 27 on the PSS. Moderate stress levels remained roughly equal across time points, whereas the percentages of low and high levels of stress almost switched across time points ($\chi^2 = 43.146$, $df = 2$, $p < .001$). Assessing the numbers of mothers who changed their category from a low/moderate to a high level of perceived stress or vice versa across the two measurement points, we also found that a higher percentage changed from a low/moderate to a high level of stress, i.e. 16.4%, than from a high to a low/moderate level of stress, i.e. 5.6%. 68.5% of mothers showed a low/moderate level of stress at both measurement points, whereas 9.6% showed a high level of stress at both measurement points. Here again, the imbalance in the amount of changers is corroborated by a significant result of the McNemar's Chi-squared test (McNemar's $\chi^2 = 35.507$, $df = 1$, $p < .001$).

The paired t-tests revealed a significant result for both measures, implying that the average difference in depressive symptom severity and perceived stress between T1 and T2 was not 0 (ps $< .001$). This provides significant evidence that the severity of depressive symptoms (H 1) and perceived stress levels (H 2) changed from T1 to T2, with an average increase of 2.78 scale points for the severity of depressive symptoms and of 3.11 scale points for perceived stress. The overall mean values are presented in Table 3.2. As a visual check of the histograms of the sum score differences for both the EPDS and PSS suggests normally distributed data, the tests of normality according to Shapiro-Wilk and Kolmogorov-Smirnov however do not, we additionally conducted Wilcoxon signed rank tests, also known as Mann-Whitney U tests. They revealed a significant result as well (ps $< .001$). In order to account for our large sample size and assess the size of the effect, we calculated Cohen's d. For the severity of depressive symptoms, our analysis yielded a moderate effect size ($d = 0.57$, 95% CI = [0.48, 0.65]). For perceived stress, it yielded a small, to borderline moderate, effect size ($d = 0.49$, 95% CI = [0.40, 0.57]). Figures 3.4 and 3.5 illustrate the distributions, boxplots, as well as the single and the overall sum scores of both outcomes across time points. The so-called rain cloud plots graphically show the overall increase of the severity of depressive symptoms and the perceived stress level.

Even though the attrition analyses did not yield any significant difference between the rates of a risk for depression of the longitudinal sample ($n = 666$) and the sample of mothers who only completed the survey of T1 ($n = 987$), it might still be noteworthy to additionally report the rates of the complete sample of T1 ($n = 1653$). Of the complete sample, 36.30% were at a high risk for depression, whereas 63.70% carried a low risk for depression, which only differs by 2.5 percentage points from the rates of the longitudinal sample at T1 reported in figure 3.2. The same applies to the levels of perceived stress of the longitudinal sample in comparison to the complete sample of T1 ($n = 1641$, 12 missing values). Of the complete sample, 15.23% showed high levels, 59.41% moderate levels, and 25.35% low levels of perceived stress, which only reveals a slight difference of

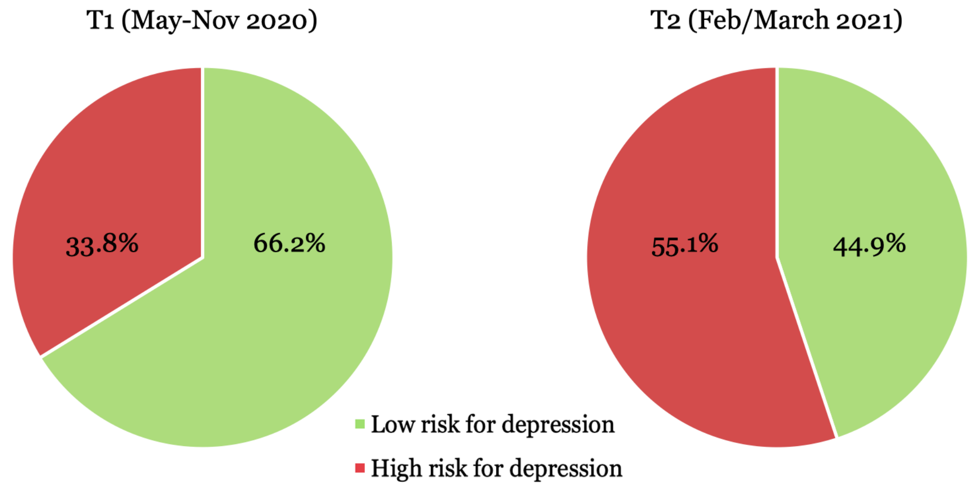

Figure 3.2: Pie charts illustrating maternal risk for depression at the first (T1) and second (T2) measurement point. Accessible results are as follows: 33.8% (95% CI 30.3-37.5%) of mothers carry a high risk and 66.2% (95% CI 62.5-69.7%) a low risk for depression at T1; 55.1% (95% CI 51.3-58.8%) carry a high risk and 44.9% (95% CI 41.2-48.7%) a low risk at T2. Figure available at https://osf.io/bg2fy/, under a CC-BY4.0 license.

3.5 percentage points between the categories of low and moderate levels of perceived stress, but not between high levels (see figure 3.3).

3.4 Cross-Lagged Panel Analysis

3.4.1 Main Analysis

Table 3.3 presents the model fit indices of all tested models.

As intended and expected, testing the (1) stability model resulted in a poor model accuracy. The pathway and reverse-pathway model, however, yielded an excellent fit according to CFI and SRMR, a good fit according to TLI, and a poor fit according to RMSEA, respectively. The pathway model revealed the following coefficients (see figure 3.6 for indices): $\beta_1 = .32$, $\beta_3 = .62$, $\beta_4 = .31$, $r_1 = .77$, $r_2 = .69$, $ps < .001$. The reverse-pathway model revealed the following coefficients: $\beta_2 = .32$, $\beta_3 = .33$, $\beta_4 = .61$, $r_1 = .77$, $r_2 = .69$, $ps < .001$. The coefficients of the reciprocal model are demonstrated in figure 3.6.

The saturated reciprocal model can only produce a perfect model fit, but may still be compared to the other models via the AIC values. Comparing the (1) stability, (2) pathway, and (4) reciprocal model clearly identified the reciprocal model as the best-fitting model with the lowest AIC value ($AIC_{stability} = 16826$, $AIC_{pathway} = 15790$, $AIC_{reciprocal} = 15774$; $\chi^2_{diff,reciprocal-pathway} = 14.57$, $p < .001$; $\chi^2_{diff,pathway-stability} = 808.38$, $p < .001$). Also, comparing the (1) stability, (3) reverse-pathway, and (4) reciprocal model clearly identified

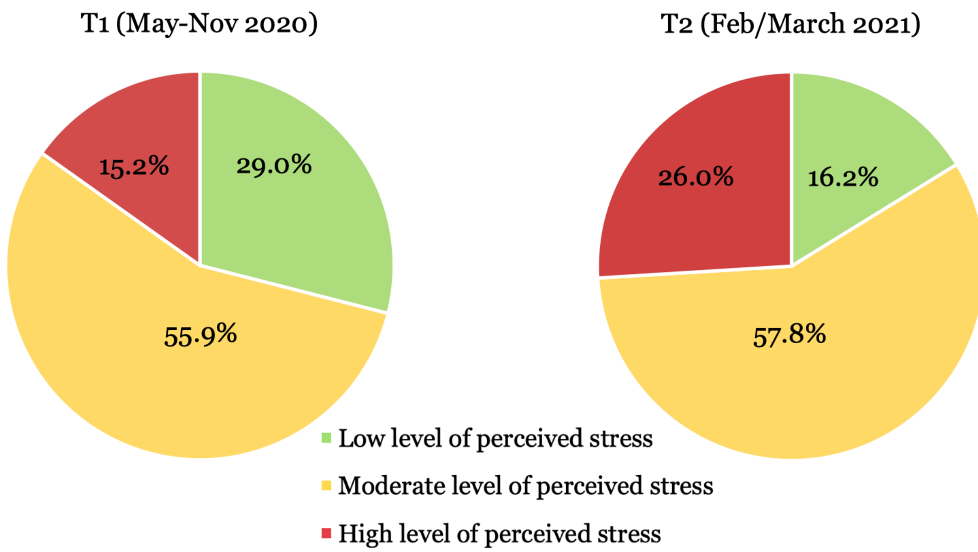

Figure 3.3: Pie charts illustrating maternal levels of perceived stress at the first (T1) and second (T2) measurement point. Accessible results are as follows: 15.2% (95% CI 12.6-18.1%) of mothers show a high level, 55.9% (95% CI 52.1-59.6%) a moderate level, and 29.0% (95% CI 25.7-32.5%) a low level of perceived stress at T1; 26.0% (95% CI 22.8-29.4%) show a high level, 57.8% (95% CI 54.0-61.5%) a moderate level, and 16.2% (95% CI 13.6-19.2%) a low level of perceived stress at T2. Figure available at https://osf.io/bg2fy/, under a CC-BY4.0 license.

Table 3.3: Fit Indices of Tested Models.

Model	χ^2	df	CFI	TLI	RMSEA [90% CI]	SRMR
(1) Stability model	821.03***	4	.375	.063	.639 [.594, .666]	.430
(2) Pathway model	14.57***	1	.990	.937	.163 [.096, .241]	.035
(3) Reverse pathway model	17.21***	1	.989	.936	.165 [.102, .237]	.036
(4) Reciprocal model	0.0	0	1.0	1.0	.0	.0

Note. χ^2 = Chi-squared test statistic; *df* = Degrees of freedom; CFI = Comparative Fit Index; TLI = Tucker-Lewis Index; RMSEA = Root mean square error of approximation; 90% CI = Upper and lower 90% confidence interval; SRMR = Standardized root mean square residual. Notably, the reciprocal model is a saturated model, inherently leading to a perfect fit.
$^{***}p < .001$.

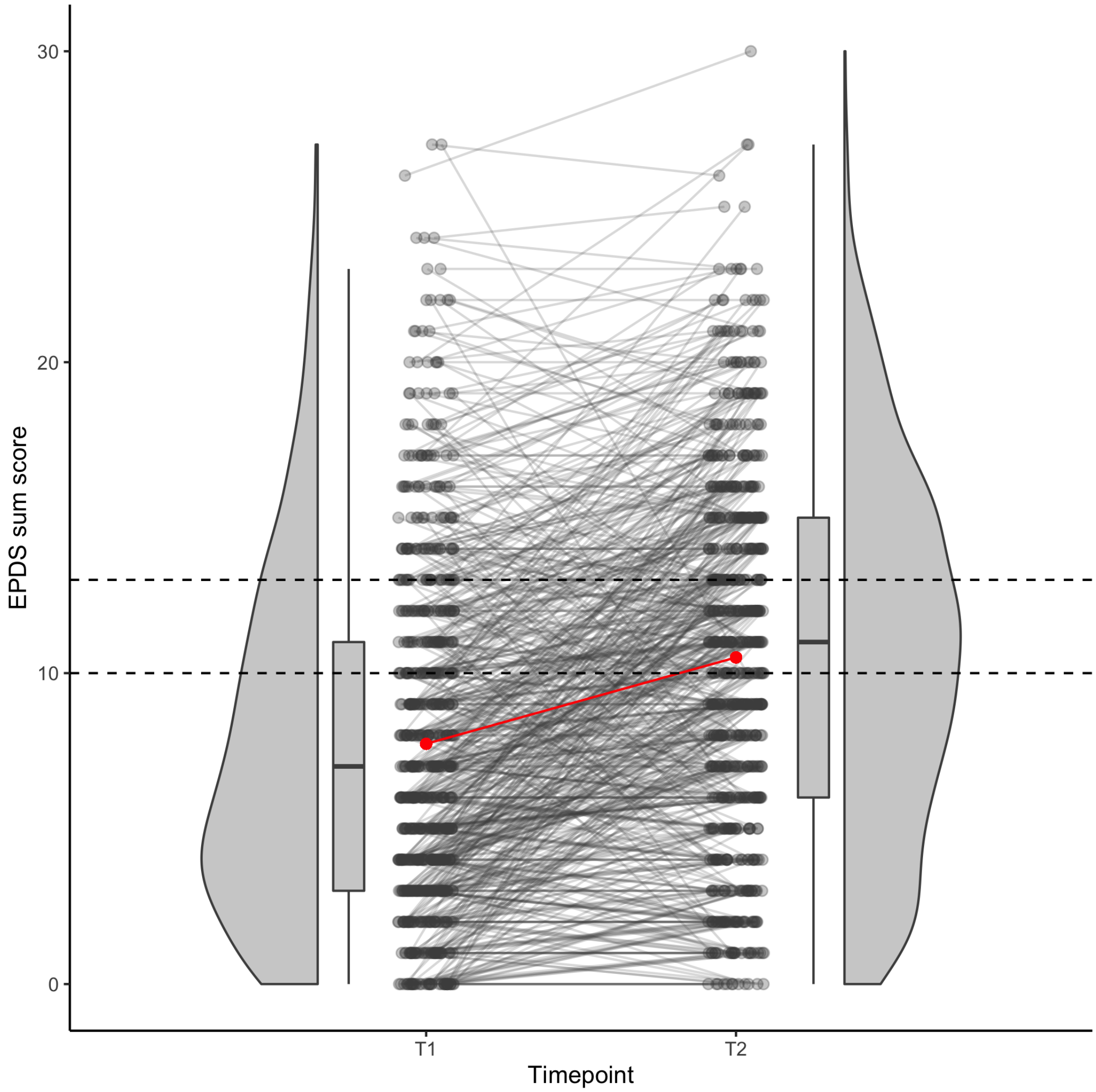

Figure 3.4: Raincloud plot of the sum scores of the Edinburgh Postnatal Depression Scale (EPDS). On the very left and the very right side of the plot, the density distribution of each measurement point is depicted. The box plots present the 0th, 25th, 50th (medians), 75th, and 100th percentiles. In the middle the paired data points are shown, connected with lines from the data point of the first measurement point (T1) to the one of the second measurement point (T2). The respective overall mean values are depicted in red and connected with a red line, reflecting the increase of the overall EPDS sum score across time points. The dashed line represents the established cut-off values at a sum score of 10 and 13, indicating a clinically relevant risk for a minor and major depression, respectively. Figure available at https://osf.io/bg2fy/, under a CC-BY4.0 license.

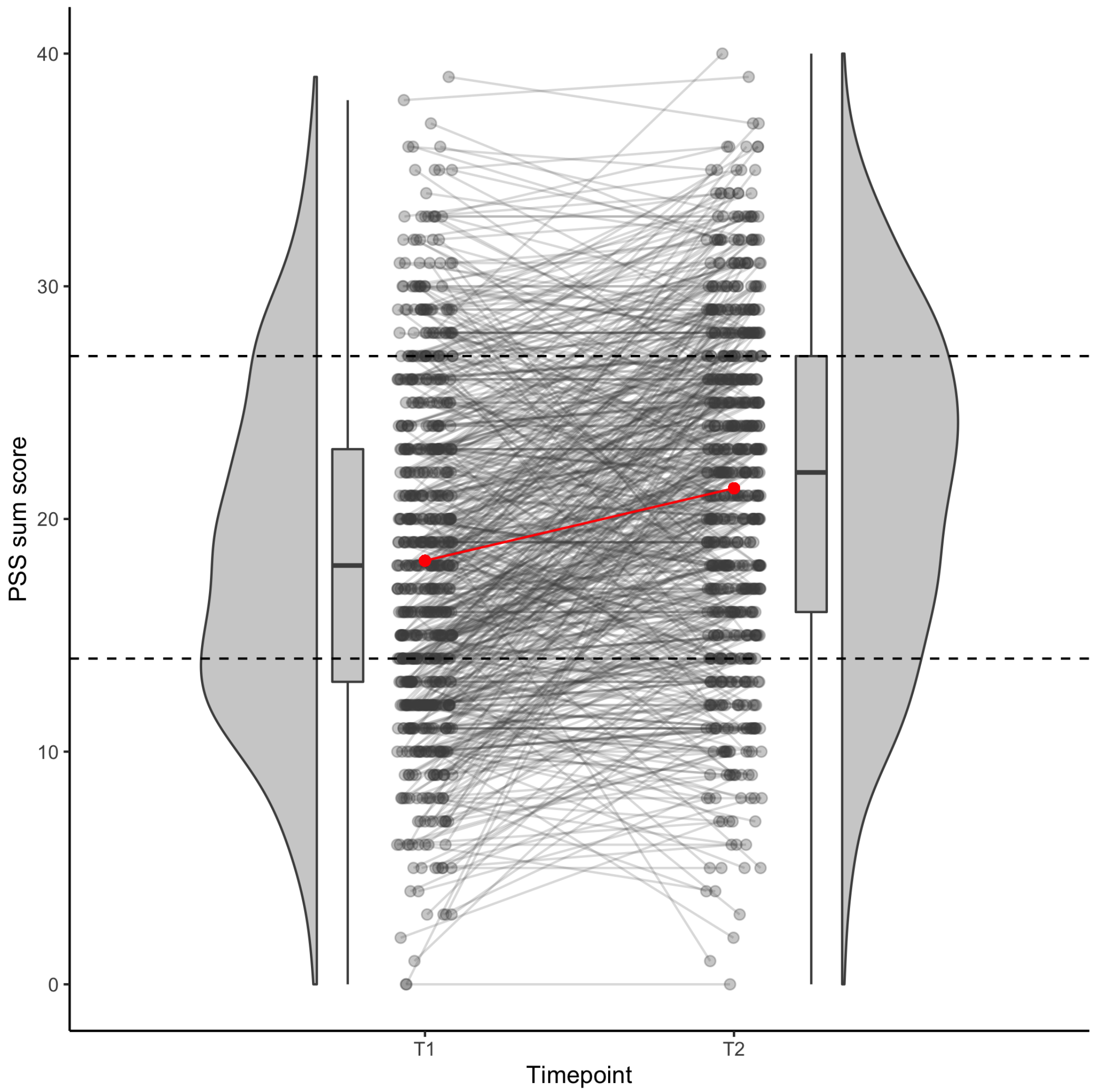

Figure 3.5: Raincloud plot of the sum scores of the Perceived Stress Scale - 10-item version (PSS). On the very left and the very right side of the plot, the density distribution of each measurement point is depicted. The box plots present the 0th, 25th, 50th (medians), 75th, and 100th percentiles. In the middle the paired data points are shown, connected with lines from the data point of the first measurement point (T1) to the one of the second measurement point (T2). The respective overall mean values are depicted in red and connected with a red line, reflecting the increase of the overall PSS sumscore across time points. The dashed lines represent established cut-off values at 14 and 27, indicating low, medium, and high levels of perceived stress. Figure available at https://osf.io/bg2fy/, under a CC-BY4.0 license.

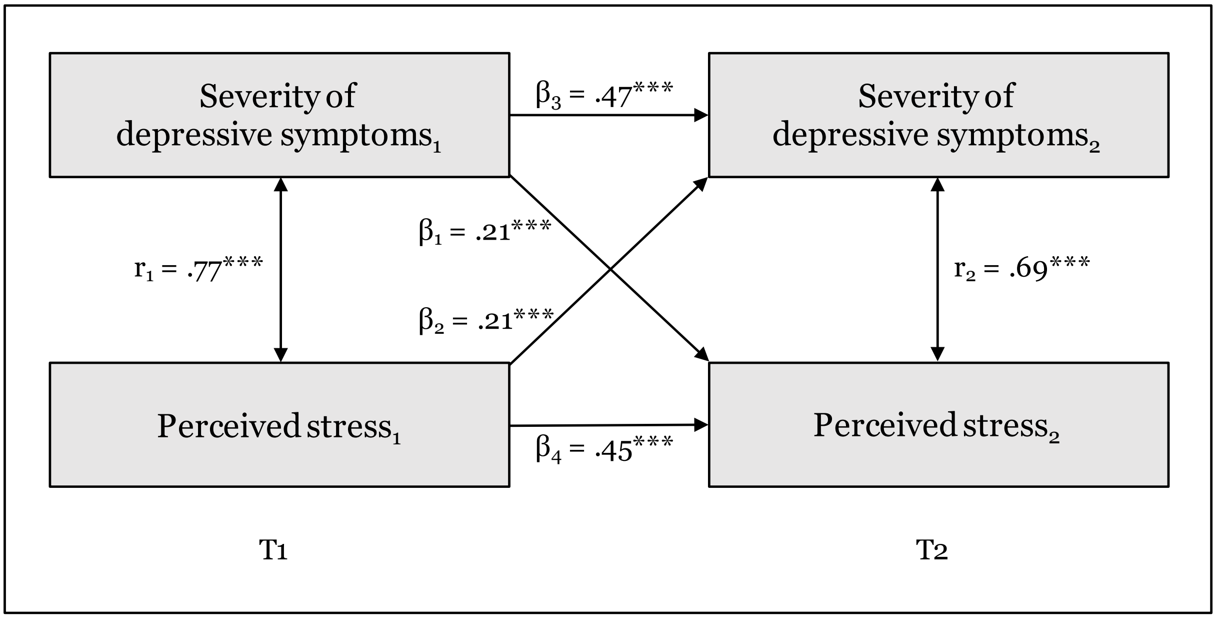

Figure 3.6: Results of the cross-lagged path analysis of the reciprocal model (4). r_i = standardized correlation coefficients; β_i = standardized regression weights; T1 = first measurement point; T2 = second measurement point. Figure available at https://osf.io/bg2fy/, under a CC-BY4.0 license.

the reciprocal model as the best-fitting model ($AIC_{stability} = 16826$, $AIC_{pathway} = 15791$, $AIC_{reciprocal} = 15774$; $\chi^2_{diff,reciprocal-reverse} = 19.19$, $p < .001$; $\chi^2_{diff,reverse-stability} = 770.99$, $p < .001$). Thus, in comparison to the AIC value of the reciprocal model, all other AIC values were larger by at least 16, which clearly lay above the pre-registered cut-off of 7. Hence, the reciprocal model may be regarded as the best-fitting model. As can be seen in figure 3.6, the significant standardized partial regression weights β_{1-4} point in the expected positive direction, confirming our hypotheses H 3-6 (ps $< .001$). Thus, a higher overall severity of depressive symptoms at T1 predicted a higher overall level of perceived stress at T2 (H 3) and a higher overall severity of depressive symptoms at T2 (H 5). Equally, a higher overall level of perceived stress at T1 predicted a higher overall severity of depressive symptoms at T2 (H 4) and a higher overall level of perceived stress at T2 (H 6). Both variables highly and positively correlated within time points, confirming our hypotheses H 7-8. The significant cross-lagged effects of the same size (β_1, β_2) corroborated the assumption that the severity of depressive symptoms and perceived stress are reciprocally related over time, even when controlled for moderate auto-regressive effects (β_3, β_4) and large correlations within time points (r_1, r_2). The respective R^2 indicated that 38.9% of the variance of perceived stress at T2 and 40.6% of the variance of the severity of depressive symptoms at T2 was explained by the reciprocal model.

3.4.2 Exploratory Analysis

Pearson's correlations of the main outcome measures with possibly important continuous control variables are presented in table 3.4. Tests for the ordinal and nominal variables are presented in supplementary files (see analyses script in 3.6.3, p. 107-130).
The following variables were significantly ($p < .05$) and meaningfully ($r > .10$) associated with the severity of depressive symptoms at T2 (see the end of subsection 3.2.3 for the full list of control variables): school degree (Spearman's rank correlation $r_s = .01$, $p < .001$), income (Spearman's rank correlation $r_s = -.18$, $p < .001$), and change in the job situation for oneself ($r_pb = .15$, $p < .001$).
The following variables were significantly and meaningfully ($r > .10$) associated with perceived stress at T2: number of children (Pearson's product-moment correlation $r_p = .13$, $p < .001$), income (Spearman's rank correlation $r_s = -.17$, $p < .001$), and change in the job situation for oneself ($r_{pb} = .12$, $p = .002$).
Notably, for the non-dichotomized variable of relationship status, a χ^2 test yielded a significant result for both the severity of depressive symptoms ($\chi^2 = 303.99$, $df = 195$, $p < .001$) and perceived stress ($\chi^2 = 314.23$, $df = 195$, $p < .001$). The point-biserial correlation, however, did not reach significance for the severity of depressive symptoms ($r_{pb} = -.06$, $p = .101$) nor for perceived stress ($r_{pb} = -.04$, $p = .329$).
Finally, the following four variables were additionally included in our reciprocal model as predictors for both the severity of depressive symptoms and perceived stress: (1) number of children, (2) school degree, (3) income, and (4) change in the job situation for oneself (dichotomized). This model yielded the following fit indices: $\chi^2 = 74.02$, $df = 8$, $p < .001$ CFI = .961, TLI = 0.894, RMSEA = .114 (90% CI = [.091, .138]), and SRMR = .076, indicating an excellent fit by the CFI as well as the SRMR, but an unacceptable fit by the others. Thus, the following findings of this model should be interpreted very cautiously. The number of children seems to predict the severity of depressive symptoms at T2 ($\beta = .06$, $p = .046$) as well as perceived stress ($\beta = .10$, $p = .002$). In addition to that, the change in job situation seems to predict the severity of depressive symptoms at T2 ($\beta = .08$, $p = .006$), but not perceived stress ($\beta = .05$, $p = .111$).
Exploring six other models (see supplementary material 3.6.4), in which the unpredictive variables were excluded, resulted in better TLI values in an excellent range above .95 as well as better RMSEA values below .10 and even below .08 for the model in which the change in the job situation as the only additional variable solely predicts the severity of depressive symptoms ($\chi^2 = 15.046$, $df = 3$, $p < .002$, CFI = .993, TLI = 0.977, RMSEA = .077 (90% CI = [.042, .118]), and SRMR = .063; $\beta = .05$, $p = .030$).
Notably, the regression weights of the control, or rather additionally predictive, variables are very small or even negligible in all exploratory models. Furthermore, for all exploratory models, the change in explained variance is minimal: exploratory models: $39.9\% < R^2_{depressiveness} < 40.6\%$ and $38.5\% < R^2_{stress} < 39.1\%$, compared to main model: $R^2_{depressiveness} = 40.6\%$ and $R^2_{stress} = 38.9\%$.

To sum up, our main model (see 3.6) seems to be robust regarding a wide range of general and COVID-specific covariates. The change in the job situation may be regarded as a valid predictor of the severity of depressive symptoms, but not of perceived stress. The number of children should be further investigated as a predictor of depressive symptoms and perceived stress in future research as model fit indices do not allow for a clear interpretation.

Table 3.4: *Pearson's Correlations of the Main Outcome Measures, the EPDS and the PSS, and Possibly Important Control Variables.*

	EPDS(T1)	PSS(T1)	EPDS(T2)	PSS(T2)	C.age	M.age	L.s.	C.o.	C.p.	C.g.	C.e.
EPDS(T1)											
PSS(T1)	.77***										
EPDS(T2)	.62***	.56***									
PSS(T2)	.55***	.61***	.80***								
C.age	.06	.11**	.08*	.06							
M.age	−.05	.01	−.03	.01	.23***						
L.s.	−.07	−.05	−.04	−.02	.07	.22***					
C.o.	.06	.08*	.08*	.09*	−.17***	−.02	.03				
C.p.	−.09*	−.08*	−.08*	−.09*	.13***	.06	−.05	−.82***			
C.g.	.02	−.03	.02	−.03	.15***	−.08*	.00	−.32***	−.03		
C.e.	.00	.01	−.05	−.03	.12**	.02	.08*	−.27***	−.05	.01	
N.c.	−.01	.10*	.07	.13***	−.02	.34***	.30***	.10*	−.06	−.08*	.01

Note. EPDS = Edinburgh Postnatal Depression Scale; PSS = Perceived Stress Scale - 10-item version (PSS); T1 = Measurement point 1; T2 = Measurement point 2; C.age = Children's age in months; M.age = Mothers' age in years; L.s. = Living space in m^2; C.o. = Caregiving by oneself in percent; C.p. = Caregiving by partner in percent; C.g. = Caregiving by grandparents in percent; C.e. = Caregiving by external caregiver in percent; N.c. = Number of children. Notably, the four percentages of caregiving time had to add up to 100% when mothers filled out the questionnaires.
$^{*}p < .05$; $^{**}p < .01$; $^{***}p < .001$.

3.4.3 Changes to the Pre-Registration

We did not deviate from the pre-registered analysis plan in any major way. As mentioned above (see subsection 3.2.3), we did not need to compensate for missing data via the FIML approach and did not need to apply a FDR correction.

3.5 Discussion

3.5.1 Summary and Comparison of Findings

The ongoing COVID-19 pandemic has particularly been challenging mothers of young children (Hübener et al., 2020; Kowal et al., 2020). Especially, maternal peripartum depressive symptoms and perceived stress may have increased in the course of the pandemic (Calvano et al., 2021; Q. Chen et al., 2022). In light of the concurrent comorbidity of depressive symptoms and perceived stress during early motherhood (Chow et al., 2019), it is of particular interest to investigate the interrelation between these two constructs (Brose et al., 2017). Hence, the aims of this study were threefold: We (1) assessed the overall severity of maternal depressive symptoms and perceived stress at two time points during the pandemic and reported prevalence rates, (2) compared the respective overall severity of depressive symptoms and perceived stress between the two time points, and (3) examined the reciprocal relation between these two constructs.

First, our analyses revealed a significant change between the prevalence rates of our two time points. The first time point was during a time of more lenient confinement measures in May to November 2020, such as open day care facilities and further open public facilities, and the second one during a time of stricter confinement measures in February and March 2021. During the latter time, most day care facilities were closed and stricter home office rules applied, which could account for the fact that we obtained a much higher prevalence of a high risk for depression in 2020 than at the beginning of 2021 (Adams et al., 2021; Hiraoka & Tomoda, 2020). That is, more than half of mothers carried a high risk for depression at the first time point, whereas about a third of mothers did so at the second time point. The same pattern applied to maternal perceived stress. About 15 % perceived a high level of stress at the first time point, whereas significantly more, i.e. about a quarter of mothers, did so at the second time point.

Second, comparing the mean difference between the two time points for both measures also revealed that both the severity of depressive symptoms and perceived stress significantly changed from the first to the second time point. Estimating the size of this change yielded a small to borderline moderate effect size of $d = 0.49$ for the increase of maternal perceived stress and an even slightly higher, moderate effect size of $d = 0.57$ for the increase of depressive symptom severity. Furthermore, many more mothers changed their risk status from being at a low risk for depression at T1 to being at a high risk at T2 (27.0%) than vice versa (5.7%). The same pattern was observed for levels of perceived stress (16.4% vs. 5.6%).

Regarding the prevalence of depressive symptoms, our results are very much in line with a recent meta-analysis by Q. Chen et al. (2022) in which they included studies until November 2021. They reported a prevalence rate of 34%, only including studies that used the stricter EPDS cut-off of equal or above 13. Applying the same cut-off, we obtained a very similar prevalence of 36.5% for February and March 2021. Our rate of 19.5% at T1 may be best compared to the rate of the meta-analysis by Yan et al. (2020) because they included studies from a similar time frame. For a study inclusion up to September 2020, their analyses yielded a similar prevalence rate of 22% at a high risk for depression in the postpartum period. Applying the more common cut-off of equal or above 10 reveals the disturbing finding that our prevalence rate is almost twice as high at T2 (55.1%) and by 10.2 percentage points higher at T1 (33.8%) than the prevalence of 23.6% found in a pre-pandemic, German sample by Reck et al. (2008). Their 95% CI of 20.8-26.5% does not overlap with neither one of ours at T2 (51.3-58.8%) nor at T1 (30.3-37.5%), rendering a significant difference of our prevalence rates of both measurement points during the pandemic to pre-pandemic prevalence rates quite likely. Another pre-pandemic, German prevalence rate of 17% (von Ballestrem et al., 2005) was even lower than the one by Reck et al. (2008). Furthermore, our results are in line with a Portuguese study by Fernandes et al. (2022) applying 3-wave Mixed Growth Models to assess maternal depressive symptoms from the third trimester of pregnancy until 6 months postpartum during the COVID-19 pandemic. They specifically tested that women under strict confinement measures showed significantly higher scores of depressive symptoms than women who were not under strict confinement measures, which reflects our change in the severity of depressive symptoms from 2020 to early 2021. The authors also found that higher anxiety and lower social support mainly explained differences in depressive symptoms.

Regarding the prevalence of a high perceived stress level, we found a similar pattern as Adams et al. (2021) and Hiraoka and Tomoda (2020): Perceived stress levels changed from 2020 to early 2021, with a higher overall stress level in early 2021, which might also be due to stricter confinement measures such as closures of child care facilities and schools at one of the measurement points. On a descriptive level, our prevalences of high stress levels are slightly higher than those of Adams et al. (2021): 15.2% vs. 12.2% during a time of more lenient confinement measures and 26.0% vs. 22.4% during a time of stricter confinement measures and stay-at-home rules. Notably, Adams et al. (2021) assessed parents (94.5% female) of children aged 5-18 years in April and May 2020 for the first time and September 2020 for the second time. We could conclude that mothers of younger children may have been even more burdened as suggested by Hübener et al. (2020) and Kowal et al. (2020). Also, during a lockdown in the second year of the pandemic mothers might have been even more worn out and stressed than during the first lockdown as reflected by increasingly higher rates of depressive symptoms (Q. Chen et al., 2022). Comparing our results to the meta-analytic pooled prevalence of stress in the general population (Mahmud et al., 2022) demonstrates that our rate is in a comparable range during a lockdown period: 26.0%

(95% CI 22.8-29.4%) vs. 29.41% (95% CI: 18.71–40.10), but considerably higher during a time of fewer confinement measures: 15.2% (95% CI 12.6-18.1%) vs. 5.10% (95% CI: 3.43–6.77). The latter difference might be explained by the generally higher challenges for mothers connected to the demands of child-rearing (Reck, Zietlow, et al., 2016), which might increase maternal stress even in times of fewer confinement measures. Notably, on a descriptive level, our rate of high levels of stress at T1 is also higher than the one found in a sample of postpartum Mexican women in August and September 2020 (10.9% [95% CI 7.8-15.0%]; Suárez-Rico et al., 2021). CIs, however, overlap to a certain degree, rendering a significant difference questionable. Moderate levels of stress are very similar between our German and the Mexican sample: 55.9% (95% CI 52.1-59.6%) vs. 58% (95% CI 52.0-64.0%). Comparing our overall perceived stress levels to pre-pandemic stress levels of mothers living in Germany (Klein et al., 2016) revealed a difference of more than one standard deviation for our mean at T2: $M = 21.32$ ($SD = 7.27$) vs. $M = 13.07$ ($SD = 6.08$). Our mean at T1 lies between both values ($M = 18.21$ [$SD = 7.24$]). We may conclude a significant overall increase of perceived stress from our first to our second measurement point in the course of the pandemic ($d = 0.49$) and, based on the literature, very probably assume an increase compared to pre-pandemic levels of stress as highlighted by retrospective comparisons (Adams et al., 2021; Calvano et al., 2021).

Third, we examined the reciprocal relationship between the severity of depressive symptoms and perceived stress of mothers with children aged 0-3. The substantial size of our correlations within time points ($r_1 = .77$, $r_2 = .69$) is in line with previous findings (rs = .63-.81; S. Cohen et al., 1983; Law et al., 2019; Reis et al., 2019). These substantial correlations suggest that the PSS may be regarded as capturing a state which puts people at risk of, i.e. is precedent to, a clinical symptomatology. At the same time, this state also belongs to a manifold set of feelings and states which characterizes clinical symptomatology. However, the significant standardized partial regression weights of the cross-lagged effects (see figure 3.6), from which the strong correlations are partialed out, might let us assume that both constructs independently predicted each other to some degree. They share a great deal of variance, but are still distinct constructs (S. Cohen et al., 1983). We, thus, might have generated some evidence for both the stress exposure model (Monroe & Reid, 2009), i.e. preceding perceived stress predicted later severity of depressive symptoms, and the stress generation model (Liu & Alloy, 2010), i.e. the preceding severity of depressive symptoms predicted later perceived stress. The strongest predictor of each depressive symptoms and perceived stress was each past depressive symptoms and perceived stress themselves as depicted by our auto-regressive effects, which is in accordance with past research (McCall-Hosenfeld et al., 2016). Still, the one cross-lagged effect ($\beta_2 = .21$) showed that perceived stress provided an additional contribution such that preceding perceived stress positively predicted the succeeding severity of depressive symptoms. And the other cross-lagged effect ($\beta_1 = .21$) demonstrated that the preceding severity of depressive symptoms enhanced the succeeding perception or appraisal of situations as stressful, i.e. unpredictable, uncontrollable, and overloading. To sum up, the size of our auto-regressive effects imply a certain stability of depressive symptoms and perceived stress across our two measurement points during the pandemic or a certain influence from the previous time point. The same size of the cross-lagged effects imply that no potential causal predominance of either one of the variables is indicated and that no single variable may be clearly described as the source or the effect variable (Kearney, 2017). These findings, however, should be regarded as preliminary and interpreted very cautiously as some methodological limitations need to be addressed (see 3.5.2). We may cautiously conclude that the association between maternal depressive symptomatology and perceived stress might be described as an evenly bidirectional or reciprocal link in which each may potentially contribute to increases in the other.

Testing a number of covariates revealed that a change in the mother's job situation seems to significantly influence the severity of depressive symptoms, but not perceived stress. This covariate is a binary variable reflecting either a change (i.e., mothers had to work at home or had to stay at home because they were not allowed to go to work) or no change (i.e., mothers were not afflicted by the pandemic in their job situation). Even though some studies have shown that the stay-at-home orders have led to increased stress levels when having to care for children (Brown et al., 2020; Freisthler, Gruenewald, et al., 2021), we rather found that having to work or stay at home resulted in greater feelings of frustration and depression. The number of children as a second covariate affecting depressive symptoms as well as perceived stress should be investigated further as our model fit was ambiguous. Kowal et al. (2020), however, identified the number of children as a clear risk factor for higher levels of stress. Notably, we did not set out to test a model of risk and protective factors but focused on the dynamics between depressive symptoms and perceived stress and merely reported additional findings of tested covariates in this paragraph.

3.5.2 Strengths, Limitations and Future Directions

To the author's best knowledge, this was the first study to assess the reciprocal relations between depressive symptomatology and perceived stress of mothers with young infants and children in the course of the COVID-19 pandemic. By applying structural equation modeling in a cross-lagged panel design, which yields standardized partial regression weights, we may have accounted for the fact that perceived stress includes symptoms associated with emotional distress, which could be confounded with depressive symptoms. Moreover, we provided prevalence rates for two time points during the pandemic whereas many other studies were cross-sectional. In order to provide comparability to a wide range of studies, we additionally presented prevalence rates according to two common cut-off scores of the EPDS (equal or above 10 or 13) and not only distinguished between high and low levels of stress, but also assessed moderate levels to guarantee comparability to a wider range of other studies. Notably, these rates were assessed in Germany where everyone, regardless of their income, has health care coverage and access to state-funded child care, which may probably have resulted in an underestimation of these prevalence rates. Many pre-pandemic and pandemic studies have found higher rates in less economically developed countries (Q. Chen et al., 2022; Dadi et al., 2020; Reck et al., 2008). Additionally, our sample predominantly was highly educated, living in a relationship, and rather well-off. It might be best designated as WEIRD, with the acronym signifying (1) western, (2) educated, (3) industrialized, (4) rich, and (5) democratic (Henrich et al., 2010). The "total" prevalence in the general population may, therefore, be even larger. However, we might assume some extent of generalisability as our results were in line with a wide range of studies including meta-analyses across a wider range around the globe than usual in psychological science due to a global pandemic. Notably, we did not assess ethnicity in our German sample, which should definitely be recommended for future studies in order to warrant better comparability to other studies. Another limitation constitutes the fact that our prevalence rates rely on screening tools in the form of self-report questionnaires, inherently carrying response biases such as social desirability or response shifts due to multiple measurement points (Rosenman et al., 2011). One also needs to keep in mind that we here report prevalence rates of *being at risk for depression*, which should not be confused with reporting prevalence rates of actual diagnoses. People above the cut-off may very likely suffer from a depressive disorder or at least suffer from subclinical depressive symptoms. The actual prevalence of clinical depressive disorders assessed with structured clinical interviews, however, may very likely be lower as shown by Reck et al. (2008): 6.1% suffered from a postpartum depressive disorder according to the structured clinical interview for DSM-IV (Wittchen et al., 1997) vs. 23.6% lay above the cut-off of the EPDS and suffered from depressive symptoms. Notably, even subsyndromal depressive disorders may detrimentally affect childhood development and the mother-child relationship (Ramchandani et al., 2005; Tietz et al., 2014). Another limitation may be that our study could carry a bias by self-selection, meaning individuals who were interested in taking part in the online survey may possess particular characteristics, such as a greater severity of depressive symptoms or higher levels of stress. This may have eventuated in an overestimation of our prevalence rates.

We also need to keep in mind that we applied the total score of the PSS, and not the subscales scores, because we were interested in the overall level of perceived stress and its dynamics with depressive symptomatology. In their validation study of a bifactorial model, Reis et al. (2019) argue that researchers should make an informed decision whether they want to use the total score or the two subscale scores (i.e., perceived helplessness and perceived self-efficacy). As we chose the former, we need to be aware of the fact that the total variance in the total score of the PSS encompasses not only true reliable variance in the general factor but also - separate from item uniqueness and measurement error - unmodeled variance which should be attributed to the two specific factors. Hence, both the means of the total PSS sum score and correlations/predictions with/of the severity of depressive symptoms should be cautiously interpreted.

Regarding the EPDS, we may raise the question of what we actually measured with this self-report measure during a time of a global pandemic. Hammen (2005) reported that interpersonal vulnerability, as captured by measures of attitudes and beliefs about the self in relationships and importance of social connectedness to the self, predicted depression succeeding stressful life events with interpersonal content. In this linkage, the pandemic may be regarded as a stressful life event with interpersonal content, or rather the negation of interpersonal content as the stressor can be seen in the vast reduction of (real) interpersonal content due to strict social distancing measures and stay-at-home orders. The additional contribution of social connectedness in the prediction of depression might be of particular importance for future studies as for now we cannot rule out that the EPDS might rather be a measure of social connectedness than a measure of depressive symptomatology during a time of strict social distancing measures. A possible latent factor of social connectedness, which is strongly linked to depression (Hammen, 2005), might have highly influenced how participants filled out the items of the EPDS. Especially in light of our slightly ambiguous evidence of metric invariance as another limitation, we cannot be completely sure if we measured the same constructs at both time points. If not, this would imply a violation of the stationarity assumption of CLPMs (Kearney, 2017) which states that variables and relationships stay the same across time. However, in order to warrant comparability to the literature in the field, we did not set out to improve the measurement model and might not even have been able to do so as the contexts in which assessments took place in the course of the pandemic differed so drastically. We leave it to future research to further validate both questionnaires in different contexts such as a pandemic in general and at different stages of a pandemic in particular.

Additionally, some critical arguments against CLPMs remain to be discussed. First, realistically it is very difficult to adhere to the assumption of synchronicity, assuming that measurements at each time point occurred at the exact same time. The time frame of our first measurement point encompassed six months, which clearly violates this assumption. We, however, managed to assess as many mothers as possible during a much narrower time frame of one month at the second measurement point. Second, we assessed auto-regressive parameters to account for stability across time. This, however, implies that there are no between-subject, or inter-individual, differences over time in stability. Hence, differences between people which do exist, such as unobserved trait-like influences or dependencies, may bias findings (Kearney, 2017). This is an important general critique of the traditional CLPM (Hamaker et al., 2015; Lucas, 2022). It is, therefore, recommended to apply a model which can separate within-person effects from between-person associations by introducing a random-intercept for each construct which are allowed to correlate, i.e., a random-intercept cross-lagged panel model (RI-CLPM). This model, however, requires at least three measurement points in order to be identified (Usami et al., 2019), rendering it technically not feasible for this study. Lüdtke and Robitzsch (2021) further argued against the RI-CLPM in general that it has restricted potential to account for unobserved stable confounder variables when assessing cross-lagged effects according to their simulation studies. Moreover, the causal estimand (i.e., the target of inference) differs between both approaches. The cross-lagged effect in the CLPM aims at the effect of increasing the exposure by one unit whereas the within-person cross-lagged effect in the RI-CLPM estimates the effect of increasing the exposure by one unit around the person mean. Lüdtke and Robitzsch (2021) asserted that this within-person causal effect is usually less relevant when testing causal hypotheses with longitudinal data as it merely conveys temporary fluctuations around the individual person means and disregards the potential causal effects which may explicate differences between persons. Despite these limitations or rather different focus of the RI-CLPM, Lucas (2022), however, argued that there are no situations where the CLPM should be preferred to alternative models that comprise information about stable traits. According to their simulation data, the CLPM is very likely to detect spurious cross-lagged effects even when they do not exist. When they do exist, though, the CLPM tends to underestimate them. Furthermore, for a two-wave design, there are many plausible alternative models which can yield the same set of six correlations among our two variables. Estimating causal effects with non-experimental data faces many challenges (Reichardt, 2019) and two-wave designs are barely enough to encounter this endeavor (Ployhart & MacKenzie, 2014). We have acknowledged this during the analysis and will soon analyze data of a third wave.

However, as we base our model on a strong theoretical foundation by other, extensive longitudinal designs, we regarded it as a first step to address the question of reciprocal effects applying a CLPM. Rogosa (1995) pointed out that research should follow a certain hierarchy when discussing reciprocal relations using cross-lagged analyses: (1) Researchers should begin with analyzing how a single construct, e.g. the severity of depressive symptoms, changes over time; (2) they should address questions about individual differences in change of the severity of depressive over time, especially correlates of change in the severity of depressive symptoms; and (3) after such evidence, it appears reasonable to raise questions about reciprocal effects. As described in the introduction (see 1.3.2), we gathered some evidence for (1) and (2) for mothers in the peripartum period, and for (3) for adolescents or first year university students. For instance, Chow et al. (2019) provided 6 waves of data of mothers' depressive symptoms and perceived stress from pregnancy to two years postpartum, corroborating the predictive quality of prepartum depressive symptoms for perceived stress levels up to two years after delivery. They applied a growth mixture model, i.e. an extension of the latent growth curve model, which is a statistical approach for identifying distinct longitudinal trajectories for variables of interest. Law et al. (2019) and Mora et al. (2008) also applied an extensive latent growth curve modeling approach assessing depressive symptoms and perceived stress in the peripartum period. Notably, a distinct trajectory emerged for a certain percentage of mothers (7%) who were always or chronically depressed up to 25 months postpartum (Mora et al., 2008). So at least for a certain percentage of mothers, depressive symptomatology may be regarded as a stable trait, highlighting the need to actually apply a RI-CLPM. Brose et al. (2017) applied a fixed and random-effects cross-lagged panel model across three waves and combined it with an experience sampling method (ESM), also known as ecological momentary assessment (EMA), in which first year university students reported on their daily experiences at 10 semi-random occasions per day across 7 days. Their findings are in accordance with the stress exposure model, implying that stress can cause increases in depressive symptoms. It is important to note that this study aimed at stressful experiences in daily life. The authors regard micro-level stressful experiences as etiological factors of depression. Assessing adolescents' depressive symptomatology and perceived stress, Calvete et al. (2015) and Martinez and Bámaca-Colbert (2019) used a traditional CLPM across three waves, putting their bidirectional effects on a less firmer empirical footing (Lucas, 2022).

Applying a traditional two-wave CLPM based on a large online survey, which was established under very difficult working conditions at the beginning of the pandemic, may be regarded as a first step to investigate the relation between maternal depressive symptoms and perceived stress during the pandemic. In the meantime while finalizing this study, a third wave of data had been collected. This creates the possibility for a future study to rerun our cross-lagged panel analyses but this time applying a random-intercept cross-lagged panel model which may be compared to a traditional, or fixed-intercept, cross-lagged panel model. The CLPM is nested within the RI-CLPM, that is, the CLPM is equivalent to the RI-CLPM when constraining the random-intercept, or stable-trait, variance to 0. However, as it may be argued whether the model fit should be the appropriate criterion for deciding between the two models (Orth et al., 2021), we will follow Lucas (2022) and rather rely on the cross-lagged effects provided by the RI-CLPM than the ones by the CLPM in case both models yield good model fits. In addition, we will run a CLPM with additional lag-2 effects (i.e., effects of variables across two units of time) as recommended by Lüdtke and Robitzsch (2021). In their simulation study, they showed that the RI-CLPM was limited in its capacity to control for unobserved stable confounder variables. The CLPM with additional lag-2 effects could adequately control for delayed effects, provided that all relevant covariates were measured. Since the latter seems a bit idealistic, even though we measured a large number of covariates, we will regard the CLPM with additional lag-2 effects as an additional exploratory model. Moreover, having a closer look at the slopes of the single lines in figures 3.4 and 3.5, our individual slopes, i.e. the size of the individual difference between T1 and T2, seem to vary to a great degree. Hence, it might even be useful to include random slopes in our future model tests once data preparation of our third measurement point will be finished.

Also, further investigations should include additional variables, such as perceived social support, couple relationship satisfaction, or bonding, as these variables have been linked to the severity of depressive symptoms and perceived stress (Jenkins et al., 2020; Leonard et al., 2020; Reck, Zietlow, et al., 2016). Future studies should also assess maternal depressive symptoms and perceived stress at multiple waves in the peripartum period, best combining an ESM approach with a cross-lagged analyses including fixed, i.e., estimating parameters that are constant across individuals, and random, i.e., estimating between-person differences, parts, as done by Brose et al. (2017) with adolescents. Thus, prevalence rates at different stages of this vulnerable period plus the bidirectional link between the two constructs can be further investigated. This may foster our understanding of how and when to preferably support mothers in order to provide leverage for policy-makers in future crisis.

3.5.3 Conclusion

This study lent support to the hypotheses that the overall severity of depressive symptoms and perceived stress of mothers with children aged 0-3 increased in the course of the COVID-19 pandemic, which is in line with current meta-analyses (Q. Chen et al., 2022; Safi-Keykaleh et al., 2022). Prevalence rates might have strongly depended on the extent of confinement measures at the time of measurement (Adams et al., 2021; Fernandes et al., 2022), corroborating the need to implement preventative interventions specifically during lockdown periods. Given that even subclinical maternal depressive symptoms may adversely affect child development (Ramchandani et al., 2005), at least 33.8% of children were at risk of developmentally suffering under the depressive symptoms of their mothers in Germany between May and November 2020, whereas a disturbingly high percentage of 55.1% were at risk in February/March 2021. 15.2% of mothers between May and November 2020 and 26.0% in February/March 2021 additionally suffered from high perceived stress levels, putting children at risk for abuse, neglect, and domestic violence (Calvano et al., 2021; Freisthler, Wolf, et al., 2021). As the severity of depressive symptoms and perceived stress seem to linearly depend on their own previous values (i.e., significant auto-regressive effects) and to reciprocally predict each other (i.e., significant cross-lagged effects), prevention and intervention programs should (1) screen and treat mothers as early as possible to mitigate the risk for succeeding depressive symptoms and perceived stress, and (2) focus on both depressive symptom reduction and perceived stress relief to most successfully decrease mothers' level of suffering in both areas. These latter results should be regarded as preliminary and interpreted very cautiously as we faced several methodological shortcomings. Nevertheless, in light of very high and increasing prevalence rates across both time points, high correlations of both constructs within time points, and a potential bidirectional link between the severity of depressive symptoms and perceived stress, we may conclude that mothers should be supported as early as possible, targeting both areas of adversities. This applies to the vulnerable peripartum period in general, and to the peripartum period during the exceptional state of a global pandemic in particular.

3.6 Supplementary Files

As we embrace the values of openness and transparency in science (http://www.researchtransparency.org/), the pre-registration, data sets, analysis code, and supplementary material concerning this chapter were also published online and may be accessed via the provided URL or DOI.

3.6.1 Pre-Registration

The study was pre-registered on AsPredicted. The pre-registration may be accessed via https://aspredicted.org/h4zz5.pdf.

3.6.2 Data

The data sets were published on PsychArchives (Woll, Reck, Marx, et al., 2022) and may be accessed via http://dx.doi.org/10.23668/psycharchives.8227. A README file is offered to guide researchers through data processing. A codebook is provided to list information such as names and labels of all variables.

3.6.3 Analysis Code

The analysis code was published on PsychArchives (Woll, Marx, et al., 2022) as a R Markdown file and may be accessed via http://dx.doi.org/10.23668/psycharchives.8228. The code is comprehensively commented to enable traceability and reproducibility of the analysis.

3.6.4 Supplementary Material

The supplementary material was published on PsychArchives (Woll, 2022b) and comprises the analysis code as a knitted PDF file based on the R Markdown file to provide an easily accessible way to retrace the analysis. It may be accessed via http://dx.doi.org/10.23668/psycharchives.8229.

Chapter 4

Ongoing Study 3: Summary of the Study Protocol of the COMPARE-Interaction Study

This chapter serves as a summary of a study protocol published within the writing period of this thesis (Zietlow et al., 2022). Nevertheless, the highlights of this cutting-edge, ongoing developmental study were summarized here to present an outlook for possible analyses in the near future. The author of this thesis had the idea to publish the study protocol and majorly drafted the manuscript as a shared first author. The full study protocol as an open access publication is attached (see appendix C). The acronym COMPARE stands for children of mentally ill parents at risk evaluation.

4.1 Theoretical Background

As already comprehensively described (see 1.2.1), maternal depressive and anxiety disorders are the most common psychiatric disorders in the peripartum period, with prevalences ranging from 6.1 % to 11% (Woody et al., 2017) for depressive disorders and 11.1 % to 17.9 % for anxiety disorders (Reck et al., 2008; van de Loo et al., 2018). It is noteworthy that peripartum depressive and anxiety disorders frequently co-occur in around 50 % of women (Penninx et al., 2011). Effects on child development for the single disorders are well documented (Glasheen et al., 2010; S. H. Goodman et al., 2011; Oyetunji & Chandra, 2020). In light of this high comorbidity, it is surprising that, to the best of our knowledge, no research has yet addressed the effects of *comorbid* peripartum depressive and anxiety disorders on child development.

Infant and child development is not solely affected by maternal psychiatric disorders, but rather the quality of mother-child interaction mediates these effects (Mäntymaa et al., 2009; Stanley et al., 2004). Given the still sparse and heterogeneous data base of how anxious mothers interact with their children, it is of particular importance to further investigate this intergenerational transmission pathway. Measures such as maternal sensitivity (see 1.1.2) and infant stress reactivity have proven to be valid predictors for infants' and children's affect regulation (Feldman et al., 2009; Müller et al., 2015; Van den Bergh et al., 2020). Besides being associated with the quality of mother-infant interaction, infants' stress reactivity may be more directly or physically influenced by the mothers' stress reactivity (Zijlmans et al., 2015). The hypothalamic-pituitary-adrenocortical (HPA) axis is one important psycho-physiological system to deal with stress on a hormonal level. Its end product is the hormone cortisol which might account for the associations between maternal stress and psychopathology as well child development (Van den Bergh et al., 2020). Elevated maternal cortisol levels as a reaction to stress may influence the offspring's functioning of the HPA axis. Consequently, children may exhibit increased cortisol levels and increased cortisol reactivity (Zijlmans et al., 2015), and a heightened risk for developmental problems. Also, a higher cortisol reactivity for both mothers and infants was associated with maternal depression and anxiety (Feldman et al., 2009).

The role fathers play in these complex associations has not yet been investigated comprehensively. More and more research has been involving fathers in developmental research (Yap & Jorm, 2015; Yap et al., 2014), revealing that insensitive and unresponsive fathers may also be a risk factor for child development, in particular socio-emotional development. Paternal sensitivity may, therefore, be regarded as a protective factor, as shown in population-based and high risk samples (Lewin et al., 2015). Furthermore, patterns of the couple interaction between father and mother have been shown to be predictive for later parent-child interaction (Tanner Stapleton & Bradbury, 2012).

In summary, the COMPARE study addresses the impact of maternal (1) depressive disorders and (2) comorbid depressive and anxiety disorders on infant and child development. A specific focus will be set on the mediating effects of mother/father-infant-interaction, in particular sensitivity, and infant stress reactivity (see figure 4.1).

4.2 Methods

The study design is longitudinal and assesses maternal and paternal psychopathology, mother-infant/father-infant interaction, as well as child cognitive and socio-emotional development at four measurement points over the first two years of children's life: T1: 3-4 months postpartum, T2: 12 months postpartum, T3: 18 months postpartum, and T4: 24 months postpartum. 174 families, more specifically, $n = 58$ mothers with a peripartum depressive disorder, $n = 58$ mothers with a peripartum depressive and comorbid anxiety disorder, and $n = 58$ healthy controls, were planned to include in the study which started in January 2018. In the meantime, 146 mother-infant dyads could be included, interviewed and tested at T1. Recruitment is in its final stage and will be finished by November 2022. Findings for the first measurement point may thus be available at the beginning of next year. 89 mother-infant dyads have already completed the whole four measurement points

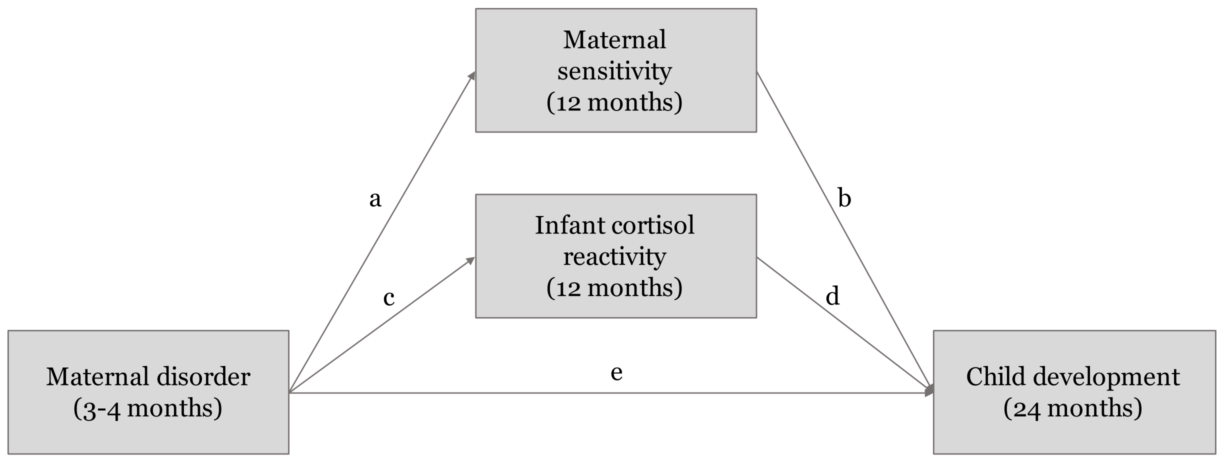

Figure 4.1: Main mediation model of the COMPARE-Interaction study (adapted from Zietlow et al., 2022, p. 8). Notably, the correlation between maternal sensitivity and infant cortisol reactivity will also be acknowledged. Figure available at https://osf.io/7xdy3/, under a CC-BY4.0 license.

and thus finished the study. Unfortunately, only 57 fathers (39 %) could be included due to no interest in participating, not enough time due to their jobs, etc., even though we offered very flexible assessment hours.

The primary outcome measures comprise infants' internalizing and externalizing behavior problems measured by the Child Behavior Checklist (CBCL; Arbeitsgruppe Deutsche Child Behavior Checklist, 2000) and the cognitive scale of the Bayley's Infant Development Scale III (Reuner & Rosenkranz, 2015) at 24 months postpartum. (1) Maternal interaction quality, more precisely maternal sensitivity coded from video recordings of free-play situations by the Coding Interactive Behavior manual (CIB; Feldman, 1998), and (2) infant stress reactivity, assessed via salivary cortisol, at the infants' age of 12 months are examined as primary mediators.

Secondary outcome measures include imitation and joint attention at 12 months as well as language development (Grimm et al., 2000), child fearfulness (Liew et al., 2011), and empathy (Paulus et al., 2013) at 24 months of age. Secondary mediators comprise further maternal interactional qualities, such as intrusiveness, limit setting, and exploration, as well as *paternal* sensitivity, intrusiveness, limit setting, and exploration, as single dimensions of the CIB. The postpartum bonding quality can also be considered as an additional mediator. Secondary independent variables include parental reflective functioning (Luyten et al., 2017) and epistemic trust (Nolte et al., n.d.), i.e. a person's acceptance and openness that information communicated by someone else may be relevant, applicable and overall trustworthy (Campbell et al., 2021; Fonagy & Allison, 2014). Fonagy and collegues regard epistemic trust as a key developmental component which children develop if being adequately mentalized by their caregivers. Notably, mentalizing describes the overarching mental capacity, operationalized by measures of reflective functioning. Furthermore, dyadic interaction quality may be also assessed via the ICEP-R, coded from videographed FFSF experiments at three-to-four months of age. A full list of measures of this comprehensive study can be found on pages 6 and 7 of the study protocol in appendix C.

Parallel mediation analyses will be carried out testing the model depicted in figure 4.1 as our main model. The standard errors and confidence intervals if the indirect, i.e. mediated, effect will be bootstrapped and bias-corrected (n = 5000 samples). Variables will be mean-centered and parameter estimates will be tested two-tailed with a critical $\alpha = .025$, that is, Bonferroni adjusted for two primary outcomes/models of child development.

4.3 Discussion

As peripartum depression as well as comorbid depressive and anxiety disorders may affect infant and child development, it is crucial to further investigate this association which may be mediated by the quality of caregiver-infant interaction. As far as we know, the COMPARE-Interaction study is the first study to longitudinally assess the influence of comorbid maternal mood disorders on child development on a behavioral, relational, hormonal, developmental, and clinical psychological level. We set a focus on children's internalizing and externalizing behavior problems and their cognitive development at 24 months of age. The focus of mediating effects was set to maternal sensitivity and infant cortisol reactivity at 12 months of age. Our multimethodological approach further allows to investigate potential linkages between a wide range of other promising and fruitful measures, such as postpartum bonding, perceived stress, parental reflective functioning, parental embodied mentalizing, and epistemic trust. Thus, several qualities of maternal mental health, different levels of transmission pathways, and effects on child development may be further investigated according to the transmission model presented in the introduction in figure 1.1.

A unique strength of this study is the inclusion of fathers which grants us the opportunity to examine families from a comprehensive perspective and to investigate their role as a potential buffer in the family system. It is crucial to expand models for developmental psychopathology and integrate the role of the wider social and cultural environment for human cognitive and socio-emotional development (Fonagy et al., 2021). Focusing on the immediate caregiving context may be regarded as insufficient. As strongly as we agree with this perspective, in practice, we even faced major difficulties of including fathers into our study. Widening the focus to including, for instance, peers or teachers in future studies might therefore require more resources. However, only thus can we further improve prevention and intervention approaches to foster children's healthy development.

Chapter 5

Overall discussion

5.1 Findings and Contributions

This work aimed to assess the relations between several domains of early human development. A specific focus lay on the associations between the mother-infant relationship, dyadic interaction, and child development in the context of maternal mental health. Additionally, the ongoing COVID-19 pandemic needed to be taken into consideration as a very particular contextual factor. In two empirical studies and one brief report of an ongoing, longitudinal developmental study, the goal was to contribute to the existing body of literature on how and when to best support both mother and child in the vulnerable peripartum period. As findings are based on foundational research, they may inform and guide policy-makers as well as further prevention and intervention research.

Study 1 investigated the mediating role of maternal pre- and postpartum bonding in the relationship between maternal depressive and/or anxiety disorders and the dyadic interaction quality. Second and third, this mediating role was examined in the context of each depressive and anxiety symptom severity. Finally, we conducted further exploratory analyses assessing the relationship between maternal bonding and the severity of (1) depressive symptoms as well as (2) anxiety symptoms across three different time points in the peripartum period.

Regarding study 1, our results did not provide evidence for a mediating effect of maternal pre- and postpartum bonding in the relationship between maternal psychopathology and the quality of mother-infant interaction, probably due to our small sample size and therefore low power. These findings are not in line with prior research showing longer latencies to interactive reparation, i.e. our measure of the coordination in mother-infant interaction, for depressed mothers (Reck et al., 2011). In our data set, the interactive reparation showed a skewed distribution, rendering a thorough assessment unfeasible. It should, therefore, be further investigated in larger samples because we regard it as a promising marker of interactive quality according to recent research (Müller et al., 2015; Müller et al., 2022). It is noteworthy that Müller et al. (2015) found no association between interactive reparation and maternal anxiety disorders, but with infant stress reactivity, might be explained by the notion that the infants react to what they experience during the interaction and not to a maternal diagnostic category. Additional exploratory analyses revealed that bonding as well as the severity of depressive and anxiety symptoms at earlier stages of the peripartum period predicted their respective subsequent level at a later peripartum stage. Both symptom measures were also negatively associated with the bonding quality 4-8 weeks postpartum. In addition to that, anxiety symptoms were negatively associated with the bonding quality at the second trimester. These findings are in line with a number of studies showing a connection between the pre- and postpartum level of depressive and anxiety symptoms, as well as bonding, respectively (Dubber et al., 2015; Ohara et al., 2017; Rossen et al., 2016). Thus our findings support previous research asserting that the administration of screenings to identify women at risk of bonding issues, depression and anxiety should start *during pregnancy* and be universal practice to foster the long-term well-being of mothers and children (Biaggi et al., 2016).

Study 2 solely focused on maternal mental health during the COVID-19 pandemic, targeting the severity of depressive symptoms and perceived stress. The aims of this study were threefold: We (1) assessed the overall severity of maternal depressive symptoms and perceived stress at two time points during the pandemic and reported prevalence rates, (2) compared the respective overall severity of depressive symptoms and perceived stress between the two time points, and (3) examined the reciprocal relation between these two constructs.

Our findings of study 2 corroborated the conjecture that the overall severity of depressive symptoms and perceived stress of mothers with children aged 0-3 increased in the course of the COVID-19 pandemic, which is in line with current meta-analyses (Q. Chen et al., 2022; Safi-Keykaleh et al., 2022). A potential explanation for the increased overall rates could be that prevalence rates might have strongly depended on the extent of confinement measures at the time of measurement (Adams et al., 2021; Fernandes et al., 2022). This underlines the need to implement preventative interventions specifically during lockdown periods. Given that even subclinical maternal depressive symptoms may adversely affect child development (Ramchandani et al., 2005), at least 33.8% of children were at risk of developmentally suffering under the depressive symptoms of their mothers in Germany between May and November 2020, whereas a disturbingly high percentage of 55.1% were at risk in February/March 2021. 15.2% of mothers between May and November 2020 and 26.0% in February/March 2021 additionally suffered from high perceived stress levels, which, according to Calvano et al. (2021) and Freisthler, Wolf, et al. (2021), put children at risk for abuse, neglect, and domestic violence. As the severity of depressive symptoms and perceived stress seems to linearly depend on their own prior values (i.e., significant auto-regressive effects) and to reciprocally predict each other (i.e., significant cross-lagged effects), prevention and intervention programs should (1) screen and treat mothers as early as possible to mitigate the risk for subsequent depressive symptoms and perceived stress, and (2) focus on both depressive symptom reduction and perceived stress relief to most successfully decrease mothers' level of suffering in both areas. These latter results should be regarded as preliminary and interpreted very cautiously as we faced some methodological shortcomings (i.e., only two assessment points not allowing to account for between-person associations by a random intercept model). Nevertheless, in light of very high and increasing prevalence rates across both time points, high correlations of both constructs within time points, and a potential bidirectional link between the severity of depressive symptoms and perceived stress, we may conclude that mothers should be supported as early as possible, targeting both areas of adversities.

Finally, the ongoing COMPARE-Interaction study was outlined to provide future perspectives, especially for the assessment of how maternal comorbid depressive and anxiety disorders may impact child cognitive and socio-emotional development compared to solely depressive disorders and a healthy control group. As far as we are aware, the COMPARE-Interaction study is the first study to longitudinally assess the influence of comorbid maternal mood disorders on child development on a behavioral, relational, hormonal, developmental, and clinical psychological level. We set a focus on children's internalizing and externalizing behavior problems and their cognitive development at 24 months of age. The focus of mediating effects was set to maternal sensitivity and infant cortisol reactivity at 12 months of age.

Summarizing the main findings of study 1 and 2, we found that preceding maternal depressive symptoms, anxiety symptoms, perceived stress, and bonding quality predicted the subsequent level of the respective measure. Also, maternal depressive symptoms were highly associated with perceived stress in the course of the COVID-19 pandemic. Moreover, maternal postpartum depressive symptoms were negatively related to the bonding quality at 4-8 weeks after birth. Maternal anxiety symptoms were negatively associated to the bonding quality in the second trimester as well as at 4-8 weeks after birth. These findings corroborate the evidence provided by previous research asserting that peripartum care has a crucial role to play at key points during both pregnancy and the postpartum period to foster both the mother-to-fetus/infant bond and to mitigate symptoms of depression, anxiety, and perceived stress (Biaggi et al., 2016; Dubber et al., 2015; Ohara et al., 2017; Rossen et al., 2016). The findings may inform and guide policy-makers as well as prevention and intervention approaches to screen and, if necessary, support mothers as early as possible. The ongoing study 3, the COMPARE-Interaction study, so far contributes in that sense that it can provide future perspectives, especially for the investigation of detrimental effects on child development.

5.2 Strengths, Limitations, and Future Research

A major strength of this work is that we applied a variety of different measures and methods to assess associations between several aspects of maternal mental health, dyadic interaction, and the mother-infant relationship. Implications for child development were theoretically corroborated and can be further examined in the COMPARE-Interaction study. Measures comprised microanalytically coded video data, self-report measures, and diagnostic interviews. The COMPARE study will also provide data of psychophysiological measures, such as infant cortisol reactivity. Furthermore, the statistical analyses included structural equation modeling applying both mediation and cross-lagged panel analyses. We also adhered to current guidelines of open science. Ensuring a transparent and reproducible research process, we published our pre-registrations, analysis scripts, and data sets on publicly accessible online platforms, i.e. PsychArchives and OSF.

Some general limitations regarding this work comprise WEIRD samples in both empirical studies, a low power in study 1, and a two-wave design in study 2. The first and second limitation may only be solved in future research if more resources are provided for research. In order to get more representative samples, monetary incentives might be helpful. Additionally, since especially clinical research is extremely time-consuming and emotionally challenging for researchers themselves (Kumar & Cavallaro, 2018), more resources for personnel is essentially needed. The limitation of a two-wave design in study 2 has already been solved as data collection for a third wave has been finished in the meantime while finalizing this work. Hence, we may base our future analysis plan for continuing investigations of the relation between depressive symptoms and perceived stress on a firmer footing. As debates about the relative merits of traditional CLPMs versus RI-CLPMs (and even more complex alternatives with random slopes, for instance) continue (Lucas, 2022; Lüdtke & Robitzsch, 2021), we aim to test a RI-CLPM against a CLPM in the near future. An exemplary R code for an RI-CLPM, which may account for between-person associations, has already been provided in the supplementary files (see 3.6.3). In case of equal model fit, it is usually recommended to rely on the more parsimonious model, i.e. the traditional CLPM. However, as it may be argued whether the model fit should be the appropriate criterion for deciding between the two models (Orth et al., 2021), we will follow Lucas (2022) and rather rely on the cross-lagged effects provided by the RI-CLPM than the ones by the CLPM in case both models yield good model fits. Their simulation studies showed better estimates for the RI-CLPM than for the CLPM for a wide range of scenarios applicable to psychological research. It will also be very interesting to test the random slopes, i.e. the rates of change between the measurement points, as they seemed to vary to a great degree across individuals in our study.

Another future perspective constitutes the opportunity to re-investigate the associations examined in study 1 and 2, i.e. between maternal depressive and anxiety disorders, bonding, stress and the quality of mother-infant interaction, in the COMPARE-Interaction study. The COMPARE study provides a larger sample size of very probably above 150 mother-infant dyads, enabling us to further assess intergenerational transmission pathways on the emotional, dyadic-behavioral, and regulatory level and to investigate a wide range of other promising and fruitful measures, such as postpartum bonding, perceived stress, parental reflective functioning, parental embodied mentalizing, and epistemic trust.

Furthermore, the COMPARE study clearly distinguishes between two clinical groups, i.e. comorbid depressive and anxiety disorders vs. depressive disorders (each additionally compared to a healthy control group). It, thus, allows us to more clearly assess the unique contribution of anxiety disorders, whereas in the study 1 section of this work we had to combine both disorders into one clinical group due to our limited sample size. However, even though the sample size of the COMPARE study is larger and represents an adequate size for our proposed analyses, it is still too limited to draw differential conclusions about individual anxiety disorders, i.e. generalized anxiety disorder, social phobia, etc.. A unique strength of the COMPARE study is the inclusion of fathers which grants us the opportunity to examine families from an overall perspective and to investigate their role as a potential buffer in the family system. As Fonagy et al. (2021) demand, it is crucial to expand models for developmental psychopathology and integrate the role of the wider social and cultural environment for human cognitive and socio-emotional development. Focusing on the immediate caregiving context is insufficient. As strongly as we agree with this perspective, in practice, we even faced major difficulties of including fathers into our study. Widening the focus to including, for instance, peers or teachers in future studies might therefore also require more resources. In an already drafted follow-up study of the COMPARE-interaction study, we aim to additionally include a peer-child interaction to assess and compare children's behavioral and affective regulation in different contexts. This may further support our understanding of social learning and development and thus guide future prevention and intervention approaches.

Currently, prevention and intervention approaches specifically focusing on the mother-infant relationship and dyadic coordination in the peripartum period are still sparse. However, according to Branjerdporn et al. (2017), several interventions targeting the mother-to-infant bond in the prepartum period have demonstrated promising results. These programs facilitate awareness of the fetal position via abdominal self-examination (Nishikawa & Sakakibara, 2013), affection expression (Chang et al., 2004), and tactile and verbal interaction with the fetus (Bellieni et al., 2007; J. S. Kim & Cho, 2004). To promote and foster well-being in the postpartum period, video-supported interventions aiming at transforming maladaptive forms of dyadic interaction into ones which more effectively decrease infant distress might be helpful (Müller et al., 2015; Reck et al., 2011). The Video Intervention Therapy (VIT) by Downing et al. (2014) appears to be a particular viable and promising approach to enhance the flexibility in the dyadic coordination of mismatching and positive matching states (Reck et al., 2022). Its effectiveness for treating bonding issues and depressive and anxiety disorders require further examination, but first results of a pilot study seem promising (Crugnola et al., 2016).

Lastly, it seems very encouraging to further assess the dyadic coordination on a micro-analytic level via non-linear time series analyses, such as Cross-Recurrence Quantification Analyses (Coco & Dale, 2014; Wallot & Leonardi, 2018; Xu et al., 2020). Such fine-grained and dynamic methods are promising approaches to further validate the measure of interactive reparation as an essential quality of dyadic co-regulation and to thus foster our understanding of the Mutual Regulation Model. This approach does not require a specific distribution of data and can deal with our categorically coded video data of study 1 very well. Every ICEP-R code is regarded as an event which is collected over time with time as the ordering variable. A Recurrence Quantification Analysis refers to the analysis of a single/individual time series (e.g. one participant alone), which can, for instance, provide the general tendency of an underlying system, e.g. the infant's self-regulatory capacities, to repeat itself. A Cross-Recurrence Quantification Analysis refers to the coupled analysis of two individuals in a dyadic interaction and reflects the patterns of coupling between two individuals, e.g. matches between mother and infant.

5.3 Conclusion

We empirically and longitudinally investigated the associations between mother-infant bonding, dyadic interaction, and maternal mental health during the peripartum period. The COVID-19 pandemic has constituted a very particular context. The findings of this work provide evidentiary support that mothers should be supported as early as possible when peripartum maternal mental health issues, such as depressive or anxiety symptomatology, impaired bonding, or perceived stress, occur. This applies to the vulnerable peripartum period in general, and to the peripartum period during the exceptional state of a global pandemic in particular. Only thus may intergenerational transmission processes be countered at early stages in order to mitigate and prevent potential detrimental effects on child development. The ongoing COMPARE-Interaction study will soon shed more light on this complex, multicausal and dynamic process.

German Summary - Zusammenfassung

Die Zeit der Schwangerschaft und der ersten Lebensmonate eines Säuglings stellen eine vulnerable Phase für dessen Bezugspersonen dar, denn die psychischen und physischen Herausforderungen der Elternschaft bringen weitreichende Implikationen für die Lebens- und Beziehungsreorganisation mit sich (O'Hara, 2009). Im Peripartalzeitraum besteht daher ein erhöhtes Risiko für Mütter, eine psychische Störung zu entwickeln (Banti et al., 2011; Howard et al., 2017). Besonders häufig treten peripartale Depressionen und Angststörungen, oftmals auch komorbid, auf (Reck et al., 2008), weswegen ein Fokus auf diese Störungsbilder im Dissertationsprojekt gelegt wurde. Woody et al. (2017) berichten in einer Stichprobe mit Müttern eine Prävalenzrate für peripartale depressive Störungen von 11,9 Prozent; für peripartale Angststörungen werden die Prävalenzraten generell sogar noch etwas höher als für depressive Störungen geschätzt (7,3-15,6 Prozent; Martini et al., 2015). Väter können ebenso von einer höheren psychischen Belastung betroffen sein (Gawlik et al., 2013). In diesem Projekt werden jedoch maternale psychische Beeinträchtigungen fokussiert, da Mütter nach wie vor in den meisten Fällen die primären Bezugspersonen sind und im Vergleich zu Vätern unproportional durch die Schwangerschaft, Versorgung und Erziehung gefordert werden (Fuchs, 2018; Harmon & Perry, 2011).

Einerseits können durch psychische Beeinträchtigungen Schwierigkeiten auf Seiten der Mütter für den Umgang mit ihren Säuglingen entstehen. Depressiven Müttern scheint es schwerer zu fallen, eine Verbindung und Beziehung mit ihren Neugeborenen, genauer ein Bonding, aufzubauen (Edhborg et al., 2011; Nonnenmacher et al., 2016). Des Weiteren geben Mütter, die an einer peripartalen Depression und Angststörung leiden, an, ein geringeres Selbstwertgefühl zu haben (Reck et al., 2012; Zietlow et al., 2014). Im Umgang mit ihren Kindern weisen sie außerdem eine geminderte Responsivität, Feinfühligkeit und Strukturiertheit auf (Kluczniok et al., 2016) Andererseits kann auf Seiten der Kinder eine maternale Depression oder Angststörung einen weitreichenden Belastungsfaktor in ihrer Entwicklung darstellen. Das Risiko der Kinder, selbst an einer Depression oder Angststörung zu erkranken, steigt auf das Zwei- bis Fünffache, wenn mindestens ein Elternteil an einer Depression erkrankt ist (Apter-Levy et al., 2013; Micco et al., 2009). Zahlreiche systematische Übersichtsarbeiten und Metaanalysen legen nahe, dass neben dem Krankheitsrisiko diverse weitere Entwicklungsparameter der Kinder durch die Psychopathologie der Mutter beeinträchtigt werden (S. H. Goodman et al., 2011; Kingston & Tough, 2014; Wan & Green, 2009). So zeigen sich beispielsweise negative Effekte sowohl auf die kognitive und

feinmotorische Entwicklung der Kinder (Koutra et al., 2013), den Spracherwerb (Quevedo et al., 2012; Reck, Van den Bergh, et al., 2018), die Bindung (Martins & Gaffan, 2000) als auch auf exekutive Funktionen und das Gedächtnis (Vänskä et al., 2011a). Aktuelle Daten weisen darauf hin, dass in der frühen Kindheit die Bezugsperson-Kind-Interaktion einen bedeutsamen Vermittlungsweg zwischen der Psychopathologie der Bezugsperson und der kindlichen Entwicklung darstellt (Müller et al., 2015). Besonders relevant in diesem Zusammenhang ist die Fähigkeit der Mutter, die Signale des Säuglings wahrzunehmen, sie richtig zu interpretieren sowie prompt und angemessen auf jene zu reagieren. Diese sogenannte maternale Feinfühligkeit, deren Konzeptualisierung auf die Bindungsforscherin Mary Ainsworth zurückgeht (Ainsworth et al., 1978), scheint vor allem im Zuge maternaler depressiver Symptomatik beeinträchtigt zu sein und negative Effekte auf die kindliche Entwicklung zu vermitteln (Edwards & Hans, 2015).

Basierend auf diesen bindungstheoretischen sowie weiteren, sozialkognitiven Konzepten (Theory of Mind; Premack and Woodruff, 1978 entwickelten Fonagy und Kolleg:innen das Konzept der Mentalisierung, in dem die Feinfühligkeit der Bezugspersonen eine wichtige Rolle einnimmt (Fonagy et al., 2002; Fonagy et al., 2015). Die Mentalisierungsfähigkeit eines Menschen beschreibt die basale Kapazität, von menschlichem Verhalten auf mentale Zustände (z.B. Bedürfnisse, Wünsche, Gefühle, Ansichten, Ziele, Überzeugungen und Gründe) zu schließen (Fonagy et al., 2002; Fonagy & Target, 2006). Diese Fähigkeit kann sich sowohl auf das eigene (mentalization of self) als auch auf das Verhalten anderer (mentalization of others) beziehen. Fonagy and Allison (2014) gehen davon aus, dass die Fähigkeit einer Bezugsperson, die Intentionen, Gedanken und Gefühle ihres Kindes adäquat zu mentalisieren, die Voraussetzung dafür bildet, ihre Kommunikation an den jeweiligen Entwicklungsstand des Kindes feinfühlig anzupassen und darauf abzustimmen. Im Zusammenhang mit psychischen Belastungsfaktoren kann die Mentalisierungsfähigkeit der Mutter jedoch beeinträchtigt werden (Luyten et al., 2017), wodurch ein feinfühliger Umgang und eine adäquate Kommunikation mit dem Kind gefährdet werden können (Fonagy & Allison, 2014), was einen Risikofaktor für die kindliche Entwicklung darstellen kann (Edwards & Hans, 2015).

Angesichts der weitreichenden negativen Einflüsse psychischer Beeinträchtigungen der Eltern auf die Entwicklung ihrer Kinder erscheint es von größter Wichtigkeit, die entsprechenden Transmissionswege umfassender zu untersuchen (Montirosso et al., 2020). Einen wichtigen Transmissionsweg stellt die Mutter-Kind-Interaktion dar (Reck et al., 2022), die sich vor allem mit einem standardisierten Experiment, dem Face-to-Face-Still-Face-Paradigma (Tronick et al., 1978), genauer untersuchen lässt. Dieses Paradigma besteht aus drei Phasen. Zunächst (1) interagieren Mutter und Kind zwei Minuten miteinander, (2) anschließend kommt es zu einer zweiminütigen Interaktionsunterbrechung, in der die Mutter mit regungsloser Mimik zwei Minuten über das Kind hinwegschaut und nicht mit ihrem Kind interagiert, und (3) in den folgenden zwei Minuten wendet die Mutter sich wieder ihrem Kind zu und nimmt die Interaktion wieder auf. Die Videoaufnahmen können im Anschluss mit dem mikroanalytischen Kodiersystem Infant and Caregiver Engagement

Phases (ICEP-R; Reck et al., 2009) ausgewertet werden. Die Qualität der dyadischen Koordination bzw. Koregulation kann über die sogenannte interactive reparation (Müller et al., 2015) operationalisiert werden. Dieser Prozess beschreibt die Qualität der wechselseitigen Regulation (mutual regulation; Gianino and Tronick, 1988) zwischen Bezugsperson und Kleinkind. Die Variable interactive reparation beschreibt die Latenzzeit, die die Dyade im Durchschnitt benötigt, um von einem affektiv und behavioral abgestimmtem Zustand (match) zum nächsten zu gelangen, das bedeutet, die Latenzzeit, die benötigt wird einen affektiv und behavioral unkoordinierten Zustand (mismatch) zu „reparieren". Die mittlere Zeitlatenz wird aus den Verhaltensströmen der Mütter und Kinder anhand definierter Ereignisse (gleichzeitiges Auftreten einzelner Codes) ermittelt.

Nur durch ein besseres Verständnis dieses komplexen, multikausalen und dynamischen Prozesses lassen sich spezifische Präventions- und Interventionsprogramme anpassen und weiterentwickeln (Downing et al., 2014). Zur genaueren Beschreibung und weiteren Untersuchung der Transmission entwickelten Reck und Kollegen auf der Basis eigener und zahlreicher weiterer Befunde ein Transmissionsmodell (Müller, 2017; Reck et al., 2022), welches in Abbildung 5.1 vereinfacht dargestellt ist. Psychische Beeinträchtigungen der Bezugspersonen beeinflussen in diesem Transmissionsmodell die kindliche Entwicklung via drei Ebenen. Auf (1) emotionaler Ebene scheint vor allem die Bezugsperson-Kind-Beziehung einen entscheidenden Mediator darzustellen (Branjerdporn et al., 2017; Mason et al., 2011). Auf (2) dyadisch-behavioraler Ebene steht die Bezugsperson-Kind-Interaktion als Mediator im Fokus (Edwards & Hans, 2015). Die dritte Ebene bildet (3) die regulatorische Mediationsebene. Auf dieser Ebene vermittelt sich der Effekt psychischer Beeinträchtigungen der Eltern auf die Entwicklung der Kinder über die Stressreaktivität der Kinder und deren Kapazität, Stress zu regulieren (Gunnar & Quevedo, 2007; Müller et al., 2016). Alle drei Mediationsebenen sind nicht unabhängig voneinander, sondern beeinflussen sich gegenseitig (Müller, 2017).

Das Dissertationsprojekt nahm einzelne Domänen und Vermittlungswege dieses Modells genauer in den Fokus. Genauer betrachtet wurden die Zusammenhänge zwischen der Mutter-Kind-Beziehung bzw. des Mutter-Kind-Bondings, der dyadischen Interaktion und der Entwicklung der Kinder im Kontext maternaler psychischer Beeinträchtigungen. Einen weiteren Kontext umfasste die COVID-19 Pandemie, die eine genauere Betrachtung maternaler Beeinträchtigungen, insbesondere der depressiven Symptomatik und des Stresserlebens, unabdingbar machten. Denn die Prävalenzraten für diese Domänen scheinen im Kontext der Pandemie gestiegen zu sein (Achterberg et al., 2021; Q. Chen et al., 2022; Suárez-Rico et al., 2021), was neben dem erhöhten Leidensdruck für Mütter auch weitreichende Auswirkungen auf deren Kinder hatte (Calvano et al., 2021; Freisthler, Gruenewald, et al., 2021). In zwei empirischen Studien und der Zusammenfassung einer aktuell laufenden Studien sollte genauer betrachtet werden, wie und wann Mütter und ihre Kinder in der vulnerablen Peripartalzeit unterstützt werden können. Da diese Untersuchungen grundlagenforschender Natur sind, können sie dazu dienen zukünftige Präventions- und Interventionsansätze weiterzuentwickeln und politische Entscheidungsträger über die Brisanz

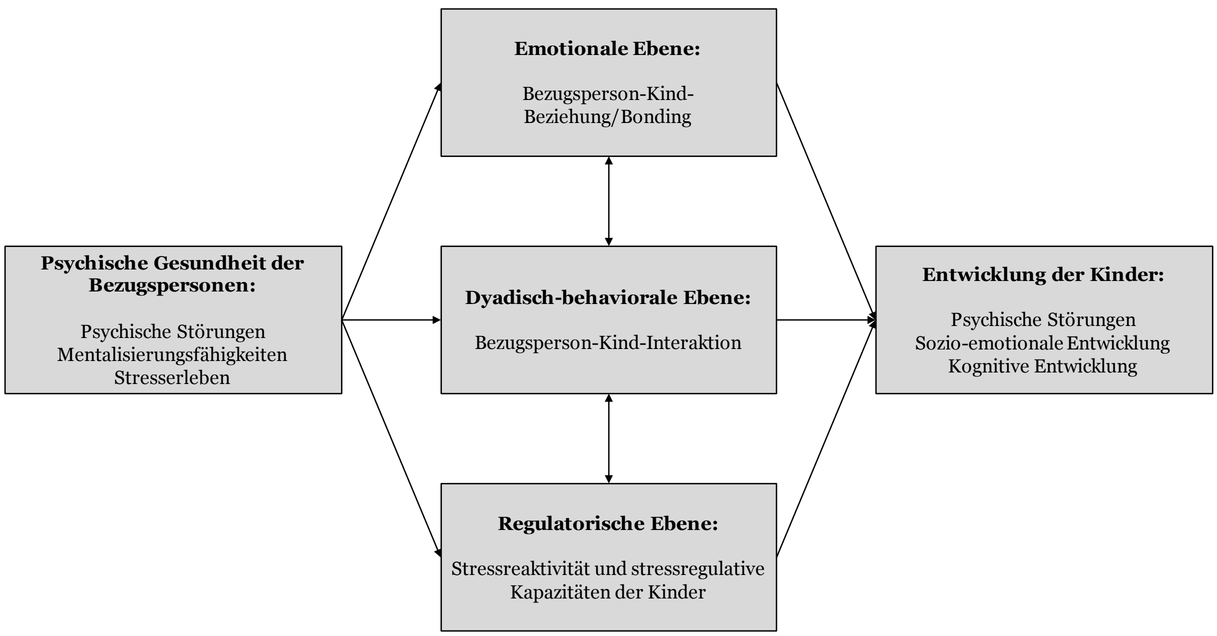

Figure 5.1: Zentrale Mediationsebenen für die Zusammenhänge zwischen der psychischen Gesundheit der Bezugspersonen und der Entwicklung ihrer Kinder (basierend auf Müller, 2017, S. 22). Es ist jedoch anzumerken, dass es sich um eine vereinfachte Modelldarstellung eines sehr komplexen, multikausalen und dynamischen Prozesses handelt. Andere potentiell beeinflussende Variablen und reziproke Effekte wurden vernachlässigt. Die Grafik ist unter einer CC-BY4.0 Lizenz auf https://osf.io/7xdy3/ abrufbar.

der Beeinträchtigungen und Folgen zu informieren.

Studie 1 untersuchte die mediierende Rolle des prä- und postpartalen Bondings im Zusammenhang zwischen maternalen Depressionen und/oder Angststörungen und der dyadischen Interaktionsqualität. Hierzu wurden 59 Mutter-Kind-Dyaden im Falle der Diagnose einer präpartalen Depression und/oder Angststörung der klinischen Gruppe oder im Falle keiner psychiatrischen Diagnose der gesunden Kontrollgruppe zugeteilt. Dies geschah anhand eines standardisierten klinischen Interviews (SKID-I; American Psychiatric Association, 2000). Im Selbstbericht wurden außerdem das prä- und postpartale Bonding, die depressive Symptomatik und die Angstsymptomatik zu zwei Messzeitpunkten während der Schwangerschaft und einem Messzeipunkt postpartum erfasst. Die Mutter-Kind-Interaktion im Alter der Kinder von drei bis vier Monaten wurde während des FFSF-Experiment erfasst, videografiert und anhand des ICEP-R Kodierschemas mikroanalytisch ausgewertet. Als Maß der Interaktionsqualität wurde die interactive reparation, d.h. die Latenzzeit, die die Dyade im Durchschnitt benötigt, um von einem affektiv und behavioral abgestimmtem Zustand (match) zum nächsten zu gelangen, herangezogen. Entgegen der formulierten Hypothesen zeigten sich keine mediierenden Effekte des prä- und postpartalen Bondings. Zusätzliche explorative Analysen lassen jedoch auf einen Zusammenhang zwischen prä- und postpartalem Bonding im Verlauf des Peripartalzeitraums schließen. Ebenso prädiziert die depressive Symptomatik im zweiten Trimenon diejenige im dritten Trimenon, die wiederum die postpartale depressive Symptomatik vorhersagt. Gleiches gilt auch für die Angstsymptomatik. Beide Symptommaße waren außerdem negativ mit der postpartalen Bondingqualität assoziiert, die Angstsymptomatik zusätzlich noch mit der Bondingqualität im zweiten Trimenon. Diese Befunde betonen, wie wichtig präpartale Screenings die beschriebenen Domänen betreffend sind, um die psychische Gesundheit von sowohl Mutter, als auch Kind zu unterstützen.

Studie 2 legte ihren Fokus auf die maternale, psychische Gesundheit während der COVID-19 Pandemie. Besonders wurden dabei die depressive Symptomatik und das Stresserleben fokussiert. Das Ziel war es, die Prävalenzraten beider Domänen während der Pandemie zu bestimmen sowie die Zusammenhänge der beiden Symptombereich genauer im Längsschnitt zu untersuchen. Hierzu wurden die depressive Symptomatik sowie das Stresserleben von 666 Müttern aus Deutschland mit Kindern im Altern von 0-3 Jahren anhand eines Onlinetools zu zwei Messzeitpunkten erhoben (T1: Mai-November 2020, T2: Februar/März 2021). Die Ergebnisse deuten darauf hin, dass sich die Belastung der Mütter in beiden Bereichen über die beiden Zeitpunkte hinweg verschlechtert hat. Zum ersten Messzeitpunkt trugen 33.8 % der Mütter ein erhöhtes Depressionsrisiko, während zum zweiten Messzeitpunkt 55.1 % ein erhöhtes Risiko zeigten. Eine potentielle Erklärung dafür könnte das unterschiedliche Ausmaß der Beschränkungen zu den beiden Zeitpunkten gewesen sein, da zum ersten Zeitpunkt weniger Beschränkungen als zum zweiten herrschten. Zum Zusammenhang zwischen beiden Maßen zeigte sich, dass die vorangehende depressive Symptomatik die nachfolgende depressive Symptomatik sowie das Stresserleben vorhersagt. Ebenso sagte das vorangehende Stresserleben das nachfolgende Stresserleben sowie die depressive Symptomatik vorher. Diese Zusammenhänge sollten jedoch aufgrund einiger methodischer Limitationen, u.a. nur zweier Erhebungswellen, vorsichtig interpretiert werden. Aus unseren Ergebnissen schließen wir, dass Mütter so früh wie möglich durch Präventions- und Interventionsprogramme gescreent und gegebenenfalls unterstützt werden, um längerfristige depressive Symptome sowie Stressymptome abzumildern. Außerdem sollten beide Symptombereiche bei der Prävention oder Behandlung des jeweils anderen Bereichs berücksichtigt werden, um größtmögliche Symptomentlastung herbeizuführen.

In einer dritten, aktuell noch laufenden Studie werden die Effekte komorbider Depressionen und Angststörungen im Vergleich zu alleinigen Depressionen und im Vergleich zu keiner psychiatrischen Symptomatik auf die Entwicklung der Kinder verglichen. Mögliche Transmissionswege auf behavioraler, relationaler und regulatorischer Ebene (siehe Abbildung 5.1) können somit zukünftig genauer untersucht werden. Vor allem konzentriert sich die Studie auf externalisierendes und internalisierendes Problemverhalten der Kinder und deren kognitive Entwicklung im Alter von 24 Monaten. Als Mediatoren potentieller negativer Effekte der maternalen Psychopathologie auf die Entwicklung der Kinder werden die Feinfühligkeit der Mütter und die Stressreaktivität der Kinder genauer analysiert.

Die Stärken und Limitationen der beiden empirischen Studien sollen im Folgenden kurz zusammengefasst werden. Eine Stärke über beide Studien hinweg besteht darin, dass eine große Bandbreite an unterschiedlichen Erhebungsinstrumenten angewandt wurde, um die Zusammenhänge zwischen verschiedenen Domänen der maternalen psychischen Gesundheit, dyadischen Interaktionsqualität und des Mutter-Kind-Bondings zu untersuchen. Die Maße umfassten mikroanalytisch kodierte Videodaten, Selbstberichtsinstrumente sowie diagnostische Interviews. Außerdem wurden komplexe Strukturgleichungsmodelle als robuste statistische Methode zur Untersuchung der Zusammenhänge eingesetzt. Der Forschungsprozess zeichnet sich außerdem durch eine hohe Transparenz und Möglichkeit zur Reproduktion der vorliegenden Befunde aus, da die Präregistrierungen, statistischen Analyseskripte sowie die pseudonymisierten Datensätze zu beiden Studien auf Onlineplattformen (PsychArchives und OSF) veröffentlicht wurden. Generelle Limitationen beziehen sich vor allem auf die kleine Stichprobengröße der ersten Studie, die relativ gebildeten, westlich-industrialisierten Stichproben in beiden Studien sowie die methodischen Limitationen des traditionellen Cross-lagged panel designs, u.a. nicht zwischen intra- und interindividuellen Unterschieden differenzieren zu können.

Die Gesamtergebnisse der Arbeit deuten darauf hin, dass maternale psychische Beeinträchtigungen, vor allem depressive Symptomatik, Angst- und Stresssymptomatik sowie Bondingbeeinträchtigungen so frühzeitig wie möglich erkannt werden sollten, um die langfristige Belastung der Mütter in diesen Bereichen abzumildern. Dies betrifft die vulnerable Peripartalzeit im Allgemeinen und die Peripartalzeit zu Zeiten einer globalen Pandemie im Besonderen. Nur so können intergenerationale Transmissionprozesse unterbrochen werden und die kognitive und sozio-emotionale Entwicklung der Kinder geschützt werden.

Appendix A

Administered Questionnaires

A.1 Edinburgh Postnatal Depression Scale (EPDS), German Version

EPDS

Wir würden gerne wissen, wie Sie sich fühlen. Bitte wählen Sie unter den folgenden Aussagen die Antwort, die am besten beschreibt, wie Sie sich in den ***letzten sieben Tagen*** gefühlt haben, nicht nur wie Sie sich heute fühlen:

In den letzten sieben Tagen...

1. konnte ich lachen und das Leben von der sonnigen Seite sehen.

   ○ So wie ich es immer konnte
   ○ Nicht ganz so wie sonst immer
   ○ Deutlich weniger als früher
   ○ Überhaupt nicht

2. konnte ich mich so richtig auf etwas freuen.

   ○ So wie immer
   ○ Etwas weniger als sonst
   ○ Deutlich weniger als früher
   ○ Kaum

3. fühlte ich mich unnötigerweise schuldig, wenn etwas schief lief.

   ○ Ja, meistens
   ○ Ja, manchmal
   ○ Nein, nicht so oft
   ○ Nein, niemals

4. war ich ängstlich und besorgt aus nichtigen Gründen.

   ○ Nein, überhaupt nicht
   ○ Selten
   ○ Ja, manchmal
   ○ Ja, häufig

5. erschrak ich leicht, bzw. reagierte panisch aus unerfindlichen Gründen.

   ○ Ja, oft
   ○ Ja, manchmal
   ○ Nein, nicht oft
   ○ Nein, überhaupt nicht

6. überforderten mich verschiedene Umstände.

- ○ Ja, die meiste Zeit war ich nicht in der Lage, damit fertig zu werden
- ○ Ja, manchmal konnte ich damit nicht fertig werden
- ○ Nein, die meiste Zeit konnte ich gut damit fertig werden
- ○ Nein, ich wurde so gut wie immer damit fertig

7. war ich so unglücklich, dass ich nicht schlafen konnte.

- ○ Ja, die meiste Zeit
- ○ Ja, manchmal
- ○ Nein, nicht sehr oft
- ○ Nein, überhaupt nicht

8. habe ich mich traurig und schlecht gefühlt.

- ○ Ja, die meiste Zeit
- ○ Ja, manchmal
- ○ Selten
- ○ Nein, überhaupt nicht

9. war ich so unglücklich, dass ich geweint habe.

- ○ Ja, die ganze Zeit
- ○ Ja, manchmal
- ○ Nur gelegentlich
- ○ Nein, niemals

10. überkam mich der Gedanke, mir selbst Schaden zuzufügen.

- ○ Ja, ziemlich oft
- ○ Manchmal
- ○ Kaum
- ○ Niemals

A.2 Stait-Trait Anxiety Inventory (STAI), German Version

STAI-S

Bitte geben Sie an, wie diese Feststellungen ***in diesem Augenblick*** auf Sie zutreffen.

		Überhaupt nicht	ein wenig	ziemlich	sehr
1	Ich bin ruhig.	1	2	3	4
2	Ich fühle mich geborgen.	1	2	3	4
3	Ich fühle mich angespannt.	1	2	3	4
4	Ich bin bekümmert.	1	2	3	4
5	Ich bin gelöst.	1	2	3	4
6	Ich bin aufgeregt.	1	2	3	4
7	Ich bin besorgt, dass etwas schief gehen könnte.	1	2	3	4
8	Ich fühle mich ausgeruht.	1	2	3	4
9	Ich bin beunruhigt.	1	2	3	4
10	Ich fühle mich wohl.	1	2	3	4
11	Ich fühle mich selbstsicher.	1	2	3	4
12	Ich bin nervös.	1	2	3	4
13	Ich bin zappelig.	1	2	3	4
14	Ich bin verkrampft.	1	2	3	4
15	Ich bin entspannt.	1	2	3	4
16	Ich bin zufrieden.	1	2	3	4
17	Ich bin besorgt.	1	2	3	4
18	Ich bin überreizt.	1	2	3	4
19	Ich bin froh.	1	2	3	4
20	Ich bin vergnügt.	1	2	3	4

-99, wenn nicht beantwortet; -88, wenn nicht korrekt beantwortet

STAI-T

Bitte geben Sie an, wie diese Feststellungen ***im Allgemeinen*** auf Sie zutreffen.

		fast nie	manch-mal	oft	fast immer
1	Ich bin vergnügt.	1	2	3	4
2	Ich werde schnell müde.	1	2	3	4
3	Mir ist zum Weinen zumute.	1	2	3	4
4	Ich glaube, mir geht es schlechter als anderen Leuten.	1	2	3	4
5	Ich verpasse günstige Gelegenheiten, weil ich mich nicht schnell genug entscheiden kann.	1	2	3	4
6	Ich fühle mich ruhig und ausgeruht.	1	2	3	4
7	Ich bin ruhig und gelassen.	1	2	3	4
8	Ich glaube, dass mir meine Schwierigkeiten über den Kopf wachsen.	1	2	3	4
9	Ich mache mir zuviel Gedanken über unwichtige Dinge.	1	2	3	4
10	Ich bin glücklich.	1	2	3	4
11	Ich neige dazu, alles schwer zu nehmen.	1	2	3	4
12	Mir fehlt es an Selbstvertrauen.	1	2	3	4
13	Ich fühle mich geborgen.	1	2	3	4
14	Ich mache mir Sorgen über mögliches Missgeschick.	1	2	3	4
15	Ich fühle mich niedergeschlagen.	1	2	3	4
16	Ich bin zufrieden.	1	2	3	4
17	Unwichtige Gedanken gehen mir durch den Kopf und bedrücken mich.	1	2	3	4
18	Enttäuschungen nehme ich so schwer, dass ich sie nicht vergessen kann.	1	2	3	4
19	Ich bin ausgeglichen.	1	2	3	4
20	Ich werde nervös und unruhig, wenn ich an meine derzeitigen Angelegenheiten denke.	1	2	3	4

-99, wenn nicht beantwortet; -88, wenn nicht korrekt beantwortet

A.3 Maternal-Fetal Attachment Scale (MFAS), German Version

MFAS

Uns interessiert, wie sehr Sie schon Kontakt zu Ihrem ungeborenen Kind herstellen. Beantworten Sie dazu bitte die folgenden Fragen nach dem Grad des Zutreffens. Dabei bedeutet:

1 = Trifft überhaupt nicht zu, 2 = Trifft meist nicht zu, 3 = Trifft eher nicht zu,
4 = Ich weiß nicht, 5 = Trifft eher zu, 6 = Trifft meist zu,
7 = Trifft ganz genau zu.

		---			0			+++
1	Ich rede mit meinem ungeborenen Baby.	1	2	3	4	5	6	7
2	Ich habe das Gefühl, dass sich die Mühen der Schwangerschaft lohnen.	1	2	3	4	5	6	7
3	Ich genieße es, meinem Bauch anzusehen, wenn er durch die Bewegungen des Babys wackelt.	1	2	3	4	5	6	7
4	Ich stelle mir bildlich vor, wie ich mein Baby füttere.	1	2	3	4	5	6	7
5	Ich freue mich sehr darauf, sehen zu können, wie mein Baby aussieht.	1	2	3	4	5	6	7
6	Ich frage mich, ob sich das Baby da drin eingeengt fühlt.	1	2	3	4	5	6	7
7	Wenn ich mit meinem, oder über mein Baby spreche, benutze ich einen Spitznamen.	1	2	3	4	5	6	7
8	Ich stelle mir vor, wie ich mein Kind versorge.	1	2	3	4	5	6	7
9	Von den Bewegungen des Babys kann ich fast erraten, was er oder sie für eine Persönlichkeit haben wird.	1	2	3	4	5	6	7
10	Für ein Mädchen habe ich schon einen Namen ausgesucht.	1	2	3	4	5	6	7
11	Ich tue Sachen, um gesund zu bleiben, welche ich nicht tun würde, wenn ich nicht schwanger wäre.	1	2	3	4	5	6	7
12	Ich frage mich, ob das Baby in mir hören kann.	1	2	3	4	5	6	7
13	Für einen Jungen habe ich schon einen Namen ausgesucht.	1	2	3	4	5	6	7
14	Ich frage mich, ob das Baby in mir denkt und fühlt.	1	2	3	4	5	6	7
15	Ich ernähre mich gesund, um sicher zu sein, dass mein Baby eine gute Ernährung erhält.	1	2	3	4	5	6	7
16	Es scheint mir, als ob mein Baby tritt und sich bewegt, um mir zu sagen, dass es Essenszeit ist.	1	2	3	4	5	6	7
17	Ich stupse mein Baby, damit es zurückstupst.	1	2	3	4	5	6	7
18	Ich kann es kaum erwarten, mein Baby zu halten.	1	2	3	4	5	6	7
19	Ich versuche mir vorzustellen, wie das Baby aussehen wird.	1	2	3	4	5	6	7
20	Ich streichele meinen Bauch, um das Baby zu beruhigen, wenn es zu viel tritt.	1	2	3	4	5	6	7
21	Ich merke, wenn das Baby Schluckauf hat.	1	2	3	4	5	6	7
22	Ich habe das Gefühl, dass mein Körper hässlich ist.	1	2	3	4	5	6	7
23	Ich habe manche Sachen aufgegeben, weil ich meinem Baby helfen möchte.	1	2	3	4	5	6	7
24	Ich taste das Füßchen meines Babys durch meinen Bauch, um es hin- und her bewegen zu können.	1	2	3	4	5	6	7

-99, wenn nicht beantwortet; -88, wenn nicht korrekt beantwortet

A.4 Postpartum Bonding Questionnaire (PBQ-16), German Version

Postpartum Bonding Questionnaire (PBQ-16)

Name: Datum:

Kreuzen Sie bitte an, wie oft folgende Aussagen für Sie zutreffend sind. Es gibt keine „richtigen“ oder „falschen“ Antworten.

	Immer	Sehr oft	Oft	Manchmal	Selten	Nie
1: Ich fühle mich meinem Baby nahe	O	O	O	O	O	O
2: Ich wünsche mir die Zeit zurück, als ich noch kein Baby hatte	O	O	O	O	O	O
3: Ich fühle mich meinem Baby gegenüber distanziert	O	O	O	O	O	O
4: Ich kuschle gern mit meinem Baby	O	O	O	O	O	O
5: Mein Baby regt mich auf	O	O	O	O	O	O
6: Mein Baby irritiert mich	O	O	O	O	O	O
7: Ich fühle mich glücklich, wenn mein Baby lächelt/lacht	O	O	O	O	O	O
8: Ich liebe mein Baby über alles	O	O	O	O	O	O
9: Ich liebe es mit meinem Baby zu spielen	O	O	O	O	O	O
10: Ich fühle mich als Mutter gefangen	O	O	O	O	O	O
11: Ich bin auf mein Baby böse	O	O	O	O	O	O
12: Mein Baby ist mir lästig	O	O	O	O	O	O
13: Mein Baby ist das Schönste auf der ganzen Welt	O	O	O	O	O	O
14: Mein Baby macht mich ängstlich	O	O	O	O	O	O
15: Mein Baby macht mich ärgerlich	O	O	O	O	O	O
16: Mein Baby ist leicht zu beruhigen	O	O	O	O	O	O

Deutsche Version des PBQ mit 16 Items von Reck et al. (2006); Originalversion des PBQ von Brockington et al. (2001)

A.5 Perceived Stress Scale - 10 Item Version (PSS), German Version

Die folgenden Fragen beschäftigen sich damit, wie häufig Sie sich während des letzten Monats durch Stress belastet fühlten. (Bitte kreuzen Sie **pro** Aussage **eine** Antwort an)		**nie** 0	**selten** 1	**manchmal** 2	**häufig** 3	**sehr oft** 4
1	Wie oft haben Sie sich im letzten Monat darüber aufgeregt, dass etwas völlig Unerwartetes eingetreten ist?	☐	☐	☐	☐	☐
2	Wie oft hatten Sie im letzten Monat das Gefühl, wichtige Dinge in Ihrem Leben nicht beeinflussen zu können?	☐	☐	☐	☐	☐
3	Wie oft haben Sie sich im letzten Monat nervös und „gestresst“ gefühlt?	☐	☐	☐	☐	☐
4	Wie oft haben Sie sich im letzten Monat sicher im Umgang mit persönlichen Aufgaben und Problemen gefühlt?	☐	☐	☐	☐	☐
5	Wie oft hatten Sie im letzten Monat das Gefühl, dass sich die Dinge nach Ihren Vorstellungen entwickeln?	☐	☐	☐	☐	☐
6	Wie oft hatten Sie im letzten Monat das Gefühl, mit all den anstehenden Aufgaben und Problemen nicht richtig umgehen zu können?	☐	☐	☐	☐	☐
7	Wie oft hatten Sie im letzten Monat das Gefühl, mit Ärger in Ihrem Leben klar zu kommen?	☐	☐	☐	☐	☐
8	Wie oft hatten Sie im letzten Monat das Gefühl, alles im Griff zu haben?	☐	☐	☐	☐	☐
9	Wie oft haben Sie sich im letzten Monat darüber geärgert, wichtige Dinge nicht beeinflussen zu können?	☐	☐	☐	☐	☐
10	Wie oft hatten Sie im letzten Monat das Gefühl, dass sich die Probleme so aufgestaut haben, dass Sie diese nicht mehr bewältigen können?	☐	☐	☐	☐	☐

References:

Büssing A, Recchia DR: Spiritual and Non-spiritual Needs Among German Soldiers and their Relation to Stress Perception, PTDS Symptoms, and Life Satisfaction – Results from a Structural Equation Modeling Approach. Journal of Religion and Health, 2016; 55(3): 747-764; Online June 2015 (DOI 10.1007/s10943-015-0073-y)

Büssing A, Falkenberg Z, Schoppe C, Recchia DR, Lötzke D: Work Stress associated Cool Down Reactions among Nurses and Hospital Physicians and their relation to Burnout Symptoms. Findings from a Cross-Sectional Study. BMC Health Services Research 2017; 17:551 (DOI 10.1186/s12913-017-2445-3)

Reference values

Bundeswehrsoldaten (n=1095)
Cronbach´s alpha = .850
PSS-10 mean 15.4 ± 6.7

Katholische Seelsorger (n=8905)
Cronbach´s alpha = .
PSS-10 mean 15.2 ± 6.1

Krankenhausärzte (n=444)
Cronbach´s alpha = .842
PSS-10 mean 18.2 ± 3.6

Pflegende (n=916)
Cronbach´s alpha = .848
PSS-10 mean 18.2 ± 6.6

Mütter mit zu früh / krank geborenen Kindern (n=125)
Cronbach´s alpha = .754
PSS-10 mean 19.9 ± 5.9

Appendix B

Coding Manual: Infant and Caregiver Engagement Phases - Revision

Infant and Caregiver Engagement Phases (ICEP)

Heidelberg Version

Revised Version 08/2009:
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Original Version 07/1999:
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The Infant and Caregiver Engagement Phases are based on Tronick's Monadic Phases Scoring System, Tronick and Weinberg's Infant and Maternal Regulatory Scoring Systems (IRSS & MRSS), and Weinberg and Tronick's work on affective configurations (Child Development, 65(5)). This coding system can be used to separately assess infant and caregiver affect, the extent to which the infant and caregiver are engaged, as well as the quality of the engagement. The codes within the Infant and Caregiver Engagement Phases are mutually exclusive and may be coded using interactive coding software, a VCR computer interface system or paper and pencil. Code in separate runs the infant and caregiver phases, the additional infant and caregiver codes and the dyadic gaze information.

Coding Basics:

- Always refer to the manual throughout coding.
- Watch the segment to be coded in its entirety before coding.
- Remember, BEHAVIOR is being coded not what the infant appears to be feeling.
- Have another coder look at the segment if you are unsure of the appropriate code.
- Do not code for long periods without a break. If you are tired and find yourself having a more difficult time than usual, please stop and come back to coding later.
- Don't forget the step-down rules. If you have to watch a segment more than twice, step down to the more neutral code.

Coding Process:

1. infant engagement phases
2. caregiver engagement phases
3. additional codes infant
4. additional codes mother
5. dyadic gaze information

INFANT ENGAGEMENT PHASES

The infant engagement phases are mutually exclusive. The phases combine information from the infant's facial expressions, direction of gaze, body posture and vocalizations.

1. **Negative Engagement (Ineg):** The infant is negative, protesting or withdrawn. The infant must display negative facial expressions (e.g., anger, sadness, disgust, distress, cry or grimace faces), and/or whimpering, complaining, fussy, or crying vocalizations. There is no gaze criterion and a variety of gestural and postural behaviors may occur (e.g., pushing the caregiver away, twisting and turning in chair, arching body).

Negative Engagement can be divided into two specific phases: Protest and Withdrawn. Always try to code whether the infant is in a Protest or Withdrawn phase. If it is not possible to make this differentiation, code the undifferentiated category of Negative Engagement. The overall feel for this code is unhappy or sad without the further differentiation of the Protest or Withdrawn codes [In typical populations, Protest will be the most common negative code and Withdrawn will be rare].

2. **Protest (Ipro):** The infant is protesting. The infant often displays facial expressions of anger, frustration, grimaces, and/or is fussing or crying. The infant tends to be active during this phase: the infant may arch his/her back, kick or bang his/her arms against the chair, try to escape /get away, gesture, want to be picked up, bat at the caregiver, or push and pull away from the caregiver. This code captures externalizing type behaviors, and can have an angry or hostile aspect. There is no gaze criterion.

3. **Withdrawn (Iwit):** The infant is withdrawn and minimally engaged with the caregiver. This phase often includes sad facial expressions, whimpering vocalizations, slumped posture, listless demeanor, and gaze aversion. The infant typically engages in few activities and gives the impression of being "spaced out" and disengaged from the caregiver. This code captures internalizing type behaviors. Although the infant often gaze averts, there is no specific gaze criterion defining this phase. Do not code withdrawn if the infant is crying or looking away from the caregiver but is focused on an object.

4. **Object/Environment Engagement (Inon):** The infant is looking at objects that are either proximal (e.g., infant seat) or distal (e.g., camera). The infant may manipulate proximal objects. The infant's eyes must be directed towards an object. The infant's facial expressions are typically interested or neutral but may be on occasion positive. The infant may or may not vocalize. Objects include the infant's hands, feet, belly or clothing; the caregiver's body (e.g., trunk, hands, jewelry); and objects that are part of the laboratory setting (e.g., chair strap, side of the chair, cameras or curtains). The caregiver's face does not constitute an object. If the infant displays negative affect or vocalizations while looking at an object, code Negative Engagement, Protest or Withdrawn. If the infant laughs or smiles while looking at an object, code Object/Environment Engagement not Social Positive Engagement (ipos).

5. **Social Monitor (Ineu):** The infant's attention is directed towards the caregiver. The infant looks at the adult's face with a neutral or interested facial expression. The infant's eyes must be oriented towards the adult's face and he/she may vocalize in a neutral/positive manner. In cases where it is difficult to differentiate between Negative

Engagement (particularly withdrawn) and Social Monitor, score Social Monitor. Similarly, if it is difficult to differentiate between Social Monitor and Social Positive Engagement, score Social Monitor. If it is difficult to differentiate between Object Engagement and Social Monitor, score Object Engagement.

6. **Social Positive Engagement (Ipos):** This scale assesses the extent to which the infant is engaged with the caregiver in an overall positive manner. The infant must display facial expressions of joy particularly smiles, but occasionally coo and play faces. The infant must look towards the caregiver's face. The infant may be vocalizing in a positive manner, laughing, babbling, or squealing. Do not code Social Positive Engagement if the infant vocalizes but does not display a smile face. A smile face includes upturned mouth, crinkly eyes and raised cheeks. The infant may be engaged with the adult in rhythmic social play-games (e.g., pat-a-cake, peek-a-boo). During these games it may not be possible for the infant to look directly at the adult's face because of the caregiver's position (e.g., adult's face buried in infant's lap) or the nature of the game (e.g., face covered in peek-a-boo). Score these instances as Social Positive Engagement as long as the infant's facial and/or vocal expressions are positive and gaze is focused towards the caregiver.

7. **Sleep (Islp):** The infant is asleep.

8. **Unscorable (Iusc):** If the baby's face is obscured because of poor camera angles, technical problems, or because the adult is blocking the baby's camera, score Unscorable. If it is possible to see part of the infant's face, code the appropriate engagement phase. Do not guess. In general, use the following rules to code Unscorable. Even though the infant's face is blocked, if it is clear that the infant is looking away from the mother, score Object/Environment Engagement. If the infant's face is obscured and the infant is fussing or crying, score the appropriate Negative Engagement code. If the infant's face is obscured and the infant seems to be looking in the direction of the mother, score Unscorable because it will be impossible to know exactly where the infant is looking or to determine the infant's facial expression. However, if the infant does not move and is in the same coding behavior from the beginning of being obscured to being observable then score that coding behavior.

A note on the use of pacifiers: The use of pacifiers is problematic because they obscure the baby's mouth. Use the following rules if a pacifier is in use: Code Social/Positive Engagement if it is CLEAR that the baby is smiling (e.g., the cheeks are clearly raised even with the pacifier). If this is not clear, use the default rule and code Social Monitor (but only if the baby is looking at the parent). If the baby is crying/fussing with a pacifier in the mouth, code the appropriate Negative Engagement code. If the baby is looking away from the caregiver and is not crying/fussing, score Object/Environment Engagement. If the baby is looking away and fussing/crying, code the appropriate Negative Engagement code.

A note on SNEEZING: If the infant sneezes and involuntarily closes his/her eyes, append the sneezing fit to the previous code. For example, if the infant looks at an object, sneezes, and then smiles at the mother, code a 4 and a 6. If the infant looks at an object, sneezes and continues to look at an object, code a continuous 4.

CAREGIVER ENGAGEMENT PHASES

The Caregiver Engagement Phases are mutually exclusive. For each phase, consider the adult's facial expressions, direction of gaze, and vocalizations.

1. **Negative Engagement (Cneg):** The adult is negative, withdrawn, intrusive or hostile. His/her facial expressions are sad, sober, expressionless, stern, angry or hostile. There are no smiles or hints of smiles. The adult's vocalizations are expressionless, sharp, angry, loud or adultlike. The adult may be silent or speak in a monotone. The adult may be leaning back in his/her chair and appear at a loss of what to do. There is no burst-pause, sing-song, or exaggerated language characteristic of motherese. When considering the adult's vocalizations, pay attention to the affective tone of the vocalizations and disregard the content of the vocalizations. There is no gaze criterion.

According to the main affect negative Engagement can be divided into three specific phases: Withdrawn, Intrusive and Hostile. Always try to code whether the adult is in the Withdrawn, Intrusive or Hostile phase. If it is not possible to make this differentiation, code the undifferentiated category of Negative Engagement. If Intrusive and Hostile behavior can be observed at once, code Hostile.

2. **Withdrawn (Cwit):** The adult is minimally engaged and withdrawn with the baby. The adult's facial expressions are sad, flat, or expressionless. There are no smiles or hints of smiles. The adult may be silent, speak or whisper in a flat or expressionless monotone. The adult may be leaning back in his/her chair, not touch the baby or touch it in a mechanical manner, and appear hesitant or at a loss of what to do. There is no burst pause, sing-song, or exaggerated vocalizations (i.e., motherese). There is no gaze criterion.

3. **Intrusive (Cint**, main affect „Tension /Agitation“, videos: 43, A1-076): The adult's engagement with the baby is characterized by intrusive affect/behavior. The adult's facial expressions are tense, stressed or little authentic. The infant is not given the chance to respond to maternal initiatives as these follow one another too fast and do not await infant reactions. Maternal and infant reactions are not well-matched so that for example the mother interrupts the infant's activities in order to pursue her own „programme“. The mother stimulates the infant excessively without caring about infant signals of discomfort and/or withdrawal. Regardless of the infant's behavior the mother acts too loud, too expressively and too close to her child. The infant's activities are restrained, for example by turning his or her face around in order to make eye contact, by holding tight hands or feet while playing etc.

4. **Hostile (Chos**, main affect „Anger/Hostility/Petulance “, videos: 21, 48): The adult's engagement with the baby is characterized by hostile affect/behavior. The adult's facial expressions are stressed out, upset or aggressive. Vocalizations are high pitched or the voice is cracking. The mother is curt with the baby, pushes him/her, drags or pulls him/her or her actions and vocalizations follow one another staccato-like. She makes fun of her baby, for example by imitating his/her vocalizations or mimic expressions.

5. **Non-Infant Focused Engagement (Cnon):** The adult is not attending to the baby and is involved in a non-infant focused activity (e.g., fixing his/her clothing, talking to the experimenter, looking at an object the infant is not looking at, rubbing eyes and face because of tiredness).

5. **Social Monitor/No Vocs or Neutral Vocs (Cneu):** The adult watches or focuses his/her attention on the baby or the baby's activities while his/her facial expressions are neutral. The caregiver may look interested in the infant and may occasionally show a hint of a smile. The adult may touch the baby. The adult can be silent or vocalize to the baby in a neutral manner. Do not code brief conversational pauses (no vocs with neutral face) as 6 unless these pauses last 2 seconds or more. Comforting sounds like shhh are coded as 6. If the caregiver's face is neutral but he/she is speaking in Motherese or in a positive tone of voice, score Phase 7 Social Monitor/Positive Vocs. In cases where it is difficult to differentiate between the Negative Engagement codes (particularly Withdrawn) and Social Monitor/No Vocs or Neutral Vocs, score a 6. Similarly if it is difficult to differentiate between Social Monitor/Neutral and Social Monitor/Positive Vocs, score Social Monitor/No Vocs or Neutral Vocs.

6. **Social Monitor/Positive Vocs (Cpvc):** The caregiver's gaze is focused on the infant or on the infant's activities. His/her facial expressions are neutral, interested, and may occasionally show a hint of a smile. Although the caregiver's face is neutral, his/her vocalizations are positive (e.g., he/she may use Motherese, make kissing or clicking sounds, sing). In cases where it is difficult to differentiate between Social Monitor/Positive Vocs and Social Positive Engagement, score Social Monitor/Positive Vocs.

7. **Social Positive Engagement (Cpos):** The caregiver expresses positive affect such as full smiles (closed or open), laughter, or play faces. The adult may vocalize to the baby using Motherese or sing but there is nothing exaggerated in his/her speaking or singing. The caregiver may play games with the infant but these games do not have a neutral quality (code 6 or 7). Instances when vocalizations (e.g., "boop") make it physically impossible to smile are coded as 8 if they are preceded by an 8. If the "boop" is preceded by a neutral face, code a 7. If, after the vocalization, the caregiver's face is not positive (e.g., neutral), code the appropriate code. Similarly, if the caregiver covers his/her face or hides his/her face in the infant's body, code these instances as 8 if they are preceded by an 8. If the caregiver emerges with a non-positive face (e.g., neutral or negative), code the appropriate code.

8. **Unscorable (Cusc):** If the adult's face is obscured because of poor camera angles or technical problems score Unscorable. Code all instances, however brief if the caregiver's face is completely obscured and if it is not possible to hear the caregiver's vocalizations. If it is possible to see part of the caregiver's face, code the appropriate engagement phase. Also, if you cannot see the face but can hear the caregiver talk using neutral or positive vocalizations, code 6 or 7. Do not guess.

ADDITIONAL INFANT AND CAREGIVER CODES

In a separate run from the phases, code infant self-comforting, distancing, and autonomic stress indicators. These infant additional codes are not mutually exclusive. Thus an infant can self-comfort while distancing him/herself from the caregiver. During this run, also code maternal rough touches and still-face violations.

If using the AACT system, code the beginning and end times of each episode during this run. Make sure that the same begin and end times are used for the infant and the caregiver. When code the appropriate episode code and the tran codes demarcating the transitional 15 sec periods between episodes.

INFANT

Self-comforting (sc)

Oral self-comforting and self-clasp may co-occur or occur sequentially. Score all instances of each.

1. **Oral Self-Comforting (Isc o):** The infant uses his/her body to provide self-stimulation. Self-comforting activities include: (1) instances when the infant sucks on his/her body (e.g., his/her thumb or wrist). There must be skin contact with the mouth and the behavior must be initiated by the infant; (2) instances when the infant sucks on or brings to his/her mouth something other than his/her body such as the strap of the chair or his/her clothing. This behavior must also be initiated by the infant; and (3) instances when the infant sucks on or brings to his/her mouth the mother’s hand or finger. There must be skin contact but this self-comforting behavior is scored regardless of who initiated the contact.

2. **Self-Clasp (Isc h):** The infant’s two hands are touching. Score if the hands are clearly clasped together. Score also when the hands/fingers are only lightly touching. Do not score if the place of contact is on the wrists or arms. Only hand-to-hand contact is scored as a self-clasp.

Distancing (Idis): The infant attempts to increase his/her physical distance from the caregiver without engaging an object. Distancing includes: (1) instances when the infant tries to get away by turning and twisting away from the caregiver. The infant’s shoulders and trunk are rotated sideways (the shoulders and trunk need not be completely rotated but some rotation must be evident) and the infant’s head is averted sideways, or up and away from the adult. The arms are usually, but not always raised above or at the level of his/her head. The back is typically, but not always arched. Do not score infants who have this constellation of behaviors but are trying to get a better look at an object; and (2) instances when the infant’s shoulders are pushed back against the chair and the torso is thrust forward and up. There is no shoulder or trunk rotation. The infant’s arms are usually down by the infant’s sides but are occasionally raised. The infant typically looks at the adult but head and gaze are sometimes averted.

Infant Autonomic Stress Indicators (Iaut): The infant exhibits behaviors, which may indicate stress or autonomic arousal such as spitting up or hiccupping. Drooling should not be coded as spitting up. The infant’s spit up should have consistency and be white or milky.

CAREGIVER

Rough Touches (tch)

Code only touches that are sharp and abrupt in nature. Ignore all other touches.

(Ctch): The caregiver's touches are abrupt, forceful, and sharp. Examples include pokes and jabs to the infant's face or head that result in the infant's head moving. Code all instances of rough touches separately even if they occur in rapid succession.

Violations (Cxst): This code is typically used during the still-face. During the still-face, the code indicates that the caregiver violated the still-face by touching or talking to the baby. Violations that involve facial expressions are not coded as Cxst but are coded with the caregiver engagement phases (If there is no violation, phase 5 will be coded).
Also code Cxst, if the mother violates the protocol during any episode by for example using a pacifier, bottle or toy. Keep in mind that only the introduction of objects not inherent to the face-to-face setting constitutes a violation. Thus, if the baby is wearing a bib and the mother plays with it, if the mother takes the baby's shoe off and plays with it, or if the mother takes her watch off and uses it as an object/toy, these instances are not considered violations. These objects are all inherent to the setting or part of the baby's/mother's clothing. The mother is being creative but is not directly violating the rules of the face-to-face procedure. However, mothers are explicitly told not to use bottles, pacifiers, and toys during the paradigm. The introduction of any of these items should therefore be coded as a violation of the still-face rules.

DYADIC GAZE INFORMATION

Dyadic Eye-Contact (dec): infant and caregiver are coordinating their gaze by looking at each other's face

Joint Activity/Looking (jal): infant and caregiver are jointly attending to the same object. The infant and the mother are coordinating their gaze but are not looking at each other. The infant must be looking at the object; while the caregiver's gaze may shift from infant to object. Objects may be the caregiver's hand (e.g. butterfly hands, Itsy Bitsy Spider), a toy held by the mother, or an infant body part (e.g. they are both attending to the infants foot because the mother is playing "Piggy goes to market") and the game is not a facial interplay game (e.g., peek-a-boo), but one in which the hands are equivalent to an object. While this code requires a mutual interaction, it captures the infant's perspective of a social interaction with the caregiver via an object. The infant can display any facial expression.

Appendix C

Study protocol of the COMPARE-Interaction Study

Open access Protocol

BMJ Open

Study protocol of the COMPARE-Interaction study: the impact of maternal comorbid depression and anxiety disorders in the peripartum period on child development

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ABSTRACT

Introduction To date, there are only few studies that compare the consequences of peripartum maternal depressive disorders (PD) versus depressive with comorbid anxiety disorders (PDCA) for infant and child development. As comorbidity is associated with greater impairment and symptom severity related to the primary diagnosis, comorbidity in mothers might raise their offspring's risk of developing internalising or externalising disorders even more than has been noted in conjunction with PD alone.

Methods and analysis This study aims to analyse the impact of parental psychopathology, particularly peripartum depression in mothers with and without comorbid anxiety disorders according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) on child cognitive and socioemotional development. Maternal/paternal psychopathology, mother–infant/father–infant interaction and child development are assessed at four measurement points over the first 2 years (T1: 3–4 months postpartum, T2: 12 months postpartum, T3: 18 months postpartum and T4: 24 months postpartum). The mediating role of mother–infant/father–infant interaction and infant stress reactivity in the relationship between PD/PDCA and infant cognitive and socioemotional development will be analysed. In the ongoing study, 174 families (n=58 mothers with PD, n=58 mothers with PDCA and n=58 healthy controls) will be recruited in inpatient and outpatient centres as well as maternity hospitals in Munich and Heidelberg.

Ethics and dissemination This study is implemented in accordance with the current guidelines of the World Medical Association (revised Declaration of Helsinki) and the General Data Protection Regulation of the European Union. The study procedures were approved by the independent ethics committees of the Department of Psychology, Ludwig-Maximilians-University Munich (74_Reck_b) and of the Medical Faculty, University Heidelberg (S-446/2017). Participation is voluntary. A signed written informed consent form must be obtained from each study subject prior to any study-specific procedure. Participants can withdraw from the study at any point in time without giving a reason or being subjected to any future disadvantages. In case of withdrawal from the study, the subject's data and material will be kept unless the participant asks for data removal. Results will be published and disseminated to further the discussion on the effects of maternal PD and PDCA on parent–infant interaction, infant stress reactivity and child development. Furthermore, study results will be presented at international congresses and expert conferences.

Strengths and limitations of this study

- The proposed method is longitudinal and multi-methodological, using behavioural, hormonal, developmental and clinical psychological measures from 3 to 24 months postpartum.
- The mediation analysis allows for a detailed examination of the quality of mother- and father-child-interaction and psychobiological variables contributing to the effect of maternal psychopathology on child development.
- Even though sample size is adequate for the proposed statistical analyses, the number of participants is limited due to the investigation of a clinical sample and does not allow to draw inferential conclusions about specific effects of individual anxiety disorders (and comorbid depression) on child development.

INTRODUCTION

Peripartum depressive disorders (PD) and comorbid anxiety disorders (PDCA)

Peripartum depressive disorders (PD), showing prevalence rates of 6.1% considering the postpartum and 11.9% considering the peripartum period,[1] and peripartum anxiety disorders (PA) with prevalence rates between 11.1% and 17.9% considering the postpartum period[2 3] are among the most frequent psychological disorders occurring around the time of childbirth. These disorders often coincide in around 50% of women, and the presence of a comorbidity can be considered as a marker of severity.[4] The long-term adverse consequences for infant and child development are well documented in the literature.[5–7] Regarding child socio-emotional development, the risk for transmitting depression[8 9] seems to be highest when both parents are affected (being up to four times higher).[10] The risk is lower if only the mother suffers from depression and is lowest if only the father is affected.[11 12] This familial transmission has also been reported in association with anxiety disorders:[13] The offspring's risk to develop an anxiety disorder is two to nine times higher.[14] However, no research has yet addressed the impact and intergenerational transmission rates of peripartum depression with comorbid anxiety disorders (PDCA).

Impact of maternal psychopathology on infants' cognitive and social-emotional development

There is ample evidence of a long-lasting negative impact of PD on cognitive development,[15] verbal abilities,[16] executive functioning and memory capacity.[17] Likewise, PD has been related to reduced socioemotional functioning and social-cognitive abilities in young children. For example, children of depressed mothers have been documented demonstrating less empathic concern towards others in distress,[18] as well as less self-regulatory behaviour and more negative emotionality.[19] However, there are studies that identified no effect of PD on children's caring behaviour.[20] Regarding PA, longitudinal studies also refer to adverse effects on cognitive child development, partially up to adolescence.[21 22] However, the impact of PDCA has not been adequately investigated to date.

Recent research on typical development has advanced our understanding of the predictive power of early socio-emotional as well as cognitive development for the child's later social and cognitive functioning.[23 24] There has been little research on specific impairments stemming from maternal depression and anxiety disorders on the child's conceptual understanding of the mind and their potentially long-lasting effects on child social and cognitive functioning; the findings so far have been inconsistent.[25 26]

Studies reveal gender differences in the development of children whose mothers suffer from psychiatric disorders: the boys of mothers with depression seem to be particularly vulnerable to externalising behaviour problems, whereas higher rates of internalising symptoms have been reported in girls.[6 27] Furthermore, studies show that male children of depressed mothers are more impaired in their social and cognitive development than female children.[27 28] Adverse developmental pathways, especially for cognitive development, have also been reported in male children of mothers with anxiety disorders.[22] Nevertheless, the available studies are heterogeneous, and some studies detected no gender effects.[17]

Of particular importance seems to be evidence that the remission of psychiatric symptoms does not necessarily lead to an improvement in the quality of the mother–child relationship and interaction, and therefore, even remitted and lifetime diagnoses may exert negative long-term influence on child development.[29 30]

Mediational relationship between maternal psychopathology and infant development

Research about risk factors for child development lead to the assumption that infant and child developmental outcomes do not solely depend on maternal psychiatric disorders but rather that the quality of mother–child interaction is an important pathway for the intergenerational transmission of psychopathology.[31 32] The interactive behaviour of depressed mothers is often characterised by a lack of sensitivity and responsiveness, passive or intrusive behaviour, a more negative and flat affect and withdrawn behaviour.[33 34] Comorbid depressed and anxious mothers have revealed similar results, but empirical data are rather sparse.[35] Regarding peripartum anxiety disorders (PA), mother–infant interactive behaviour studies also display heterogeneity: some suggest less sensitive and warm maternal interaction,[19 36] while others do not.[5] Results of our own group with a sample of postpartum anxious mothers and their infants suggest links between maternal prepartum stress, infant stress reactivity and affect regulation during mother–child interaction up to preschool age.[37 38] It remains unclear whether these inconsistent results are due to different methodology and methodological problems (heterogeneous diagnoses within the anxious groups, varying questionnaires or interview data).

Empirical findings from several studies have highlighted the importance of specific patterns of parent–infant interaction for infants' affect regulation during the first 6 months.[39 40] Infants have a repertoire of self-regulatory behaviours believed to pacify their stressful experiences, but it is assumed that these behaviours do not fully suffice to handle distress.[38 41] Self-regulation in infancy includes the capacity to maintain positive states as well as manage distress and negative states.[42] Caregivers are thought to play an important role in the development of stress regulation in infants. If the caregiver cannot (or does not) respond adequately to the child's emotion and interpersonal regulation failures, infants engage in self-directed stress regulation and develop less tolerance to negative affect and lower stress regulation competence.[43 44]

The hypothalamic–pituitary–adrenocortical (HPA) axis is one major regulating system to cope with stress on hormonal level. Its end product cortisol is intensively discussed as a key molecule in underlying mechanism accounting for the association between maternal stress and psychopathology during pregnancy and infant as well as child development. Research indicates that elevated maternal cortisol levels in response to stress may affect the offspring's HPA axis functioning. Consequences might be increased cortisol levels and increased cortisol reactivity[45] and, in the long run, an increased risk for developmental problems in the offspring.[46] Regarding infant stress reactivity and daytime cortisol during the first 18 months of life, infants of mothers with PDCA revealed relatively higher cortisol levels from morning to bedtime, higher bedtime values and heightened cortisol reactivity compared with infants of non-depressed mothers and infants of depressed mothers. Furthermore, cortisol's effects on infant development are moderated by the autonomic nervous system, with alpha-amylase as a key indicator of autonomic stress regulation.[47 48]

The role fathers play in child development during the peripartum period and early infancy in families with mothers suffering from PD and PDCA has not yet been examined. Our project offers a unique opportunity for further investigation. Sensitive fathers can be regarded as a protective factor for child development, a factor demonstrated in population-based and high-risk samples.[49] However, if they are insensitive and unresponsive, for example, due to psychiatric symptoms, fathers might also be a risk factor for child development, with long-term negative consequences especially for socioemotional development.[50 51]

To sum up, the negative impact of PD on infant socioemotional and cognitive development is well documented in the literature. To date, there are no studies comparing mothers with PD alone to mothers with PDCA. As comorbidity goes along with greater impairment and symptom severity related to the primary diagnosis, comorbidity in mothers might raise their offspring's risk of developing internalising disorders even more than has been noted in conjunction with PD alone. This study is designed to assess mothers with PD and PDCA according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), fathers and their infants, as well as a healthy control group (CG) at four measurement times (see figure 1). The study will be run in Munich and Heidelberg. Given the high prevalence of PD and PA and the increased risk for children of depressed and anxious mothers to having adverse developmental problems, further research in this field is urgently needed.

The planned trial

The following relations will be investigated in this observational longitudinal study.

1. We hypothesise that the degree of maternal disorder severity correlates with greater impairment in infant development at 12, 18 and 24 months.
2. We hypothesise that both, mother–infant/father–infant interaction and infant stress reactivity at 12 months of infant age, mediate the relationship between the maternal disorder severity at 3–4 months postpartum and infant socioemotional as well as cognitive development at 24 months of age. Thus, we will analyse a mediating effect of mother–infant/father–infant interaction and infant stress reactivity on infant cognitive and socioemotional development in the context of maternal disorder severity.

Moreover, research shows that patterns of couple interaction are predictive for later parent–child interaction.[52] Therefore, additional dyadic analyses will include couple interaction, the couples' heart rate variability (HRV) and the couples' cortisol reactivity during an instructed conflict discussion in the laboratory at the infants' age of 3–4 months. It is assumed that the parents' individual and couple-based stress responses during couple interactions in the child's early life serve as possible mediators for the relationship between maternal PD and PDA and child development. In the current study, neuroendocrine and psychobiological mediators of this relationship will be captured during instructed real-time interactions. Furthermore, maternal blood samples are taken to examine the endogenous oxytocin level, gonadal hormones and epigenetic parameters of the oxytocin gene and oxytocin receptor gene. Additional analyses will further address the relation between maternal psychopathology, parent–infant interaction and HRV of mother/father and child during dyadic interaction at 3–4, 12 and 24 months. We will focus on the analysis of the synchrony between cortisol reactivity, HRV during dyadic interaction and interactional behavioural patterns. These analyses will be conducted in an exploratory manner to generate hypotheses for future research.

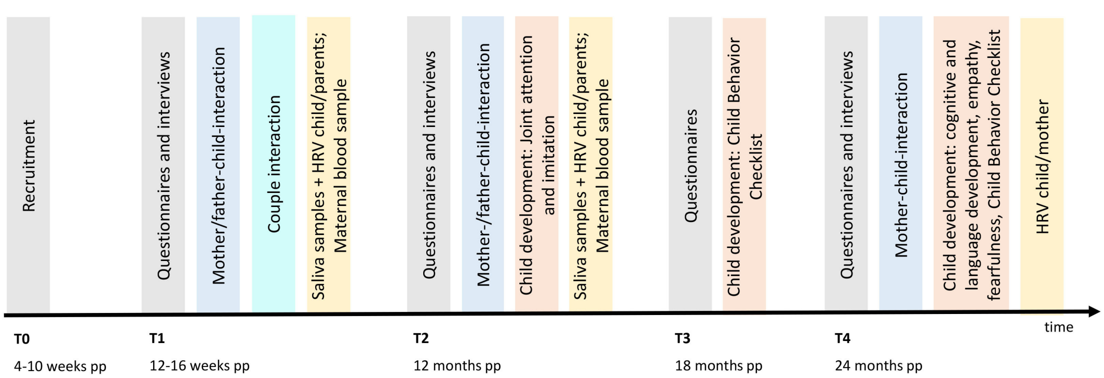

Figure 1 Overview of study design. HRV, heart rate variability.

In summary, this study will address the influence of maternal PD and PDCA on infant and child development with a special focus on the mediating effects of parent–infant interaction and infant stress reactivity. Our findings will contribute to better understand the underlying mediating effects, which may help to further improve prevention and intervention approaches.

METHODS AND ANALYSIS

Design overview

In order to investigate the previously mentioned points 1 and 2, an observational longitudinal study will be implemented. As the two clinical groups ((1) PDCA and (2) PD)) and the CG are formed based on the mother's mental health status, our study design can be characterised as a natural experiment. The three groups will be accompanied throughout the infants' first 2 years of life and to be more precise throughout four different measurement points at the infants' age of 3–4 (T1), 12 (T2), 18 (T3) and 24 (T4) months. See figure 1 for an overview (figure 1).

Our primary outcome measures include infant socio-emotional development, more specifically internalising and externalising behaviour problems assessed with the Child Behavior Checklist (CBCL),[53] and cognitive development assessed with the cognitive scale of the Bayley's Infant Development Scale III[54] at 24 months postpartum. Maternal interaction quality 12 months postpartum, more precisely maternal sensitivity coded via the Coding Interactive Behavior, as well as infant-cortisol reactivity at 12 months of age are considered as primary mediators.

In the exploratory analyses, infant gender is considered as a moderator for the interactive mediational path,[55] while for the mediation by infant stress reactivity, infant gender[56] and alpha-amylase[47] are considered as moderators.

Our secondary outcome measures are imitation and joint attention at 12 months as well as empathy, language development and child fearfulness at 24 months. Secondary mediators are further interactional qualities (eg, exploration, intrusiveness and limit setting) as well as father–infant interaction (eg, sensitivity, exploration, intrusiveness and limit setting).

Participant eligibility and recruitment

Eligible participants

Clinical groups: subjects need to fulfil the DSM-5 criteria for a PD or for a PDCA, meaning the DSM-5 criteria have to be fulfilled at a time from the beginning of the pregnancy until the end of the fourth month postpartum.

Controls need to have no current or lifetime diagnosis and should not have received psychotherapy or more than seven therapeutic counselling sessions at any time in their life. Seven sessions represented the maximum length of diagnostics for psychotherapy in the German healthcare system.

Exclusion criteria for all groups

Mothers: acute suicidality, current or lifetime diagnosis of psychosis and bipolar disorder (one psychotic episode during the puerperium is not an exclusion criterion); diagnosed substance use disorder since they have become aware of their pregnancy

Infants: preterm birth defined as gestational age at birth of less than 36 weeks and 1 day; multiple birth infants; less than seven points in any of the three APGAR scores (1, 5 and 10 min after birth); and confirmed physical or developmental disorders, which make participation impossible or unwise.

Participant recruitment

Participants will be recruited both online and by flyers disseminated through midwives, gynaecologists, paediatricians, in pharmacies and in maternity hospitals as well as mothering forums or self-help groups (eg, 'Shadow and Light') and registration offices in Munich and Heidelberg. They receive thorough information about the study procedures both orally and in written form. We estimate that 1.447 mothers per year can be asked to participate in our study (considering an annual birth rate of 15.000 infants in Munich and 4.300 in Heidelberg/Mannheim, a prevalence rate of 6% for PD and 11% for PA and an estimated rate of 50% of mothers seeking help). In order to avoid high rates of non-participations due to feelings of self-blame, which is often recognised in PD,[57] the recruitment material and procedure is designed and conducted cautiously and empathetically.

The COMPARE study started in January 2018, but recruitment for the first test interval T1 has not been completed yet. A percentage of 64.4 of the required participants (112 of 174) have been recruited so far. The fourth test interval T4 started in March 2020. The total assessment status of the longitudinal study can, therefore, be described as less than half of the procedure. Additionally, since March 2020, recruitment and assessment have been partly delayed by the coronavirus pandemic.

Participant and public involvement

Participants or the public were not involved in the design or implementation of this study. The results will not be disseminated to the participants directly, but the anonymised data will be openly accessible in the Open Science Framework.

Screening assessment and group allocation

Screening assessment

Participants will take part in a screening procedure via a phone interview prior to inclusion.

Group formation procedure

According to our natural experimental design, the formation of the three groups: PD, PDCA and CG is based on the outcome of the clinical interview (DSM-5) conducted at T1.

Power analysis and size estimation

Sample size was estimated for the regression-based mediation model (see point 2 of 'The Planned Trial') with MedPow.R using 'R' (V.3.3.2)[58] with 'R-Studio' (V.1.0.44). Therefore, a c' path with a direct effect of 0.00 was scheduled. As we assume to find effects of medium size,[59] we concluded an effect of r=0.30 for paths a and b. As two models will be calculated (one for socioemotional development and one for cognitive development), we considered a Bonferroni-adjusted two-sided α-error of 0.025. We aim to achieve a power of 1-β=0.80. We thus estimate the study sample size to include 135 subjects. As the actual mediation model contains two mediators, the pursued number of cases presents a minimum of the necessary study sample size. Furthermore, we anticipate a conventional study drop-out rate of 20%. Thus, overall, 174 mother–infant dyads will have to be recruited (thus, n=58 per subgroups and n=87 per study centre in Heidelberg and Munich).

Experimental procedure at T1, T2, T3 and T4

At measurement point T1 (3–4 months), mothers' and fathers' psychological health will be assessed via the clinical interview for DSM-5.[60 61] Clinical screenings will be repeated at 12 months (T2) and 24 months (T4). In April 2020, we expanded the clinical interviews and screenings by a standardised questionnaire assessing the families' situation during the coronavirus pandemic. Parent–infant interaction at T1 will be measured by the Face-to-Face Still-Face experiment,[62] which will be videotaped. In order to measure the level of cortisol and alpha-amylase, saliva samples of the infants will be taken before and directly after as well as 20 and 30 min after the starting point of the Face-to-Face Still-Face experiment. Additionally, heart rates of the infants and the caregivers will be recorded during dyadic interaction. The couple interaction at T1 will consist of a 15 min conversation about two couple issues chosen by the couple from a standardised list in advance.[63] The parents' saliva will be collected before and directly after as well as 30 and 45 min after the starting point of the couple interaction. Moreover, parental heart rate will be measured during couple interaction. Furthermore, maternal blood samples will be collected at the beginning of the assessment point in order to measure endogenous oxytocin level, gonadal hormones and epigenetic parameters of the oxytocin gene and oxytocin receptor gene. At T2, the parent–infant interaction will be conducted in form of a 13 min free play situation including a 3 min limit setting task. Again, infants' salvia samples will be collected before, directly after as well as 28 and 38 min after the interaction experiment. Moreover, the infants will take part in an imitation[64] and two joint attention tasks.[65 66] Again, maternal blood samples will be collected. At T3 and T4, infant behaviour and development will be measured by the CBCL[53] and the Caregiver-Teacher-Report Form[67] filled out by the parents and an additional caregiver. At T4, an 11 min free play situation including a 1 min frustration task will be conducted. Additionally, infant cognitive and socioemotional development will be assessed. All assessments will be video recorded and coded afterwards. See figure 1 and table 1 for an overview of the study design and the measures for each measurement point. For all measurement points, a time frame for assessment of 4 weeks will be accepted (T1: 3 months and 0 days to 3 months and 30 days; T2–4: 12/18/24 months±14 days).

Detailed description of measures, methods and instruments used

Interactional measures

Parent–infant interaction

Face-To-Face Still-Face paradigm (T1)

At T1, parent–infant interaction will be assessed during the Face-to-Face Still-Face paradigm, a widely used paradigm for evaluating the quality of early parent–infant interaction.[62] It consists of three episodes each lasting 2 min: first, an initial face-to-face interaction in which the mothers/fathers are instructed to play with their infant as usual (without the aid of toys and pacifiers). Next, the still-face episode follows in which the parents have to turn their head aside while silently counting to ten and then turn back to the infant but not engage in any gestures, facial expressions or vocalisations. Finally, the procedure ends with the reunion episode in which the parent is required to resume face-to-face play with the infant.

Free play and limit setting task (T2)

This interactional task consists of three episodes: in episode 1, lasting 5 min, mother/father and child engage in a free play with a given set of toys. In episode 2, the mother/father is asked to take place in a seat in some distance to the child and to focus on a newspaper for 3 min. In episode 3, the mother/father can reunite with the child in a free play lasting 5 min.

Free play and frustration task (T4)

In this interactional paradigm, mother and child engage in a 10 min free play with a given set of toys. After 10 min, they are requested to clean up all toys for 1 min.

Couple interaction

During T1, in order to evaluate the influence of the quality of the parental relationship, couple interaction behaviour will be assessed during a 15 min standard and instructed discussion.[63] As in previous experimental designs,[68–70] the parents are asked to rate the intensity of 23 predetermined areas of couple conflict with regard to their own relationship. They then chose two topics (eg, finances, educational issues and leisure time) of continuing disagreement for the later discussion, which is videotaped and coded for behaviour.

Coding scheme for the interactional paradigms

All interaction sequences (parent–infant/child interaction and couple interaction) will be coded following the coding interactive behaviour manual (CIB) developed by Ruth Feldman. The couple conflict discussion

Table 1 Schedule of measures used in the study

Measures	Citation	T1	T2	T3	T4
Interactional measures					
Mother–infant interaction					
Face-to-Face Still-Face Paradigm	62	×			
Free play+limit setting			×		
Free play+frustration task					×
Father–child interaction					
Face-to-Face Still-Face Paradigm	62	×			
Free play+limit setting			×		
Couple interaction					
Topic suggestions for discussion and follow-up questionnaire	63	×			
Psychobiological measures					
Mother blood sample		×	×		
Parent–child HRV		×	×		×
Couple HRV		×			
Child cortisol and alpha-amylase saliva sample		×	×		
Parental cortisol and alpha-amylase saliva sample		×			
Interviews					
Diagnostic interview for mental disorders according to DSM 5	61	×			
Attachment style interview	75	×			
Questionnaires					
Sociodemographic details		×	×	×	×
Edinburgh Postnatal Depression Scale	84	×	×	×	×
Agoraphobic Cognitions Questionnaire, Body Sensations Questionnaire and Mobility Inventory	85	×	×	×	×
Postpartum Bonding Questionnaire 16R	86	×	×		
Lips Maternal Self-Confidence Scale		×		×	
Partnership Questionnaire	63	×	×		
Social Support Questionnaire	87	×	×	×	
Dyadic Coping Inventory	88	×			×
Remembered parenting behaviours (Fragebogen zum erinnerten elterlichen Erziehungsverhalten)	89	×			
Parental Bonding Instrument	90	×			
Experiences in Close Relationships-Revised	91	×			
Infant Behaviour Questionnaire	92	×			
Personality Inventory for DSM-5 – Brief Form	93	×			
Childhood Trauma Questionnaire	94	×			
Parenting Stress Index	95		×	×	×
Vulnerable Attachment Style Questionnaire	96		×		×
Parenting styles (Erziehungsfragebogen für Eltern)	97				×
Epistemic Trust Questionnaire	98				×
Parental Reflective Functioning Questionnaire	99				×
Child development					
Imitation	64		×		
Joint attention	65 66		×		
Child empathy	78				×

Continued

Table 1 Continued

Measures	Citation	T1	T2	T3	T4
Child fearfulness	79				×
Language assessment (Sprachentwicklungstest für zweijährige Kinder)	77				×
Bayley's Infant Development Scale III	54				×
Child Behaviour Checklist	53			×	×
Caregiver-Teacher Report Form	67			×	×

DSM 5, Diagnostic and Statistical Manual of Mental Disorders; HRV, heart rate variability; T1, first measurement point; T2, second measurement point; T3, third measurement point (online assessment); T4, fourth measurement point.

will also be coded with the CIB, which was extended for couple interaction. The CIB is a widely used, macroanalytic rating system for analysing dyadic interaction. The system uses multiple codes for the infants, parents and dyadic codes that aggregate into meaningful theoretically based constructs (eg, sensitivity, intrusiveness, reciprocity, social engagement and withdrawal). The psychometric characteristics are all well described.[71] Microanalytically, the parent–infant interaction episodes of T1 will be coded with the German translation and revision of the Infant and Caregiver Engagement Phases (ICEP-R).[72] The ICEP-R phases combine information from the face, direction of gaze and vocalisations of the infants and caregivers. We will code the videos using the Mangold Interact coding software with 1 s time intervals.

The interaction sequences will be coded by blind and reliable coders who are independent of the current study; 10%–20% of the videos will be double coded for inter-rater reliability.

Psychobiological measures

Maternal blood samples

Maternal blood samples are taken to examine the endogenous oxytocin level, gonadal hormones and epigenetic parameters of the oxytocin gene and oxytocin receptor gene.

Infant stress reactivity

To determine infant stress reactivity, cortisol and alpha-amylase will be extracted from infant saliva, which will be collected according to standard protocols[73] during all interaction paradigms at T1 and T2. Saliva is collected before (C1) and after (C2) as well as 20 min (C3) and 30 min (C4) after the starting point of the Face-to-Face-Still-Face paradigm at T1, and likewise before and after, as well as 28 and 38 min after the starting point of the interactional paradigms at T2. Following analytic procedures,[74] the area under the curve with respect to increase (AUC_I) will be calculated as an index for infant cortisol reactivity. This measure is the integral of the curve resulting from the four cortisol measures (C1, C2, C3 and C4) and denotes the time distance between measurements, in contrast to statistical tests for repeated measures. AUC_I is calculated with reference to the first value (C1) and therefore measures the change over time.

Parental stress reactivity

As described previously, parental stress reactivity (cortisol and alpha-amylase) will be collected via saliva samples, before, directly, 30 and 40 min after the couple interaction paradigm.

Infants' and caregivers' HRV

As a cardiovascular measure of the emotion regulation capacity, the HRV of the caregiver and infant will be measured during the Face-to-Face-Still-Face paradigm, the limit setting task and the frustration task at T1, T2 and T4. HRV will be conducted with a one-electrode sensor (eMotion Faros 90°, Sampling Rate 250 Hz) and is calculated via R-R intervals (HR/min=60.000 ms/min/R-R intervals per ms). The analysis will be calculated with Kubios HRV (V.2.0) concentrating on respiratory sinus arrhythmia.

Parental HRV

According to the analyses of parent–infant HRV, the parental HRV will be assessed during couple interaction at T1.

Diagnostic measures

Diagnostic Interview for Mental Disorders according to DSM-5 (DIPS-OA)

In this study, participants' mental disorders will be assessed with a structured clinical interview, the Diagnostic Interview for Mental Disorders according to DSM 5 (DIPS-OA).[60 61] It assesses lifetime, as well as current and past diagnoses. All clinical assessments will be conducted by trained and experienced psychologists.

Attachment Style Interview (ASI)

This semistructured interview focuses on current behaviour and attitudes to assess adult attachment, including secure, anxious (enmeshed or fearful) and avoidant (angry-dismissive or withdrawn) attachment styles. Dual/disorganised attachment style is characterised by a 'double' classification of style, occurring when no clear attachment pattern can be recognised. In order to assure the quality of the ratings, 10%–20% randomly selected tapes will be double coded by two independent study coders.[75]

Infant and child development

Cognitive development

Cognitive development will be assessed at T4 using the cognitive scale of the Bayley Scales of Infant Development- III.[54] The Bayley Scales allow for the assessment of infants' and toddlers' development between 1 and 42 months of age. The Bayley-III indices and subscales demonstrate good internal consistency and good split-half consistency according to the Spearman-Brown formula.[76] Regarding construct validity, confirmatory factor analysis of the subtests of the cognitive, language, and motor scales supported a three-factor model across all ages. The Bayley-III scales have been normed for German infants and children.[54]

Language abilities

For the assessment of language abilities (verbal understanding and language production), we will administer a standardised German language test for children aged 2 years (Sprachentwicklungstest, SETK-2).[77] The duration of use is about 15–20 min. It has been found to have a (mostly) high validity and reliability (with Cronbach's alpha between 0.56 and 0.95 for the four subscales).

Cognitive and socioemotional development: joint attention, imitation, child fearfulness and empathy

At the age of 12 months, we will assess gaze and point following,[65] declarative and imperative point production and understanding,[66] and imitation of object-related and intransitive action skills as predictors of later sociocognitive development.[64] This will be expanded on at 24 months by an assessment of empathy as a milestone of constructive social behaviour[78] and of child fearfulness (spider task).[79]

Socioemotional development: CBCL/Caregiver Teacher Report Form

At T3 and T4, parents and additional caregivers will rate the children's socioemotional development by filling out the Child Behaviour Checklist/Caregiver Teacher Report Form.[53 67] These measures assess internalising and externalising behaviour problems in children (0=absent, 1=occurs sometimes, 2=occurs often). Internalising behaviour includes emotional reactive behaviour, anxious/depressive symptoms, somatic complaints and withdrawn behaviour, whereas attention deficits and aggressive behaviour are characteristics for externalising behaviour. In both questionnaires, higher scores indicate more problematic child behaviour. T-scores above 60 can be seen as clinically relevant. Psychometric properties are described as satisfying.

Data analysis plan

Statistical analyses will be conducted using the Statistical Package for Social Sciences (IBM SPSS current V.27.0.0.0) and R (current V.4.0.1).[58] We will carry out conditional process analyses using the SPSS-Macro 'PROCESS' (current V.3.5).[80] We will analyse the model depicted in figure 2. The SEs and CIs of the indirect (mediated) effects will be bootstrapped and bias corrected (n=5000 samples). Variables will be mean centred. Estimates will be tested two tailed (critical α=0.025; Bonferroni adjusted for two primary outcomes of child development). According to our hypotheses, a significant initial direct pathway e of our conditional process analyses will reflect the association between maternal disorder severity, which will be coded by the ordinal variable in the following order: CG: 0, PD: 1 and PDCA: 2, and child development, that is, the higher the ordinal coded variable, the more impaired child development (hypothesis 1). Concerning the parallel mediators, we expect significant indirect pathways a*b and c*d, that is, the higher the ordinal coded variable, the lower the maternal sensitivity/the higher the infant cortisol reactivity, the more impaired child development (hypothesis 2). Mediators will be allowed to correlate in our analyses. Moreover, the differences between the groups will be explored by applying one-factorial (multivariate) analyses of variance (MANOVA and ANOVA).

All metric variables will be preliminarily analysed for normal distribution (Kolmogorov-Smirnov and Shapiro-Wilk tests), linearity (scatterplots), homoscedasticity (scatterplots) and independence (Durbin-Watson coefficient). The unit of analyses is the caregiver-infant dyad.

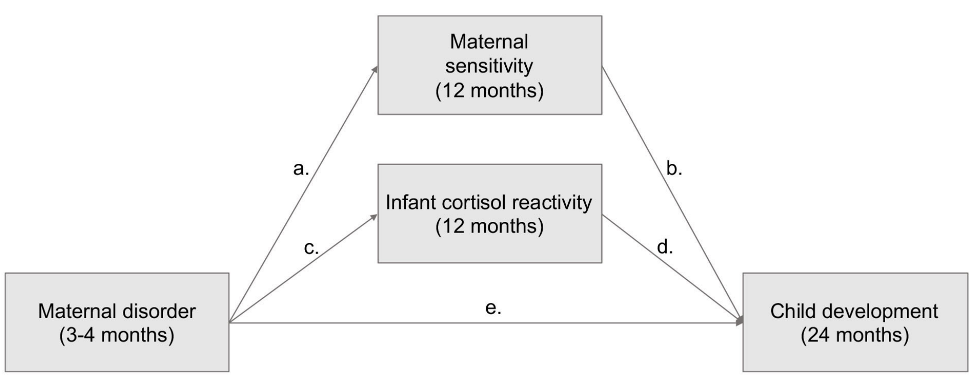

Figure 2 Mediation model.

In case of missing values and incomplete cases, we will determine whether the missing completely at random (MCAR) condition is fulfilled by using Little's MCAR test.[81] If non-significant, missing values are unlikely to depend on third variables and will be estimated using multiple imputations[82] according to standard practice.[83]

DISCUSSION

PDCA and PD may influence infant and child cognitive and socioemotional development. The quality of caregiver–infant interaction is said to play a crucial role in this transmission process. To our best knowledge, our study is the first one to address the impact of PDCA and PD on child development on a behavioural, hormonal, developmental and clinical psychological level in a longitudinal design. Our multimethodological approach casts a wide net of possible linkages that allow broad and comprehensive analyses in an exploratory manner. A focus, however, will be laid on the effects of PDCA and PD on children's internalising and externalising behaviour problems as well as on their cognitive development at 24 months postpartum. In this context, we focus on the mediating role of maternal sensitivity and infant-cortisol reactivity at 12 months of age. The identification of specific behavioural and psychobiological patterns might further inform prevention and intervention approaches. A unique strength of our study is the inclusion of fathers, allowing to view families from an overall perspective and to examine their role as a possible buffer in the family system. An acknowledged study limitation can be seen in the number of participants that represents an adequate sample size for our proposed statistical analyses is too small, though, to draw differential conclusions about individual anxiety disorders.

ETHICS AND DISSEMINATION

Ethics, consent to participate and dissemination

This study is implemented in accordance with the current guidelines of the World Medical Association (revised Declaration of Helsinki) and the General Data Protection Regulation of the European Union (EU-GDPR). The study procedures were approved by the independent ethics committees of the Department of Psychology, Ludwig-Maximilians-University Munich (74_Reck_b) and of the Medical Faculty, University Heidelberg (S-446/2017). Participation is voluntary. A signed written informed consent form must be obtained from each study subject prior to any study-specific procedure. Participants can withdraw from the study at any point in time without giving a reason or being subjected to any future disadvantages. In case of withdrawal from the study, the subject's data and material will be kept unless the participant asks for data removal.

Results will be internationally published and disseminated to further the discussion on the effects of maternal PD and PDCA on parent–infant interaction, infant stress reactivity and child development. Furthermore, study results will be presented at international congresses and expert conferences.

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