



Universidade do Minho
Escola de Psicologia

Tiago Miguel Pires Pinto

**Mother and father's perinatal mental health,
family processes, and infant development**

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family processes, and infant development**

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Professora Doutora Bárbara Figueiredo

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I hereby declare having conducted my dissertation with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

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SAÚDE MENTAL PERINATAL DA MÃE E DO PAI, PROCESSOS DA FAMÍLIA, E DESENVOLVIMENTO DO BEBÉ

Resumo

Com vista a contribuir para a literatura sobre a saúde mental perinatal, os processos da família e o desenvolvimento do bebé, a presente tese tem dois objetivos principais. O objetivo principal 1 foi analisar o impacto dos sintomas de depressão pré-natal da mãe e da coparentalidade na autorregulação do bebé, considerando o papel da variabilidade cardíaca fetal no impacto dos sintomas de depressão pré-natal da mãe e da coparentalidade na autorregulação do bebé. Considerando a adversidade associada à pandemia de COVID-19, o objetivo principal 2 foi analisar o impacto da pandemia de COVID-19 na saúde mental pós-natal da mãe e do pai, na relação conjugal, e na autorregulação do bebé. A presente tese compõe sete artigos interrelacionados. Inclui uma coorte de mães, pais, e bebés avaliados desde o início da gravidez até seis meses pós-parto, com um grupo avaliado antes e outro avaliado durante a pandemia de COVID-19. Os resultados do objetivo principal 1 revelaram que (1) a coparentalidade negativa às duas semanas pós-parto acentuou o impacto dos sintomas de depressão pré-natal da mãe na autorregulação do bebé aos três meses; (2) a variabilidade cardíaca fetal mostrou-se preditor e um mediador do impacto dos sintomas de depressão pré-natal da mãe na autorregulação do bebé aos três meses; e (3) os bebés com baixa variabilidade cardíaca fetal apresentaram maior autorregulação quando mães ou pais reportaram menos coparentalidade negativa, mas menor autorregulação quando mães ou pais reportaram mais coparentalidade negativa. Os resultados do objetivo principal 2 revelaram que (1) as mães e pais a enfrentar a pandemia de COVID-19 reportaram mais sintomas depressivos e mais interações conjugais negativas aos seis meses pós-parto, e os seus bebés apresentaram menor autorregulação aos seis meses, quando comparados com mães, pais, e bebés que não enfrentaram a pandemia de COVID-19; (2) a interação conjugal positiva prévia associou-se a menos sintomas depressivos pós-parto apenas nas mães e pais a enfrentar a pandemia de COVID-19; e (3) o impacto da coparentalidade positiva prévia na autorregulação mostrou-se maior nos bebés a enfrentar a pandemia de COVID-19, do que nos bebés que não enfrentaram a pandemia de COVID-19. Os resultados foram discutidos e enquadrados concetualmente, considerando os seus contributos para a literatura sobre a saúde mental perinatal da mãe e do pai, os processos da família e o desenvolvimento do bebé.

Palavras-chaves: sintomas de depressão e ansiedade; coparentalidade e relação conjugal; variabilidade cardíaca fetal; autorregulação do bebé; pandemia de COVID-19.

MOTHER AND FATHER'S PERINATAL MENTAL HEALTH, FAMILY PROCESSES, AND INFANT DEVELOPMENT

Abstract

Aiming to contribute to the literature on mother and father's perinatal mental health, family processes, and infant development, the present thesis has two main aims. Main aim 1 was to analyze the impact of mother's prenatal depressive symptoms and coparenting on infant self-regulation, considering the role of fetal heart rate variability in the impact of both mother's prenatal depressive symptoms and coparenting on infant self-regulation. Considering the adversity associated with COVID-19 pandemic, main aim 2 was to analyze the impact of COVID-19 pandemic on mother and father's postnatal mental health, couple's relationship quality, and infant self-regulation. This thesis was comprised by seven interrelated papers. It includes a cohort of mothers, fathers, and infants assessed from early pregnancy to six months postpartum, with one group assessed before and another assessed during COVID-19 pandemic. Findings from main aim 1 revealed that (1) negative coparenting at two weeks postpartum accentuated the negative impact of mother's prenatal depressive symptoms on infant self-regulation at three months; (2) fetal heart rate variability predicted infant self-regulation and mediated the negative impact of mother's prenatal depressive symptoms on infant self-regulation at three months; and (3) infants with low fetal heart rate variability presented higher self-regulation when mothers or fathers reported less negative coparenting, while lower self-regulation when mothers or fathers reported more negative coparenting, than infants with high fetal heart rate variability. Findings from main aim 2 revealed that (1) mothers and fathers facing COVID-19 pandemic reported more depressive symptoms and more couple's negative interactions at six months postpartum, and their infants presented less self-regulation at six months, when compared with mothers, fathers, and infants that not faced COVID-19 pandemic; (2) previous couple's positive interaction was associated with less postpartum depressive symptoms only in mothers and fathers facing COVID-19 pandemic; and (3) the impact of previous positive coparenting on self-regulation was higher in infants facing COVID-19 pandemic, than in infants that not faced COVID-19 pandemic. Findings were discussed and conceptually framed considering their contributes to the literature on mother and father's perinatal mental health, family processes, and infant development.

Keywords: depressive and anxiety symptoms; coparenting and couple's relationship; fetal heart rate variability; infant self-regulation; COVID-19 pandemic.

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ABBREVIATIONS

2019 coronavirus disease – COVID-19

ANS - Autonomic nervous system

ASQ:SE - Ages and Stages Questionnaire: Social Emotional

BSID-II - Bayley Scales of Infant Development – II

CRS - Coparenting Relationship Scale

CTG - Cardiotocography examination

DOHAD - Developmental origins of health and disease

DST - Differential susceptibility theory

EPDS - Edinburgh Postnatal Depression Scale

FFSF - Face-to-Face Still-Face paradigm

FHRV – Fetal heart rate variability

HPA - Hypothalamic-pituitary-adrenal

IBQ-R - Infant Behavior Questionnaire - Revised short form

MANOVA - Multivariate Analysis of Variance

NBAS - Neonatal Behavior Assessment Scale

NNS - Neonatal Intensive Care Unit Network Neurobehavioral Scale

PNS - Parasympathetic nervous system

PRISMA - Preferred Reporting Items for Systematic Reviews and Meta-Analysis

RQ - Relationship Questionnaire

RSA – Respiratory sinus arrhythmia

SNS - Sympathetic nervous system

STAI-S - State-Trait Anxiety Inventory – state

WHO - World Health Organization

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PUBLICATIONS OF THE DISSERTATION

This doctoral thesis was based on the following original publications:

- I. Pinto, T. M., & Figueiredo, B. (under review). Measures of infant self-regulation during the first year of life: a systematic review. *International Journal of Behavioral Development*.
- II. Pinto, T. M., Feinberg, M. E., & Figueiredo, B. (under review). Coparenting quality moderates the impact of mother's prenatal depressive symptoms on infant self-regulation. *Development and Psychopathology*.
- III. Pinto, T. M., Nogueira-Silva, C., & Figueiredo, B. (under review). Fetal heart rate variability and infant self-regulation. *Developmental Psychology*.
- IV. Pinto, T. M., & Figueiredo, B. (under review). Differential impact of negative coparenting on infant self-regulation: the role of fetal heart rate variability. *Journal of Child Psychiatry and Psychology*.
- V. Pinto, T. M., & Figueiredo, B. (accepted with major revisions). The impact of COVID-19 pandemic on mother and father's postpartum depressive symptoms and negative couple interactions. *Families, Systems, & Health*.
- VI. Pinto, T. M., Mesquita, S., & Figueiredo, B. (under review). The protective impact of previous couple's positive interaction on the perinatal mental health of mothers and fathers facing COVID-19 pandemic. *Psychological Science*.
- VII. Pinto, T. M., & Figueiredo, B. (under review). Positive coparenting can buffer self-regulation problems in infants facing COVID-19 pandemic. *Infant Mental Health Journal*.

INTRODUCTION

The introduction section of this doctoral thesis aims to provide an overview of mother and father's perinatal mental health, family processes, and infant development during the first year of life. The first part of the introduction section comprises an overview of the literature on (1.1) mother and father's perinatal mental health, and (1.2) family processes. It also comprises an overview of the (1.3) concept of infant self-regulation as a major dimension of infant development during the first year of life, with several implications for further development. Additionally, this part provides an in-depth overview of the literature regarding the impact of perinatal mental health and family processes on infant development, namely on the impact of (1.4) mother's prenatal depression and (1.5) coparenting on infant self-regulation. The literature on the possible role of fetal heart rate variability (FHRV) in the impact of both (1.6) mother's prenatal depression and (1.7) coparenting on infant self-regulation is also presented.

Considering the adversity associated with the 2019 coronavirus disease (COVID-19) pandemic, the second part of the introduction section is dedicated to the literature on the impact of COVID-19 pandemic on the mother and father's perinatal mental health, family processes, and infant development. This section provides an in-depth overview of COVID-19 pandemic as a major adverse condition, and its impact on mother and father's postnatal depressive symptoms, couple's relationship quality, and infant development. A literature review is presented regarding the studies on (2.2) the impact of COVID-19 pandemic on perinatal mental health and couple's relationship quality, and on (2.3) the infant development; as well as on (2.4) the protective and risk impact of couple's relationship quality on the perinatal mental health of mothers and fathers facing adverse conditions; and (2.5) the impact of coparenting on infant development in the presence of adverse conditions.

The third part of the introduction section provides a description of the aims and hypothesis of the studies comprising the current thesis, considering the pieces of evidence provided by the reviewed literature presented in Part 1 and Part 2 of the introduction section.

Part 1

1.1. Mother and father's perinatal mental health

The transition to parenthood is a major developmental life transition associated with several individual, couple and family adjustments (Cowan & Cowan, 2012; Demick, 2002; Figueiredo et al., 2018). This demanding and stressful transition requires the reorganization of both inner experience and the external behavior, including the reorganization of individual and family roles and relationships (Cigoli & Scabini, 2006; Cowan & Cowan, 2012).

This extremely challenging period increases depressive and anxiety symptoms in mothers and fathers, amplifies differences within the couple, raises marital dissatisfaction (Doss et al., 2009; Figueiredo et al., 2018; Lawrence et al., 2008), and has the potential to place couples at risk for mental health problems (Figueiredo & Conde, 2011a; LeStrat et al., 2011; Underwood et al., 2016). Several studies have been showing that the transition to parenthood is associated with increased depressive and anxiety symptoms both in mothers and fathers (e.g., Don et al., 2014; Figueiredo & Conde, 2011b; Underwood et al., 2016).

Depression and anxiety are two common perinatal mental health problems. Literature provides evidence that depression and anxiety are more prevalent during pregnancy than during the postpartum period, for both mothers and fathers (Cameron et al., 2016; Figueiredo & Conde, 2011a; Leach et al., 2016; Leach et al., 2017; Paulson & Bazemore, 2010). Literature also suggests that depression and anxiety during pregnancy are strong predictors of postpartum depression or anxiety, both in mothers and fathers (Figueiredo et al., 2007; Fisher et al., 2016; Maleki et al., 2018; Martini et al., 2015).

Literature provides evidence that mothers usually report more depression and anxiety than fathers, both during pregnancy and the postpartum period (Figueiredo & Conde, 2011a; Parfitt & Ayers, 2014; Paulson et al., 2016). Period-prevalence on perinatal depression estimates that 5% to 25% of mothers and 2% to 19% of fathers are depressed during pregnancy (Cameron et al., 2016; Paulson & Bazemore, 2010; Shorey et al., 2018; Underwood et al., 2016). Regarding the postpartum period, 4% to 19% of mothers and 0% to 31% of fathers were reported to be depressed (Cameron et al., 2016; Paulson & Bazemore, 2010; Figueiredo & Conde, 2011a; Shorey et al., 2018). Likewise, period-prevalence on perinatal anxiety estimates that 7% to 60% of mothers and 3% to 25% of fathers show high-anxiety during pregnancy (Goodman et al., 2016; Leach et al., 2016; Leach et al., 2017; Rubertsson et al., 2014).

Regarding the postpartum period, 5% to 33% of mothers and 3% to 51% of fathers present high anxiety (Figueiredo & Conde, 2011a; Philpott et al., 2019; Leiferman et al., 2021; Rao et al., 2020).

1.2. Family processes

Couple's relationship and coparenting are two major family processes, highly related with mother and father's perinatal mental health. Although the transition to parenthood has been associated with a deterioration of couple's relationship quality (Doss et al., 2009; Lawrence et al., 2008), previous couple's positive and negative interactions can be, respectively, a protective or a risk factor for mothers and fathers' mental health during pregnancy and the postnatal period (e.g., Don & Mickelson, 2012; Figueiredo et al., 2008; Whisman et al., 2011). A supportive prenatal couple's relationship was associated with higher well-being in mothers during the postnatal period (e.g., Stapleton et al., 2012). Additionally, an adjusted and supportive couple's relationship over the transition to parenthood, with more positive and less negative interactions, was associated with a decrease in emotional distress in mothers and less depressive and anxiety symptoms in mothers and fathers (e.g., Don & Mickelson, 2012; Figueiredo et al., 2008; Whisman et al., 2011). On the other hand, poor prenatal couple's relationship quality (e.g., conflict behavior, low tenderness, and poor communication) was associated with an increase in postnatal depressive symptoms in fathers (e.g., Gawlik et al., 2014). Similarly, prenatal couple's dissatisfaction was associated with an increase in postnatal anxiety symptoms in mothers and fathers (e.g., Don et al., 2014).

Coparenting relationship is progressively developed across the transition to parenthood, but already operative during pregnancy (Altenburger et al., 2014; Favez et al., 2013; Figueiredo, 2014; Van Egeren, 2004), when parents start to develop representations of themselves as coparents (Feinberg, 2003; Pinto & Figueiredo, 2019; Van Egeren, 2003). From this perspective, when partners start to discuss issues related to coparenting (e.g., how will they manage caregiving together), they already have begun a coparenting relationship, long before childbirth (Altenburger et al., 2014; Favez et al., 2013; Van Egeren & Hawkins, 2004).

Coparenting is defined as the reciprocal involvement of both parents in childrearing, including schooling, socialization, responsibilities, and decisions about their children's life. This dyadic relationship refers specifically to the coordination and support that each coparent provides to the other in childcare (Feinberg, 2002). Feinberg (2003) proposed an empirically based coparenting ecological model, conceptualizing coparenting in four interrelated dimensions: (a) the agreement or disagreement on

childrearing issues, (b) the division of labor, (c) the support *versus* undermining for the coparental role, and (d) the joint management of family interactions.

The way that both parents adjust to their new roles as coparents can be influenced by multiple factors. Feinberg's (2003) ecological model suggests that coparenting is shaped by four main factors: (a) individual parental characteristics, (b) child characteristics, (c) interparental relationship, and (d) contextual sources of stress and support. Mother and father's perinatal mental health problems, namely depressive symptoms, were associated with lower levels of coparental cooperation and higher levels of conflict and competition (e.g., Bronte-Tinkew et al., 2009; Pinto et al., 2019; Tissot et al., 2017; Tissot et al., 2019).

1.3. Infant self-regulation

Developing self-regulatory mechanisms is a major developmental task during infancy (Bell & Deater-Deckard, 2007), with a major role in further infant mental health and development (Eisenberg et al., 2004; Perry et al., 2016; Williams et al., 2016). Self-regulation results from the activity of "processes that serve to modulate reactivity" (Rothbart et al., 2011, p. 442), and grants adequate behaviors and appropriate responses to situational demands (van den Bergh & Mennes, 2006). Self-regulating processes vary according to the infant age and reactivity pattern, including orienting, fearful inhibition, angry attack, surgent or extraverted approach, and effort of behavior control, based on the executive attention system (Rothbart et al., 2011). Empirical evidence indicates that several self-regulation processes that are manifested early in infancy occur in a nonconscious and automatic level (Aarts, 2007; Bargh & Morsella, 2008). Infants have the ability to engage in sensorimotor activities and interact with others, and this ability plays a major role in the development of self-control through all life cycle (Crockenberg & Leerkes, 2004; Morales et al., 2005; Rothbart et al., 2011).

Physiological and behavioral states are progressively regulated during the first year of life (Bell & Deater-Deckard, 2007; Calkins, 2009). Infants start first regulating their physiological states which promote their behavioral regulation (Calkins, 2009; Porges, 2007). Vagal inhibition in response to stress and activation during recovery from stress are both associated with effective self-regulatory behaviors, such as higher soothability (e.g., Bazhenova et al., 2001; Ham & Tronick, 2006; Stifter & Corey, 2001), while difficulties in regulating vagal tone during stressful situations are associated with self-regulatory difficulties in later ages (e.g., El-Sheikh et al., 2009; Graziano & Derefinko, 2013). Behaviors manifested during the first 12 months of age, namely self-soothing and orienting, serve self-regulatory functions

(Rothbart et al., 2011; Rothbart et al., 1992). Orienting is an effective way of lowering the expression of negative affect, serving as a major self-regulatory mechanism (Sheese et al., 2009). Infants who can quickly disengage from distressing situations are less susceptible to negative affect and easier to soothe (Crockenberg & Leerkes, 2004; Morales et al., 2005). Infant self-regulation is a resource to promote further development, while self-regulation difficulties predict a variety of adjustment problems, including internalizing and externalizing problems, lower social skills, and disrupted physiological regulation to stress (Eisenberg et al., 2004; Perry et al., 2016; Williams et al., 2016).

1.4. The impact of mother's prenatal depression on infant self-regulation

The “developmental origins of health and disease” (DOHAD) hypothesis highlights the impact of prenatal environment on further infant mental and physical health and disease (Barker et al., 1989; Gluckman & Hanson, 2004). According to this hypothesis, the exposure to an adverse prenatal environment can have developmental programming effects on the fetus, leading to higher vulnerability for poor mental health outcomes across the life span (Monk et al., 2013; Raikkonen et al., 2011). Mother's prenatal mental health problems, and specifically prenatal depression, can negatively influence the intrauterine environment and consequently infant development, namely self-regulation (Monk et al., 2013; Raikkonen et al., 2011; van den Bergh, 2011).

Literature provides evidence of the adverse impact of mother's prenatal depression on infant self-regulation (see Henrichs & van den Bergh, 2015 for a review). Infants of prenatally depressed mothers demonstrate poor regulation of the emotional state, lower autonomic stability, more sleep and feeding problems, and more difficult temperament, such as negative emotionality, irritability, activity problems, and excessive crying (Babineau et al., 2015; Baibazarova et al., 2013; Dias & Figueiredo, 2020; Figueiredo et al., 2017; Martini et al., 2017; van den Berg et al., 2009).

Prenatal depression may alter the embryotic environment, and consequently impact fetal neurodevelopment (Raikkonen et al., 2011; Szpunar & Parry, 2018; van den Bergh, 2011). This may lead to delayed fetal neurobehavioral development (e.g., lower FHRV) and consequently to lower self-regulation in the infant (Davis et al., 2011; Figueiredo et al., 2017).

1.5. The impact of mother's prenatal depression on infant self-regulation: the role of FHRV

Recent literature provides evidence of the mother's prenatal depression adverse impact on FHRV. Fetuses of prenatally depressed mothers were found to show low FHRV, both in rest or in stimulation conditions (Davis et al., 2011; Figueiredo et al., 2017), and greater FHR reactivity to a lab-induced stressor (Monk et al., 2011; Monk et al., 2004).

FHRV is considered a marker of fetal neurobehavioral development that might be associated with later infant self-regulation (DiPietro et al., 2007; DiPietro et al., 2015; Figueiredo et al., 2017). Infants with lower FHRV were found to present lower autonomic stability, higher negative affect, lower orienting regulation, poorer mental development, poorer language development and symbolic play, as well as more behavioral difficulties and fewer prosocial behavior (Bornstein et al., 2002; DiPietro et al., 2007; DiPietro et al., 2018; Figueiredo et al., 2017; Howland et al., 2020; Werner et al., 2007). FHRV might also be considered an early precursor of infant self-regulation, as it may reflect emerging individual differences in the development of the autonomic nervous system (ANS), which is related with the infant capacity for behavioral regulation (Appelhans & Luecken, 2006; DiPietro et al., 2007, DiPietro et al., 2015; Porges, 2007; van den Bergh, 2017).

Literature highlights that the adverse impact of mother's prenatal depression on infant self-regulation may occur through its impact on fetal neurodevelopment (Henrichs & van den Bergh, 2015). An adverse impact of mother's prenatal depression was found on both FHRV and infant self-regulation, although mostly in separate studies (Martini et al., 2017; Monk et al., 2011; van den Berg et al., 2009). A recent longitudinal study proposed FHRV as a mediator of the adverse impact of mother's prenatal depression on neonate's neurobehavioral maturity, specifically on autonomic stability – an indicator of self-regulation (Figueiredo et al., 2017). FHRV is considered a marker of fetal neurobehavioral development associated with infant self-regulation and thus may be an early precursor of the adverse impact of mother's prenatal depressive symptoms on infant self-regulation (Appelhans & Luecken, 2006; DiPietro et al., 2007; DiPietro et al., 2015; van den Bergh, 2017).

1.6. The impact of coparenting on infant self-regulation

Developmental Psychopathology highlights the importance of exploring the environmental mechanisms and processes that impact infant development, namely in the family environment, as well as the contribute of infant's characteristics to explain the differential impact of environment on infant development (Sroufe, 1997; Rutter & Sroufe, 2000). Coparenting - the reciprocal involvement of both parents in childrearing, and specifically the coordination and support that each parent provides to the other in childcare, contributes largely to the family environment (Feinberg, 2002, 2003).

Coparenting has four interrelated dimensions: (a) the agreement or disagreement on childrearing issues, (b) the division of labor, (c) the support versus undermining for the coparental role, and (d) the joint management of family interactions (Feinberg, 2002, 2003). Positive coparenting dimensions (cooperation, support) were found to enhance infant self-regulation, namely self-soothing (e.g., Feinberg et al., 2009). On the other hand, negative coparenting has been found to impact infant development, and specifically self-regulation (e.g., Feinberg et al., 2009; Teubert & Piquart, 2010). Interparental conflict was associated with lower levels of infant self-regulation, such as lower levels of vagal tone (e.g., Busuito & Moore, 2017; Moore, 2010; Porter et al., 2003). Negative coparenting dimensions (conflict, undermining) were also associated with increased risk of emotional and behavioral problems in children (e.g., Lamela et al., 2016; Scrimgeour et al., 2013; Teubert & Piquart, 2010).

Literature provides evidence that coparenting can serve as a development-enhancing or a risk-promoting environment for infant self-regulation (Busuito & Moore, 2017; Feinberg et al., 2009; Teubert & Piquart, 2010). The impact of coparenting on infant self-regulation can be explained through two pathways: infant's experiences of emotional arousal or parents-infant interaction (Busuito & Moore, 2017; Calkins & Hill, 2007; Moore et al., 2009). Positive coparenting may provide repeated experiences of positive emotional arousal to the infant. Additionally, positive coparenting may also improve cohesive, secure, and coordinated parent-infant interaction and co-regulation. In contrast, negative coparenting interactions (e.g., conflict) may expose the infant to repeated experiences of negative emotional arousal. Moreover, negative coparenting may increase disrupted parenting, leading to disrupted parent-infant interaction and co-regulation. Thus, negative coparenting interactions during infancy may increase infant negative emotional arousal, disrupt parenting, undermine cohesive parent-infant interaction, consequently affecting infant self-regulation.

1.7. The impact of coparenting on infant self-regulation: the role of FHRV

Differential susceptibility theory (DST) suggests that some infants are disproportionately susceptible to the impact of either development-enhancing or risk-promoting environments, due to their high neurobiological plasticity (Belsky, 2005; Belsky & Pluess, 2009). Neurobiological plasticity is instantiated in genetic (e.g., short allele of 5-HTTLPR gene), endophenotypic (e.g., vagal reactivity), and phenotypic (e.g., negative affectivity) factors that synergistically operate as susceptibility markers, increasing the impact of environment on infant development (Ellis et al., 2011). DST also suggests that endophenotypic and phenotypic susceptibility markers are programmed in the prenatal environment (Boyce & Ellis, 2005; Hartman & Belsky, 2018; Obradović et al., 2010; Pluess & Belsky, 2011), namely through developmental programming effects of mother's prenatal mental health problems (Barker et al., 1989; Gluckman & Hanson, 2004; Henrichs & Van den Bergh, 2015).

Literature provides evidence that lower FHRV is associated with both mother's prenatal mental health and infant self-regulation problems (Davis et al., 2011; DiPietro et al., 2007; DiPietro et al., 2018; Figueiredo et al., 2017; Howland et al., 2020; Monk et al., 2011). Lower FHRV may be considered a prenatal endophenotypic susceptibility marker associated with lower self-regulation in the infant (DiPietro et al., 2007; DiPietro et al., 2018). FHRV may reflect emerging individual differences in the development of the ANS, related to infant self-regulatory capacity (DiPietro et al., 2007; Porges, 2007; van den Bergh, 2017). Namely, infants with lower FHRV were found to present lower autonomic stability, higher negative affect, and lower orienting regulation (DiPietro et al., 2007; DiPietro et al., 2018; Figueiredo et al., 2017; Howland et al., 2020).

As a development-enhancing or a risk-promoting environment for infant development, positive coparenting can enhance infant self-regulation development, while negative coparenting can increase the risk of self-regulation problems (Busuito & Moore, 2017; Feinberg et al., 2009; Teubert & Pinguart, 2010). Nevertheless, the impact of both positive and negative coparenting on infant self-regulation may be higher in infants with lower FHRV, and so lower FHRV is a prenatal endophenotypic susceptibility marker of infant self-regulation (DiPietro et al., 2007; DiPietro et al., 2018).

Part 2

2.1. COVID-19 pandemic

The COVID-19 pandemic is a major adverse condition, and thus can be a major empirical laboratory to analyze the impact of adversity on mother and father's perinatal mental health, family processes, and infant development, as well as on the factors that could increase resilience or vulnerability in mothers, fathers, and infants facing adverse conditions. COVID-19 is a highly infectious disease and has posed a global health threat (Brooks et al., 2020). COVID-19 pandemic is considered a major threat to people's health and the worldwide consequences for health and socioeconomic systems are devastating. COVID-19 was firstly recognized in December 2019 and his infection spread rapidly throughout the world. The World Health Organization (WHO) declared Public Health Emergency of International Concern on January 30th, 2020, and a pandemic on March 11th, 2020 (WHO, 2020). The first case of COVID-19 in Portugal was reported on March 2nd, 2020, and after three months the epidemiological situation reported 36 690 cases and 1 517 deaths related to COVID-19 in a population of 10 million (June 15th, 2020; Directorate-General for Health, 2020).

After the declaration of the pandemic, several countries worldwide declared state of emergency - Portugal declared a state of emergency on March 18th, 2020. Several public health measures were progressively implemented to contain the spread of SARS-CoV-2 infection, namely physical distancing measures, closing schools, educational facilities, public spaces, and nonessential shops, national movement restrictions, and confinement (European Centre for Disease Prevention and Control, 2020).

Although crucial to control COVID-19 pandemic, the negative impact of confinement measures on mental health may be equally devastating. People in confinement may experience a wide range of negative feelings, including fear, anger, sadness, irritability, guilt, or confusion, which can make isolation challenging for mental health (Brooks et al., 2020). The negative impact of confinement measures in similar situations as COVID-19 pandemic is well documented in the literature (e.g., Jeong et al., 2016; Shultz et al., 2016; Wu et al., 2005). Several studies were already conducted across different countries to assess the impact of COVID-19 outbreak/pandemic on mental health (e.g., Brooks et al., 2020; Liu et al., 2020; Wang et al., 2020). In China, a study found that 16.5% of participants reported moderate to severe depressive symptoms and 28.8% of participants reported moderate to severe anxiety symptoms (Wang et al., 2020). Additionally, the confinement measures associated with COVID-19 pandemic can have a negative impact on family and couple's relationship quality by increasing conflicts between the

couple. Indeed, studies reported an increase in domestic violence during COVID-19 pandemic (Campbell, 2020; Sediri et al., 2020).

2.2. The impact of COVID-19 pandemic on mother and father's perinatal mental health and couple's relationship quality

The adverse impact of COVID-19 pandemic on mental health and couple's relationship quality can be particularly higher in most vulnerable groups, namely those undergoing major life transitions (Almeida et al., 2020; Reference Group on Mental Health and Psychosocial Support in Emergency, 2020). As previously described, the transition to parenthood is a major life transition associated with several individual, couple and family adjustments (Cowan & Cowan, 2012; Demick, 2002; Figueiredo et al., 2018).

Studies were already conducted to analyze the impact of COVID-19 pandemic on mothers' mental health during pregnancy and the postpartum period (see Yan et al., 2020 for a review). These studies found increased anxiety and depressive symptoms in mothers during COVID-19 pandemic, both during pregnancy and the postpartum period (Durankuş & Aksu, 2020; Lebel et al., 2020; Wu et al., 2020; Zanardo et al., 2020). Although an increase in domestic violence during COVID-19 pandemic was reported (Campbell, 2020; Sediri et al., 2020), to our knowledge, there is no data available regarding the impact of COVID-19 pandemic on couple's relationship quality during pregnancy or the postpartum period.

2.3. The impact of COVID-19 pandemic on infant development

Although infants and young children are not one of the most vulnerable population groups to SARS-CoV-2 infection (Lee & Raszka, 2021), an adverse impact of COVID-19 on infant development has been recently reported (e.g., Wang et al., 2020). Infants facing COVID-19 pandemic were found to present lower social-emotional development at three months (Wang et al., 2020). One of the main explaining factors of the adverse impact of COVID-19 pandemic on infant development can be mother and father's mental health problems and negative parenting (Provenzi et al., 2021). An increase on mother and father's depression and anxiety has been reported during COVID-19 pandemic, namely during the postpartum period (Zanardo et al., 2020). Nevertheless, positive parenting has been shown to buffer the adverse impact of COVID-19 pandemic on children's mental health (Russell et al., 2020).

2.4. The impact of couple's relationship on the perinatal mental health of mothers and fathers facing adverse conditions

According to the resilience model (Rutter, 1985), the impact of protective factors on mental health is higher during adverse conditions. The protective and risk impact of previous couple's positive and negative interaction on mental health during the transition to parenthood has been particularly reported for mothers and fathers facing adverse conditions (e.g., Chen et al., 2016; Røsand et al., 2012; Tseng et al., 2017). Prenatal couple's intimacy and satisfaction were associated with postnatal mental health in primiparous mothers and fathers, especially in the context of stressful events (e.g., Røsand et al., 2012; Wynter et al., 2014). Pregnant women who faced natural disasters but were satisfied with their couple's relationship revealed fewer mental health problems (e.g., somatic symptoms, anxiety/sleep loss, impaired social activity, and depressive tendencies) during the postnatal period (Sato et al., 2016). Mothers who suffered pregnancy loss reported lower levels of depressive and anxiety symptoms when couple's relationship quality was high, compared to women with moderate to low couple's relationship quality (e.g., Kagami et al., 2012). Furthermore, in women who undertook elective abortions, those who reported higher couple's relationship quality presented lower trauma symptoms than those who reported lower couple's relationship quality (Canário et al., 2011). In another study, better couple's relationship quality was associated with lower depressive and anxiety symptoms during pregnancy, in women with high-risk pregnancies (Chen et al., 2016).

Regarding gender differences in the impact of couple's positive and negative interaction on perinatal mental health, studies are scarce and provide mixed results. While Røsand and colleagues (2012) found a similar impact of couple's relationship satisfaction both in mothers and fathers, Kagami and colleagues (2012) found that couple's relationship quality was not associated with depressive and anxiety symptoms in fathers, although it was in mothers.

2.5. The impact of coparenting on infant development in the presence of adverse conditions

Although in separate studies, literature provides evidence that positive coparenting can buffer the negative impact of adversity on infant mental health and development, while negative coparenting can increase the negative impact of adversity on infant mental and development (e.g., Essex et al., 2003; Herrero et al., 2020; Jamison et al., 2017). Positive coparenting dimensions were found to buffer the negative impact of adversity on children psychological adjustment, namely in the context of poverty or

divorce (Herrero et al., 2020; Jamison et al., 2017). Contrarily, negative coparenting dimensions were found to increase the negative impact of adversity on children psychological adjustment, namely in the context of parental mental health problems (Essex et al., 2003).

Part 3

Current thesis

Developmental psychopathology perspective acknowledges the importance of understanding the mechanisms and the causal processes in the prenatal and postnatal environments that impact infant development (Rutter & Stroufe, 2000; Sroufe, 1997). Regarding the prenatal environment, mother's prenatal mental health problems have been showing to negatively influence the intrauterine environment and consequently fetal and infant development (e.g., Dias & Figueiredo, 2020; Field, 2011; Henrichs & Van den Bergh, 2015). Coparenting has been shown to be a major element of the postnatal environment influencing infant development, even when parenting quality is considered (e.g., Cummings et al., 2000; Feinberg et al., 2009; Teubert & Pinquart, 2010).

As a development-enhancing or a risk-promoting environment, coparenting may shape the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. Mother's prenatal depressive symptoms could have an adverse impact on infant self-regulation, leading to delayed fetal and infant self-regulation maturation (e.g., Davis et al., 2011; Figueiredo et al., 2017; Martini et al., 2017). The impact of positive and negative coparenting on infant self-regulation could be higher in infants of mothers with higher prenatal depressive symptoms, due to their delayed self-regulation maturation. Namely, infants of mothers with higher prenatal depressive symptoms could be more susceptible to the impact of both positive and negative coparenting. The positive experiences provided by positive coparenting interactions (e.g., support) could help promote the development of self-regulation, attenuating the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. Contrarily, the negative experiences provided by negative coparenting interactions (e.g., conflict) may accentuate the adverse impact of mother's prenatal depressive symptoms on infant self-regulation, increasing the risk of self-regulation problems.

Literature also highlights that the adverse impact of mother's prenatal depression on infant self-regulation may occur through its impact on fetal neurodevelopment (Henrichs & van den Bergh, 2015). As described in Part 1, an adverse impact of mother's prenatal depression was found on both FHRV and

infant self-regulation, although mostly in separate studies (e.g., Martini et al., 2017; Monk et al., 2011; van den Berg et al., 2009). FHRV is considered a marker of fetal neurobehavioral development associated with infant self-regulation and thus may be an early precursor of the adverse impact of mother's prenatal depressive symptoms on infant self-regulation (Appelhans & Luecken, 2006; DiPietro et al., 2007; DiPietro et al., 2015; van den Bergh, 2017).

Furthermore, the impact of both positive and negative coparenting on infant self-regulation may be higher in infants with lower FHRV, and so lower FHRV may be a prenatal endophenotypic susceptibility marker of infant self-regulation (DiPietro et al., 2007; DiPietro et al., 2018). Due to higher neurobiological plasticity (Ellis et al., 2011), infants with lower FHRV may be more susceptible to the positive experiences provided by positive coparenting interactions, promoting the development of their self-regulatory mechanisms. Moreover, infants with lower FHRV may also be more susceptible to the negative experiences provided by negative coparenting interactions, which may increase the risk of self-regulation problems.

COVID-19 pandemic is a major adverse condition, and thus can be a major empirical laboratory to analyze the impact of adversity on mother and father's perinatal mental health, family processes and infant development. Recent studies found increased anxiety and depressive symptoms in mothers during COVID-19 pandemic, both during pregnancy and the postpartum period (Durankuş & Aksu, 2020; Lebel et al., 2020; Wu et al., 2020; Zanardo et al., 2020). However, data is needed on the impact of COVID-19 pandemic on father's mental health during the postpartum period. Furthermore, despite being reported an increase of domestic violence during COVID-19 pandemic (Campbell, 2020; Sediri et al., 2020), as much as we know, there is no data available on the impact of COVID-19 pandemic on couple's relationship quality during the transition to parenthood. This is particularly relevant, considering the negative impact of mother and father's perinatal mental health problems and couple's relationship quality on infant development (Figueiredo et al., 2017; Gutierrez-Galve et al., 2015; Ramchandani et al., 2005). Additionally, an adverse impact of COVID-19 on infant development has been recently reported (e.g., Wang et al., 2020). Namely, infants facing COVID-19 pandemic were found to present lower social-emotional development at three months (Wang et al., 2020).

The adversity associated with COVID-19 can also represent an opportunity to study the family processes that could increase resilience or vulnerability in mothers, fathers, and infants during adverse conditions. According to the resilience model (Rutter, 1985), the impact of protective factors on mental health is higher during adverse conditions. The couple's relationship can be either a protective or a risk factor for mother and father's perinatal mental health, with an expectable higher impact in mothers and

fathers facing adversity (e.g., Chen et al., 2016; Røsand et al., 2012; Tseng et al., 2017). Coparenting is a major dimension of the family context that has been shown to have a greater impact on child adjustment than parenting (Holland & McElwain, 2013; Teubert & Pinquart, 2010). As a development-enhancing or a risk-promoting environment, positive coparenting can buffer the negative impact of COVID-19 pandemic on infant self-regulation, while negative coparenting can increase the adverse impact of COVID-19 pandemic on infant self-regulation.

Aiming to contribute to the literature on mother and father's perinatal mental health, family processes, and infant development, the present thesis had two main aims. The **main aim 1** was to analyze the impact of mother's prenatal depressive symptoms and coparenting on infant self-regulation, considering the role of FHRV in the impact of both mother's prenatal depressive symptoms and coparenting on infant self-regulation. The specific objectives are: (1) to analyze the moderator role of positive and negative coparenting in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. (2) to analyze the mediator role of FHRV in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months; and (3) to analyze the moderator role of FHRV in the impact of positive and negative coparenting on infant self-regulation at three months.

Considering the adversity associated with COVID-19 pandemic, the **main aim 2** was to analyze the impact of COVID-19 pandemic on mother and father's postnatal mental health, couple's relationship, and infant self-regulation. The specific objectives are: (1) to analyze the impact of COVID-19 pandemic on mother and father's postnatal depressive and anxiety symptoms, couple's relationship, and on infant self-regulation; (2) to analyze the protective and risk impact of previous couple's positive and negative interaction (assessed before COVID-19 pandemic) on mother and father's postnatal depressive and anxiety symptoms in the presence of an adverse condition - COVID-19 pandemic; and (3) to analyze the impact of previous positive and negative coparenting (assessed before COVID-19 pandemic) on infant self-regulation in the presence of an adverse condition - COVID-19 pandemic.

The present doctoral thesis is comprised of seven interrelated papers that were specifically designed to address the two main aims and the six specific objectives. The **Paper I** consists in a systematic review of the literature that informed the empirical background of the present thesis and provided evidence to design the empirical studies, namely when selecting the measure to assess infant self-regulation. As infant self-regulation has been distinctly conceptualized, operationalized and measured in the literature, **Paper I** aimed to systematically review the measures used to assess infant self-regulation during the first 12 months of life (see Table 1).

The empirical work is presented in six publications. To address the proposed **main aim 1**, the present thesis includes a cohort of mothers, fathers and infants who were assessed from early pregnancy to three months postpartum. To address the proposed **main aim 2**, the present thesis includes a sample of mothers, fathers, and infants from the cohort described in **main aim 1** who were recruited before COVID-19 pandemic and assessed at six months postpartum, with one group of mothers, fathers, and infants assessed before and another assessed during COVID-19 pandemic.

The **first specific objective** of **main aim 1** was addressed on **Paper II**, the **second specific objective** was addressed on **Paper III**, and the third specific objective on **Paper IV**. **Paper II** (Pinto et al., under review) was designed to address the **first specific objective** of **main aim 1** by analyzing the moderator role of positive and negative coparenting in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. **Paper III** (Pinto et al., under review) was designed to address the **second specific objective** of **main aim 1** by analyzing the mediator role of FHRV in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. **Paper IV** (Pinto & Figueiredo, under review) was designed to address the **third specific objective** of **main aim 1**, by analyzing the moderator role of FHRV in the impact of positive and negative coparenting on infant self-regulation at three months (see Table 1).

Paper V (Pinto & Figueiredo, accepted with major revisions) was designed to address the **first specific objective** of **main aim 2** by analyzing the impact of COVID-19 pandemic on mother and father's anxiety and depressive symptoms, and couple's relationship quality at six months postpartum. **Paper VI** (Pinto et al., under review) was designed to address the **second specific objective** of **main aim 2** by analyzing the protective and risk impact of previous couple's positive and negative interaction (assessed before COVID-19 pandemic) on mother and father's postnatal depressive and anxiety symptoms in the presence of an adverse condition - COVID-19 pandemic. **Paper VII** (Pinto et al., under review) was designed to address the **first and third specific objectives** of **main aim 2** by analyzing (1) the impact of COVID-19 pandemic on infant self-regulation and (2) the impact of previous positive and negative coparenting (assessed before COVID-19 pandemic) on infant self-regulation in the presence of an adverse condition - COVID-19 pandemic (see Table 1).

The conclusion section of this thesis offers an integrated discussion of the results found in the seven papers, considering the theoretical backgrounds and the empirical evidence previously presented. Limitations and strengths of the included studies are acknowledged, implications for both practice and research are provided, and an overall conclusion is presented.

METHOD

The methods section aims to present the methods' description of the seven interrelated papers that comprise the present thesis. First, the methods' description of the systematic review (**Paper I**) is presented. The methods' description of the six empirical papers (**Paper II, Paper III, Paper IV, Paper V, Paper VI, and Paper VII**) are presented afterwards. The main characteristics of the seven papers are presented in Table 1.

Systematic review

Literature search

The systematic review included in the present thesis (**Paper I**) was conducted according with the standard protocol based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Moher et al., 2009). The literature search was conducted to identify manuscripts referring to infant self-regulation during the first 12 months of life. The electronic search for relevant papers was independently performed by two researchers and was conducted in three databases: MEDLINE, ISI Web of Knowledge, and PsycINFO. The search was limited to English, Portuguese, Spanish, and French written articles. The following search term was used: infant AND self-regulation.

In the first stage, the titles, and the abstracts ($N = 154$) were independently analyzed by the two researchers to identify potentially relevant manuscripts. Abstracts that did not assess infant self-regulation were excluded ($n = 40$). In the second stage, the full texts of the potentially relevant articles ($n = 114$) were independently evaluated by the two researchers for inclusion and exclusion criteria examination. In case of disagreement, consensus was reached through discussion. Data from the reviewed studies that met the inclusion criteria was extracted for three data sheets. This information was extracted by one researcher and then reviewed by the other researcher. The studies were organized according to the aim of the systematic review: measures used to assess infant self-regulation during the first 12 months of life.

Table 1

Main characteristics of the seven papers included in the doctoral thesis

	Aims	Studied variables	Data analytic strategy
Main aim 1	Paper I To systematically review the measures used to assess infant self-regulation during the first 12 months of life	(1) behavioral measures (2) physiological measures	Preferred Reporting Items for Systematic Reviews and Meta-Analysis
	Paper II To analyze the moderator role of positive and negative coparenting in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months	(1) mother's prenatal depressive symptoms (2) positive and negative coparenting (3) infant self-regulation	Moderation model using multiple and hierarchical linear regressions
	Paper III To analyze the mediator role of fetal heart rate variability in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months	(1) mother's prenatal depressive symptoms (2) fetal heart rate variability (3) infant self-regulation	Mediation model using four multiple linear regression
	Paper IV To analyze the moderator role of fetal heart rate variability in the impact of positive and negative coparenting on infant self-regulation at three months	(1) positive and negative coparenting (2) fetal heart rate variability (3) infant self-regulation	Moderation model using multiple and hierarchical linear regressions

Main aim 2	Paper V	To analyze the impact of COVID-19 pandemic on mother and father's anxiety and depressive symptoms, and couple's relationship quality at six months postpartum	(1) COVID-19 pandemic (2) postpartum couple's positive and negative interaction (3) postpartum depressive and anxiety symptoms	Multivariate Analysis of Variance
	Paper VI	To analyze the protective and risk impact of previous couple's positive and negative interaction (assessed before COVID-19 pandemic) on mother and father's postnatal depressive and anxiety symptoms during a major adverse condition, COVID-19 pandemic	(1) previous couple's positive and negative interaction (2) COVID-19 pandemic (3) postpartum depressive and anxiety symptoms	Moderation models using multiple and hierarchical linear regressions
	Paper VII	To analyze the impact of previous positive and negative coparenting (assessed before COVID-19 pandemic) on infant self-regulation during an adverse condition - COVID-19 pandemic.	(1) previous positive and negative coparenting (2) COVID-19 pandemic (3) infant self-regulation	Moderation models using multiple and hierarchical linear regressions

Empirical studies

Procedures

The present research was conducted in accord with the Helsinki Declaration and received previous approval from the Ethical Commissions of University of Minho and Hospital de Braga (see Appendix). Couples were recruited at a Public Health Service in Northern Portugal during the first trimester of pregnancy (10-13 gestational weeks), before the first fetal ultrasound. The study exclusion criteria were as follows: not reading or writing Portuguese, not being married or cohabiting, multiparous mothers and fathers, multiple gestations, and gestations with obstetric complications. The aims and the procedures of the study were explained, and the mothers and fathers willing to participate provided a written consent form. From the 146 primiparous couples contacted at the public Health Service and willing to be contacted by email to participate in the study, 130 couples were willing to participate and completed the questionnaires at the first trimester of pregnancy (89.0%).

This study had a longitudinal design with five assessment waves: (1) first trimester of pregnancy (10-20 gestational weeks, $M = 13.46$, $SD = 2.42$), (2) third trimester of pregnancy (30 -33 gestational weeks, $M = 32.19$, $SD = 2.81$), (3) two weeks postpartum (2-8 postpartum weeks, $M = 3.39$, $SD = 2.05$), (4) three months postpartum (11-21 postpartum weeks, $M = 14.56$, $SD = 2.22$), and six months postpartum (24-32 postpartum weeks, $M = 24.36$, $SD = 3.12$). At each assessment wave, both mothers and fathers independently completed online a socio-demographic questionnaire, and measures of depressive and anxiety symptoms, positive and negative coparenting, and couple's positive and negative interactions. At the third trimester of pregnancy, FHRV was recorded during routine cardiotocography examination (CTG) by a nurse at the Public Health Service where the couples were recruited. At two weeks, three, and six months postpartum, both mothers and fathers independently completed measures of positive and negative coparenting, and infant self-regulation. From the couples who completed the questionnaires at the first trimester of pregnancy, 103 mothers and 103 fathers completed the questionnaires at two weeks and at three months postpartum (79.0%; $n = 206$) and were included in **Paper II**. From these couples, 86 mothers provided FHR data, and 86 mothers and 86 fathers completed the questionnaires at two weeks and at three months postpartum (72.9%; $n = 172$) and were included in **Paper III** and **Paper IV**.

Mothers, fathers, and infants were assessed at six months postpartum, before or during COVID-19 pandemic. The group of participants assessed during COVID-19 pandemic included mothers and

fathers that completed the online questionnaires after COVID-19 outbreak was declared a Public Health Emergency of International Concern by WHO on 30 January 2020 (between February and May 2020).

Participants included in **Paper V** completed online a sociodemographic questionnaire and measures of anxiety and depressive symptoms, and couple's positive and negative interactions during the first trimester (between May 2018 and June 2019) and at six months postpartum (between November 2018 and May 2020). Participants included in **Paper VI** completed online measures of previous couple's positive and negative interactions during the first trimester of pregnancy and measures of depressive and anxiety symptoms at six months postpartum. Participants included in **Paper VII** completed online measures of positive and negative coparenting and of infant self-regulation at two weeks and at six months postpartum.

From the mothers and fathers that completed the questionnaires at the first trimester of pregnancy ($N = 236$), 206 mothers and fathers completed the questionnaires at two weeks postpartum, and 142 mothers and fathers (60.2%) completed the questionnaires at six months postpartum. The families assessed at six months postpartum during COVID-19 pandemic did not differ from the families assessed at six months postpartum before COVID-19 pandemic, regarding mothers and father's sociodemographic characteristics, and infant characteristics.

The dropout rate from the first trimester of pregnancy to six months postpartum did not differ in the groups of mothers and fathers assessed before (39.6%) or during COVID-19 pandemic (40.0%), $\chi^2 = 1.12$, $p = .319$. Likewise, the dropout rate from two weeks to six months postpartum did not differ in the groups of mothers, fathers, and infants assessed before (31.0%) or during COVID-19 pandemic (31.2%), $\chi^2 = 0.81$, $p = .549$.

Participants

The sample used to address the **main aim 1** comprised 103 primiparous couples, 206 mothers or fathers, and their infants ($n = 103$). Mothers and fathers were married (50.9%) or cohabiting (49.1%). Most were Portuguese (91.4% of mothers and 94.6% of fathers), employed (89.6% of mothers and 89.2% of fathers), and were from medium or high socioeconomic levels (86.7% of mothers and 91.1% of fathers). Half of mothers and fathers were aged between 30 and 39 years old (52.1%; $M_{\text{mothers}} = 29.66$, $SD = 4.57$; $M_{\text{fathers}} = 31.51$, $SD = 5.29$), and had more than 12 years of education (59.5% of mothers and 48.4% of fathers; see Table 2). Regarding pregnancy, most reported good or very good pregnancy acceptance (92.2% of mothers and 95.7% of fathers) and the conception was spontaneous (92.2%). Regarding delivery, more than half was vaginal (62.2%). Regarding the infants, all were first-born, 53.7% female and 46.3% male. Most infants were born at term (≥ 37 gestational weeks; 91.5%; $M = 39.24$, $DP = 1.25$) and with more than 2500g (96.3%; $M = 3386.51$, $DP = 591.18$). More than half were exclusively breastfed during the first three months of age (63.5%). Most infants did not have health problems during the first three months of age (86.5%) and the mothers were the primary caregiver (94.6%; see Table 3).

The sample used to address the **main aim 2** comprised 71 primiparous couples, 142 mothers or fathers and their infants ($n = 71$), with 36 families assessed at six months postpartum during COVID-19 pandemic ($n = 36$ mothers, $n = 36$ fathers, and $n = 36$ infants) and 35 families assessed at six months postpartum before COVID-19 pandemic ($n = 35$ mothers, $n = 35$ fathers, and $n = 35$ infants). Mothers and fathers were married (50.8%) or cohabiting (49.2%). Most mothers and fathers were Portuguese (92.0%), aged between 19 and 39 years old (92.9%), were employed (90.9%), were from medium or high socioeconomic levels (89.7%), and had nine or more years of schooling (98.5%; see Table 2). Most infants were born at term (≥ 37 gestational weeks; 94.4%), at more than 2500g (93.6%), do not had health problems during the first three months (85.7%), and mothers were the primary caregiver (94.6%). More than 50% were male (52.0%), born by vaginal delivery (61.8%), and were exclusively breastfed during the first three months (65.1%; see Table 3).

Table 2

Mother and father's sociodemographic characteristics

		Assessed from the first trimester of pregnancy to three months postpartum	Assessed from the first trimester of pregnancy to six months postpartum	
		Total	Before COVID-19 pandemic	During COVID-19 pandemic
		<i>N</i> = 206	<i>n</i> = 70	<i>n</i> = 72
		%	%	%
<i>Age (years)</i>	19-29	42.3	32.3	38.3
	30-39	52.1	54.4	58.7
	≥ 40	5.6	13.3	3.0
<i>Socioeconomic level</i>	High	44.6	49.2	43.8
	Medium	44.3	35.6	49.1
	Low	11.1	15.2	7.1
<i>Occupational status</i>	Employed	89.4	89.9	89.9
	Unemployed	10.6	10.1	10.1
<i>Education (in years)</i>	≤ 9	3.2	2.7	0.0
	10 – 12	42.9	36.7	38.5
	> 12	53.9	60.6	61.5

Table 3

Infant's biometric and sociodemographic characteristics.

		Assessed from two weeks to three months postpartum	Assessed from two weeks to six months postpartum	
		Total <i>N</i> = 103 (%)	Before COVID-19 pandemic <i>n</i> = 35 (%)	During COVID-19 pandemic <i>n</i> = 36 (%)
Sex	Female	53.7	51.0	53.0
	Male	46.3	49.0	47.0
Gestational weeks at birth	≥ 37	91.5	92.0	91.0
	35 - 37	8.5	8.0	9.0
Birthweight	≥ 2500 g	96.3	96.6	96.0
	1660 - 2500 g	3.7	3.4	4.0
Breastfeeding at three months	Exclusive	63.5	66.0	64.2
	Non-exclusive	36.5	44.0	45.8
Health problems at three months	No	86.5	87.3	84.1
	Yes	13.5	12.7	15.9
Primary caregiver at three months	Mother	94.6	95.0	94.2
	Father	5.4	5.0	5.8

Measures

Socio-demographic information. The Socio-demographic Questionnaire (Figueiredo et al., 2009) was used in **all the six empirical papers** to collect mother and father's sociodemographic and obstetric data information (e.g., marital status, nationality, age, socioeconomic level, occupational status, years of education, pregnancy acceptance, mode of conception, and type of delivery) and infant's biometric and sociodemographic characteristics (e.g., sex, gestational weeks at birth, birthweight, breastfeeding, health problems, and primary caregiver).

Depressive symptoms. The Portuguese version of the Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) was used in **Paper II, Paper III, Paper V, and Paper VI** to assess mother's prenatal and mother and father's postnatal depressive symptoms. The EPDS is a 10-item self-report scale scored on a four-point Likert-type scale designed to assess the intensity of depressive symptoms within the previous seven days. This instrument has been used in several studies with mothers and fathers during pregnancy and the postpartum period (e.g., Figueiredo et al., 2014; Figueiredo et al., 2018; Pinto et al., 2018). The Portuguese version of the EPDS showed good internal consistency in mothers and fathers both during pregnancy and the postpartum period (e.g., Figueiredo et al., 2014; Figueiredo et al., 2018; Pinto et al., 2018). In the present sample, Cronbach's alphas ranged from .78 to .88 (α 's range = .80 – .88 in mothers; α 's range = .78 – .85 in fathers).

Anxiety symptoms. The State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) consists of two 20-item scales scored on a four-point Likert-type scale that measures individual differences in anxiety proneness as a personality trait and the intensity of anxiety as an emotional state (STAI-S). The STAI-S was used in **Paper V and Paper VI** to assess mother and father's postnatal anxiety symptoms. When responding to the STAI-S scale, participants report the intensity of their feelings of anxiety at the moment. Several studies have used this measure with mothers and fathers during the postpartum period (Figueiredo et al., 2018; Figueiredo & Conde, 2011; Pinto et al., 2016). The STAI-S Portuguese version showed good internal consistency in mothers and fathers (Figueiredo et al., 2018; Figueiredo & Conde, 2011; Pinto et al., 2018). In the present sample, Cronbach's alphas ranged from .88 to .94 for mothers and fathers.

Positive and negative coparenting. The Portuguese version of the Coparenting Relationship Scale (CRS; Feinberg et al., 2012; Lamela et al., 2016; Lamela et al., 2018) was used in **Paper II**, **Paper IV**, and **Paper VII** to assess mother and father's reports of positive and negative coparenting. The CRS is a 35-item self-report scale scored on a seven-point Likert-type scale designed to assess the four domains of coparenting proposed by Feinberg (2003) and comprises six subscales: (1) coparenting agreement subscale (four items) that assesses the degree that each parent agrees with matters related to the infant's education (e.g., My partner and I have different ideas regarding our child's eating, sleeping, and other routines); (2) coparenting closeness subscale (five items) that assesses the degree to which coparenting enhanced intimacy and strengthened the couple's relationship (e.g., My relationship with my partner is stronger now than before we had a child); (3) exposure to conflict subscale (five items) that assesses the degree that parents expose the infant to conflicts related to their education (e.g., One or both of you say cruel or hurtful things to each other in front of the child); (4) coparenting support subscale (six items) that assesses the perception of coparenting support from the other parent (e.g., My partner makes me feel like I'm best possible parent for our child); (5) coparenting undermining subscale (six items) that assesses the perception that coparenting is regulated by critics, guilt and competition between the parents (e.g., My partner sometimes makes jokes or sarcastic comments about the way I am as a parent); and (6) endorse partner parenting subscale (seven items) that assesses one's own positive attitude toward the other parent's parenting (e.g., I believe my partner is a good parent).

The Portuguese version of the CRS showed good internal consistency in mothers and fathers (Lamela et al., 2016; Lamela et al., 2018). In the present sample, Cronbach's alphas ranged from .80 to .92 (α 's range = .80 – .88 in mothers; α 's range = .84 – .92 in fathers). Composite scores for mother and father's positive and negative coparenting were calculated by standardizing each scale, summing the positive (agreement, closeness, support, and endorse partner parenting) and negative (exposure to conflict, undermining) subscales and dividing by the number of subscales, respectively.

Couples' positive and negative interactions. The Relationship Questionnaire (RQ; Figueiredo et al., 2008) was used in **Paper V** and **Paper VI** to assess mother and father's reports of couple's relationship positive and negative interactions. The RQ is a brief 12-item self-report questionnaire scored on a four-point Likert-type scale (from one to four) that assesses couples' positive (positive subscale, eight items) and negative (negative subscale, four items) interactions. The total score for each dimension is computed by averaging the scores of the items of each subscale. This questionnaire was designed to be completed in a short time, is behaviorally focused and appropriate for mothers and fathers, and has been used to

assess couples' positive and negative interactions during the transition to parenthood (e.g., Figueiredo et al., 2018). The positive interaction subscale includes sense of support and care, affection, closeness and joint interests and activities (e.g., Do you and your partner show affection to each other?). The negative interaction subscale includes irritability, arguments and criticisms (e.g., Do you and your partner get irritable with each other?). Higher scores on these subscales reflect more positive or more negative interactions (Figueiredo et al., 2008). The RQ showed good internal consistency in mothers and fathers during the postpartum period (Figueiredo et al., 2018; Figueiredo et al., 2008). In the present sample, Cronbach's alphas ranged from .80 to .92 for mothers and fathers on the positive and negative subscales.

FHRV. FHR signals were continuously recorded during CTG examination with no stimulus being presented. FHR signals were continuously recorded and stored using the Omniview-SisPorto system (Ayres-de-Campos et al., 2008). A fetal monitor was used to export FHR signals every 0.25 seconds in beats per minute, rounded to the nearest quarter of a beating. Data were subsequently exported to an Excel 2020 worksheet. FHRV was used in **Paper III** and **Paper IV**, obtained by calculating the difference between the highest and lowest FHR frequency value per minute.

Infant self-regulation. The orienting regulation dimension of the Infant Behavior Questionnaire - Revised short form (IBQ-R; Gartstein & Rothbart, 2003; Putnam et al., 2014) was used in **Paper II**, **Paper III**, **Paper IV**, and **Paper VII** to assess infant self-regulation. The IBQ-R short form comprises 91 items in 14 scales, scored in a seven-point Likert-type scale, related to the frequency of occurrence of the infants' behaviors in several specific situations during the previous week or two weeks. The orienting dimension is comprised by the mean scores of four scales: low-intensity pleasure (seven items), cuddliness (six items), duration of orienting (six items) and soothability (seven items) scales.

The IBQ-R has globally shown validity and reliability in different cultural backgrounds and across different infant ages (e.g., Dias et al., 2021). The orienting regulation dimension of the IBQ-R Portuguese version showed good internal consistency (α 's = .60 - .80; Costa & Figueiredo, 2018). In the present sample, Cronbach's alphas ranged from .69 to .74 (α 's range = .72 - .74 in mothers; α 's range = .69 - .71 in fathers). Although both mothers and fathers reported on their infant self-regulation, only the orienting regulation scores reported by the primary caregiver were included in the analysis (mostly mothers; see Table 3).

PAPER I

MEASURES OF INFANT SELF-REGULATION DURING THE FIRST YEAR OF LIFE:

A SYSTEMATIC REVIEW

Pinto, T. M. & Figueiredo, B. (under review). Measures of infant self-regulation during the first year of life: a systematic review. *International Journal of Behavioral Development*

Abstract

Infant self-regulation has been distinctly conceptualized, operationalized and measured in the literature, leading to several struggles, namely in comparing results from different studies. This study aimed to systematically review the measures used to assess infant self-regulation during the first 12 months of life. This systematic review was conducted according with the PRISMA statement protocol. From 154 selected papers, 46 provided information on behavioral and physiological measures to assess infant self-regulation during the first 12 months of life and were included in the review. Twenty-six behavioral (21 observational and 5 parent-report) and 2 physiological different measures were identified. Contrasts were identified when comparing studies using behavioral or physiological measures. Studies with longitudinal design, comprising larger samples, and aiming to assess infant self-regulation later in infancy, mostly used behavioral measures than physiological measures (87%). Contrasts were also identified when comparing behavioral studies using observational or parent-reported measures. Studies comprising lower samples and aiming to assess infant self-regulation earlier in infancy, mostly used observational than parent-reported measures (76%). Measures used to assess infant self-regulation during the first 12 months of life are generally selected according with the study design, the sample size, and mainly the infant age. Studies targeting younger infants used physiological measures and studies targeting older infants used behavioral measures, with observational measures used with younger infants and parental-reported measures used with older infants during the first year of life. When measuring self-regulation is important to consider the infant age, in order to fit the measure procedures with the infant self-regulation development level, that is how self-regulation is established and manifested.

Keywords: infant; self-regulation; behavioral measures; physiological measures; observational measures; parent-reported measures.

Introduction

Self-regulation results from the activity of “processes that serve to modulate reactivity” (Rothbart et al., p. 442) and granted adequate behaviors and appropriate responses to situational demands (van den Bergh & Mennes, 2006). Self-regulating processes vary according with the infant age and reactivity pattern and include orienting, fearful inhibition, angry attack, surgent or extraverted approach, and behavior control the effort based on the executive attention system (Rothbart et al., 2011).

Infants have the ability to engage in sensorimotor activities and to voluntarily contact others, and this ability plays a major role in the development of self-control through all life cycle (Crockenberg & Leerkes, 2004; Morales et al., 2005; Rothbart et al., 2011). Empirical evidence indicated that several self-regulation processes manifested early in infancy occur in a nonconscious and automatic level (e.g., Aarts, 2007; Bargh & Morsella, 2008). Behaviors manifested during the first 12 months of age, namely self-soothing and orienting, serve self-regulatory functions (Rothbart et al., 2011; Rothbart et al., 1992). Orienting is an effective way of lowering the expression of negative affect, serving as a major self-regulatory mechanism (e.g., Sheese et al., 2009). Infants who can quickly disengage from distressing objects are less susceptible to negative affect and easier to soothe (Crockenberg & Leerkes, 2004; Morales et., 2005).

Self-regulation is a major developmental task in infancy. Physiological and behavioral states are progressively regulated during the first year of life (Bell & Deater-Deckard, 2007; Calkins, 2009). Infants start first to regulate their physiological states which promotes their behavioral regulation (Calkins, 2009; Porges, 2007). Vagal inhibition in response to stress and activation during recovery from stress are both associated with effective self-regulatory behaviors, such as higher soothability (e.g., Bazhenova et al., 2001; Ham & Tronick, 2006; Stifter & Corey, 2001), while difficulties in regulating vagal tone during stressing tasks are associated with self-regulatory difficulties in later ages (e.g., El-Sheikh et al., 2009; Graziano & Derefinko, 2013). Infant self-regulation is a resource to promote further development, while self-regulation difficulties predict a variety of adjustment problems, including internalizing and externalizing problems, lower social skills, and disrupted physiological regulation to stress (e.g., Eisenberg et al., 2004; Perry et al., 2016; Williams et al., 2016).

Infant self-regulation has been distinctly conceptualized, operationalized and measured in the literature, leading to several struggles, namely in comparing results from different studies (Bell & Deater-Deckard, 2007; Cole et al., 2004). Infant self-regulation has been conceptualized and operationalized using different indicators – physiological (e.g., vagal reactivity) and behavioral (e.g., orienting regulation,

self-soothing), and different measures have been used to assess this construct, namely observational or parent-reported measures (Bell & Deater-Deckard, 2007; Cole et al., 2004).

This study aimed to systematically review the measures used to assess infant self-regulation during the first 12 months of life. To assess self-regulation early in infancy is a major issue to understand self-regulatory processes in typically developing infants and to identify infants with self-regulation difficulties. This systematic review may contribute to assist researchers and clinical practitioners to select the more adequate measures to assess infant self-regulation at different ages and in diverse contexts and circumstances.

Method

This systematic review was conducted according with the standard protocol based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement (Moher et al., 2009).

Literature search

The literature search was conducted in three databases: MEDLINE, ISI Web of Knowledge, and PsycINFO for relevant papers. This search was conducted to identify manuscripts that referred to infant self-regulation during the first 12 months of life. The search was limited to English, Portuguese, Spanish, and French written articles. The following search term was used: infant AND self-regulation. The electronic search was first performed by one author (TMP) and then independently replicated by another author (BF). In a first stage, the titles, and the abstracts ($N = 154$) were independently analyzed by two authors (TMP and BF) to identify potentially relevant manuscripts. Abstracts that did not assess infant self-regulation were excluded ($n = 40$). In the second stage, the full texts of the potentially relevant articles ($n = 114$) were independently evaluated by the two authors for inclusion and exclusion criteria examination. In case of disagreement, consensus was reached through discussion.

Inclusion and exclusion criteria

For this review, only original empirical articles that studied infant self-regulation during the first 12 months of life were included. Studies were included according with the following criteria: (a) original studies; (b) studies including infants aged between zero and 12 months; (c) and studies assessing infant self-regulation. Exclusion criteria included: (a) non-original research (e.g., literature reviews, systematic reviews, or meta-analysis); (b) research projects; (c) studies with a qualitative design; and (d) studies assessing self-regulation in infants above 12 months of age.

Quality assessment

The quality of all studies was assessed according with a Quality Index checklist based on the system of Downs and Black (1998). This Quality Index is a 27-item checklist that was designed to assess the methodological quality of randomized and non-randomized studies and is comprised of five subscales. As some items did not apply to most of the revised studies, 14 from the total 27 items were selected to score the studies. All items are scored between zero and one, with exception of one item that was scored between zero and two. Total scores range between zero and 15, with higher scores indicating better methodological quality. Papers scoring more than 10 were qualified as good, those scoring between seven and 10 were qualified as moderate, and those scoring less than seven were qualified as poor.

Data extraction

Data from studies that met the inclusion criteria was extracted for three data sheets (see Table 4, 5, and 6). This information was extracted by one author (TMP) and then reviewed by another author (BF). The studies were organized according with the objective of this systematic review: measures used to assess infant self-regulation during the first 12 months of life.

Results

Database's search

The literature search identified 154 relevant papers (after the elimination of duplicates). After the examination of titles and abstracts, 40 non-relevant papers were excluded. The full text of the remaining 114 papers were examined for inclusion/exclusion criteria. After the full text reading, 68 papers were excluded as they met one or more exclusion criteria and 46 papers were included in the review (see Figure 1).

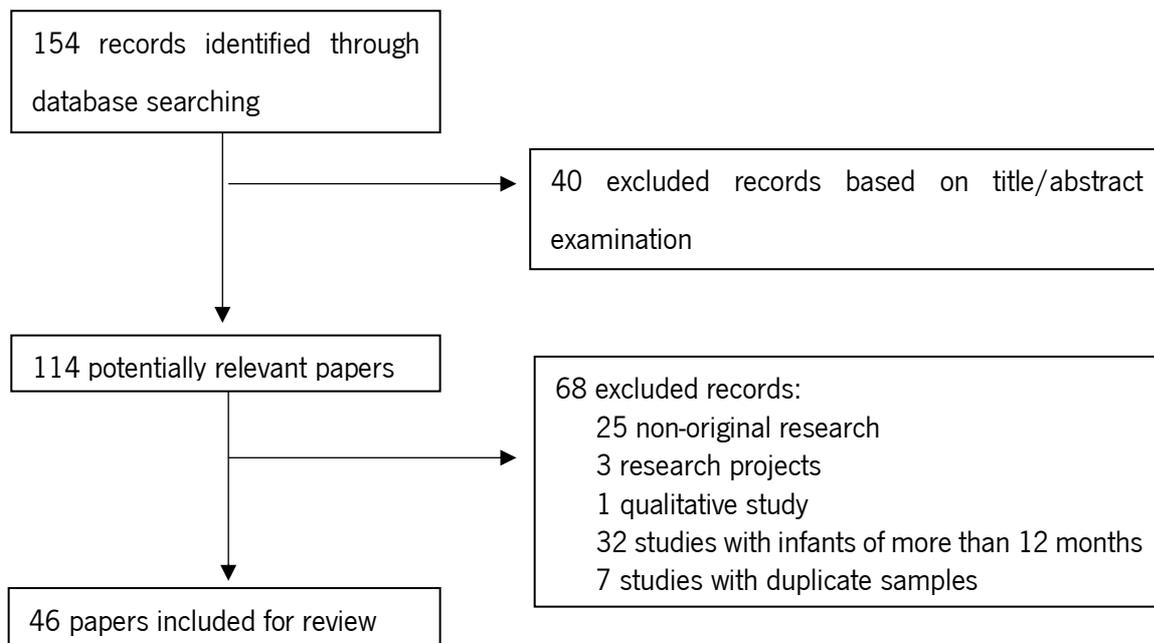


Figure 1. Search strategy flow chart

Articles reviewed

Most studies (83%) were conducted in the United States ($n = 28$) or in European countries ($n = 10$) and one study was conducted both in the United States and in Austria (Coyle et al., 2012). More than half of studies presented a longitudinal design (70%; $n = 32$) and assessed infant self-regulation one time across the 12 months of life (93%; $n = 43$). Studies' sample size ranged between 15 and 7450 infants, $M_{\text{sample}} = 374.63$ (Grenier et al., 2003; Radesky et al., 2014). Infant's age ranged between zero point one and 12 months (Anzman-Frasca et al., 2013; Hernández-Martínez et al., 2008; Lester et al., 1996; Lundqvist-Persson, 2001; Warnock et al., 2014). A higher percentage of studies were qualified as good (70%; $n = 32$) and the remaining studies were qualified as moderate.

Regarding the measures to assess infant self-regulation during the first 12 months of life, most studies used behavioral measures (87%; $n = 40$), four studies used physiological measures (Busuito & Moore, 2017; Gray et al., 2017; Moore et al., 2009; Smith et al., 2016), and two studies used both behavioral and physiological measures (Dale et al., 2011; Lester et al., 1996). Most of the studies assessing infant self-regulation with behavioral measures, used observational measures (76%; $n = 31$), nine studies used parent-reported measures and one study used both observational and parent-reported measures (Anzman-Frasca et al., 2013). A total of 28 behavioral or physiological measures to assess infant self-regulation during the first 12 months of life were identified.

Behavioral measures to assess infant self-regulation during the first year of life

Observational measures. Table 4 summarizes the observational behavioral measures to assess infant self-regulation during the first 12 months of life. More than half of longitudinal studies used observational measures to assess infant self-regulation (62%; $n = 20$). Studies' sample size ranged between 15 and 1053 infants, $M_{\text{sample}} = 142.50$ infants (Grenier et al., 2003; Salisbury et al., 2007). Infant's age ranged between 0.1 and 12 months, $M_{\text{age}} = 3.52$ months. A total of 21 different observational measures were identified in the 33 studies (see Table 4).

Most studies used one observational measure to assess infant self-regulation (88%; $n = 29$). From the four studies using more than one observational measure to assess infant-self-regulation, one study used two observational measures (Lundqvist-Persson, 2001), two studies used three observational measures (Feldman et al., 2002; Wolf et al., 2002) and one study used four observational measures (Wiebe et al., 2014). Most of these studies used more than one observational measure to assess self-

regulation more than once time in different ages across the first 12 months of life (Feldman et al., 2002; Lundqvist-Persson, 2001; Wolf et al., 2002). On the other hand, the study conducted by Wiebe and colleagues (2014) used four observational measures to assess different dimensions of self-regulation (e.g., emotional, attentional) in infant with six months of age.

The Neonatal Intensive Care Unit Network Neurobehavioral Scale (NNS; Lester & Tronick, 2004) and the Face-to-Face Still-Face paradigm (FFSF; Tronick et al., 1978) were the observational measures used by more studies to assess infant self-regulation (53%; $n = 17$). The NNS was the observational measure used by more studies to assess self-regulation in neonates, $M_{age} = 0.9$ months, while the FFSF was the observational measure used by more studies to assess self-regulation in older infants, $M_{age} = 5.4$ months. All the studies using the FFSF measured infant self-regulation during the interaction between the infant and the mother.

Besides these measures, the Neonatal Behavior Assessment Scale (NBAS; Brazelton, & Nugent, 1995) and the Bayley Scales of Infant Development – II (BSID-II; Bayley, 1993) were also used by more than one study. The NBAS was used in five studies to assess self-regulation in neonates, $M_{age} = 0.3$ months, and the BSID-II was used in two studies to assess self-regulation in older infants, $M_{age} = 5.3$ months.

Parent-reported measures. Table 5 summarizes the parent-reported behavioral measures to assess infant self-regulation during the first 12 months of life. All the longitudinal studies assessed infant self-regulation using parent-reported measures. Studies' sample size ranged between 15 and 1053 infants, $M_{sample} = 1347.33$ infants (Milgrom et al., 2015; Radesky et al., 2014). Infant's age ranged between four and 12 months, $M_{age} = 8.0$ months. A total of five different parent-reported measures were identified in the 10 studies (see Table 5). All the studies used one parent-reported measure to assess infant self-regulation and selected the mothers of the infants to complete the parent-reported measures.

The Infant Behavior Questionnaire - Revised (IBQ-R; Gartstein & Rothbart, 2003) was the parent-reported measure used by more studies to assess infant self-regulation (50%; $n = 5$). This measure was used in infants between four and 12 months of age, $M_{age} = 6.9$ months. Besides the IBQ-R, the Ages and Stages Questionnaire: Social Emotional (ASQ:SE; Squires et al., 2001) was also used in two studies in infants with 9-10 months of age (Milgrom et al., 2015; van den Heuvel et al., 2015).

Physiological measures to assess infant self-regulation during the first year of life

Table 6 summarizes the physiological measures to assess infant self-regulation during the first 12 months of life. Studies assessing infant self-regulation using physiological measures presented either a longitudinal or a cross-sectional (50%; $n = 3$) design. Studies' sample size ranged between 44 and 167 infants, $M_{\text{sample}} = 88.50$ infants (Gray et al., 2018; Lester et al., 1996). Infant's age ranged between 0.1 and 10 months, $M_{\text{age}} = 5.98$ months. A total of two different physiological measures were identified in the six studies (see Table 6). All the studies used one physiological measure to assess infant self-regulation.

Infant's vagal regulation through the recording of respiratory sinus arrhythmia (RSA; Porges, 1985; 2001; 2007) was the physiological measure used by most studies to assess infant self-regulation (83%; $n = 5$). This measure was used in infants between zero point one and nine months of age, $M_{\text{age}} = 5.2$ months. More than half of these studies assessed infant's vagal regulation during the FFSF (60%; $n = 3$), one study assessed vagal regulation during BSID examination (Dale et al., 2011), and the remaining study assessed vagal regulation during NBAS examination (Lester et al., 1996). Besides the assessment of infant's vagal regulation, the examination of frontal electroencephalogram asymmetry (Coan & Allen, 2004; Schmidt, 2008) was also used by one study in infants with 10 months of age (Smith et al., 2016).

Table 4

Observational measures to assess infant self-regulation during the first 12 months of life

First author (year of publication)	Country	Design	<i>N</i>	Age (months)	Self-regulation measure
Velez et al. (2018)	USA	Longitudinal	41	1	Neonatal Intensive Care Unit Network Neurobehavioral Scale
Salisbury et al. (2016)	USA	Longitudinal	184	1	Neonatal Intensive Care Unit Network Neurobehavioral Scale
Stroud et al. (2016)	USA	Longitudinal	45	1	Neonatal Intensive Care Unit Network Neurobehavioral Scale
Conradt et al. (2015)	USA	Longitudinal	128	5	Face-to-Face Still-Face paradigm
l'Etoile et al. (2015)	USA	Cross-sectional	30	5.3	Infant Behavior Rating Scales-Revised
Noe et al. (2015)	Germany	Cross-sectional	68	3.9	Face-to-Face Still-Face paradigm
Lin et al., (2014)	USA	Longitudinal	295	3	Tronick's Monadic Phases
MacLean et al. (2014)	USA	Cross-sectional	84	4.1	Face-to-Face Still-Face paradigm
Warnock et al., (2014)	Canada	Longitudinal	21	0.1	Newborn Distress Pain Related Behavior Coding
					Arm Restraint task
					Visual delayed response task
Wiebe et al. (2014)	USA	Longitudinal	218	6	Novel object habituation task
					Fagan Test of Infant Intelligence
Zhang et al. (2014)	China	Cross-sectional	281	6	Free Play
Anzman-Frasca et al., (2013)	USA	Longitudinal	110	12	Toy Removal Task
Conradt et al., (2013)	USA	Longitudinal	482	0.3	Neonatal Intensive Care Unit Network Neurobehavioral Scale
Pineda et al., (2013)	USA	Longitudinal	75	1	Neonatal Intensive Care Unit Network Neurobehavioral Scale
Coyle et al., (2012)	USA	Longitudinal	39	1	Neonatal Intensive Care Unit Network Neurobehavioral Scale

	Austria				
Lundqvist-Persson et al., (2012)	Sweden	Longitudinal	51	1, 3, 6	Neonatal Behavioral Assessment Scale Bayley Scales of Infant Development - II
Yolton et al., (2011)	USA	Longitudinal	318	1	Neonatal Intensive Care Unit Network Neurobehavioral Scale
Chow et al., (2010)	USA	Longitudinal	36	6.1	Face-to-Face Still-Face paradigm
Ferreira et al., (2010)	Brazil	Cross-sectional	32	0.5	Manual for the Naturalistic Observation of Newborn Behavior
Liaw et al., (2010)	Taiwan	Cross-sectional	24	0.5	Bathing task
Montirosso et al., (2010)	Italy	Cross-sectional	50	9.2	Face-to-Face Still-Face paradigm
Stroud et al. (2009)	USA	Longitudinal	318	0.5	Neonatal Intensive Care Unit Network Neurobehavioral Scale
Hernández-Martínez et al., (2008)	Spain	Longitudinal	163	0.1	Neonatal Behavior Assessment Scale
Sheese et al., (2008)	USA	Cross-sectional	50	6.5	Mask Presentation task
Salisbury et al., (2007)	USA	Longitudinal	1053	1	Neonatal Intensive Care Unit Network Neurobehavioral Scale
Crandell et al., (2003)	UK	Cross-sectional	20	2.1	Face-to-Face Still-Face paradigm
Grenier et la., (2003)	USA	Cross-sectional	15	1	Caregiving task
				0.1	State Observation Procedure
Feldman et al., (2002)	Israel	Longitudinal	146	3	Behavior Response Paradigm
				6	Toy Exploration task
Rosenblum et al., (2002)	USA	Longitudinal	100	7	Face-to-Face Still-Face paradigm
				0.3	Neonatal Behavioral Assessment Scale
Wolf et al., (2002)	Netherlands	Longitudinal	30	3	Infant Behavioral Assessment

				6	Bayley Scales of Infant Development—II
Lundqvist-Persson (2001)	Sweeden	Longitudinal	38	0.1	Neonatal Behavioral Assessment Scale
Weinberg et al., (1999)	USA	Cross-sectional	81	6	Face-to-Face Still-Face paradigm
Lester et al., (1996)	USA	Cross-sectional	44	0.1	Neonatal Behavioral Assessment Scale

Table 5

Parent-reported measures to assess infant self-regulation during the first 12 months of life

First author (year of publication)	Country	Design	<i>N</i>	Age (months)	Self-regulation measure
Jones et al. (2018)	USA	Longitudinal	111	4	Infant Behavior Questionnaire - Revised
Bush et al. (2017)	USA	Longitudinal	151	4	Infant Behavior Questionnaire - Revised
Williams et al. (2017)	Australia	Longitudinal	4109	8.8	Australian Temperament Scales
van de Weijer-Bergsma et al. (2016)	Netherlands	Longitudinal	76	7	Infant Behavior Questionnaire - Revised
Milgrom et al. (2015)	Australia	Longitudinal	29	9	Ages and Stages Questionnaire: Social Emotional
van den Heuvel et al. (2015)	Netherlands	Longitudinal	90	9.7	Ages and Stages Questionnaire: Social Emotional
Radesky et al., (2014)	USA	Longitudinal	7450	9	Infant Toddler Symptom Checklist
Anzman-Frasca et al. (2013)	USA	Longitudinal	110	12	Infant Behavior Questionnaire - Revised
Martinos et al. (2012)	UK	Longitudinal	60	7.5	Infant Behavior Questionnaire - Revised
Dale et al., (2011)	USA	Longitudinal	50	9	Regulatory Disorders Checklist

Table 6

Physiological measures to assess infant self-regulation during the first 12 months of life

First author (year of publication)	Country	Design	<i>N</i>	Age (months)	Self-regulation measure
Busuito et al. (2017)	USA	Cross-sectional	53	6.8	Vagal regulation through respiratory sinus arrhythmia
Gray et al. (2017)	USA	Longitudinal	167	4	Vagal regulation through respiratory sinus arrhythmia
Smith et al. (2016)	USA	Longitudinal	65	10	Frontal electroencephalogram asymmetry
Dale et al., (2011)	USA	Longitudinal	50	9	Vagal regulation through respiratory sinus arrhythmia
Moore et al. (2009)	USA	Cross-sectional	152	6	Vagal regulation through respiratory sinus arrhythmia
Lester et al., (1996)	USA	Cross-sectional	44	0.1	Vagal regulation through respiratory sinus arrhythmia

Discussion

This study provided a systematic review of the measures used to assess infant self-regulation during the first 12 months of life. This systematic review included 46 studies performed in different countries, over the last two decades.

Behavioral versus physiological measures to assess infant self-regulation during the first year of life

Infant self-regulation during the first 12 months of life is generally assessed using behavioral measures; only two studies combined both behavioral and physiological measures (Dale et al., 2011; Lester et al., 1996). The behavioral versus physiological measures used to assess infant self-regulation were found to vary according with the study design, the sample size, and the infant age.

Regarding the study design, longitudinal studies tended to use behavioral measures, while physiological measures are used either in longitudinal or cross-sectional studies. Regarding the sample size, studies comprising higher samples ($M_{\text{sample}} = 744.92$) tended to use behavioral measures, while studies comprising lower samples ($M_{\text{sample}} = 88.50$) tended to use physiological measures. Regarding infant's age, studies aiming to assess self-regulation in older infants ($M_{\text{age}} = 8.0$ months) tended to use behavioral measures, and specifically parent-reported measures, while studies aiming to assess self-regulation in younger infants ($M_{\text{age}} = 5.98$ months) tended to use physiological measures (except the study conducted by Smith and collaborators, 2016).

Observational versus parent-reported measures to assess infant self-regulation during the first year of life

Behavioral measures to assess infant self-regulation are usually observational; only one study was identified combining both observational and parent-reported measures (Anzman-Frasca et al., 2013). The observational versus parent-reported measures used to assess infant self-regulation were found to vary according with the sample size and infant's age. Regarding the sample size, studies comprising lower samples tended to use observational measures ($M_{\text{sample}} = 142.50$), while studies comprising higher samples tended to use parent-reported measures ($M_{\text{sample}} = 1347.33$). Regarding infant's age, studies aiming to assess infant self-regulation since birth used observational measures, while studies aiming to assess infant self-regulation since the four months of infant's life used parent-reported measures. This

could be due to the fact that there are no parent-reported measures designed to be applied in infants with less than three months of age, so only observational measures could be used.

Observational measures. Several observational measures were identified, assessing infant self-regulation from birth to 12 months of infant's life (see Table 4). The observational measure used was found to vary according with infant's age. Studies aiming to assess self-regulation in neonates tended to use the NNS (Lester & Tronick, 2004) or the NBAS (Brazelton & Nugent, 1995), while studies aiming to assess self-regulation in older infants tended to use the FFSF (Tronick et al., 1978) or the BSID-II (Bayley, 1993).

The NNS and the NBAS were designed to assess the neurobehavioral performance in neonates, and both include specific tasks to assess self-regulation (Brazelton & Nugent, 1995; Lester & Tronick, 2004). These procedures allow the observation of several self-regulatory behaviors in the neonate, such as peak of excitement, rapidity of build-up, irritability, lability of states, cuddliness, consolability, and self-quieting activity (e.g., Brazelton & Nugent, 1995; Lester & Tronick, 2004). Likewise, both the FFSF (Tronick et al., 1978) and the BSID-II (Bayley, 1993) include specific tasks to assess self-regulation in older infants. The FFSF is performed during parent-infant interaction and is comprised of three brief segments that challenge infant self-regulation in response to temporary parental emotional unavailability (Tronick, 1989; Weinberg & Tronick, 1996). This procedure allows the observation of several behaviors (e.g., avoidance, gaze aversion, and attention seeking) that the infant can manifest to regulate the distress elicited during the FFSF (e.g., Conradt et al., 2015; MacLean et al., 2014; Noe et al., 2015). The BSID-II is an observational measure designed to assess infant motor and mental development and includes the assessment of infant self-soothing behaviors as part of infant socio-emotional development (Bayley, 1993). The BSID-II assessment is performed during the examiner-infant interaction and allows to observe infant self-soothing behaviors (e.g., looking at a moving red ball, at toys with different sounds or at a silver-colored bell) in response to stressful tasks (e.g., Lundqvist-Persson et al., 2012; Wolf et al., 2002).

Parent-reported measures. There are few studies using parent-reported measures to assess infant self-regulation and few parent-reported measures were identified (see Table 5). Contrarily to observational measures, the parent-reported measure used did not vary according with infant's age, and no parent-reported measures were found to assess self-regulation in infants with less than three months. Regardless of infant's age, studies assessing infant self-regulation with parent-reported measures tended to use the IBQ-R (Gartstein & Rothbart, 2003) or the ASQ:SE (Squires et al., 2001).

The IBQ-R (Gartstein & Rothbart, 2003) and the ASQ:SE (Squires et al., 2001) allow the assessment of infant orienting and self-soothing behaviors. The IBQ-R is a parent-reported measure designed to assess temperament in infants with three to 12 months of age. Although the IBQ-R was designed to assess infant temperament, this instrument was the most used parent-reported measure in the reviewed studies to assess infant self-regulation. Specifically, the orienting regulation dimension of the IBQ-R allows the assessment of infant orienting and self-soothing behaviors, observed by parents in daily routine situations and across several contexts. Self-regulation theory (Rothbart et al., 2011) suggested that self-regulation is conceptually related with temperament. One of the major functions of infant self-regulation is the regulation of temperament characteristics. On the other hand, temperament reflects individual differences in emotional, motor, and attentional reactivity to as well as individual differences in the regulation of this reactivity (Dias et al., 2021; Rothbart et al., 2011).

The ASQ:SE is a parent-reported measure designed to assess socio-emotional development in infants aged between six and 60 months and assesses infant self-regulation problems as an indicator of lower socio-emotional development. The self-regulation subscale of the ASQ:SE specifically assesses infant self-soothing behaviors, observed by parents in daily routine situations (e.g., Milgrom et al., 2015; van den Heuvel et al., 2015).

Physiological measures to assess infant self-regulation during the first year of life

There are few studies using physiological measures to assess infant self-regulation and two physiological measures were identified (see Table 6). Contrarily to the studies using behavioral measures, the physiological measure used did not vary according with infant's age. Regardless of infant's age, five of the six identified studies used infant's vagal regulation through RSA as a physiological measure of infant self-regulation.

The RSA is a derivative of the parasympathetic nervous system (PNS) activity and is an index of heart rate variability in the respiratory frequency range (Porges, 1985). The autonomic nervous system

comprises both a sympathetic (SNS) branch, which initiates physiological arousal, and a PNS branch, which modulates SNS input to the heart and other target organs, regulating recovery and restoring autonomic homeostasis (Porges, 2001, 2007). Vagal tone is a component of PNS control and according to Porges' polyvagal theory is a major physiological marker of self-regulation (Porges, 2001, 2007). Vagal regulation refers to the adequate activation or inhibition of vagal tone. Vagal tone is activated during periods of relative quiescence, which slows down heart rate and allows a focus on homeostatic processes, promoting exploration of the environment. Vagal tone is inhibited when the environment presents some challenges, which increases heart rate, promoting the manifestation of self-regulatory behaviors. When environmental challenges ceased, vagal tone is activated (Beauchaine et al., 2007; Porges, 2001, 2007). Vagal inhibition can be detected by decreases in the amplitude of RSA during situations that can challenge infant behavioral self-regulation (e.g., Busuito et al., 2017; Gray et al., 2017). Most of the studies assessed infant's vagal regulation during FFSF, one of the most used behavioral observational measures to assess infant self-regulation.

Conclusions

This study provided a systematic review on the behavioral and physiological measures used to assess infant self-regulation during the first 12 months of life. Several measures were identified, and they were presented and discussed according to their typology at two levels: (1) behavioral versus physiological measures, and (2) observational versus parent-reported behavioral measures. Infant self-regulation is mostly assessed using (1) behavioral measures (instead physiological measures) and using (2) observational measures (instead parent-reported measures).

Contrasts were identified when comparing (1) studies using behavioral or physiological measures, regarding the study design, the sample size, and infant's age. Studies with longitudinal design, comprising larger samples, and aiming to assess infant self-regulation later in infancy, mostly used behavioral measures than physiological measures. Contrasts were also identified when comparing (2) behavioral studies using observational or parent-reported measures, namely regarding the sample size and infant's age. Studies comprising lower samples and aiming to assess infant self-regulation earlier in infancy, mostly used observational than parent-reported measures. Despite different, both observational and parent-reported measures provide key information to assess infant self-regulation (e.g., Rothbart & Bates, 2006). Observational measures assess infant self-regulation during a specific situation, while parent-reported measures allow the assessment of infant self-regulation in daily routine situations across a variety

of contexts where parents have more opportunities to observe the infant. Observational measures can be more adequate to assess infant-self-regulation during a stressful situation, while parent-reported measures can be more adequate to assess self-regulation during and across the days of the infant's life. Combining both observational and parent-reported measures could provide a broader assessment of infant self-regulation.

On the other hand, studies aiming to assess self-regulation earlier in infancy tend to use observational measures. This could be due to the fact that there are no parent-reported measures designed to be applied in infants with less than three months of age. However, considering the advantages of using parent-reported measures, adapting parent-reported measures to assess self-regulation in younger infants could be a major advance to the literature and practice in the field.

Finally, it is important to note that most of the reviewed studies used only one measure to assess of infant self-regulation. However, as infant self-regulation is conceptually defined as a multidimensional and complex construct (Rothbart et al., 2011), including observational, parent-reported, and physiological indicators of self-regulation could represent a major advance to the assessment of infant self-regulation. Moreover, to study the psychometric characteristics of parent-reported measures using observational and/or physiological measures could advance the assessment of infant self-regulation during the first year of life.

This study also identified the behavioral and physiological measures most used to assess infant self-regulation. Regarding behavioral measures, the NNS (Lester & Tronick, 2004) and the NBAS (Brazelton & Nugent, 1995) were identified as the observational measures most used to assess self-regulation in younger infants. While the FFSF (Tronick et al., 1978) and the BSID-II (Bayley, 1993) were identified as the observational measures most used to assess self-regulation in older infants. The IBQ-R (Gartstein & Rothbart, 2003) and the ASQ:SE (Squires et al., 2001) were identified as the parent-reported measures most used to assess infant self-regulation. Regarding physiological measures, infant's vagal regulation through RSA was identified as the measure most used to assess infant self-regulation.

The development of self-regulation during infancy has several implications for further development and adjustment (e.g., Eisenberg et al., 2004; Perry et al., 2016; Williams et al., 2016). To study self-regulation early in infancy is a major issue to understand self-regulatory processes in developing infants and to identify infants with self-regulation difficulties. Measures used to assess infant self-regulation during the first 12 months of life are generally selected according with the study design, the sample size, and mainly the infant age. Studies targeting younger infants used physiological measures

and studies targeting older infants used behavioral measures, with observational measures used with younger infants and parental-reported measures used with older infants during the first year of life.

The present systematic review contributes to research and practice on infant self-regulation, assisting researchers and clinical practitioners to select adequate measures to assess infant self-regulation at different ages and in diverse circumstances. When measuring self-regulation is important to consider the infant age, in order to fit the measure procedures with the infant self-regulation development level, that is how self-regulation is established and manifested.

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PAPER II

COPARENTING QUALITY MODERATES THE IMPACT OF MOTHER'S PRENATAL DEPRESSIVE
SYMPTOMS ON INFANT SELF-REGULATION

Pinto, T. M., Feinberg, M. E., & Figueiredo, B. (under review). Coparenting quality moderates the impact of mother's prenatal depressive symptoms on infant self-regulation. *Development and Psychopathology*

Abstract

As a development-enhancing or a risk-promoting environment, coparenting may shape the impact of mother's prenatal depressive symptoms on infant self-regulation. This study aimed to analyze the moderator role of positive and negative coparenting in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. A sample of 103 primiparous couples ($N = 206$ parents) were recruited at the first trimester of pregnancy. Mothers reported on depressive symptoms at the first trimester of pregnancy, and both parents reported on depressive symptoms, coparenting, and infant self-regulation at two weeks and three months postpartum. Results indicated that higher levels of mother's prenatal depressive symptoms and higher levels of mother and father's report of negative coparenting at two weeks postpartum predicted lower infant self-regulation at three months. Negative coparenting at two weeks postpartum accentuated the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. The results support a view of negative coparenting as a risk-promoting environment that can accentuate the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. Infants in families with mothers with elevated prenatal depressive symptoms and with high levels of negative coparenting may be at high risk of self-regulation problems.

Keywords: mother's prenatal depressive symptoms; coparenting; infant self-regulation.

Introduction

Developmental psychopathology perspective acknowledges the importance of understanding the mechanisms and the causal processes in the prenatal and postnatal environments that impact infant development (Sroufe, 1997; Rutter & Sroufe, 2000). Regarding the prenatal environment, mother's prenatal mental health problems have been showing to negatively influence the intrauterine environment and consequently fetal and infant development (e.g., Dias & Figueiredo, 2020; Field, 2011; Henrichs & Van den Bergh, 2015). Coparenting has been shown to be a major element of the postnatal environment influencing infant development, even when parenting quality is taken into account (e.g., Cummings et al., 2000; Feinberg et al., 2009; Teubert & Pinquart, 2010).

Developing self-regulatory capacity is a major developmental task in infancy (Bell & Deater-Deckard, 2007). Self-regulation is defined "as processes that serve to modulate reactivity" (Rothbart et al., 2011, p. 442). Self-regulating mechanisms include orienting of attention, inhibition, angry attack, surgent or extraverted approach, and the effortful control of behavior based on the executive attention system (Rothbart et al., 2011; Rothbart et al., 1992). Infants' capacity to deploy these self-regulatory mechanisms is a resource that promotes further development, while self-regulation difficulties predict a variety of adjustment problems, including internalizing and externalizing problems, impaired social skills, and disrupted physiological regulation to stress (e.g., Eisenberg et al., 2004; Perry et al., 2016; Williams et al., 2016).

Mother's prenatal depressive symptoms and postnatal coparenting quality may impact infant development partly due to their impact on infants' self-regulatory capacity. Literature provides evidence of the adverse impact of mother's prenatal depression on infant self-regulation (e.g., Henrichs & Van den Bergh, 2015). Infants of prenatally depressed mothers demonstrate poor regulation of emotional state, disorganized sleep, more difficult temperament, and lower autonomic stability (e.g., Babineau et al., 2015; Dias & Figueiredo, 2020; Martini et al., 2017). One explanation for these findings is that mother's prenatal depression may affect the embryonic environment, leading to delayed fetal and consequently infant self-regulation maturation (e.g., Davis et al., 2011; Figueiredo et al., 2017).

An additional possible pathway is based on the notion that mother's prenatal depression leads to a higher probability of postnatal depression (Figueiredo et al., 2007). Parental postnatal depressive symptoms may then exacerbate negative coparenting interactions, leading to lower levels of coparental cooperation and higher levels of conflict and competition (e.g., Bronte-Tinkew et al., 2009; Tissot et al., 2017; Tissot et al., 2019). Coparenting is defined as the reciprocal involvement of both parents in

childrearing—including schooling, socialization, responsibilities, and decisions about their children’s lives. This dyadic relationship refers specifically to the coordination and support that each coparent provides to the other in childcare (Feinberg, 2002). Feinberg (2003) proposed an empirically based coparenting ecological model, conceptualizing coparenting in four interrelated dimensions: (a) the agreement or disagreement on childrearing issues, (b) the division of labor, (c) the support versus undermining for the coparental role, and (d) the joint management of family interactions.

Coparenting quality can serve as a development-enhancing or a risk-promoting environment for infant self-regulation. Positive coparenting dimensions (cooperation, support) have been shown to improve infant self-regulation, namely self-soothing (e.g., Feinberg et al., 2009). On the other hand, negative coparenting dimensions (e.g., conflict, undermining) predict children’s emotional and behavioral problems, across developmental stages (e.g., Lamela et al., 2016; Scrimgeour et al., 2013; Teubert & Pinquart, 2010). Coparenting quality can impact infant self-regulation through two pathways, namely through the infant’s experiences of emotional arousal or parent-infant interaction (e.g., Busuito & Moore, 2017; Calkins & Hill, 2007; Moore et al., 2009). Positive coparenting may provide repeated experiences of positive emotional arousal, thereby improving cohesive, secure, and coordinated parent-infant interaction and co-regulation. In contrast, negative coparenting interactions (e.g., conflict) may expose the infant to repeated experiences of negative emotional arousal, as well as disrupted parenting, leading to disrupted parent-infant interaction and co-regulation. In infancy, interparental conflict is associated with lower levels of infant self-regulation, such as lower overall infant vagal tone (e.g., Busuito & Moore, 2017; Moore, 2010; Porter et al., 2003). Coparenting relations are a subset of overall interparental relations that have been shown to have a greater impact on child adjustment during early childhood than the overall interparental relationship (Holland & McElwain, 2013; Teubert & Pinquart, 2010). Thus, negative coparenting interactions during infancy may increase infant negative emotional arousal, disrupt parenting, undermine cohesive parent-infant interaction, and consequently affect infant self-regulation.

As a development-enhancing or a risk-promoting environment, coparenting may shape the adverse impact of mother’s prenatal depressive symptoms on infant self-regulation. Analyzing the moderator role of positive and negative coparenting in the impact of mother’s prenatal depressive symptoms on infant self-regulation may represent an advance on developmental psychopathology literature. Mother’s prenatal depressive symptoms could have an adverse impact on infant self-regulation, leading to delayed fetal and infant self-regulation maturation (e.g., Davis et al., 2011; Figueiredo et al., 2017; Martini et al., 2017). The impact of positive and negative coparenting on infant self-regulation could be higher in infants of mothers with higher prenatal depressive symptoms, due to their delayed self-

regulation maturation. Namely, infants of mothers with higher prenatal depressive symptoms could be more susceptible to the impact of both positive and negative coparenting. The positive experiences provided by positive coparenting interactions (e.g., support) could help to promote the development of self-regulation, attenuating the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. Contrarily, the negative experiences provided by negative coparenting interactions (e.g., conflict) may accentuate the adverse impact of mother's prenatal depressive symptoms on infant self-regulation, increasing the risk of self-regulation problems. This study aimed to analyze the moderator role of positive and negative coparenting in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months.

Method

Participants

The sample comprised 103 primiparous couples, 206 mothers or fathers. All mothers and fathers were married (50.9%) or cohabiting (49.1%). Most were Portuguese (91.4% of mothers and 94.6% of fathers), employed (89.6% of mothers and 89.2% of fathers), and were from medium or high socioeconomic levels (86.7% of mothers and 91.1% of fathers). Half of mothers and fathers were aged between 30 and 39 years old (52.1%; $M_{\text{mothers}} = 29.66$, $SD = 4.57$; $M_{\text{fathers}} = 31.51$, $SD = 5.29$), and had more than 12 years of education (59.5% of mothers and 48.4% of fathers; see Table 7). Regarding pregnancy, most reported good or very good pregnancy acceptance (92.2% of mothers and 95.7% of fathers) and the conception was spontaneous (92.2%). Regarding delivery, more than half was vaginal (62.2%).

Table 7

Mother and father's sociodemographic characteristics

		Mothers	Fathers	Total
		<i>n</i> = 103	<i>n</i> = 103	<i>N</i> = 206
		%	%	%
<i>Age (years)</i>	19-29	49.1	35.5	42.3
	30-39	48.3	55.9	52.1
	≥ 40	2.6	8.6	5.6
<i>Socioeconomic level</i>	High	51.4	37.8	44.6
	Medium	35.3	53.3	44.3
	Low	13.3	8.9	11.1
<i>Occupational status</i>	Employed	89.6	89.2	89.4
	Unemployed	10.4	10.8	10.6
<i>Education (in years)</i>	≤ 9	0.0	6.4	3.2
	10 – 12	40.5	45.2	42.9
	> 12	59.5	48.4	53.9
<i>Pregnancy acceptance</i>	Very good/good	92.2	95.7	93.9
	Neither good nor bad	4.4	2.1	3.3
	Very bad/bad	3.4	2.2	2.8

All infants were first-born, 53.7% female and 46.3% male. Most infants were born at term (≥ 37 gestational weeks; 91.5%; $M = 39.24$, $SD = 1.25$) and with more than 2500g (96.3%; $M = 3386.51$, $SD = 591.18$). More than half were exclusively breastfed during the first three months of age (63.5%). Most infants did not have health problems during the first three months of age (86.5%) and the mothers were the primary caregiver (94.6%; see Table 8).

Table 8

Infant's biometric and sociodemographic characteristics.

		<i>N</i> = 103 (%)
Sex	Female	53.7
	Male	46.3
Gestational weeks at birth	≥ 37	91.5
	< 37	8.5
Birthweight	≥ 2500 g	96.3
	< 2500 g	3.7
Breastfeeding at three months	Exclusive	63.5
	No-exclusive	36.5
Health problems at three months	No	86.5
	Yes	13.5
Primary caregiver at three months	Mother	94.6
	Father	5.4

Procedures

The present research was conducted in accord with the Helsinki Declaration and received previous approval from the Ethical Commission of all institutions involved. Couples were recruited at a public Health Service in Northern Portugal during the first trimester of pregnancy, before the first fetal ultrasound (10-13 gestational weeks). The study exclusion criteria were not reading or writing Portuguese, not being married or cohabiting, multiparous mothers and fathers, multiple gestations, and gestations with obstetric complications. The aims and the procedures of the study were explained, and the mothers and fathers willing to participate provided a written consent form. From the 146 primiparous couples contacted at the public Health Service and willing to be contacted by email to participate in the study, 130 couples were willing to participate and completed the questionnaires at the first trimester of pregnancy (89%).

This study had a longitudinal design with three online assessment waves: (1) first trimester of pregnancy (10-20 gestational weeks, $M = 13.46$, $SD = 2.42$), (2) two weeks postpartum (2-8 postpartum weeks, $M = 3.39$, $SD = 2.05$), and (3) three months postpartum (11-21 postpartum weeks, $M = 14.56$,

$SD = 2.22$). At the first trimester of pregnancy, both mothers and fathers independently completed a socio-demographic questionnaire and a measure of depressive symptoms. At two weeks and three months postpartum, both mothers and fathers completed measures of depressive symptoms, coparenting, and infant self-regulation. From the couples who completed the questionnaires at the first trimester of pregnancy, 103 mothers and 103 fathers completed the questionnaires at two weeks and at three months postpartum (79.0%; $n = 206$).

The mothers and fathers who completed all the assessment waves did not differ from those mothers and fathers who did not complete the data, in terms of sociodemographic characteristics and infant's biometric and sociodemographic data. In addition, no differences were found between the mothers and fathers who completed all the assessment waves and those who did not completed in the studied variables at each assessment wave.

Measures

Sociodemographic Questionnaire. Information about the mothers, fathers, and infants was collected using a Sociodemographic Questionnaire (Figueiredo et al., 2009).

Prenatal and postnatal depressive symptoms. The Portuguese version of the Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) was used to assess mother's prenatal and mother and father's postnatal depressive symptoms. The EPDS is a 10-item self-report scale scored on a four-point Likert-type scale designed to assess the intensity of depressive symptoms within the previous seven days. This instrument has been used in several studies with mothers and fathers during pregnancy and the postpartum period (e.g., Figueiredo et al., 2014; Figueiredo et al., 2018; Pinto et al., 2018). The Portuguese version of the EPDS showed good internal consistency in mothers and fathers both during pregnancy and the postpartum period (e.g., Figueiredo et al., 2014; Figueiredo et al., 2018; Pinto et al., 2018). In the present sample, Cronbach's alphas ranged from .78 to .88 (α 's range = .80 – .88 in mothers; α 's range = .78 – .85 in fathers).

Coparenting. The Portuguese version of the Coparenting Relationship Scale (CRS; Feinberg et al., 2012; Lamela et al., 2016; Lamela et al., 2018) was used to assess positive and negative coparenting. The CRS is a 35-item self-report scale scored on a seven-point Likert-type scale designed to assess the four domains of coparenting proposed by Feinberg (2003) and comprises six subscales: (1) coparenting agreement subscale (four items) that assesses the degree that each parent agrees with matters related to the infant's education (e.g., My partner and I have different ideas regarding our child's eating, sleeping, and other routines); (2) coparenting closeness subscale (five items) that assesses the degree to which coparenting enhanced intimacy and strengthened the couple's relationship (e.g., My relationship with my partner is stronger now than before we had a child); (3) exposure to conflict subscale (five items) that assesses the degree that parents expose the infant to conflicts related to their education (e.g., One or both of you say cruel or hurtful things to each other in front of the child); (4) coparenting support subscale (six items) that assesses the perception of coparenting support from the other parent (e.g., My partner makes me feel like I'm best possible parent for our child); (5) coparenting undermining subscale (six items) that assesses the perception that coparenting is regulated by critics, guilt and competition between the parents (e.g., My partner sometimes makes jokes or sarcastic comments about the way I am as a parent); and (6) endorse partner parenting subscale (7 items) that assesses one's own positive attitude toward the other parent's parenting (e.g., I believe my partner is a good parent).

The Portuguese version of the CRS showed good internal consistency in mothers and fathers (Lamela et al., 2016; Lamela et al., 2018). In the present sample, Cronbach's alphas ranged from .80 to .92 (α 's range = .80 – .88 in mothers; α 's range = .84 – .92 in fathers). Composite scores for mother and father's positive and negative coparenting were calculated by standardizing each scale, summing the positive (agreement, closeness, support, and endorse partner parenting) and negative (exposure to conflict, undermining) subscales and dividing by the number of subscales, respectively.

Infant self-regulation. The orienting regulation dimension of the Infant Behavior Questionnaire - Revised short form (IBQ-R; Gartstein & Rothbart, 2003; Putnam et al., 2014) was used to assess infant self-regulation. The IBQ-R short form comprises 91 items in 14 scales, scored in a seven-point Likert-type scale, related to the frequency of occurrence of the infants' behaviors in several specific situations during the previous week or two weeks. The orienting dimension is comprised the mean scores of four scales: low-intensity pleasure (seven items), cuddliness (six items), duration of orienting (six items) and soothability (seven items) scales.

The IBQ-R has globally shown validity and reliability in different cultural backgrounds and across different infant ages (e.g., Dias et al., 2021). The orienting regulation dimension of the IBQ-R Portuguese version showed good internal consistency (α 's = .60 - .80; Costa & Figueiredo, 2018). In the present sample, Cronbach's alphas ranged from .69 to .74 (α 's range = .72 - .74 in mothers; α 's range = .69 - .71 in fathers). Although both mothers and fathers reported on their infant self-regulation, only the orienting regulation scores reported by the primary caregiver were included in the analysis (mostly mothers; see Table 8).

Data analysis

To analyze the moderator role of positive and negative coparenting in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months, a moderation model was tested using multiple and hierarchical linear regression (Baron & Kenny, 1986). Model one included mother's depressive symptoms at the first trimester of pregnancy as independent variable and infant self-regulation at three months as dependent variable. Model two included variables from model one, adding mother and father's positive and negative coparenting at two weeks postpartum. Model three included variables from model one and two, adding the interaction between them. We included mother and father's depressive symptoms at two weeks postpartum as covariates in the models.

The significant interactions between the independent variables were graphed using one standard deviation above and below the mean of the moderator variables. Statistical significance was considered at $p < .05$. Statistical analyses were performed using SPSS version 26.0 (SPSS Inc., USA).

Results

Preliminary analyses

Descriptive statistics are presented in Table 9. Significant correlations were found between mother's depressive symptoms at the first trimester of pregnancy, mother and father's positive and negative coparenting at two weeks postpartum, and infant self-regulation at three months, $r_s = -.26-.42$, $p_s < .01$. Significant correlations were also found between mother and father's depressive symptoms, $r_s = .35-.50$, $p_s < .01$, and between mother and father's positive and negative coparenting at two weeks postpartum, $r_s = -.45-.43$, $p_s < .01$ (see Table 10).

Table 9

Descriptive statistics of the study's variables

	<i>M</i>	<i>SD</i>
Mother's prenatal depressive symptoms	5.47	4.04
Mother's postnatal depressive symptoms	4.59	3.59
Father's postnatal depressive symptoms	3.20	3.04
Mother's positive coparenting	24.93	4.39
Father's positive coparenting	25.36	10.73
Mother's negative coparenting	2.78	1.11
Father's negative coparenting	2.60	1.55
Infant self-regulation	5.30	0.70

Notes. *M* = mean; *SD* = standard deviation.

Impact of mother's prenatal depressive symptoms and of mother and father's positive and negative coparenting on infant self-regulation at three months

Results indicated that mother's prenatal depressive symptoms significantly ($p < .01$) predicted infant self-regulation, accounting for 6% of the variance. Higher levels of mother's prenatal depressive symptoms predicted lower levels of infant self-regulation at three months, $\beta = -3.15$, $p = .028$ (see Table 11).

Mother and father's negative coparenting at two weeks postpartum significantly ($p < .01$) predicted infant self-regulation, accounting for 12% of the variance. Higher levels of negative coparenting reported by mothers, $\beta = -1.40$, $p = .027$, and fathers, $\beta = -1.61$, $p = .031$ predicted less infant self-regulation at three months, $\beta = 0.80$, $p = .049$. Mother and father's positive coparenting at two weeks postpartum did not predict infant self-regulation at three months (see Table 11).

Table 10

Correlations among study variables

	1	2	3	4	5	6	7	8
1. Mother's prenatal depressive symptoms	1.00							
2. Mother's postnatal depressive symptoms	.50***	1.00						
3. Father's postnatal depressive symptoms	.39**	.35**	1.00					
4. Mother's positive coparenting	-.39***	-.34**	-.42***	1.00				
5. Father's positive coparenting	-.30**	-.34**	-.37**	.47***	1.00			
6. Mother's negative coparenting	.34**	.33**	.53***	-.75***	-.48**	1.00		
7. Father's negative coparenting	.33**	.34**	.56***	-.45**	-.73***	.55***	1.00	
8. Infant self-regulation	-.36**	-.29**	-.26**	.42***	.33**	-.32**	-.35**	1.00

** $p < .01$; *** $p < .001$

The moderator role of mother and father's positive and negative coparenting in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months

Significantly increasing the variance explained by the second linear regression, the third linear regression for infant self-regulation at three months was statistically significant ($p < .001$) and explained 18% of the variance (adjusted $R^2 = .18$). The interaction between mother's depressive symptoms at the first trimester of pregnancy and mother's report of negative coparenting at two weeks postpartum significantly predicted infant self-regulation at three months, $\beta = 2.90$, $p = .028$. Likewise, the interaction between mother's depressive symptoms at the first trimester of pregnancy and father's report of negative coparenting at two weeks postpartum significantly predicted infant self-regulation at three months, $\beta = 2.84$, $p = .029$ (see Table 11).

The plot of the interactions revealed that among families with low levels of negative coparenting, the impact of mother's prenatal depressive symptoms on infant self-regulation was small. However, among families with high levels of negative coparenting, infant self-regulation was substantially lower when mothers reported more prenatal depressive symptoms (see Figure 2). The interactions between mother's prenatal depressive symptoms and mother and father's positive coparenting, respectively, did not significantly predict infant self-regulation (see Table 11).

Table 11

The moderator role of mother and father's positive and negative coparenting at two weeks postpartum in the impact of mother's prenatal depression symptoms on infant self-regulation at three months

	Total R^2	F	β	p	R^2 change
<i>Model one</i>	.07 (.06)	5.04**			
Mother's prenatal depressive symptoms			-3.15	.028	
<i>Model two</i>	.13 (.12)	5.79***			.06***
Mother's positive coparenting			1.14	.108	
Father's positive coparenting			1.13	.098	
Mother's negative coparenting			-1.40	.027	
Father's negative coparenting			-1.61	.031	
<i>Model three</i>	.20 (.18)	6.27***			.07***
Mother's prenatal depressive symptoms x mother's positive coparenting			-2.93	.233	
Mother's prenatal depressive symptoms x father's positive coparenting			-2.79	.103	
Mother's prenatal depressive symptoms x mother's negative coparenting			2.90	.028	
Mother's prenatal depressive symptoms x father's negative coparenting			2.84	.039	

Notes. The model was adjusted for mother and father's postnatal depressive symptoms.

** $p < .01$; *** $p < .001$

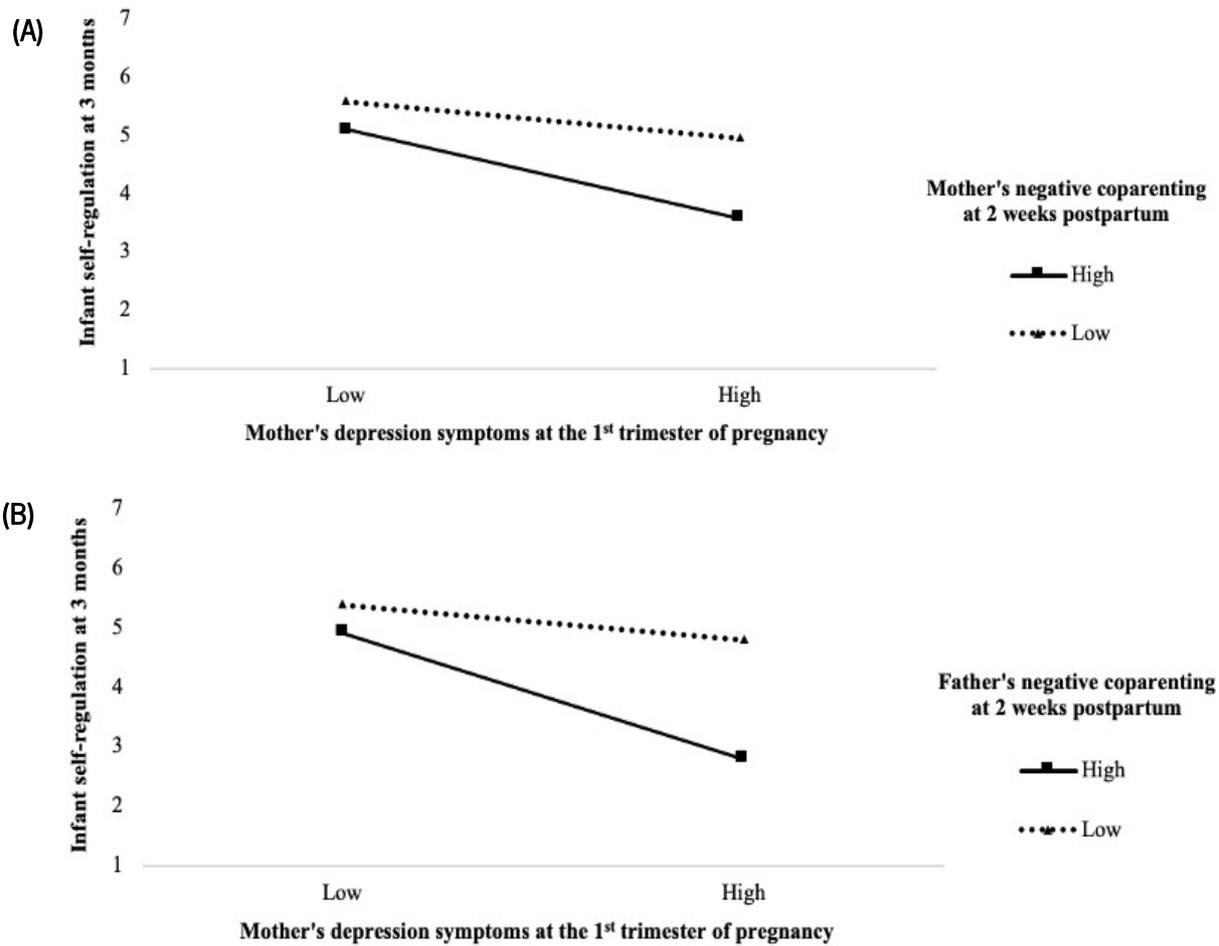


Figure 2. Graphic representation of the moderator role of mother (A) and father's (B) negative coparenting at two weeks postpartum in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months.

Discussion

This study analyzed the moderator role of positive and negative coparenting in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. The study shows that experiences provided by negative coparenting interactions reported by mothers and fathers, accentuated the adverse impact of mother's prenatal depressive symptoms on infant self-regulation development, increasing the risk of self-regulation problems.

Results showed the possible adverse impact of mother's prenatal depressive symptoms on infant self-regulation at three months. Higher levels of mother's prenatal depression symptoms predicted less infant self-regulation at three months. This result is congruent with previous studies (e.g., Babineau et al., 2015; Dias & Figueiredo, 2020; Figueiredo et al., 2017). This finding seems to be significant, as the model had controlled mother and father's postnatal depressive symptoms. It is possible that mother's prenatal depressive symptoms predicted infant self-regulation over and above parents' postnatal levels of depression due to influences on the fetal environment and development (Henrichs & Van den Bergh, 2015). Prenatal depression is associated with maternal sleep difficulties, and more unhealthy habits, namely tobacco consumption and poorer nutrition (e.g., Miguez et al., 2019; Monk et al., 2013). As a consequence, disruptive hormonal alterations may occur in the embryonic environment (e.g., Szpunar & Parry, 2018), leading to delayed fetal and infant self-regulation maturation (Davis et al., 2011; Figueiredo et al., 2017; Martini et al., 2017).

Results showed the possible adverse impact of mother and father's negative coparenting at two weeks postpartum on infant self-regulation at three months. More negative coparenting at two weeks postpartum reported by both mothers and fathers predicted less infant self-regulation at three months. These results are congruent and advance the findings of previous studies (e.g., Feinberg et al., 2009; Moore, 2010; Porter et al., 2003) while showing the specific impact of negative coparenting during the early postpartum period on the development of infant self-regulation at three months of life. This finding also advances the ones of previous studies as the adverse impact of mother and father's negative on infant self-regulation was observed, when mother and father's postnatal depressive symptoms was controlled in the model. It is possible that negative coparenting predicted infant self-regulation over and above mother and father's postnatal levels of depression. Including father's reports of coparenting is also one of the major advances of the present study to the literature. Results also suggested no impact of mother and father's positive coparenting at two weeks postpartum on infant self-regulation at three

months. This finding may suggest that negative coparenting could have a higher impact on the early self-regulation development, than positive coparenting.

Mother and father's negative coparenting moderated the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. Results showed that, mother's prenatal depressive symptoms were more strongly related to lower infant self-regulation when mothers or fathers reported higher negative coparenting at two weeks postpartum. Findings suggested that the impact of mother and father's negative coparenting on infant self-regulation is higher in infants of mothers with higher prenatal depressive symptoms. Results also suggested that mother and father's positive coparenting does not moderate the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. This finding reinforces the evidence of negative coparenting as a risk-promoting environment for early self-regulation development.

Although the prenatal environment plays a major role in the development of self-regulation (e.g., Henrichs & Van den Bergh, 2015), infants' regulatory capacities during the first year of life are supported by and developed through parents–infant co-regulation (e.g., Calkins & Hill, 2007; Moore et al., 2009). Findings supported the view of negative coparenting as risk-promoting environment for infant self-regulation (e.g., Moore, 2010; Porter et al., 2003). Mother and father's negative coparenting (e.g., exposure to conflict) may negatively impact infant self-regulation development by exposing the infant to repeated negative experiences of emotional arousal (e.g., Busuito & Moore, 2017). Moreover, mother and father's negative coparenting (e.g., undermining) may negatively impact infant self-regulation by increasing disrupted parenting, leading to disrupted parents-infant interaction and co-regulation (e.g., Calkins & Hill, 2007; Moore et al., 2009). Due to delayed self-regulation maturation associated with mother's prenatal depressive symptoms (e.g., Davis et al., 2011; Figueiredo et al., 2017; Martini et al., 2017), infants of mothers with higher levels of prenatal depressive symptoms could present higher susceptibility to the adverse impact of negative coparenting. The negative experiences provided by negative coparenting interactions may accentuate the adverse impact of mother's prenatal depressive symptoms on infant self-regulation and may increase the risk of self-regulation problems. Findings from this study advance the literature on infant self-regulation by suggesting (1) the adverse impact of mother's prenatal depressive symptoms (assessed at the first trimester of pregnancy) on infant self-regulation; and (2) negative coparenting during the early postpartum period as a risk-promoting environment that can accentuate the adverse impact of mother's prenatal depressive symptoms on infant self-regulation.

Limitations

This study presented some limitations that should be noted. The voluntary nature of the participation in the study may have led to a selection bias. Mothers and fathers who agreed to participate may be those who feel more involved and satisfied with the pregnancy and the postpartum experience. However, no differences were found between mothers and fathers that completed all the assessment waves and those who did not. As independent and dependent variables were generated by the same informants, a common-method variance may have inflated the links between the study variables. Specifically, infant self-regulation was assessed with a parent-reported measure. However, previous literature found an association between parent-reported and observational measures of infant self-regulation, suggesting that parents are reliable informants of their infant's behaviors when they are their primary caregiver (e.g., Rothbart et al., 2011). Considering this, in the present study, the reports of self-regulation were provided by the infant's primary caregiver. Parent-reported measures allow the assessment of infant self-regulation in daily routine situations across a variety of contexts where parents have more opportunities to observe the infant than an observer (Rothbart et al., 2011). Moreover, infant self-regulation was assessed with the IBQ-R short form, a parent-reported measure design to assess infant temperament. However, as self-regulation is a process that serves to modulate temperamental reactivity (Rothbart et al., 2011), the IBQ-R has been pointed out as a useful self-reported measure to assess infant self-regulation (Pinto & Figueiredo, under review).

Implications for practice and research

The findings of the present study have major implications for clinical practice and research. Infants in families of mothers with elevated prenatal depressive symptoms and with high levels of negative coparenting may be at high risk of self-regulation problems. Interventions targeting infant mental health and development problems should start early in infancy targeting both mother mental health and coparenting quality. To reduce negative coparenting interactions during the early postpartum period could help to prevent self-regulation problems, particularly in infants at higher risk of self-regulation problems, associated with mother's prenatal symptoms. Delivering interventions with a such multi-factor approach are feasible; indeed, couple-focused interventions across pregnancy and the postpartum period have demonstrated positive impact on parental mental health, coparenting, and infant development (e.g., Feinberg et al., 2009; Feinberg et al., 2016).

This study suggested that mother and father's negative coparenting increases the adverse impact of mother's prenatal depressive symptoms on infant self-regulation at three months. Following developmental psychopathology conceptual model, future research should explore the mechanisms underlying the impact of mother's prenatal depressive symptoms (e.g., lower fetal heart rate variability) that could explain why infants of mothers with higher levels of prenatal depressive symptoms are more susceptible to the impact of negative coparenting. Future studies should also explore the underlying mechanisms (e.g., infant vagal reactivity) and processes (e.g., disrupted parents-infant interaction) that could explain the adverse impact of negative coparenting on infant self-regulation.

Conclusion

This study represents an advance in the family developmental psychopathology literature by finding that mother and father's negative coparenting accentuates the adverse impact of mother's prenatal depressive symptoms on infant self-regulation development at three months of life. Negative coparenting can be a risk-promoting environment, increasing the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. Infants in families with mothers with elevated prenatal depressive symptoms and high levels of negative coparenting may be at high risk of self-regulation problems.

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PAPER III

FETAL HEART RATE VARIABILITY AND INFANT SELF-REGULATION

Pinto, T. M., Nogueira-Silva, C., & Figueiredo, B. (under review). Fetal heart rate variability and infant self-regulation. *Developmental Psychology*

Abstract

Mother's prenatal depressive symptoms have an adverse impact on both fetal heart rate variability (FHRV) and infant self-regulation. FHRV is considered a marker of fetal neurobehavioral development associated with infant self-regulation and thus may be an early precursor of the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. This study analyzed the mediator role of FHRV in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. The sample comprised 86 first-born infants and their mothers. Mothers reported on depressive symptoms at the first trimester of pregnancy and on depressive symptoms and infant self-regulation at three months postpartum. FHRV was recorded during routine cardiotocography at the third trimester of pregnancy. A mediation model was tested, adjusting for mother's postnatal depressive symptoms. Results indicated that higher levels of mother's prenatal depressive symptoms predicted both lower FHRV and lower infant self-regulation at three months. FHRV predicted infant self-regulation at three months. FHRV mediated the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. Findings suggested FHRV as an early precursor of infant self-regulation that underlies the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. Infants of mothers with higher levels of prenatal depressive symptoms could be at risk of self-regulation problems, partially due to their lower FHRV.

Keywords: mother's prenatal depressive symptoms; fetal heart rate variability; infant self-regulation.

Introduction

The “developmental origins of health and disease” (DOHAD) hypothesis highlights the impact of prenatal environment on further infant mental and physical health and disease (Barker et al., 1989; Gluckman & Hanson, 2004). According to this hypothesis, the exposure to an adverse prenatal environment can have developmental programming effects on the fetus, leading to higher vulnerability for poor mental health outcomes across the life span (Monk et al., 2013; Raikkonen et al., 2011). Mother’s prenatal mental health problems, and specifically prenatal depression, can negatively influence the intrauterine environment and consequently infant development, namely self-regulation (Monk et al., 2013; Raikkonen et al., 2011; van den Bergh, 2011).

Developing self-regulatory mechanisms is a major developmental task during infancy (Bell & Deater-Deckard, 2007). Self-regulation is defined “as processes that serve to modulate reactivity” (Rothbart et al., 2011, p. 442). Self-regulating mechanisms include orienting of attention, inhibition, angry attack, surgent or extraverted approach, and the effortful control of behavior based on the executive attention system (Rothbart et al., 2011; Rothbart et al., 1992). Self-regulation allows the infant to manifest adequate behaviors and to appropriately respond to situational demands in accordance with his/her age and reactivity pattern (van den Bergh & Mennes, 2006).

Literature provides evidence of the adverse impact of mother’s prenatal depression on infant self-regulation (see Henrichs & van den Bergh, 2015 for a review). Infants of prenatally depressed mothers demonstrate poor regulation of emotional state, lower autonomic stability, more sleep and feeding problems, and more difficult temperament, such as negative emotionality, irritability, activity problems, and excessive crying (Babineau et al., 2015; Baibazarova et al., 2013; Dias & Figueiredo, 2020; Figueiredo et al., 2017; Martini et al., 2017; van den Berg et al., 2009).

Prenatal depression may alter the embryotic environment (Szpunar & Parry, 2018; van den Bergh, 2011), and consequently impact fetal neurodevelopment (Raikkonen et al., 2011; van den Bergh 2011). This may lead to delayed fetal neurobehavioral development (e.g., lower fetal heart rate variability) and consequently to lower self-regulation in the infant (Davis et al., 2011; Figueiredo et al., 2017). Recent literature provides evidence of the adverse impact of mother’s prenatal depression on fetal heart rate variability (FHRV). Fetuses of prenatally depressed mothers were found to show low FHRV, both in rest or in stimulation conditions (Davis et al., 2011; Figueiredo et al., 2017), and greater FHR reactivity to a lab-induced stressor (Monk et al., 2011; Monk et al., 2004).

FHRV is considered a marker of fetal neurobehavioral development that might be associated with later infant self-regulation (DiPietro et al., 2007; DiPietro et al., 2015; Figueiredo et al., 2017). Infants with lower FHRV were found to present lower autonomic stability, higher negative affect, lower orienting regulation, poorer mental development, poorer language development and symbolic play, as well as more behavioral difficulties and fewer prosocial behavior (Bornstein et al., 2002; DiPietro et al., 2007; DiPietro et al., 2018; Figueiredo et al., 2017; Howland et al., 2020; Werner et al., 2007). FHRV might also be considered an early precursor of infant self-regulation, as it may reflect emerging individual differences in the development of the autonomic nervous system (ANS), which is related with the infant capacity for behavioral regulation (Appelhans & Luecken, 2006; DiPietro et al., 2007; DiPietro et al., 2015; Porges, 2007; van den Bergh, 2020).

Literature highlights the importance of exploring the underlying mechanisms of the adverse impact of mother's prenatal depression on infant self-regulation (Henrichs & van den Bergh, 2015). An adverse impact of mother's prenatal depression was found on both FHRV and infant self-regulation, although mostly in separate studies (Martini et al., 2017; Monk et al., 2011; van den Berg et al., 2009). A recent longitudinal study proposed FHRV as an underlying mechanism of the adverse impact of mother's prenatal depression on neonate's neurobehavioral maturity, specifically on autonomic stability – an indicator of self-regulation (Figueiredo et al., 2017). FHRV is considered a marker of fetal neurobehavioral development associated with infant self-regulation and thus may be an early precursor of the adverse impact of mother's prenatal depressive symptoms on infant self-regulation (Appelhans & Luecken, 2006; DiPietro et al., 2007, DiPietro et al., 2015; van den Bergh, 2020). Following this hypothesis, this study aimed to analyze the mediator role of FHRV in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. To address this aim, the present study controlled for mother's postnatal depression symptoms. This is a major issue addressed by this study, considering that mother's prenatal depressive symptoms were found to increase the risk of higher levels of postnatal depressive symptoms (Figueiredo et al., 2007; Fisher et al., 2016) and that mother's postnatal depressive symptoms was associated with lower levels of infant self-regulation (Granat et al., 2017; Manian & Bornstein, 2009).

Method

Participants

The sample comprised 86 first-born infants and their mothers. Mothers were married (51.0%) or cohabiting (49.0%). Most were Portuguese (92.3%), employed (89.7%), and were from medium or high socio-economic levels (86.9%). Half of mothers were aged between 30 and 39 years old (48.4%; $M = 29.57$, $SD = 4.52$), and had more than 12 years of education (59.5%; see Table 12). Regarding pregnancy, most reported good or very good pregnancy acceptance (92.4%) and the conception was spontaneous (93%). Regarding delivery, more than half was vaginal (62.2%).

Infants were 53.5% female and 46.5% male. Most infants were born at term (≥ 37 gestational weeks; 92%; $M = 39.25$, $SD = 1.27$) and with more than 2500g (96.5%; $M = 3386.53$, $SD = 591.48$). More than half were exclusively breastfed during the first three months of age (63.8%). Most infants did not have health problems during the first three months of age (87.2%) and the mothers were the primary caregiver (95%; see Table 12).

Table 12

Mother and infant's sociodemographic and biometric characteristics.

			<i>N</i> = 86 (%)
Mothers	Age (years)	19-29	49.1
		30-39	48.4
		≥ 40	2.5
	Socioeconomic level	High	51.4
		Medium	35.5
		Low	13.1
	Occupational status	Employed	89.7
		Unemployed	10.3
	Education (in years)	10 – 12	40.5
		> 12	59.5
Pregnancy acceptance	Very good/good	92.4	
	Neither good or bad	4.2	
	Very bad/bad	3.4	
Infants	Sex	Female	53.5
		Male	46.5
	Gestational weeks at birth	≥ 37	92.0
		< 37	8.0
	Birthweight	≥ 2500 g	96.5
		< 2500 g	3.5
	Breastfeeding at three months	Exclusive	63.8
		No-exclusive	36.2
	Health problems at three months	No	87.2
		Yes	13.3
Primary caregiver at three months	Mother	95.0	
	Father	5.0	

Procedures

The present research was conducted in accord with the Helsinki Declaration and received previous approval from the Ethical Commissions of all institutions involved (SECVS 042/2016; 99/2017). Mothers were recruited at a public Health Service in Northern Portugal during the first trimester of pregnancy (10-13 gestational weeks), before the first fetal ultrasound. The study exclusion criteria were not reading or writing Portuguese, not being married or cohabiting, multiparous, multiple gestations, and gestations with obstetric complications. The aims and the procedures of the study were explained, and the mothers willing to participate provided a written consent form. From the 146 mothers contacted at the public Health Service and willing to be contacted by email to participate in the study, 130 mothers were willing to participate and completed the questionnaires at the first trimester of pregnancy (89%).

This study had a longitudinal design with three assessment waves. At the first trimester of pregnancy (10-20 gestational weeks, $M = 13.46$, $SD = 2.42$), mothers completed online a socio-demographic questionnaire and a measure of depressive symptoms. At the third trimester of pregnancy (30-33 gestational weeks, $M = 32.19$, $SD = 2.81$), FHRV was recorded during routine cardiotocography examination (CTG) by a nurse at the public Health Service where the mothers were recruited. At three months postpartum (11-21 postpartum weeks, $M = 14.56$, $SD = 2.22$), mothers completed online measures of depressive symptoms and infant self-regulation.

From the mothers who completed the questionnaires at the first trimester of pregnancy, 86 mothers provided FHR data and completed the questionnaires at three months postpartum (66.2%). The mothers who completed all the assessment waves did not differ from those mothers who did not complete the data, in terms of sociodemographic characteristics and infant's biometric and sociodemographic data. In addition, no differences were found between the mothers who completed all the assessment waves and those who did not completed in the studied variables at each assessment wave.

Measures

Sociodemographic Questionnaire. Information about the mothers and infants was collected using a Sociodemographic Questionnaire (Figueiredo et al., 2009).

Prenatal and postnatal depressive symptoms. The Portuguese version of the Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) was used to assess mother's prenatal and postnatal depressive symptoms. The EPDS is a 10-item self-report scale scored on a four-point Likert-type scale designed to assess the intensity of depressive symptoms within the previous seven days. This instrument has been used in several studies with mothers during pregnancy and the postpartum period (e.g., Figueiredo et al., 2014; Figueiredo et al., 2018). The Portuguese version of the EPDS showed good internal consistency in mothers both during pregnancy and the postpartum period (e.g., Figueiredo et al., 2014; Figueiredo et al., 2018). In the present sample, Cronbach's alphas ranged from .80 to .88.

Fetal heart rate variability. FHR signals were continuously recorded during CTG examination with no stimulus being presented. FHR signals were recorded continuously and stored using the Omniview-SisPorto system (Ayres-de-Campos et al., 2008). A fetal monitor was used to export FHR signals every 0.25 seconds in beats per minute, rounded to the nearest quarter of a beat. Data were subsequently exported to an Excel 2020 worksheet. FHRV was by calculating the difference between the highest and lowest FHR frequency value, per minute.

Infant self-regulation. The orienting regulation dimension of the Infant Behavior Questionnaire - Revised short form (IBQ-R; Gartstein & Rothbart, 2003; Putnam et al., 2014) was used to assess infant self-regulation. The IBQ-R short form comprises 91 items in 14 scales, scored in a seven-point Likert-type scale, related to the frequency of occurrence of the infants' behaviors in several specific situations during the previous week or two weeks. The orienting dimension is comprised the mean scores of four scales: low-intensity pleasure (13 items), cuddliness (17 items), duration of orienting (12 items) and soothability (18 items) scales. The IBQ-R has globally shown validity and reliability in different cultural backgrounds and across different infant ages (e.g., Dias et al., 2021). The orienting regulation dimension of the IBQ-R Portuguese version showed good internal consistency (α 's = .60 - .80; Costa & Figueiredo, 2018). In the present sample, Cronbach's alphas ranged from .72 to .74.

Data analysis

To analyze the mediator role of FHRV in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months, a mediation model was tested (see Figure 1) using four multiple linear regressions (Baron & Kenny, 1986). In the first regression, mother's prenatal depressive symptoms (at the first trimester of pregnancy) were entered as the independent variable and FHRV as the independent variable (Path a). In the second regression, FHRV (at the third trimester of pregnancy) was entered as the independent variable and infant self-regulation (at three months) as the dependent variable (Path b). In the third regression, mother's prenatal depressive symptoms were entered as the independent variable and infant self-regulation as the dependent variable (Path c). The fourth regression included both mother's prenatal depressive symptoms and FHRV as independent variables and infant self-regulation as the dependent variable (Path c'). The mediation model was adjusted for the gestational weeks when FHRV was assessed and for mother's postnatal depressive symptoms (at three months postpartum). The Sobel test was performed. Statistical significance was considered at $p < .05$. Statistical analyses were performed using SPSS version 26.0 (SPSS Inc., USA).

Results

Preliminary analyses

Descriptive statistics are presented in Table 13. Mother's depressive symptoms at the first trimester of pregnancy was associated with both lower FHRV and lower levels of infant self-regulation at three months, $r = -.42$ - $-.47$, all $ps < .001$. Higher FHRV was associated with higher levels of infant self-regulation at three months, $r = .56$, $p < .001$ (see Table 14).

Mother's depressive symptoms at the first trimester of pregnancy was associated with mother's depressive symptoms at three months postpartum, $r = .38$, $p < .001$. Mother's depressive symptoms at three months postpartum was associated with infant self-regulation three months, $r = -.29$, $p = .012$ (see Table 14). Thus, the tested mediation model was adjusted for mother's depressive symptoms at three months postpartum. No associations were found between mother's depressive symptoms at the first trimester of pregnancy and mother and infant's sociodemographic and biometric data.

Table 13

Descriptive statistics of the study's variables

	<i>M</i>	<i>SD</i>
Mother's prenatal depressive symptoms	5.46	4.02
Mother's postnatal depressive symptoms	4.47	3.37
Fetal heart rate variability	12.22	6.58
Infant self-regulation at three months	5.28	0.69

Notes. *M* = Mean; *SD* = Standard deviation.

Table 14

Correlations among study variables

	1	2	3	4
1. Mother's prenatal depressive symptoms	1.00			
2. Mother's postnatal depressive symptoms	.38***	1.00		
3. Fetal heart rate variability	-.47***	.30**	1.00	
4. Infant self-regulation at three months	-.42***	-.29**	.56***	1.00

** $p < .01$; *** $p < .001$ **Impact of mother's prenatal depressive symptoms on FHRV and on infant self-regulation at three months**

Results from the first regression (Path a) indicated that mother's prenatal depressive symptoms significantly predicted FHRV, accounting for 8% of the variance. Higher levels of mother's prenatal depressive symptoms predicted lower FHRV, $\beta = -0.47$, $p < .001$.

Likewise, results from the third regression (Path c) indicated that mother's prenatal depressive symptoms significantly predicted infant self-regulation, accounting for 7% of the variance. Higher levels of mother's prenatal depressive symptoms predicted lower levels of infant self-regulation at three months, $\beta = -0.37$, $p = .002$ (see Table 15).

Impact of FHRV on infant self-regulation at three months

Results from the second regression (Path b) indicated that FHRV significantly predicted infant self-regulation, accounting for 10% of the variance. Higher FHRV predicted higher levels of infant self-regulation at three months, $\beta = 0.96$, $p < .001$ (see Table 15).

The mediator role of FHRV in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months

The mediation model to test whether FHRV mediated the impact of mother's prenatal depressive symptoms on infant self-regulation at three months is presented in Table 15 and in Figure 3. Results from the fourth regression (Path c') indicated that FHRV significantly predicted infant self-regulation at three months, accounting for 13% of the variance, $\beta = 1.01$, $p = .032$. However, mother's prenatal depressive symptoms were no longer a predictor of lower levels of infant self-regulation at three months, $\beta = -0.23$, $p = .201$. These results suggested the mediator role of FHRV in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. Additionally, the Sobel test was statistically significant, *Sobel test* = -2.40, *SE* = 0.30, $p = .021$, suggesting the indirect impact of the independent variable (mother's prenatal depressive symptoms) on the dependent variable (infant self-regulation at three months), via the mediator (FHRV).

Table 15

The mediator role of FHRV in the impact of mother's prenatal depression symptoms on infant self-regulation at three months

	Total R ²	F	β	p
<i>Path a. FHRV</i>				
Mother's prenatal depressive symptoms	.09 (.08)	7.39***	-0.47	< .001
<i>Path b. Infant self-regulation</i>				
FHRV	.11 (.10)	8.79***	0.96	< .001
<i>Path c. Infant self-regulation</i>				
Mother's prenatal depressive symptoms	.08 (.07)	6.47***	-0.37	.002
<i>Path c'. Infant self-regulation</i>				
Mother's prenatal depressive symptoms	.14 (.13)	15.06***	-0.23	.201
FHRV			1.01	.032

Notes. FHRV = Fetal heart rate variability; the model was adjusted for the gestational weeks when FHRV was assessed and for mother's postnatal depressive symptoms; *Sobel test* = -2.40, *SE* = 0.30, *p* = .021

****p* < .005

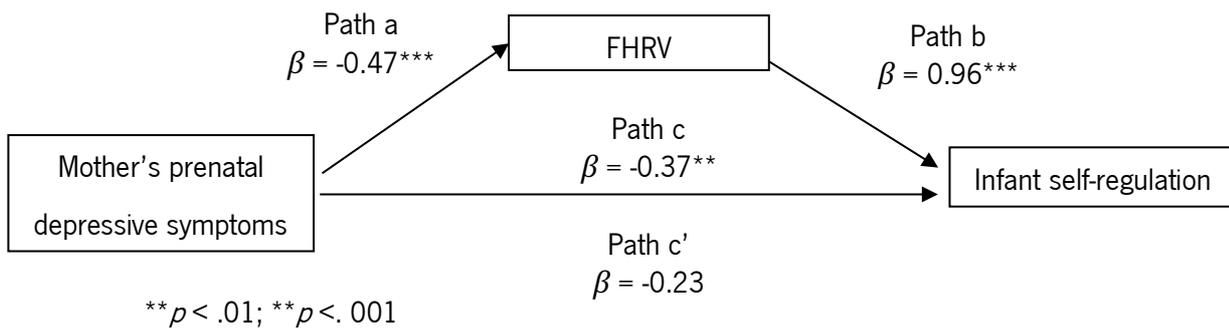


Figure 3. Mediation model results: the impact of mother's prenatal depressive symptoms on infant self-regulation at three months is mediated by fetal heart rate variability.

Discussion

This study analyzed the mediator role of FHRV in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. The study suggests FHRV as an early precursor of infant self-regulation that underlies the adverse impact of mother's depressive symptoms on infant self-regulation. It is important to highlight that this study controlled for mother's postnatal depression symptoms, considering the association between mother's postnatal depressive symptoms and both prenatal depressive symptoms and infant self-regulation (Figueiredo et al., 2007; Fisher et al., 2016; Granat et al., 2017; Manian & Bornstein, 2009).

Results provided evidence of the adverse impact of mother's prenatal depressive symptoms on FHRV. Higher levels of mother's depressive symptoms at the first trimester of pregnancy predicted lower FHRV assessed at the third trimester of pregnancy. This result is congruent with a previous study showing lower HRV in fetuses of prenatally depressed mothers at the third trimester of pregnancy (Figueiredo et al., 2017). This finding advances the previous literature by showing the adverse impact of mother's depressive symptoms early in pregnancy on FHRV assessed at the third trimester of pregnancy in a condition where no stimuli was presented, which provides information on baseline FHRV. This result suggests lower neurobehavioral development in fetuses of mothers with higher levels of prenatal depressive symptoms, as FHRV is an indicator of the ANS maturation of the fetus (DiPietro et al., 2015).

Likewise, results provided evidence of the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. Higher levels of mother's prenatal depression symptoms predicted less infant self-regulation at three months. This result is congruent with previous studies showing the adverse impact of mother's prenatal depression on infant self-regulation (Babineau et al., 2015; Baibazarova et al., 2013; Dias & Figueiredo, 2020; Martini et al., 2017; van den Berg et al., 2009). This finding seems to be significant, as the model had controlled mother's postnatal depressive symptoms, and no impact of mother's postnatal depressive symptoms was observed on infant self-regulation at three months. Mother's prenatal depressive symptoms may predict infant self-regulation over and above mother's postnatal levels of depression due to developmental programming effects on the fetus (Barker et al., 1989; Gluckman & Hanson, 2004).

Results also provided evidence of the association between FHRV and infant self-regulation. Higher FHRV predicted higher levels of infant self-regulation at three months. This finding is congruent with previous studies (e.g., DiPietro et al., 2007; DiPietro et al., 2018; Howland et al., 2020; Werner et al., 2007) and supports the idea that FHRV is an early precursor of infant self-regulation (Appelhans &

Luecken, 2006; van den Bergh, 2020). FHRV has been suggested to be an early marker of the ANS development (DiPietro et al., 2007; DiPietro et al., 2015; Porges, 2007). Namely, significant stability of HRV has been shown from the fetal period to the first year of infant's life (DiPietro et al., 2007). The ANS is associated with infant capacity for behavioral and autonomic regulation (DiPietro et al., 2015; Porges, 2007). Likewise, infant's vagal regulation was associated with higher levels of self-regulation during infancy (Bazhenova et al., 2001; Ham & Tronick, 2006; Stifter & Corey, 2001), as well as in later ages (El-Sheikh et al., 2009; Graziano & Derefinko, 2013).

Results provided evidence that FHRV mediated the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. In the present study, the fetuses of mothers with higher levels of prenatal depressive symptoms showed lower HRV, which predicted lower levels of infant self-regulation at three months. This result is congruent with a previous study (Figueiredo et al., 2017) and suggests lower FHRV as an early precursor of infant self-regulation that underlies the adverse impact of mother's depressive symptoms on infant self-regulation. Infants of mothers with higher levels of prenatal depressive symptoms could be at risk of self-regulation problems, partially due to their lower FHRV. Findings are framed and provide support to the DOHAD hypothesis (Barker et al., 1989; Gluckman & Hanson, 2004) proposing that the exposure to mother's prenatal depression may have developmental programming effects on infant self-regulation. According to the DOHAD hypothesis, higher levels of prenatal depressive symptoms may lead to a dysregulation of the mother's hypothalamic-pituitary-adrenal (HPA) axis and its hormonal end products, altering the embryotic environment (Szpunar & Parry, 2018; van den Bergh 2011), and consequently altering the neurodevelopment of the fetus (Raikkonen et al., 2011; van den Bergh 2011). Infants of mothers with higher levels of prenatal depressive symptoms may have alterations in the development of their ANS that can lead to lower levels of self-regulation. Lower FHRV may reflect an ANS dysfunction and a decreased ability of the sinus node of the heart to respond to external signals and a reduced ability to respond to the demands of the environment (Lazinski et al., 2008), which could difficult the development of infant self-regulatory mechanisms (Bell & Deater-Deckard, 2007). Difficulties in the development of self-regulatory mechanisms can increase the risk of self-regulation problems during infancy and in further development (Eisenberg et al., 2004; Perry et al., 2016; Williams et al., 2016).

Limitations

This study presented some limitations that should be noted. The voluntary nature of the participation in the study may have led to a selection bias. Mothers who agreed to participate in the study and to provide FHR data may be those who feel more involved and satisfied with the pregnancy and the postpartum experience. However, no differences were found between mothers that completed all the assessment waves and those who did not. Infant self-regulation was assessed with a parent-reported measure. Literature suggests that postnatal depressive symptoms can negatively bias mother's perceptions of their infant's behavior (Field et al., 1993; Rothbart et al., 2011). Considering this, mother's postnatal depressive symptoms were controlled in the statistical analysis. Moreover, previous literature also suggests that parents are reliable informants of their infant's behaviors when they are their primary caregiver (Rothbart et al., 2011). Then, in the present study, most of the reports of self-regulation were provided by the infant's primary caregiver. The use of parent-reported measures has a major advantage as it allow the assessment of infant self-regulation in daily routine situations across a variety of contexts where parents have more opportunities to observe the infant than an observer (Rothbart et al., 2011).

Implications for practice and research

The findings of the present study have major implications for clinical practice and research. Infants of mothers with higher levels of prenatal depressive symptoms could be at risk of self-regulation problems, partially due to their lower FHRV. To screen and intervene on mothers with higher levels of depressive symptoms during early pregnancy could help to prevent delayed fetal neurodevelopment, and consequently, later self-regulation problems in the infant. The monitoring of fetuses with lower HRV could also allow to follow those infants at risk of self-regulation problems, and those who may need intervention early in infancy.

This study suggests that FHRV as an early precursor of infant self-regulation that underlies the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. Considering the low variance explained by the mediation model, future research should explore possible prenatal (e.g., maternal-fetal HPA axis dysregulation) and postnatal (e.g., infant HRV and reactivity) mechanisms that can underly the adverse impact of mother's prenatal depressive symptoms on both FHRV and infant self-regulation. Future research could also be conducted to clarify the potential long-term adverse impact of

mother's prenatal depressive symptoms on FHRV and infant self-regulation, examining the impact of duration, timing, and severity of depressive symptoms on self-regulation across development.

Conclusion

This study represents an advance in the literature on the developmental origins of self-regulation by suggesting FHRV as an early precursor of infant self-regulation that underlies the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. Infants of mothers with higher levels of prenatal depressive symptoms could be at risk of self-regulation problems, partially due to their lower FHRV.

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PAPER IV

**DIFFERENTIAL IMPACT OF NEGATIVE COPARENTING ON INFANT SELF-REGULATION: THE ROLE OF
FETAL HEART RATE VARIABILITY**

Pinto, T. M., & Figueiredo, B. (under review). Differential impact of negative coparenting on infant self-regulation: the role of fetal heart rate variability. *Journal of Child Psychiatry and Psychology*

Abstract

Infants can be more susceptible to the impact of both development-enhancing and risk-promoting environments due to higher neurobiological plasticity. Lower fetal heart rate variability (FHRV) may be a prenatal endophenotypic susceptibility marker and increase the impact of both positive and negative coparenting on infant self-regulation. This study analyzed the moderator role of FHRV in the impact of positive and negative coparenting on infant self-regulation at three months. The sample comprised 86 first-born infants and their mothers and fathers. FHRV was recorded during routine cardiotocography examination at the third trimester of gestation. Mothers and fathers reported on coparenting and infant self-regulation at two weeks and three months postpartum. Results indicated that FHRV moderated the impact of mother and father's negative coparenting at two weeks postpartum on infant self-regulation at three months. Infants with low FHRV presented (1) higher levels of self-regulation when mothers or fathers reported less negative coparenting, while (2) lower levels of self-regulation when mothers or fathers reported more negative coparenting, than infants with high FHRV. Findings suggested lower FHRV as a prenatal endophenotypic susceptibility marker that increases the impact of negative coparenting on infant self-regulation. Infants with low FHRV may be more susceptible to the impact of negative coparenting and can be those (1) who better develop self-regulatory mechanisms in the presence of less negative coparenting, while (2) at high risk of self-regulation problems in the presence of more negative coparenting.

Keywords: positive and negative coparenting; fetal heart rate variability; infant self-regulation; neurobiological plasticity; prenatal endophenotypic susceptibility marker.

Introduction

Developmental Psychopathology highlights the importance of exploring the environmental mechanisms and processes that impact infant development, namely in the family environment, as well as the contribute of infant's characteristics to explain the impact of environment on infant development (Sroufe, 1997; Rutter & Stroufe, 2000). Coparenting - the reciprocal involvement of both parents in childrearing, and specifically the coordination and support that each parent provides to the other in childcare, contributes largely to the family environment (Cummings et al., 2000; Feinberg, 2002, 2003).

Developing self-regulatory mechanisms is a major developmental task during infancy (Bell & Deater-Deckard, 2007). Self-regulation is defined “as processes that serve to modulate reactivity” (Rothbart et al., 2011, p. 442), allowing the infant to manifest adequate behaviors and to appropriately respond to environment demands, in accordance with his/her age and reactivity (van den Bergh & Mennes, 2006). Self-regulating mechanisms include orienting of attention, inhibition, angry attack, surgent or extraverted approach, and the effortful control of behavior based on the executive attention system (Rothbart et al., 2011; Rothbart et al., 1992). Infants' capacity to deploy self-regulatory mechanisms is a resource that promotes development, while self-regulation problems predict several adjustment problems, namely internalizing and externalizing problems, impaired social skills, and disrupted physiological regulation to stress (Eisenberg et al., 2004; Perry et al., 2016; Williams, Nicholson et al., 2016).

Literature provides evidence that coparenting quality can serve as a development-enhancing or a risk-promoting environment for infant self-regulation (Busuito & Moore, 2017; Feinberg et al., 2009; Teubert & Pinquart, 2010). Coparenting has four interrelated dimensions: (a) the agreement or disagreement on childrearing issues, (b) the division of labor, (c) the support versus undermining for the coparental role, and (d) the joint management of family interactions (Feinberg, 2002, 2003). Positive coparenting dimensions (cooperation, support) were found to enhance infant self-regulation, namely self-soothing (Feinberg et al., 2009). On the other hand, negative coparenting has been found to impact infant development, and specifically self-regulation (Feinberg et al., 2009; Teubert & Pinquart, 2010). Interparental conflict was associated with lower levels of infant self-regulation, such as lower levels of vagal tone (Busuito & Moore, 2017; Moore, 2010; Porter et al., 2003). Negative coparenting dimensions (conflict, undermining) were also associated with increased risk of emotional and behavioral problems in children (Lamela et al., 2016; Scrimgeour et al., 2013; Teubert & Pinquart, 2010).

The impact of coparenting on infant self-regulation can be explained through two pathways: infant's experiences of emotional arousal or parent-infant interaction (Busuito & Moore, 2017; Calkins & Hill, 2007; Moore et al., 2009). Positive coparenting may provide repeated experiences of positive emotional arousal, thus improving cohesive, secure, and coordinated parent-infant interaction and co-regulation. In contrast, negative coparenting interactions (e.g., conflict) may expose the infant to repeated experiences of negative emotional arousal, as well as disrupted parenting, leading to disrupted parent-infant interaction and co-regulation. Thus, negative coparenting interactions during infancy may increase infant negative emotional arousal, disrupt parenting, undermine cohesive parent-infant interaction, consequently affecting infant self-regulation.

Differential susceptibility theory (DST) suggests that some infants are disproportionately susceptible to the impact of both development-enhancing and risk-promoting environments due to their high neurobiological plasticity (Belsky, 2005; Belsky & Pluess, 2009). Neurobiological plasticity is instantiated in genetic (e.g., short allele of 5-HTTLPR gene), endophenotypic (e.g., vagal reactivity), and phenotypic (e.g., negative affectivity) factors that synergistically operate as susceptibility markers, increasing the impact of environment on infant development (Ellis et al., 2011). DST also suggests that endophenotypic and phenotypic susceptibility markers are programmed in the prenatal environment (Boyce & Ellis, 2005; Hartman & Belsky, 2018; Obradović et al., 2010; Pluess & Belsky, 2011), namely through developmental programming effects of mother's prenatal mental health problems (Barker et al., 1989; Gluckman & Hanson, 2004; Henrichs & Van den Bergh, 2015).

Literature provides evidence that lower fetal heart rate variability (FHRV) is associated with both mother's prenatal mental health and infant self-regulation problems (Davis et al., 2011; DiPietro et al., 2007; DiPietro et al., 2018; Figueiredo et al., 2017; Howland et al., 2020; Monk et al., 2011). Lower FHRV may be considered a prenatal endophenotypic susceptibility marker associated with lower self-regulation in the infant (DiPietro et al., 2007; DiPietro et al., 2018). FHRV may reflect emerging individual differences in the development of the autonomic nervous system (ANS), related with infant self-regulatory capacity (DiPietro et al., 2007; Porges, 2007; van den Bergh, 2020). Namely, infants with lower FHRV were found to present lower autonomic stability, higher negative affect, and lower orienting regulation (DiPietro et al., 2007; DiPietro et al., 2018; Figueiredo et al., 2017; Howland et al., 2020).

As a development-enhancing or a risk-promoting environment, positive coparenting can enhance infant self-regulation development, while negative coparenting can increase the risk of self-regulation problems (Busuito & Moore, 2017; Feinberg et al., 2009; Teubert & Pinguart, 2010). Nevertheless, the impact of both positive and negative coparenting on infant self-regulation may be higher in infants with

lower FHRV, and so lower FHRV a prenatal endophenotypic susceptibility marker of infant self-regulation (DiPietro et al., 2007; DiPietro et al., 2018).

To analyze the moderator role of FHRV in the impact of positive and negative coparenting on infant self-regulation may represent an advance to the literature on infant self-regulation development and on the differential impact of family environment on infant self-regulation, according to infant's characteristics. Due to higher neurobiological plasticity (Ellis et al., 2011), infants with lower FHRV may be more susceptible to the positive experiences provided by positive coparenting interactions, promoting the development of their self-regulatory mechanisms. Moreover, infants with lower FHRV may also be more susceptible to the negative experiences provided by negative coparenting interactions, which may increase the risk of self-regulation problems. Following this hypothesis, the study aimed to analyze the moderator role of FHRV in the impact of positive and negative coparenting on infant self-regulation at three months.

Method

Participants

The sample comprised 86 first-born infants and their mothers and fathers (172 mothers or fathers). Infants were 53.5% female and 46.5% male. Most infants were born at term (≥ 37 gestational weeks; 92%; $M = 39.25$, $SD = 1.27$) and with more than 2500g (96.5%; $M = 3386.53$, $SD = 591.48$). More than half were exclusively breastfed during the first three months of age (63.8%). Most infants did not have health problems during the first three months of age (87.2%) and the mothers were the primary caregiver (95%; see Table 16).

Table 16

Infant's biometric and sociodemographic characteristics.

		<i>N</i> = 86 (%)
Sex	Female	53.5
	Male	46.5
Gestational weeks at birth	≥ 37	92.0
	< 37	8.0
Birthweight	≥ 2500 g	96.5
	< 2500 g	3.5
Breastfeeding at three months	Exclusive	63.8
	No-exclusive	36.2
Health problems at three months	No	87.2
	Yes	13.3
Primary caregiver at three months	Mother	95.0
	Father	5.0

Mothers and fathers were married (51%) or cohabiting (49%). Most were Portuguese (92.3% of mothers and 95.1% of fathers), employed (89.7% of mothers and 89.4% of fathers), and were from medium or high socio-economic levels (86.9% of mothers and 91.6% of fathers). Half of mothers and fathers were aged between 30 and 39 years old (48.8%; $M_{\text{mothers}} = 29.57$, $SD = 4.52$; $M_{\text{fathers}} = 31.91$, $SD = 5.28$), and had more than 12 years of education (59.5% of mothers and 49.3% of fathers). Regarding pregnancy, most reported good or very good pregnancy acceptance (92.4% of mothers and 95.9% of fathers) and the conception was spontaneous (93%). Regarding delivery, more than half was vaginal (62.2%).

Procedures

The present research was conducted in accord with the Helsinki Declaration and received previous approval from the Ethical Commission of all institutions involved. Couples were recruited at a public Health Service in Northern Portugal during the first trimester of gestation (10-13 gestational weeks), before the first fetal ultrasound. The study exclusion criteria were not reading or writing Portuguese, not being married or cohabiting, multiparous mothers or fathers, multiple gestations, and gestations with obstetric complications. The aims and the procedures of the study were explained, and the mothers and fathers willing to participate provided a written consent form. From the 146 couples contacted at the public Health Service and willing to be contacted by email to participate in the study, 130 couples were willing to participate and completed the questionnaires at the first trimester of gestation (89%).

This study had a longitudinal design with three assessment waves. At the third trimester of gestation (30-33 gestational weeks, $M = 32.19$, $SD = 2.81$), FHRV was recorded during routine cardiotocography examination (CTG) by a nurse at the public Health Service where the couples were recruited. Both mothers and fathers independently completed online a socio-demographic questionnaire. At two weeks (2-8 postpartum weeks, $M = 3.39$, $SD = 2.05$) and three months postpartum (11-21 postpartum weeks, $M = 14.56$, $SD = 2.22$), both mothers and fathers completed online measures of coparenting and infant self-regulation. From the couples who completed the questionnaires at the third trimester of gestation ($N = 118$), 86 mothers provided FHR data, and 86 mothers and 86 fathers completed the questionnaires at two weeks and at three months postpartum (72.9%; $n = 172$). The mothers and fathers who completed all the assessment waves and provided FHR data did not differ from those mothers and fathers who did not complete the data, regarding sociodemographic characteristics and infant's biometric and sociodemographic data. No differences were found between the mothers and fathers who completed all the assessment waves and provided FHR data and those who did not completed in the studied variables at each assessment wave.

Measures

Sociodemographic Questionnaire. Information was collected using a Sociodemographic Questionnaire (Figueiredo et al., 2009).

Coparenting. The Portuguese version of the Coparenting Relationship Scale (CRS; Feinberg et al., 2012; Lamela et al., 2016; Lamela et al., 2018) was used to assess positive and negative coparenting. The CRS is a 35-item self-report scale scored on a seven-point Likert-type scale designed to assess the four domains of coparenting proposed by Feinberg (2003) and comprises six subscales: (1) coparenting agreement subscale (four items) that assesses the degree that each parent agrees with matters related to the infant's education, (2) coparenting closeness subscale (five items) that assesses the degree to which coparenting enhanced intimacy and strengthened the couple's relationship; (3) exposure to conflict subscale (five items) that assesses the degree that parents expose the infant to conflicts related to their education; (4) coparenting support subscale (six items) that assesses the perception of coparenting support from the other parent; (5) coparenting undermining subscale (six items) that assesses the perception that coparenting is regulated by critics, guilt and competition between the parents; and (6) endorse partner parenting subscale (seven items) that assesses one's own positive attitude toward the other parent's parenting.

The Portuguese version of the CRS showed good internal consistency in mothers and fathers (Lamela et al., 2016; Lamela et al., 2018). In the present sample, Cronbach's alphas ranged from .80 to .92 (α 's range = .80 – .88 in mothers; α 's range = .84 – .92 in fathers). Composite scores for mother and father's positive and negative coparenting were calculated by standardizing each scale, summing the positive (agreement, closeness, support, and endorse partner parenting) and negative (exposure to conflict, undermining) subscales and dividing by the number of subscales, respectively.

Fetal heart rate variability. FHR signals were continuously recorded during CTG examination with no stimulus being presented. FHR signals were recorded continuously and stored using the Omniview-SisPorto system (Ayres-de-Campos et al., 2008). A fetal monitor was used to export FHR signals every 0.25 seconds in beats per minute, rounded to the nearest quarter of a beat. Data were subsequently exported to an Excel 2020 worksheet. FHRV was obtained by calculating the difference between the highest and lowest FHR frequency value, per minute.

Infant self-regulation. The orienting regulation dimension of the Infant Behavior Questionnaire - Revised short form (IBQ-R; Gartstein & Rothbart, 2003; Putnam et al., 2014) was used to assess infant self-regulation. The IBQ-R short form comprises 91 items in 14 scales, scored in a seven-point Likert-type scale, related to the frequency of occurrence of the infants' behaviors in several specific situations during the previous week or two weeks. The orienting dimension is comprised the mean scores of four scales: low-intensity pleasure (seven items), cuddliness (six items), duration of orienting (six items) and soothability (seven items) scales.

The IBQ-R has globally shown validity and reliability in different cultural backgrounds and across different infant ages (Dias et al., 2021). The orienting regulation dimension of the IBQ-R Portuguese version showed good internal consistency (α 's = .60 - .80; Costa & Figueiredo, 2018). In the present sample, Cronbach's alphas ranged from .69 to .74 (α 's range = .72 - .74 in mothers; α 's range = .69 - .71 in fathers). Although both mothers and fathers reported on their infant self-regulation, only the orienting regulation scores reported by the primary caregiver were included in the analysis (mostly mothers; see Table 1).

Data analysis

To analyze the moderator role of FHRV in the impact of positive and negative coparenting on infant self-regulation at three months, a moderation model was tested using multiple and hierarchical linear regressions (Baron & Kenny, 1986). Model one included mother and father's positive and negative coparenting at two weeks postpartum as independent variable and infant self-regulation at three months as dependent variable. Model two included variables from model one, adding FHRV. Model three included variables from model one and two, adding the interaction between them. The moderation model was adjusted for the gestational weeks when FHRV was assessed and for mother and father's positive and negative coparenting at three months postpartum.

The significant interactions between the independent variables were graphed using one standard deviation above and below the mean of the moderator variable (FHRV). Statistical significance was considered at $p < .05$. Statistical analyses were performed using SPSS version 26.0 (SPSS Inc., USA).

Results

Preliminary analyses

Descriptive statistics are presented in Table 17. Significant intercorrelations were found between mother and father's positive and negative coparenting at two weeks postpartum. Higher levels of mother and father's positive coparenting at two weeks postpartum were associated with higher levels of infant self-regulation at three months, while higher levels of mother and father's negative coparenting at two weeks postpartum were associated with lower levels of infant self-regulation at three months. Higher FHRV was associated with higher levels of infant self-regulation at three months. No associations were found between mother and father's positive or negative coparenting at two weeks postpartum and FHRV (see Table 18). Additionally, no associations were found between FHRV and infant's and mother and father's sociodemographic and biometric data.

Table 17

Descriptive statistics of the study's variables

	<i>M</i>	<i>SD</i>
FHRV at the third trimester of gestation	12.22	6.58
Mother's positive coparenting at two weeks postpartum	24.99	4.41
Father's positive coparenting at two weeks postpartum	25.37	10.74
Mother's negative coparenting at two weeks postpartum	2.77	1.12
Father's negative coparenting at two weeks postpartum	2.60	1.54
Infant self-regulation at three months	5.28	0.69

Notes. *M* = Mean; *SD* = Standard deviation; FHRV = Fetal heart rate variability.

Table 18

Correlations among study variables

	Third trimester of gestation		Two weeks postpartum			Three months postpartum
	1	2	3	4	5	6
	FHRV	Mother's positive coparenting	Father's positive coparenting	Mother's negative coparenting	Father's negative coparenting	Infant self-regulation
1. FHRV	1.00					
2. Mother's positive coparenting	.19	1.00				
3. Father's positive coparenting	.14	.47***	1.00			
4. Mother's negative coparenting	-.12	-.75***	-.48**	1.00		
5. Father's negative coparenting	-.23	-.45***	-.73***	.55***	1.00	
6. Infant self-regulation	.56***	.42**	.33**	-.33**	-.35**	1.00

Notes. FHRV = Fetal heart rate variability.

** $p < .01$; *** $p < .001$

Impact of mother and father's positive and negative coparenting on infant self-regulation at three months

Results indicated that mother and father's negative coparenting at two weeks postpartum significantly predicted infant self-regulation, accounting for 13% of the variance. Higher levels of negative coparenting reported by mothers, $\beta = -1.40$, $p = .027$, and fathers, $\beta = -1.61$, $p = .031$ predicted less infant self-regulation at three months. Mother and father's positive coparenting at two weeks postpartum did not predict infant self-regulation at three months (see Table 19).

FHRV and infant self-regulation at three months

Significantly increasing the variance explained by the first linear regression, the second linear regression for infant self-regulation at three months was statistically significant ($p < .001$) and explained 18% of the variance. Higher FHRV predicted higher levels of infant self-regulation at three months, $\beta = 0.99$, $p < .001$ (see Table 19).

The moderator role of FHRV in the impact of mother and father's positive and negative coparenting on infant self-regulation at three months

Significantly increasing the variance explained by the second linear regression, the third linear regression for infant self-regulation at three months was statistically significant ($p < .001$) and explained 25% of the variance. The interaction between mother's report of negative coparenting at two weeks postpartum and FHRV significantly predicted infant self-regulation at three months, $\beta = 2.78$, $p = .012$. Likewise, the interaction between father's report of negative coparenting at two weeks postpartum and FHRV significantly predicted infant self-regulation at three months, $\beta = 3.02$, $p = .003$ (see Table 19).

Table 19

The moderator role of FHRV in the impact of mother and father's positive and negative coparenting at two weeks postpartum on infant self-regulation at three months

	Total R ²	F	β	p	R ² change
<i>Model one</i>	.14 (.13)	7.89***			
Mother's positive coparenting			1.14	.108	
Father's positive coparenting			1.13	.098	
Mother's negative coparenting			1.40	.027	
Father's negative coparenting			1.61	.031	
<i>Model two</i>	.19 (.18)	10.09***			.05***
FHRV			0.99	< .001	
<i>Model three</i>	.26 (.25)	12.07***			.07***
Mother's positive coparenting x FHRV			1.47	.152	
Father's positive coparenting x FHRV			1.11	.278	
Mother's negative coparenting x FHRV			2.78	.012	
Father's negative coparenting x FHRV			3.02	.003	

Notes. FHRV = Fetal heart rate variability; the model was adjusted for the gestational weeks when FHRV was assessed and for mother and father's positive and negative coparenting at three months postpartum.

*** $p < .005$

The plot of the interactions revealed that infants with low FHRV presented (1) higher levels of self-regulation at three months when mothers or fathers reported less negative coparenting at two weeks postpartum and (2) lower levels of self-regulation at three months when mothers or fathers reported more negative coparenting at two weeks postpartum, than infants with high FHRV. In infants with high FHRV, the impact of mother and father’s negative coparenting at two weeks postpartum on self-regulation at three months was smallest (see Figure 4).

The interactions between mother and father’s positive coparenting at two weeks postpartum and FHRV, respectively, did not significantly predict infant self-regulation at three months (see Table 19).

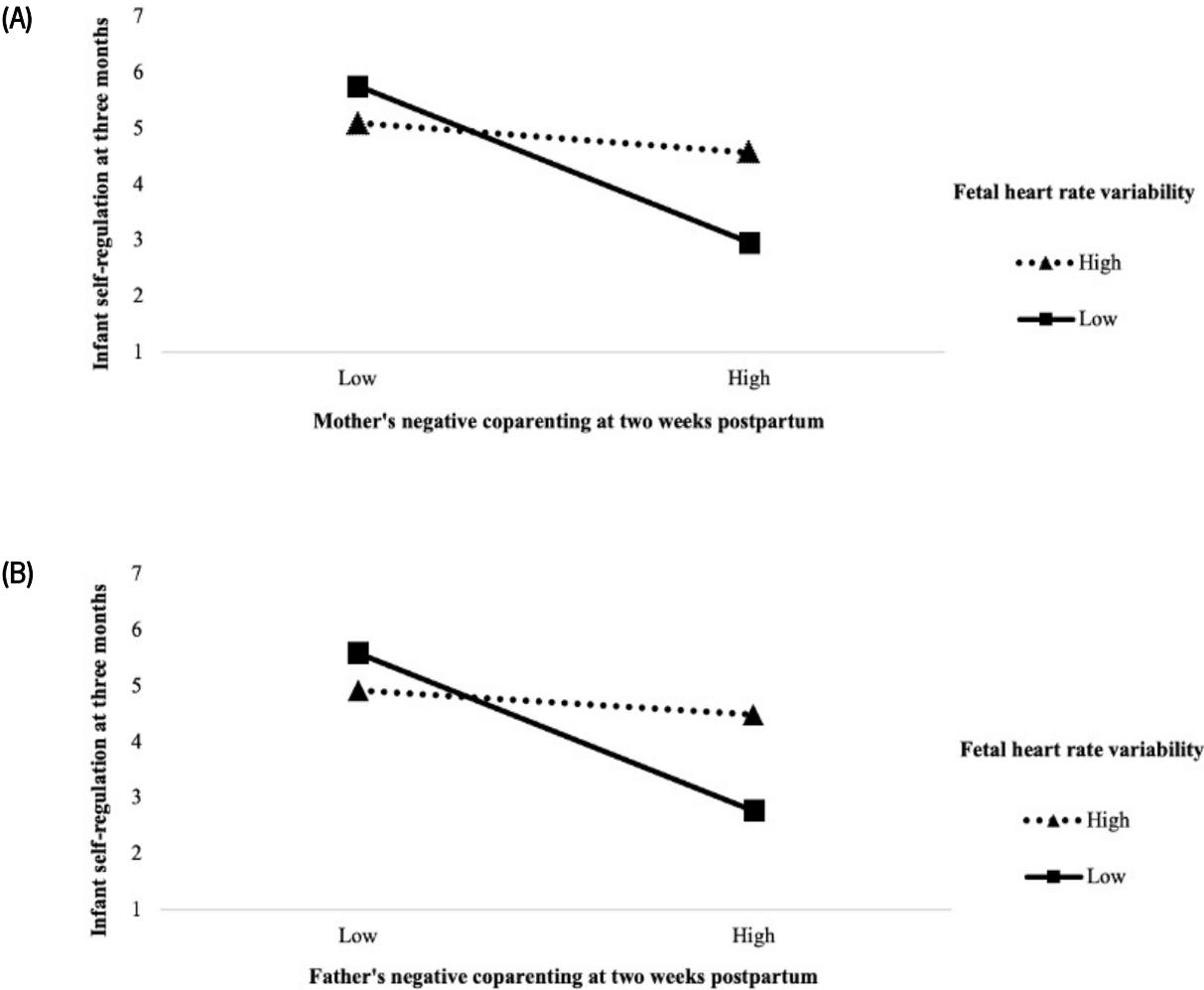


Figure 4. Graphic representation of the moderator role of fetal heart rate variability in the impact of mother (A) and father’s (B) negative coparenting at two weeks postpartum on infant self-regulation at three months.

Discussion

This study analyzed the moderator role of FHRV in the impact of positive and negative coparenting on infant self-regulation at three months. The study suggests lower FHRV as a prenatal endophenotypic susceptibility marker that increases the impact of negative coparenting on infant self-regulation.

Results provided evidence of the impact of mother and father's negative coparenting on infant self-regulation at three months. More negative coparenting at two weeks postpartum reported by both mothers and fathers predicted less infant self-regulation at three months. These results are congruent and advance the findings of previous studies (Feinberg et al., 2009; Moore, 2010; Porter et al., 2003), while suggesting the specific adverse impact of negative coparenting during the early postpartum period on the development of infant self-regulation at three months of life. Results also suggested no impact of mother and father's positive coparenting at two weeks postpartum on infant self-regulation at three months. This finding may suggest that negative coparenting could have a higher impact on the early self-regulation development, than positive coparenting.

Infant self-regulation during the first year of life is supported by and developed through parents–infant co-regulation (Bell & Deater-Deckard, 2007). Findings supported the view of negative coparenting as a risk-promoting environment for infant self-regulation (Moore, 2010; Porter et al., 2003). There are two possible explaining pathways of the adverse impact of negative coparenting on infant self-regulation. Mother and father's negative coparenting (e.g., exposure to conflict) may negatively impact infant self-regulation development by exposing the infant to repeated negative experiences of emotional arousal or by increasing disruptive parenting, and thus undermining cohesive parent-infant interaction and co-regulation (Calkins & Hill, 2007; Busuito & Moore, 2017; Moore et al., 2009). Results provided evidence of the association between FHRV and infant self-regulation at three months. Lower FHRV predicted lower levels of infant self-regulation at three months. This result is congruent with previous studies proposing an association between lower FHRV and lower levels of infant self-regulation (DiPietro et al., 2007, DiPietro et al., 2018; Howland et al., 2020). FHRV may reflect emerging individual differences in the development of the ANS, related with the infant's self-regulatory capacity (DiPietro et al., 2018; Porges, 2007; van den Bergh, 2020). Namely, dysregulation of the ANS (e.g., lower vagal regulation) was associated with lower levels of self-regulation during infancy (Bazhenova et al., 2001; Ham & Tronick, 2006; Stifter & Corey, 2001).

Results provided evidence that FHRV moderates the impact of mother and father's negative coparenting at two weeks postpartum on infant self-regulation at three months. Results showed that

infants with low FHRV presented (1) higher levels of self-regulation when mothers or fathers reported less negative coparenting, while (2) lower levels of self-regulation when mothers or fathers reported more negative coparenting, than infants with high FHRV. In infants with high FHRV, the impact of mother and father's negative coparenting on self-regulation was smallest. Results also provided evidence that FHRV does not moderate the impact of mother and father's positive coparenting on infant self-regulation at three months. This finding could be related with the fact that, in the present study, no impact of positive coparenting at two weeks postpartum was found on infant self-regulation at three months. Likewise, no differential impact of mother and father's positive coparenting at two weeks postpartum was found on self-regulation in infants with low FHRV, compared with infants with high FHRV. These findings are framed and provided evidence to DST (Belsky, 2005; Belsky & Pluess, 2009; Ellis et al., 2011) by suggesting lower FHRV as a prenatal endophenotypic susceptibility marker that may increase the impact of negative coparenting on infant self-regulation. According to DST, infants with lower FHRV may be more susceptible to the impact of negative coparenting due to their higher neurobiological plasticity that may already be present during their fetal development. Infants with lower FHRV may better develop their self-regulatory mechanisms in the presence of less negative coparenting interactions, while they may be at high risk of self-regulation problems in the presence of more negative coparenting interactions. This suggested that infants with lower FHRV are more susceptible to the negative experiences provided by negative coparenting interactions. Specifically, infants with lower FHRV may be more susceptible to the repeated negative experiences of emotional arousal (Busuito & Moore, 2017) provided by mother and father's negative coparenting interactions (e.g., conflict). Additionally, infants with low FHRV may also be more susceptible to the increased disrupted parents-infant interaction and co-regulation (Calkins & Hill, 2007; Moore et al., 2009), associated with mother and father's negative coparenting (e.g., undermining). According to the "for better and for worse" hypothesis provided by DST (Belsky, 2005), infants with lower FHRV may have increased capacity to deploy self-regulatory mechanisms during early development in the presence of less negative coparenting interactions, which can promote their further development (Williams et al., 2016). These infants may be more susceptible to the cohesive, secure, and coordinated parent-infant interaction and co-regulation, associated with positive coparenting interactions. However, infants with lower FHRV may be at increased risk of self-regulation problems in the presence of more negative coparenting interactions and can be those more susceptible to present further developmental problems, as self-regulation problems were associated more adjustment problems, including internalizing and externalizing problems, impaired social skills, and disrupted physiological regulation to stress in later ages (Eisenberg et al., 2004; Perry et al., 2016).

Limitations

This study presented some limitations that should be noted. The voluntary nature of the participation in the study may have led to a selection bias. Mothers and fathers who agreed to participate may be those who feel more involved and satisfied with the pregnancy and the postpartum experience. However, no differences were found between mothers and fathers that provided FHR data and completed all the assessment waves and those who did not. Infant HRV was not considered in this study, which does not allow to assure that the observed impacts on infant self-regulation are only due to FHRV. A common-method variance may have inflated the links between mother and father's coparenting and infant self-regulation as these variables were generated by the same informants. Specifically, infant self-regulation was assessed with a parent-reported measure. However, parent-reported measures have a major advantage. Parent-reported measures allow the assessment of infant self-regulation in daily routine situations across a variety of contexts where parents have more opportunities to observe the infant than an observer (Pinto & Figueiredo, under review; Rothbart et al., 2011). Moreover, previous literature suggests that parents are reliable informants of their infant's behaviors when they are their primary caregiver (Rothbart et al., 2011). Considering this, in the present study, the reports of self-regulation were provided by the infant's primary caregiver.

Implications for practice and research

The findings of the present study have implications for clinical practice and research. Infants with lower FHRV may be more susceptible to the impact of negative coparenting and can be those who better develop their self-regulatory mechanisms in the presence of less negative coparenting interactions, while can be those at high risk of self-regulation problems in the presence of more negative coparenting interactions.

Interventions targeting infant mental health and development problems should start early in infancy and should target coparenting quality (Feinberg et al., 2016). To reduce negative coparenting interactions during the early postpartum period can contribute to promote the development of self-regulation and help to prevent self-regulation problems, particularly in infants with lower FHRV. According to the "for better and for worse" hypothesis provided by DST (Belsky, 2005), infants with lower FHRV may also be those more susceptible to the positive impact of interventions targeting coparenting quality during early development.

This study provided evidence on lower FHRV as a prenatal endophenotypic susceptibility marker that may increase the impact of negative coparenting on infant self-regulation at three months. Integrating developmental and family psychopathology conceptual models and DST, future research should explore the underlying mechanisms that can explain why infants with lower FHRV are more susceptible to the impact of negative coparenting. To analyze mother, father, and infant's psychophysiological processes (e.g., vagal tone and vagal reactivity) during triadic interactions, considering the role of FHRV, can contribute to explain why infants with lower FHRV are more susceptible to the impact of negative coparenting on self-regulation.

Conclusion

This study advances the literature on infant self-regulation development and on the differential impact of family environment on infant self-regulation by providing evidence on lower FHRV as a prenatal endophenotypic susceptibility marker that may increase the impact of negative coparenting on infant self-regulation. Infants with lower FHRV may be more susceptible to the impact of negative coparenting and can be those (1) who better develop their self-regulatory mechanisms in the presence of less negative coparenting, while (2) at high risk of self-regulation problems in the presence of more negative coparenting.

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PAPER V

**THE IMPACT OF COVID-19 PANDEMIC ON MOTHER AND FATHER'S POSTPARTUM DEPRESSIVE
SYMPTOMS AND NEGATIVE COUPLE INTERACTIONS**

Pinto, T. M., & Figueiredo, B. (accepted with major revisions). The impact of COVID-19 pandemic on mother and father's postpartum depressive symptoms and negative couple interactions. *Families, Systems, & Health*

Abstract

The negative impact of COVID-19 pandemic on mental health and couple's relationship can be particularly higher in most vulnerable groups, namely mothers and fathers during the transition to parenthood. This study analyzed the impact of COVID-19 pandemic on mother and father's anxiety and depressive symptoms, and couple's relationship quality at six months postpartum. A sample of 142 primiparous mothers and fathers recruited before COVID-19 pandemic were assessed at six months postpartum, before ($n = 70$) or during COVID-19 pandemic ($n = 72$). Participants completed measures of anxiety and depressive symptoms, and couple's positive and negative interactions. Results indicated significant effects of COVID-19 pandemic on mother and father's depressive symptoms and couple's negative interactions at six months postpartum. Mothers and fathers assessed at six months postpartum during COVID-19 pandemic reported more depressive symptoms and more couple's negative interactions than mothers and fathers assessed at six months postpartum before COVID-19 pandemic. Findings provided evidence on the negative impact of COVID-19 pandemic on mother and father's postpartum depressive symptoms and negative couple's relationship. COVID-19 pandemic may increase the risk of mother and father's mental health problems and negative couple's relationship during the postpartum period.

Keywords: COVID-19 pandemic; anxiety symptoms; depressive symptoms; couple relationship; postpartum period.

Introduction

The 2019 coronavirus disease (COVID-19) is a highly infectious disease and have posed a global health threat (Wang et al., 2020). COVID-19 pandemic is considered a major threat to people's health and the worldwide consequences for health and socioeconomic systems are devastating. COVID-19 was firstly recognized in December and his infection spread rapidly throughout the world. The World Health Organization declared Public Health Emergency of International Concern on 30 January 2020 and a pandemic on 11 March 2020 (WHO, 2020). The first case of COVID-19 in Portugal was reported on 2 March 2020, and the epidemiological situation reported 36 690 cases and 1 517 deaths related to COVID-19 in a population of 10 million (15 June 2020; Directorate-General for Health, 2020).

After the declaration of pandemic, several countries worldwide declared state of emergency - Portugal declared state of emergency on 18 March 2020. Several public health measures were progressively implemented to contain the spread of SARS-CoV-2 infection (e.g., physical distancing measures, closing schools, educational facilities, public spaces, and nonessential shops, national movement restrictions, and confinement) (European Centre for Disease Prevention and Control, 2020).

Although crucial to control COVID-19 pandemic, the negative impact of confinement measures on mental health may be equally devastating. People in confinement may experience a wide range of negative feelings, including fear, anger, sadness, irritability, guilt, or confusion, which can make the isolation challenging for mental health (Brooks et al., 2020). The negative impact of confinement measures in similar situations as COVID-19 pandemic is well documented in the literature (Jeong et al., 2016; Shultz et al., 2016; Wu et al., 2005). Regarding COVID-19, several studies were already conducted across different countries to assess the impact of COVID-19 outbreak/pandemic on mental health (Brooks et al., 2020; Liu et al., 2020; Wang et al., 2020). In China, a study found that 28.8% of participants reported moderate to severe anxiety symptoms and 16.5% reported moderate to severe depressive symptoms (Wang et al., 2020). Additionally, the confinement measures associated with COVID-19 pandemic can have a negative impact on family and couple's relationship quality by increasing conflicts between the couple. Namely, studies reported an increase of domestic violence during COVID-19 pandemic (Campbell, 2020; Sediri et al., 2020).

The negative impact of COVID-19 pandemic on mental health and couple's relationship quality can be particularly higher in most vulnerable groups, namely those undergoing major life transitions (Almeida et al., 2020; Reference Group on Mental Health and Psychosocial Support in Emergency, 2020). The transition to parenthood is a major life transition associated with several individual, couple and family

adjustments (Cowan & Cowan, 2012; Demick, 2002; Figueiredo et al., 2018). This demanding and stressful life transition, requires reorganization of both the inner experience and the external behavior, including the reorganization of individual and family roles and relationships (Cigoli & Scabini, 2006; Cowan & Cowan, 2012). The transition to parenthood increases anxiety and depressive symptoms in mothers and fathers, amplifies differences within the couple, raises marital dissatisfaction (Doss et al., 2009; Figueiredo et al., 2018; Lawrence et al., 2008), and has the potential to place couples at risk for mental health problems (Figueiredo & Conde, 2011; LeStrat et al., 2011; Underwood et al., 2016). Several studies have been showing that the transition to parenthood is associated with increased risk for mental health problems (e.g., anxiety and depressive symptoms) both in mothers and fathers (Don et al., 2014; Figueiredo & Conde, 2011; Underwood et al., 2016), as well as with a deterioration of couple's relationship quality (Doss et al., 2009; Figueiredo et al., 2018; Lawrence et al., 2008).

Studies were already conducted to analyze the impact of COVID-19 pandemic on mothers' mental health during pregnancy and the postpartum period (see Yan et al., 2020 for a review). These studies found increased anxiety and depressive symptoms in mothers during COVID-19 pandemic, both during pregnancy and the postpartum period (Durankuş & Aksu, 2020; Lebel et al., 2020; Wu et al., 2020; Zanardo et al., 2020). However, data is needed on the impact of COVID-19 pandemic on father's mental health during the postpartum period. Additionally, despite an increase of domestic violence during COVID-19 pandemic was reported (Campbell, 2020; Sediri et al., 2020), there is no data available on the impact of COVID-19 pandemic on couple's relationship quality during the transition to parenthood. This is particularly relevant, considering the negative impact of mother and father's perinatal mental health problems and couple's relationship quality on infant development (Figueiredo et al., 2017; Gutierrez-Galve et al., 2015; Ramchandani et al., 2005).

This study aimed to analyze the impact of COVID-19 pandemic on mother and father's anxiety and depressive symptoms, and on couple's relationship quality at six months postpartum.

Method

Participants

The sample comprised 142 primiparous mothers ($n = 71$) and fathers ($n = 71$), 72 assessed during COVID-19 pandemic ($n = 36$ mothers and $n = 36$ fathers) and 70 assessed before COVID-19 pandemic ($n = 35$ mothers and $n = 35$ fathers). All mothers and fathers were married (50.9%) or cohabiting (49.1%). Most mothers and fathers were Portuguese (93.0%), aged between 19 and 39 years old (91.9%), were employed (89.9%), were from medium or high socio-economic levels (88.9%), and had nine or more years of schooling (98.7%; see Table 20). Most infants were born at term (≥ 37 gestational weeks; 94.7%) and at more than 2500g (93.8%). More than 50% were male (57.4%).

Procedures

The present research was conducted in accord with the Helsinki Declaration and received previous approval from the Ethical Commission of all institutions involved. Participants takes part from a larger longitudinal cohort collected before COVID-19 pandemic. Mothers and fathers were recruited at a public Health Service in Northern Portugal during the first trimester of pregnancy (between May 2018 and June 2019). The study exclusion criteria were not reading or writing Portuguese, multiparous mothers and fathers, multiple gestations, and gestations with obstetric complications. The aims and the procedures of the study were explained, and the mothers and fathers who were willing to participate provided a written consent form.

Mothers and fathers were assessed at six months postpartum (24-32 postpartum weeks, $M = 24.56$, $SD = 2.22$), before or during COVID-19 pandemic (see Figure 5). The group of participants assessed during COVID-19 pandemic included all mothers and fathers that completed the online questionnaires after COVID-19 outbreak was declared a Public Health Emergency of International Concern by WHO on 30 January 2020 (between February and May 2020). Participants completed online a sociodemographic questionnaire and measures of anxiety and depressive symptoms, and couple's positive and negative interactions (between November 2018 and May 2020).

In order to identify the potential confounders, mother and father's sociodemographic characteristics, as wells as anxiety and depressive symptoms, and couple's relationship quality at the first trimester of pregnancy (10-20 gestational weeks, $M = 13.46$, $SD = 2.42$), before COVID-19 pandemic,

were included in the present study and considered in the data analysis. From the mothers and fathers that completed the questionnaires at the first trimester of pregnancy, 142 mothers and fathers (60.2%) completed the questionnaires at six months postpartum. The dropout rate did not differ in the groups of mothers and fathers assessed at six months postpartum before (39.6%) or during COVID-19 pandemic (40.0%), $\chi^2 = 1.12$, $p = .319$.

Table 20
Sociodemographic characteristics of mothers and fathers

	COVID-19 pandemic			
	During	Before	Total $N = 142$ %	
	Mothers and fathers $n = 72$ %	Mothers and fathers $n = 70$ %		
	<i>Age (years)</i>			
19-29	38.3	32.3		35.3
30-39	58.7	54.4	56.6	
≥ 40	3.0	13.3	8.1	
<i>Socioeconomic level</i>				
High	43.8	49.2	46.5	
Medium	49.1	35.6	42.4	
Low	7.1	15.2	11.1	
<i>Occupational status</i>				
Employed	89.9	89.9	89.9	
Unemployed	10.1	10.1	10.1	
<i>Schooling (in years)</i>				
≤ 9	0.0	2.7	1.3	
10 – 12	38.5	36.7	37.6	
> 12	61.5	60.6	61.1	

Measures

Socio-demographic variables. Information about the participants (e.g., age, marital status, socioeconomic level, occupational status, and years of schooling) was collected using a socio-demographic questionnaire.

Anxiety symptoms. The State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) consists of two 20-item scales scored on a four-point Likert-type scale that measures individual differences in anxiety proneness as a personality trait and the intensity of anxiety as an emotional state (STAI-S). The STAI-S was used to assess mother and father's anxiety symptoms. When responding to the STAI-S scale, participants report the intensity of their feelings of anxiety at the moment. Several studies have used this measure with mothers and fathers during the postpartum period (Figueiredo et al., 2018; Figueiredo & Conde, 2011; Pinto et al., 2016). The STAI-S Portuguese version showed good internal consistency in mothers and fathers (Figueiredo et al., 2018; Figueiredo & Conde, 2011; Pinto et al., 2018). In the present sample, Cronbach's alphas ranged from .88 to .94 for mothers and fathers.

Depressive symptoms. The Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) was used to assess mother and father's depressive symptoms. The EPDS is a 10-item self-report scale scored on a four-point Likert-type scale designed to assess the intensity of depressive symptoms within the previous seven days. This instrument has been used in several studies with mothers and fathers during the postpartum period (Figueiredo et al., 2018; Figueiredo & Conde, 2011; Pinto et al., 2016). The EPDS Portuguese version showed good internal consistency in mothers and fathers (Figueiredo et al., 2018; Figueiredo & Conde, 2011; Pinto et al., 2018). In the present sample, Cronbach's alphas ranged from .78 to .88 for mothers and fathers.

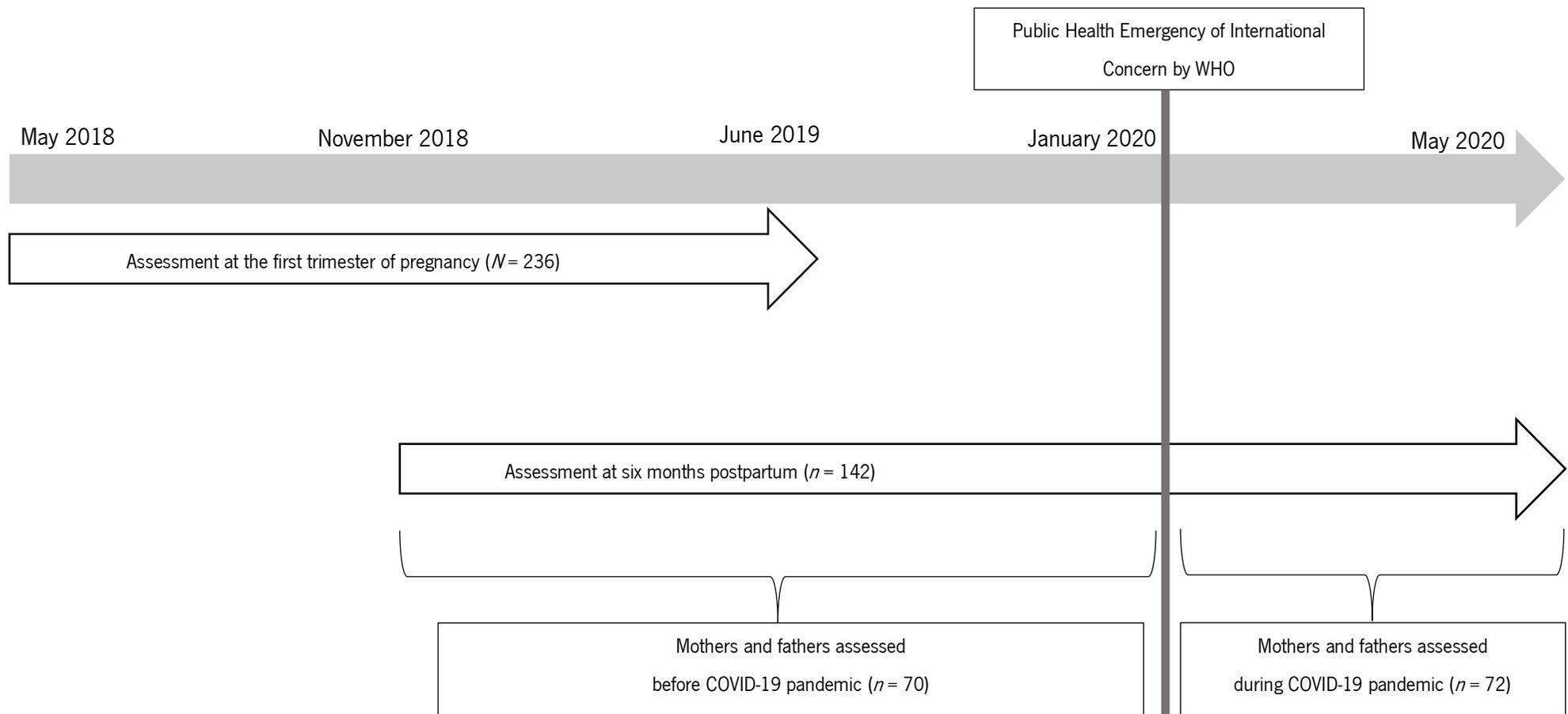


Figure 5. Study flowchart.

Couples' positive and negative interactions. The Relationship Questionnaire (RQ; Figueiredo et al., 2008) was used to assess couple's relationship positive and negative interactions. The RQ is a brief 12-item self-report questionnaire scored on a four-point Likert-type scale (from one to four) that assesses couples' positive (positive subscale, eight items) and negative (negative subscale, four items) interactions. The total score for each dimension is computed by averaging the scores of the items of each subscale. This questionnaire was designed to be completed in a short time, is behaviorally focused and appropriate for mothers and fathers, and has been used to assess couples' positive and negative interactions during the transition to parenthood (Figueiredo et al., 2018). The positive interaction subscale includes sense of support and care, affection, closeness and joint interests and activities (e.g., Do you and your partner show affection to each other?). The negative interaction subscale includes irritability, arguments and criticisms (e.g., Do you and your partner get irritable with each other?). Higher scores on these subscales reflect more positive or more negative interactions (Figueiredo et al., 2008). The RQ showed good internal consistency in mothers and fathers during the postpartum period (Figueiredo et al., 2018; Figueiredo et al., 2008). In the present sample, Cronbach's alphas ranged from .80 to .92 for mothers and fathers on the positive and negative subscales.

Data analysis

Two Multivariate Analysis of Variance (MANOVA) models were performed to analyze the impact of COVID-19 pandemic on mother and father's anxiety and depressive symptoms, and on couple's relationship quality at six months postpartum. The two MANOVA models included COVID-19 pandemic (one = group assessed during COVID-19 pandemic; zero = group assessed before COVID-19 pandemic), gender (one = mothers; zero = fathers) and the interaction between COVID-19 pandemic and gender as independent variables. The first MANOVA model included anxiety (STAI-S scores) and depressive symptoms (EPDS scores) at six months postpartum as dependent variables. The second MANOVA model included positive (RQ positive subscale scores) and negative interactions (RQ negative subscale scores) at six months postpartum as dependent variables. Pairwise comparisons were applied using Bonferroni correction to analyze group differences. Statistical significance was considered at $p < .05$. Statistical analyses were performed using SPSS version 26.0 (SPSS Inc., USA).

Results

Analysis of potential confounders

Results revealed that the mothers and fathers allocated in the group assessed during COVID-19 pandemic did not differ from the mothers and fathers allocated in the group assessed before COVID-19 pandemic, regarding mothers and father's sociodemographic characteristics.

Results also revealed no differences between the mothers and fathers allocated in the group assessed during COVID-19 pandemic and the mothers and fathers allocated in the group assessed before COVID-19 pandemic on anxiety, $F(1,141) = 0.02$, $p = .889$, and depressive symptoms, $F(1,141) = 0.22$, $p = .639$, at the first trimester of pregnancy, before COVID-19 pandemic. Likewise, no differences were found between the two groups on couple's positive, $F(1,141) = 1.58$, $p = .213$, and negative interactions, $F(1,141) = 2.35$, $p = .129$, at the first trimester of pregnancy, before COVID-19 pandemic. As no differences were noted between the mothers and fathers allocated in the group assessed during COVID-19 pandemic and the mothers and fathers allocated in the group assessed before COVID-19 pandemic, these variables were not included in the models as covariates.

Impact of COVID-19 pandemic on mother and father's anxiety and depressive symptoms at six months postpartum

Results revealed non-significant multivariate effects of COVID-19 pandemic on mother and father's anxiety and depressive symptoms at six months postpartum, $Wilks' \lambda = 0.94$, $F(2,140) = 2.60$, $p = .109$. However, significant univariate effects of COVID-19 pandemic were found on mother and father's depressive symptoms at six months postpartum, $F(1,141) = 3.72$, $p = .048$. Mothers and fathers assessed at six months postpartum during COVID-19 pandemic reported more depressive symptoms than mothers and fathers assessed at six months postpartum before COVID-19 pandemic (see Table 21).

Table 21

The impact of COVID-19 pandemic on mother and father's anxiety and depressive symptoms at six months postpartum

	Before COVID-19 pandemic <i>n</i> = 70		During COVID-19 pandemic <i>n</i> = 72		<i>F</i>	<i>df</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
	Anxiety symptoms	29.71	9.03	31.75		
Depressive symptoms	3.61	2.99	4.88	4.52	3.72*	1,141

Notes. *M* = Mean; *SD* = Standard Deviation.

**p* < .05

Non-significant multivariate and univariate effects of gender were found on mother and father's anxiety and depressive symptoms at six months postpartum, *Wilks' lambda* = 0.96, $F(1,141) = 1.99$, *p* = .155. Likewise, non-significant multivariate and univariate effects of the interaction between COVID-19 pandemic and gender were found, *Wilks' lambda* = 0.99, $F(1,141) = 0.49$, *p* = .617.

Impact of COVID-19 pandemic on mother and father's positive and negative interactions at six months postpartum

Results revealed significant multivariate effects of COVID-19 pandemic on mother and father's positive and negative interactions at six months postpartum, *Wilks' lambda* = 0.93, $F(2,140) = 3.15$, *p* = .048. Significant univariate effects of COVID-19 pandemic were found on mother and father's negative interactions at six months postpartum, $F(1,141) = 6.11$, *p* = .015. Mothers and fathers assessed at six months postpartum during COVID-19 pandemic reported more couple's negative interactions than mothers and fathers assessed at six months postpartum before COVID-19 pandemic (see Table 22).

Table 22

The impact of COVID-19 pandemic on mother and father's positive and negative interactions at six months postpartum.

	Before COVID-19		During COVID-19		<i>F</i>	<i>df</i>
	pandemic		pandemic			
	<i>n</i> = 70		<i>n</i> = 72			
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Positive interaction	3.57	0.58	3.50	0.60	0.87	1,141
Negative interaction	1.78	0.53	1.94	0.56	6.11*	1,141

Notes. *M* = Mean; *SD* = Standard Deviation.

**p* < .05

Non-significant multivariate and univariate effects of gender were found on mother and father's positive and negative interactions at six months postpartum, *Wilks' lambda* = 0.99, $F(2,140) = 0.29$, $p < .748$. Likewise, non-significant multivariate and univariate effects of the interaction between COVID-19 pandemic and gender were found, *Wilks' lambda* = 0.96, $F(2,140) = 1.71$, $p = .188$.

Discussion

This study analyzed the impact of COVID-19 pandemic on mother and father's anxiety and depressive symptoms, and on couple's relationship quality at six months postpartum. Findings provided evidence on the negative impact of COVID-19 pandemic on mother and father's depressive symptoms and couple's negative interactions at six months postpartum. Mothers and fathers assessed at six months postpartum during COVID-19 pandemic reported more depressive symptoms and more couple's negative interactions than mothers and fathers assessed at six months postpartum before COVID-19 pandemic. These results are in line with a previous study that found more postpartum depressive symptoms in mothers during the COVID-19 pandemic (Zanardo et al., 2020), and with previous studies showing an increase of domestic violence during COVID-19 pandemic (Campbell, 2020; Sediri et al., 2020). This study findings advance the ones of previous studies by analyzing the impact of COVID-19 pandemic on both mother and father's anxiety and depressive symptoms, and couple's relationship quality during the postpartum period. To our knowledge, this is the first study analyzing the impact of COVID-19 pandemic on father's mental health and couple's relationship quality during the postpartum period. It is important

to highlight that gender was considered in the tested models and no impact of the interaction between COVID-19 pandemic and gender were found on mother and father's depressive symptoms, and couple's negative interactions at six months postpartum. This result may suggest that COVID-19 pandemic equally impacts mothers and fathers, in terms of their mental health and couple's relationship quality during the postpartum period.

The confinement measures associated with COVID-19 pandemic may have a negative impact on mother and father's mental health and couple's relationship quality during the postpartum period. Both mothers and fathers have to make several adjustments in order to address the demands of parenting during the postpartum period (Cowan & Cowan, 2012; Demick, 2002; Figueiredo et al., 2018), that can increase the risk for postpartum mental health problems (Don et al., 2014; Figueiredo & Conde, 2011; Underwood et al., 2016), as well as the risk for a deterioration of couple's relationship (Doss et al., 2009; Figueiredo et al., 2018; Lawrence et al., 2008).

Any situation that places human life at risk activates a set of concerns, with specific disturbing concerns for mothers and fathers during the postpartum period. In addition to the difficulty in dealing with the adversity associated with the fear of COVID-19, the confinement measures associated with COVID-19 pandemic may increase the demands of parenting both in mothers and fathers. COVID-19 pandemic adds a set of restrictions to parents, potentially requiring several changes on infant care, mother/father-infant relationship, and parenting practices, that have to be managed with the teleworking and the financial burden associated with the layoff situation. This challenging context can raise disagreements between the couple, increasing couple's negative interactions and increasing mother and father's depressive symptoms during the postpartum period.

Strengths and limitations

The main strength of this study is the use of a cohort where all the mothers and fathers were recruited before COVID-19 pandemic, with one group of mothers and fathers assessed at six months postpartum during COVID-19 pandemic. This allowed to analyze the impact of COVID-19 pandemic on mother and father's anxiety and depressive symptoms, and couple's relationship quality, considering participants baseline levels at the first trimester of pregnancy, before the presence of COVID-19 pandemic. However, some limitations should also be pointed out. As this cohort was not collected aiming to assess the impact of COVID-19 pandemic on mother and father's postpartum mental health, major relevant information that could explain the study findings was not collected. This includes the presence of SARS-

CoV-2 infection in the mother, the father, or other family member, specific symptoms related with the fear of COVID-19, the changes in the perinatal care due to COVID-19 pandemic, family-teleworking balance, and the economic burden associated with the layoff situation. Additionally, potential confounds unrelated to COVID-19 pandemic may have interfered in the observed findings. However, the mothers and fathers allocated in the group assessed during COVID-19 pandemic were similar to the mothers and fathers allocated in the group assessed before COVID-19 pandemic on their sociodemographic characteristics, as well as on their levels of anxiety and depressive symptoms, and couple's relationship quality before the presence of COVID-19 pandemic. A higher sample size would also have allowed to conduct more complex statistical analysis.

Implications for clinical practice and research

This study has major implications for clinical practice. Findings provide evidence that support the need to (1) screen mothers and fathers with perinatal mental health problems and negative couple's relationship, and (2) design new strategies to reduce mother and father's perinatal mental health problems and negative couple's during the COVID-19 pandemic. Couple-focused interventions over the transition to parenthood have demonstrated good outcomes on variables such as parental mental health, parenting, and infant development (Feinberg et al., 2016). Couple-focused interventions should be adapted using e-technology to support both mothers and fathers during COVID-19 pandemic and in future similar crisis situations. Additionally, interventions to promote mother and father's mental health during COVID-19 pandemic should address parents' concerns, supporting parental decisions and offering strategies to increase feelings of security and parenting self-efficacy. This could be achieved by decreasing mother and father's feelings of isolation and increasing their social, emotional and instrumental support.

Implications for future research are also pointed out. Future studies should analyze the role of mother or the father's SARS-CoV-2 infection when studying the impact of COVID-19 pandemic on mother and father's mental health and couple's relationship quality during the transition to parenthood. To explore the explaining factors (mediators) of COVID-19 pandemic impact on mother and father's mental health problems, and negative couple's relationship during the postpartum period could also be a major contribution to the literature in this field. Several psychological and socioeconomic factors can explain the impact of COVID-19 pandemic and should be considered by future studies. Namely, specific symptoms related with the fear of COVID-19, the changes in the perinatal care due to COVID-19 pandemic, family-teleworking balance, and the economic burden associated with the layoff situation.

Conclusion

Findings provided evidence on the possible negative impact of COVID-19 pandemic on mother and father's postpartum depressive symptoms and couple's relationship quality. COVID-19 pandemic may increase the risk of mother and father's postpartum mental health problems and negative couple's relationship during the postpartum period.

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PAPER VI

**THE PROTECTIVE IMPACT OF PREVIOUS COUPLE'S POSITIVE INTERACTION ON THE PERINATAL
MENTAL HEALTH OF MOTHERS AND FATHERS FACING COVID-19 PANDEMIC**

Pinto, T. M., Mesquita, S., & Figueiredo, B. (under review). The protective impact of previous couple's positive interaction on the perinatal mental health of mothers and fathers facing COVID-19 pandemic.

Psychological Science

Abstract

Couple's relationship can be either a protective or a risk factor for perinatal mental health, with an expectable higher impact in mothers and fathers facing adversity. This study analyzed the protective and risk impact of previous couple's positive and negative interaction on mother and father's postnatal depressive and anxiety symptoms during a major adversity condition, COVID-19 pandemic. A sample of 142 primiparous mothers and fathers from a cohort recruited before COVID-19 pandemic were assessed at the first trimester of pregnancy and again at six months postpartum, before ($n = 70$) or during COVID-19 pandemic ($n = 72$). Previous couple's positive interaction at the first trimester of pregnancy was associated with less postnatal depressive symptoms only in mothers and fathers assessed during COVID-19 pandemic. Findings suggested a protective impact of previous couple's positive interaction on postnatal depressive symptoms in mothers and fathers facing COVID-19 pandemic.

Keywords: adversity; protective and risk factors; couple's relationship, couple's positive and negative interaction; postnatal depressive symptoms; postnatal anxiety symptoms; COVID-19 pandemic.

Introduction

The transition to parenthood is a major life transition associated with several individual, couple and family adjustments (Cowan & Cowan, 2012; Demick, 2002; Figueiredo et al., 2018). This demanding and stressful life transition requires reorganization of both the inner experience and the external behavior, including the reorganization of individual and family roles and relationships (e.g., Cigoli & Scabini, 2006; Cowan & Cowan, 2012; Katz-Wise et al., 2010). The adjustment to the transition to parenthood poses challenges for the couple's relationship, increasing the risk of perinatal mental health problems in mothers and fathers (e.g., Figueiredo et al., 2018). In fact, the transition to parenthood is associated with increased anxiety and depressive symptoms in mothers and fathers (e.g., Don et al., 2014; Figueiredo & Conde, 2011; Underwood et al., 2016).

Previous couple's positive and negative interactions can be, respectively, a protective or a risk factor for mothers and fathers' mental health during pregnancy and the postnatal period (e.g., Don & Mickelson, 2012; Figueiredo et al., 2008; Whisman et al., 2011). A supportive prenatal couple's relationship was associated with higher well-being in mothers during the postnatal period (e.g., Stapleton et al., 2012). Additionally, an adjusted and supportive couple's relationship over the transition to parenthood, with more positive and less negative interactions, was associated with a decrease in emotional distress in mothers and less depressive symptoms and anxiety symptoms in mothers and fathers (e.g., Don & Mickelson, 2012; Figueiredo et al., 2008; Whisman et al., 2011). On the other hand, poor prenatal couple's relationship quality (e.g., conflict behavior, tenderness, and poor communication) was associated with an increase in postnatal depressive symptoms in fathers (e.g., Gawlik et al., 2014). Similarly, prenatal couple's dissatisfaction was associated with an increase in postnatal anxiety symptoms in mothers and fathers (e.g., Don et al., 2014).

The protective and risk impact of previous couple's positive and negative interaction on mental health during the transition to parenthood has been particularly reported for mothers and fathers facing adverse situations (e.g., Chen et al., 2016; Røsand et al., 2017). Prenatal couple's intimacy and satisfaction were associated with postnatal mental health in primiparous mothers and fathers, especially in the context of stressful events (e.g., Røsand et al., 2012; Wynter et al., 2014). Pregnant women facing natural disasters but who were satisfied with couple's relationship revealed less mental health problems (e.g., somatic symptoms, anxiety/sleep loss, impaired social activity and depressive tendencies) during the postnatal period (Sato et al., 2016). Mothers who suffered pregnancy loss reported lower levels of depressive and anxiety symptoms when couple's relationship quality was high, compared to women with

moderate to low couple's relationship quality (e.g., Kagami et al., 2012). Furthermore, in women who undertook elective abortions, those who reported higher couple's relationship quality presented lower trauma symptoms than those who reported lower couple's relationship quality (Canário et al., 2011). In another study, better couple's relationship quality was associated with lower depressive and anxiety symptoms during pregnancy, in women with high-risk pregnancies (Chen et al., 2016).

Regarding gender differences in the impact of couple's positive and negative interaction on perinatal mental health, studies are scarce and provide mixed results. While Røsand and colleagues (2012) found a similar impact of couple's relationship satisfaction both in men and women, Kagami and colleagues (2012) found that couple's relationship quality was not associated with depressive and anxiety symptoms in men, although it was in women.

The 2019 coronavirus (COVID-19) pandemic is a major adversity situation, and thus can be a major empirical laboratory to analyze the impact of adversity on mother and father's perinatal mental health, as well as possible protective and risk impact of the perinatal mental health of mothers and fathers facing adversity. COVID-19 is a highly infectious disease with negative consequences for people's health and well-being (Wang et al., 2020). Confinement measures implemented to contain the spread of SARS-CoV-2 infection have an adverse impact on mental health (e.g., Brooks et al., 2020; Liu et al., 2020; Wang et al., 2020), namely in mothers and fathers during pregnancy (e.g., Durankuş & Aksu, 2020; Lebel et al., 2020; Wu et al., 2020) and the postnatal period (e.g., Pinto & Figueiredo, 2020; Zanardo et al., 2020). COVID-19 pandemic was found to be associated with higher prenatal depressive and anxiety symptoms in mothers (Durankuş & Aksu, 2020; Lebel et al., 2020; Wu et al., 2020), and postnatal depressive symptoms in mothers and fathers (Pinto & Figueiredo, 2020; Zanardo et al., 2020).

Couple's relationship can be either a protective or a risk factor for mother and father's perinatal mental health, with an expectable higher impact in mothers and fathers facing adversity (e.g., Chen et al., 2016; Røsand et al., 2012; Tseng et al., 2017). This study aimed to analyze the protective and risk impact of previous couple's positive and negative interaction (assessed before COVID-19 pandemic) on mother and father's postnatal depressive and anxiety symptoms during a major adversity condition, COVID-19 pandemic.

Method

Participants

The sample comprised 142 primiparous mothers ($n = 71$) and fathers ($n = 71$), 72 assessed during COVID-19 pandemic ($n = 36$ mothers and $n = 36$ fathers) and 70 assessed before COVID-19 pandemic ($n = 35$ mothers and $n = 35$ fathers). All mothers and fathers were married (50.9%) or cohabiting (49.1%). Most mothers and fathers were Portuguese (93.0%), aged between 19 and 39 years old (91.9%), were employed (89.9%), were from medium or high socio-economic levels (88.9%), and had nine or more years of schooling (98.7%; see Table 23). Most infants were born at term (≥ 37 gestational weeks; 94.7%), and at more than 2500g (93.8%). More than 50% were male (57.4%) and born by vaginal delivery (62.2%). The mothers and fathers assessed at six months postpartum during COVID-19 pandemic did not differ from the mothers and fathers assessed at six months postpartum before COVID-19 pandemic, regarding mothers and father's sociodemographic characteristics, and infant characteristics.

Procedures

The present research was conducted in accord with the Helsinki Declaration and received previous approval from the Ethical Commission of all institutions involved. Participants taken part from a larger longitudinal cohort collected before COVID-19 pandemic. Mothers and fathers were recruited at a public Health Service in Northern Portugal during the first trimester of pregnancy (between May 2018 and June 2019). The study exclusion criteria were not reading or writing Portuguese, multiparous mothers and fathers, multiple gestations, and gestations with obstetric complications. The aims and the procedures of the study were explained, and the mothers and fathers who were willing to participate provided a written consent form.

Two assessment waves were considered: (1) first trimester of pregnancy (10-20 gestational weeks, $M = 13.46$, $SD = 2.42$) and (2) six months postpartum (24-32 postpartum weeks, $M = 24.56$, $SD = 2.22$). Participants completed online measures of previous couple's positive and negative interactions during the first trimester of pregnancy (between May 2018 and June 2019) and measures of postnatal depressive and anxiety symptoms at six months postpartum (between November 2018 and May 2020). Mothers and fathers were assessed at six months postpartum, before or during COVID-19 pandemic. The group of participants assessed during COVID-19 pandemic included mothers and fathers that completed

the online questionnaires after COVID-19 outbreak was declared a Public Health Emergency of International Concern by WHO on 30 January 2020 (between February and May 2020).

From the mothers and fathers that completed the questionnaires at the first trimester of pregnancy ($N = 236$), 142 mothers and fathers (60.2%) completed the questionnaires at six months postpartum. The dropout rate did not differ in the groups of mothers and fathers assessed at six months postpartum before (39.6%) or during COVID-19 pandemic (40.0%), $\chi^2 = 1.12$, $p = .319$.

Table 23

Sociodemographic characteristics of mothers and fathers.

	COVID-19 pandemic		
	During	Before	Total
	Mothers and fathers	Mothers and fathers	
	$n = 72$	$n = 70$	
%	%		
<i>Age (years)</i>			
19-29	38.3	32.3	35.3
30-39	58.7	54.4	56.6
≥ 40	3.0	13.3	8.1
<i>Socioeconomic level</i>			
High	43.8	49.2	46.5
Medium	49.1	35.6	42.4
Low	7.1	15.2	11.1
<i>Occupational status</i>			
Employed	89.9	89.9	89.9
Unemployed	10.1	10.1	10.1
<i>Schooling (in years)</i>			
≤ 9	0.0	2.7	1.3
10 – 12	38.5	36.7	37.6
> 12	61.5	60.6	61.1

Measures

Socio-demographic variables. Information about the participants (e.g., age, marital status, socioeconomic level, occupational status, and years of schooling) was collected using a socio-demographic questionnaire.

Couple's positive and negative interactions. The Relationship Questionnaire (RQ; Figueiredo et al., 2008) was used to assess couple's relationship positive and negative interactions. The RQ is a brief 12-item self-report questionnaire scored on a four-point Likert-type scale (from one to four) that assesses couples' positive (positive subscale, eight items) and negative (negative subscale, four items) interactions. The total score for each dimension is computed by averaging the scores of the items of each subscale. This questionnaire was designed to be completed in a short time, is behaviorally focused and appropriate for mothers and fathers, and has been used to assess couples' positive and negative interactions during the transition to parenthood (e.g., Figueiredo et al., 2018). The positive interaction subscale includes sense of support and care, affection, closeness and joint interests and activities (e.g., Do you and your partner show affection to each other?). The negative interaction subscale includes irritability, arguments, and criticisms (e.g., Do you and your partner get irritable with each other?). Higher scores on these subscales reflect more positive or more negative interactions (Figueiredo et al., 2008). The RQ showed good internal consistency in mothers and fathers during the postnatal period (e.g., Figueiredo et al., 2008). In the present sample, Cronbach's alphas ranged from .80 to .92 for mothers and fathers on the positive and negative subscales.

Depressive symptoms. The Edinburgh Postnatal Depression Scale (EPDS; Cox et al., 1987) was used to assess mother and father's depressive symptoms. The EPDS is a 10-item self-report scale scored on a four-point Likert-type scale designed to assess the intensity of depressive symptoms within the previous seven days. This instrument has been used in several studies with mothers and fathers during the postnatal period (e.g., Figueiredo et al., 2018; Figueiredo & Conde, 2011; Pinto et al., 2018). The EPDS Portuguese version showed good internal consistency in mothers and fathers (e.g., Figueiredo et al., 2018; Figueiredo & Conde, 2011; Pinto et al., 2018). In the present sample, Cronbach's alphas ranged from .78 to .88 for mothers and fathers.

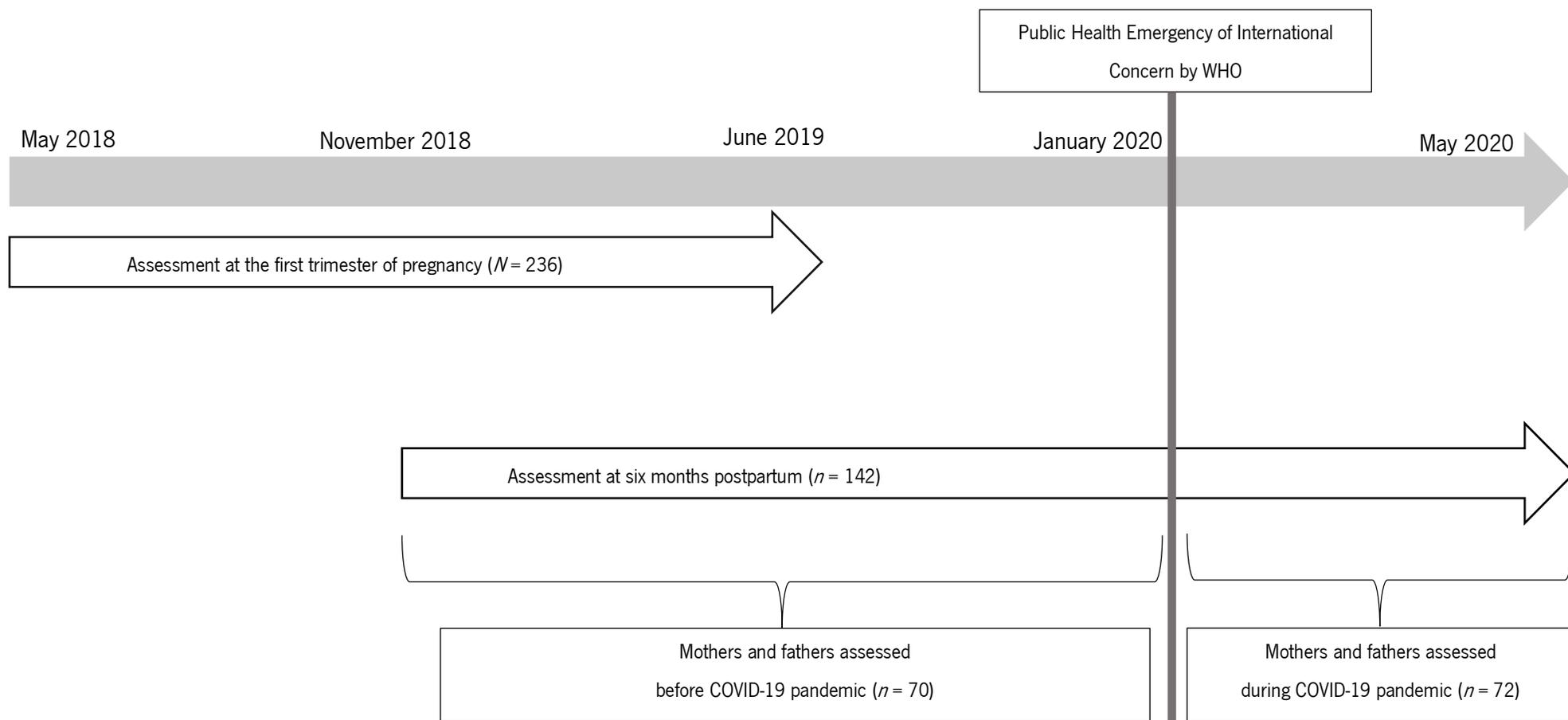


Figure 6. Study flowchart.

Anxiety symptoms. The State-Trait Anxiety Inventory (STAI; Spielberger et al., 1983) consists of two 20-item scales scored on a four-point Likert-type scale that measures individual differences in anxiety proneness as a personality trait and the intensity of anxiety as an emotional state (STAI-S). The STAI-S was used to assess mother and father's anxiety symptoms. When responding to the STAI-S scale, participants report the intensity of their feelings of anxiety at the moment. Several studies have used this measure with mothers and fathers during the postnatal period (e.g., Figueiredo et al., 2018; Figueiredo & Conde, 2011; Pinto et al., 2016). The STAI-S Portuguese version showed good internal consistency in mothers and fathers (e.g., Figueiredo et al., 2018; Figueiredo & Conde, 2011; Pinto et al., 2018). In the present sample, Cronbach's alphas ranged from .88 to .94 for mothers and fathers.

Data analysis

To analyze the protective and risk impact of previous couple's positive and negative interactions on mother and father's postnatal depressive and anxiety symptoms during COVID-19 pandemic, two moderation models were tested using multiple and hierarchical linear regressions, according to Baron and Kenny guidelines (1986). The models included (1) previous couple's positive and negative interactions (RQ positive and negative scores at the first trimester of pregnancy), (2) COVID-19 pandemic (during COVID-19 pandemic = 1; before COVID-19 pandemic = -1), (3) the interaction between previous couple's positive or negative interactions and COVID-19 pandemic (Path c), and (4) the interaction between previous couple's positive or negative interactions, COVID-19 pandemic, and gender (mother = 1; father = -1) as independent variables and mothers and fathers' depressive (model 1) or anxiety symptoms (model 2) at six months postpartum as dependent variables. The models were adjusted for couple's positive and negative interactions at six months postpartum to control the effect of COVID-19 pandemic on couple's relationship quality during the postnatal period (Pinto & Figueiredo, under review). The significant interactions between the independent variables and the moderator were graphed using one standard deviation above and below the mean as high, medium, and low values. Conditional effects were tested to compare the effects of previous couple's positive and negative interaction on mother and father's postnatal depressive and anxiety symptoms in the group of mothers and fathers assessed at six months postpartum during *versus* before COVID-19 pandemic. The statistical assumptions regarding linear regressions were analyzed and multicollinearity was determined. Statistical significance was considered at $p < .05$. Statistical analyses were performed using SPSS version 26.0 (SPSS Inc., USA).

Results

Descriptive statistics of the studied variables are presented in Table 24.

The impact of previous couple's positive and negative interactions at the first trimester of pregnancy on mother and fathers' depressive and anxiety symptoms at six months postpartum

The first linear regression for depressive symptoms at six months postpartum was statistically significant ($p < .05$) and explained 4% of the variance (adjusted $R^2 = .04$). Previous couple's positive interaction at the first trimester of pregnancy was associated fewer depressive symptoms in mothers and fathers at six months postpartum, $\beta = -0.25$, $p = .027$. Previous couple's negative interaction at the first trimester of pregnancy was not associated with depressive symptoms in mothers and fathers at six months postpartum, $\beta = 0.02$, $p = .886$ (see Table 25).

The first linear regression for anxiety symptoms at six months postpartum was not statistically significant. Neither previous couple's positive or negative interactions at the first trimester of pregnancy were found to be associated with anxiety symptoms in mothers and fathers at six months postpartum (see Table 26).

The impact of COVID-19 pandemic on mother and fathers' depressive and anxiety symptoms at six months postpartum

Significantly increasing the variance explained by first the linear regression, the second linear regression for depressive symptoms at six months postpartum was statistically significant ($p < .05$) and explained 7% of the variance (adjusted $R^2 = .07$). Mothers and fathers assessed at six months postpartum during COVID-19 pandemic presented more depressive symptoms than mothers and fathers assessed at six months postpartum before COVID-19 pandemic, $\beta = 0.80$, $p = .049$ (see Table 25).

The second linear regression for anxiety symptoms at six months postpartum was not statistically significant. COVID-19 pandemic was not associated with anxiety symptoms in mothers and fathers at six months postpartum (see Table 26).

Table 24

Descriptive statistics of the study's variables

	Before COVID-19 pandemic		During COVID-19 pandemic		Total	
	<i>n</i> = 70		<i>n</i> = 72		<i>N</i> = 142	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Previous couple's positive interaction at the first trimester of pregnancy	3.72	0.37	3.77	0.24	3.75	0.32
Previous couple's negative interaction at the first trimester of pregnancy	1.88	0.55	1.78	0.40	1.84	0.49
Depressive symptoms at six months postpartum	3.61	2.99	4.88	4.52	4.18	3.79
Anxiety symptoms at six months postpartum	29.71	9.03	31.75	10.73	30.63	9.83

Notes. *M* = Mean; *SD* = Standard deviation.

The interaction impact between previous couple's positive and negative interactions and COVID-19 pandemic on mother and fathers' depressive and anxiety symptoms at six months postpartum

Significantly increasing the variance explained by the second linear regression, the third linear regression for depressive symptoms at six months postpartum was statistically significant ($p < .01$) and explained 12% of the variance (adjusted $R^2 = .12$). The interaction between previous couple's positive interaction at the first trimester of pregnancy and COVID-19 pandemic was significantly associated with depressive symptoms in mothers and fathers assessed at six months postpartum, $\beta = -3.32$, $p = .020$ (see Table 25 and Figure 8).

Table 25

Independent and interaction impact between previous couple's positive or negative interactions at the first trimester of pregnancy, COVID-19 pandemic, and gender on mother and father's depressive symptoms at six months postpartum

<i>Depressive symptoms at six months postpartum</i>	R^2 (R^2_{Aj})	F	β	p	R^2 change
<i>First linear regression</i>	.06 (.04)	2.99*			
Previous couple's positive interaction			-0.25	.027	
Previous couple's negative interaction			0.02	.886	
<i>Second linear regression</i>	.10 (.07)	3.16*			.04*
COVID-19 pandemic			0.80	.049	
<i>Third linear regression</i>	.16 (.12)	3.27**			.06*
Previous couple's positive interaction x COVID-19 pandemic			-3.32	.020	
Previous couple's negative interaction x COVID-19 pandemic			-0.61	.176	
<i>Fourth linear regression</i>	.16 (.12)	3.19**			.00
Previous couple's positive interaction x COVID-19 pandemic x gender			-0.04	.851	
Previous couple's negative interaction x COVID-19 pandemic x gender			0.01	.924	

Notes. The model was adjusted for couple's positive and negative interactions at six months postpartum.

* $p < .05$; ** $p < .01$

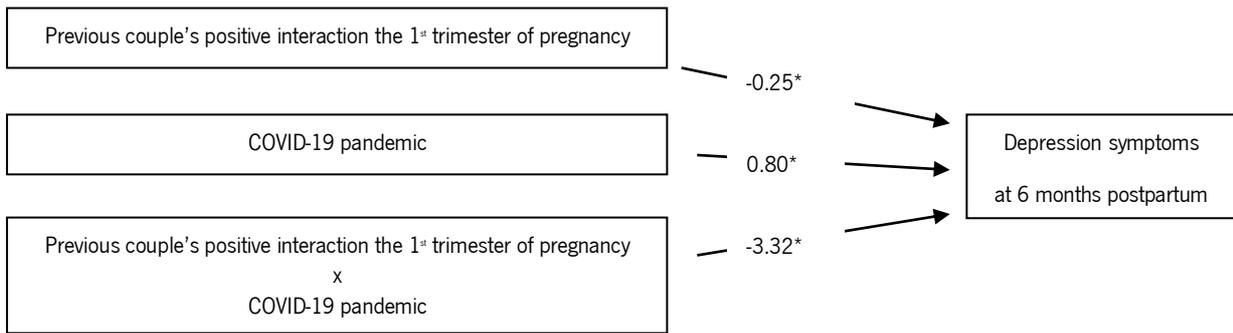


Figure 7. Model to test the interaction impact between previous couple's positive interaction at the first trimester of pregnancy and COVID-19 pandemic on mothers and fathers' depressive symptoms at six months postpartum.

Conditional effects revealed that the impact of previous couple's interaction at first trimester of pregnancy on depressive symptoms was significant in mothers and fathers assessed at six months postpartum during COVID-19 pandemic, $\beta = -7.26$, $p = .003$. While no significant impact of previous couple's positive interaction at the first trimester of pregnancy were found on depressive symptoms in mothers and fathers assessed at six months postpartum before COVID-19 pandemic, $\beta = -1.44$, $p = .336$. Mothers and fathers with previous high couple's positive interaction at the first trimester of pregnancy that were assessed at six months postpartum during COVID-19 pandemic revealed lower depressive symptoms than mothers and fathers with previous low couple's positive interaction at the first trimester of pregnancy that were assessed at six months postpartum during COVID-19 pandemic (see Figure 8).

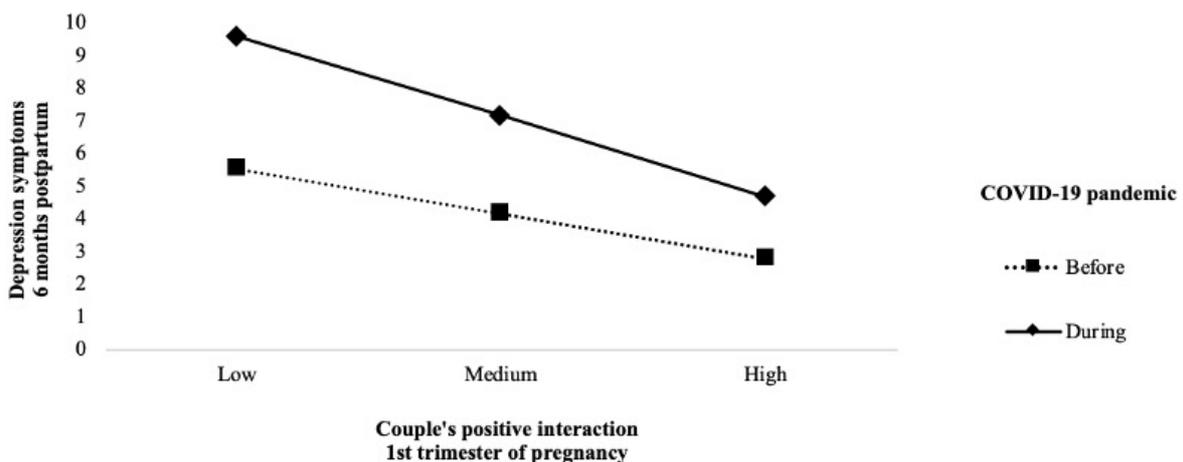


Figure 8. The interaction impact between previous couple's positive interaction at the first trimester of pregnancy and COVID-19 pandemic on mothers and fathers' depressive symptoms at six months postpartum.

The third linear regression for anxiety symptoms at six months postpartum was not statistically significant. The interaction between previous couple's positive interaction at the first trimester of pregnancy and COVID-19 pandemic was not associated with anxiety symptoms in mothers and fathers at six months postpartum (see Table 26).

Table 26

Independent and interaction impact between previous couple's positive or negative interactions at the first trimester of pregnancy, COVID-19 pandemic, and gender on mother and father's anxiety symptoms at six months postpartum

<i>Anxiety symptoms at six months postpartum</i>	<i>R² (R²Aj)</i>	<i>F</i>	<i>β</i>	<i>p</i>	<i>R² change</i>
<i>First linear regression</i>	.03 (.01)	1.42			
Previous couple's positive interaction			-0.14	.218	
Previous couple's negative interaction			0.07	.519	
<i>Second linear regression</i>	.05 (.02)	1.40			.01
COVID-19 pandemic			0.12	.251	
<i>Third linear regression</i>	.08 (.03)	1.50			.03
Previous couple's positive interaction x COVID-19 pandemic			-1.36	.355	
Previous couple's negative interaction x COVID-19 pandemic			-0.81	.089	
<i>Fourth linear regression</i>	.08 (.03)	1.48			.03
Previous couple's positive interaction x COVID-19 pandemic x gender			-0.28	.775	
Previous couple's negative interaction x COVID-19 pandemic x gender			0.31	.819	

Notes. The model was adjusted for couple's positive and negative interactions at six months postpartum.

The interaction impact between previous couple's positive and negative interactions, COVID-19 pandemic, and gender on mother and fathers' depressive and anxiety symptoms at six months postpartum

The fourth linear regression for mother and father's depressive symptoms at six months postpartum was not statistically significant. The interaction between previous couple's positive or negative interactions at the first trimester of pregnancy, COVID-19 pandemic, and gender was not associated with depressive symptoms in mothers and fathers assessed at six months postpartum (see Table 25).

Likewise, the fourth linear regression for mother and father's anxiety symptoms at six months postpartum was not statistically significant. The interaction between previous couple's positive or negative interactions at the first trimester of pregnancy, COVID-19 pandemic, and gender was not associated with anxiety symptoms in mothers and fathers assessed at six months postpartum (see Table 26).

Discussion

This study analyzed the protective and risk impact of previous couple's positive and negative interactions (assessed before COVID-19 pandemic) on mother and father's postnatal depressive and anxiety symptoms during a major adversity condition, COVID-19 pandemic. Findings provided evidence on the impact of COVID-19 pandemic on mother and father's postnatal depressive symptoms, while no impact was found on mother and father's postnatal anxiety symptoms. Mothers and fathers assessed at six months postpartum during COVID-19 pandemic reported more depressive symptoms than mothers and fathers assessed at six months postpartum before COVID-19 pandemic. This result is in line with a previous study reporting more postnatal depressive symptoms in mothers during the COVID-19 pandemic (Zanardo et al., 2020). Findings suggested that COVID-19 pandemic is a major adversity condition for mother and father's mental health during the postnatal period (e.g., Taubman – Ben-Ari et al., 2021), with impact at individual, family and socioeconomic levels (e.g., Chivers et al., 2020; Kusin & Choo, 2021). COVID-19 pandemic may increase feelings of isolation in mothers and fathers and decrease the support from family and friends in childcare, while increasing the demands of parenting during the postnatal period (Chivers et al., 2020; Kwong et al., 2021; Kusin & Choo, 2021). COVID-19 pandemic requires several changes on parenting practices, while increasing the financial burden of mothers and fathers associated with the layoff situation (e.g., Kusin & Choo, 2021).

Findings provided evidence on the protective impact of previous couple's positive interaction on mothers and fathers' postnatal depressive symptoms, while no impact of previous couple's negative

interaction was found. Previous couple's positive interaction at the first trimester of pregnancy predicted fewer depressive symptoms in mothers and fathers at six months postpartum. These results suggest a protective impact of previous couple's positive interactions on mothers and fathers' postnatal depressive symptoms, while no impact was found on mothers and fathers' postnatal anxiety symptoms.

Findings provided evidence on the protective impact of previous couple's positive interaction on postnatal depressive symptoms, specifically in mothers and fathers facing COVID-19 pandemic, while no impact of previous couple's negative interaction was found. Mothers and fathers with previous high couple's positive interaction that were assessed at six months postpartum during COVID-19 pandemic reported lower depressive symptoms than mothers and fathers with previous low couple's positive interaction at the first trimester of pregnancy that were assessed at six months postpartum during COVID-19 pandemic. While no significant impact of previous couple's positive interaction was found on depressive symptoms in mothers and fathers assessed at six months postpartum before COVID-19 pandemic. These findings are in line with previous research suggesting that previous positive couple's relationship is a protective factor against mental health problems in mothers and fathers facing different adverse situations (e.g., Chen et al., 2016; Røsand et al., 2012; Tseng et al., 2017). Findings of the present study can be framed with resilience models proposing that protective factors have usually a greater impact on mental health in the presence of adversity (Rutter, 1985).

The positive dimensions of previous couple's interaction may be particularly important to help mothers and fathers adapt to the challenges associated with COVID-19 pandemic, thus enhancing resilience during adverse situations. The protective role of previous couple's positive interaction on mothers and fathers' postnatal depressive symptoms can be due to a number of factors, such as a higher support between the couple during the transition to parenthood (e.g., Don & Mickelson, 2012; Stapleton et al., 2012). Couple's positive interaction includes better communication within the couple, which could help them adjust to their new roles as parents. The supportive aspect of couple's relationship may explain why previous couple's positive interaction has a protective effect on postnatal depressive symptoms and not on postnatal anxiety symptoms, as high couple's positive interaction is associated with higher support between the couple, which can specifically decrease depressive symptoms (e.g., Iles et al., 2011). These findings also highlight the importance of positive dimensions of previous couple's interaction for mother and father's postnatal depressive symptoms, as no impact of previous couple's negative interaction were found.

Findings also provided evidence that previous couple's positive interaction has a protective impact on the postnatal depressive symptoms for both mothers and fathers facing COVID-19 pandemic.

No significant interaction between previous couple's positive interaction, COVID-19 pandemic, and gender was found on mothers and fathers' postnatal depressive symptoms. This result is in line with previous research (e.g., Røsand et al., 2012) and suggests that previous couple's positive interaction can have a protective impact on both mother and fathers' postnatal depressive symptoms. As such, the positive dimension of previous couple's relationship can be a major source of support for both parents, helping them to deal with the adversity of COVID-19 pandemic. Mothers and fathers with previous high couple's relationship quality assessed before COVID-19 pandemic may easily support each other when facing the increased demands of parenting due to COVID-19 pandemic.

Strengths and limitations

The main strength of this study is the use of a longitudinal cohort where all the mothers and fathers were recruited before COVID-19 pandemic, with one group of mothers and fathers assessed at six months postpartum during COVID-19 pandemic and another group assessed before COVID-19 pandemic. This allowed to analyze the protective and risk impact of previous couple's positive and negative interactions – assessed before COVID-19 pandemic – on postnatal depressive and anxiety symptoms in mothers and fathers facing COVID-19 pandemic.

Several limitations should also be pointed out. As this longitudinal cohort was not collected aiming to assess the protective and risk impact of previous couple's positive and negative interactions on postnatal depressive and anxiety symptoms in mothers and fathers facing COVID-19 pandemic, major confounding variables of the observed impact were not collected. This includes the presence of SARS-CoV-2 infection in the mother, the father, or other family member, specific symptoms related with the fear of COVID-19 and the economic burden associated with the layoff situation. The generalization of findings should also be taken with caution, as the sample of this study comprises mothers and fathers with low socioeconomic risk (e.g., high socioeconomic level, employed, and highly educated).

Implications for clinical practice and research

This study has major implications for clinical practice. Findings suggested that previous couple's positive interaction can help to reduce postnatal depressive symptoms in mothers and fathers facing COVID-19 pandemic. Psychological interventions aiming to reduce mother and father's perinatal mental health problems during the COVID-19 pandemic should target couple's relationship since early pregnancy, promoting couple's positive interactions.

Future studies should analyze the protective impact of previous couple's positive interaction on mental health in highly vulnerable groups of mothers and fathers facing COVID-19 pandemic. Namely, mothers and/or fathers infected with SARS-CoV-2, working as health care professionals, in situation of poverty, and with previous physical and/or mental health problems. To explore the explaining factors by which previous couple's positive interaction can protect postnatal mental health in mothers and fathers during COVID-19 pandemic is also a major contribution to the literature in this field.

Conclusion

Findings suggested the protective impact of previous couple's positive interaction on postnatal depressive symptoms in mothers and fathers facing a major adversity condition, COVID-19 pandemic. Previous couple's positive interaction can help to reduce postnatal mental health problems in mothers and fathers facing adversity, COVID-19 pandemic.

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PAPER VII

POSITIVE COPARENTING CAN BUFFER SELF-REGULATION PROBLEMS IN INFANTS FACING COVID-19

PANDEMIC

Pinto, T. M., & Figueiredo, B. (under review). Positive coparenting can buffer self-regulation problems in infants facing COVID-19 pandemic. *Infant Mental Health Journal*

Abstract

Coparenting can be a development-enhancing or risk-promoting environment for infant self-regulation, with higher impact in infants in the presence of adversity. This study aimed to analyze the impact of previous positive and negative coparenting on infant self-regulation in the presence of an adverse condition - COVID-19 pandemic. A sample of 71 first-born infants and their mothers and fathers from a longitudinal cohort were assessed at two weeks postpartum before COVID-19 pandemic and again at six months postpartum, before ($n = 35$) or during COVID-19 pandemic ($n = 36$). Mothers and fathers completed measures of positive and negative coparenting and infant self-regulation at two weeks and six months postpartum. Results revealed that the presence of COVID-19 pandemic moderates the impact of mother and father's previous positive coparenting on infant self-regulation at six months, while the impact of mother and father's previous negative coparenting was not moderated by the presence of COVID-19 pandemic. The impact of mother and father's previous positive coparenting on self-regulation was higher in infants facing COVID-19 pandemic, than in infants that not faced COVID-19 pandemic. Findings suggested that positive coparenting can be a development-enhancing environment for infant self-regulation, with higher impact in the presence of COVID-19 pandemic. Positive coparenting can buffer self-regulation problems in infants facing adverse conditions.

Keywords: adversity; development-enhancing and risk-promoting environments; positive and negative coparenting; infant self-regulation; COVID-19 pandemic.

Introduction

Developing self-regulatory mechanisms is a major developmental task during infancy (Bell & Deater-Deckard, 2007), with a major role on further infant mental health and development (Eisenberg et al., 2004; Perry et al., 2016; Williams et al., 2016). Self-regulation is defined “as processes that serve to modulate reactivity” (Rothbart et al., 2011, p. 442), allowing the infant to manifest adequate behaviors and to appropriately respond to environment demands, in accordance with his/her age and reactivity (van den Bergh & Mennes, 2006). Self-regulating mechanisms include orienting of attention, inhibition, angry attack, surgent or extraverted approach, and the effortful control of behavior based on the executive attention system (Rothbart et al., 2011).

Coparenting has been shown to be a major element of the family environment influencing infant development, even when parenting quality is considered (Cummings et al., 2000; Feinberg et al., 2009; Holland & McElwain, 2013; Teubert & Pinquart, 2010). Literature provides evidence that coparenting can serve as a development-enhancing or a risk-promoting environment for infant self-regulation (Busuito & Moore, 2017; Feinberg et al., 2009; Teubert & Pinquart, 2010). Positive coparenting dimensions (e.g., parental cooperation and support) were found to enhance infant self-regulation, namely self-soothing (Feinberg et al., 2009). Contrarily, negative coparenting (e.g., parental conflict and undermining) has been found to negatively impact infant development, and specifically self-regulation (Feinberg et al., 2009; Teubert & Pinquart, 2010). Interparental conflict was associated with lower levels of infant self-regulation, such as lower levels of vagal tone (Busuito & Moore, 2017; Moore, 2010; Porter et al., 2003). Negative coparenting dimensions were also associated with increased risk of emotional and behavioral problems in children (Lamela et al., 2016; Scrimgeour et al., 2013; Teubert & Pinquart, 2010).

Although in separate studies, literature provides evidence that positive coparenting can buffer the negative impact of adversity on infant mental health and development, while negative coparenting can increase the negative impact of adversity on infant mental and development (Essex et al., 2003; Herrero et al., 2020; Jamison et al., 2017). Positive coparenting dimensions were found to buffer the negative impact of adversity on children psychological adjustment, namely in the context of poverty or divorce (Herrero et al., 2020; Jamison et al., 2017). Contrarily, negative coparenting dimensions were found to increase the negative impact of adversity on children psychological adjustment, namely in the context of parental mental health problems (Essex et al., 2003).

The 2019 coronavirus (COVID-19) pandemic is a major adverse condition, and thus can be a major empirical laboratory to analyze the impact of adversity on infant development, as well as the factors

that could increase resilience or vulnerability in infants in the presence of adversity. COVID-19 is a highly infectious disease with negative consequences for people's health and well-being (Brooks et al., 2020). Despite infants and young children are not one of the most vulnerable population groups to SARS-CoV-2 infection (Lee & Raszka, 2021), an adverse impact of COVID-19 on infant development has been recently reported (e.g., Wang et al., 2020). Infants facing COVID-19 pandemic were found to present lower social-emotional development at three months (Wang et al., 2020).

One of the main explaining factors of the adverse impact of COVID-19 pandemic on infant development can be mother and father's mental health problems and negative parenting (e.g., Provenzi et al., 2021). An increase on mother and father's depression and anxiety has been reported during COVID-19 pandemic, namely during the postpartum period (Pinto & Figueiredo, under review; Zanardo et al., 2020). Nevertheless, positive parenting has been shown to buffer the adverse impact of COVID-19 pandemic on children mental health (Russell et al., 2020).

Coparenting is a major dimension of the family context that have been shown to have a greater impact on child adjustment than parenting (Holland & McElwain, 2013; Teubert & Pinquart, 2010). As a development-enhancing or a risk-promoting environment, positive coparenting can buffer the negative impact of COVID-19 pandemic on infant self-regulation, while negative coparenting can increase the adverse impact of COVID-19 pandemic on infant self-regulation. Following this hypothesis, this study aimed to analyze the impact of previous positive and negative coparenting (assessed before COVID-19 pandemic) on infant self-regulation in the presence of an adverse condition - COVID-19 pandemic.

Method

Participants

The sample comprised 71 first-born infants and their mothers and fathers, 36 assessed during COVID-19 pandemic and 35 assessed before COVID-19 pandemic. Infants were 52.0% female and 48.0% male. Most infants were born at term (≥ 37 gestational weeks; 91.5%; $M = 39.24$, $SD = 1.25$) and with more than 2500g (96.3%; $M = 3386.51$, $SD = 591.18$). Almost a half were exclusively breastfed during the first six months of age (44.4%). Most infants did not have health problems during the first six months of age (79.0%) and the mothers were the primary caregiver (96.8%; see Table 27). All mothers and fathers were married (50.9%) or cohabiting (49.1%). Most mothers and fathers were Portuguese (93.0%), aged between 19 and 39 years old (91.9%), were employed (89.9%), were from medium or high socio-economic

levels (88.9%), and had nine or more years of schooling (98.7%). The infants assessed at six months during COVID-19 pandemic did not differ from the infants assessed at six months before COVID-19 pandemic, regarding their biometric and sociodemographic characteristics, and their mothers and father's sociodemographic characteristics.

Table 27

Infant biometric and sociodemographic characteristics

	COVID-19 pandemic		
	During <i>n</i> = 36 %	Before <i>n</i> = 35 %	Total <i>N</i> = 71 %
<i>Sex</i>			
Female	53.0	51.0	52.0
Male	47.0	49.0	48.0
<i>Gestational weeks at birth</i>			
≥ 37	91.0	92.0	91.5
35 - 37	9.0	8.0	8.5
<i>Birthweight</i>			
≥ 2500 g	96.0	96.6	96.3
1660 - 2500 g	4.0	3.4	3.7
<i>Breastfeeding at six months</i>			
Exclusive	44.3	44.5	44.4
No-exclusive	55.7	55.5	55.6
<i>Health problems at six months</i>			
No	79.0	78.5	79.0
Yes	21.0	20.5	21.0
<i>Primary caregiver at six months</i>			
Mother	96.6	97.0	96.8
Father	3.4	3.0	3.2

Procedures

The present research was conducted in accord with the Helsinki Declaration and received previous approval from the Ethical Commission of all institutions involved. Infants and their mothers and fathers taken part from a larger longitudinal cohort collected before COVID-19 pandemic. Mothers and fathers were recruited at a public Health Service in Northern Portugal during the first trimester of pregnancy (between May 2018 and June 2019). The study exclusion criteria were not reading or writing Portuguese, multiparous mothers and fathers, multiple gestations, and gestations with obstetric complications. The aims and the procedures of the study were explained, and the mothers and fathers who were willing to participate provided a written consent form.

Two assessment waves were considered: (1) two weeks postpartum (2-8 postpartum weeks, $M = 3.39$, $SD = 2.05$) and (2) six months postpartum (24-32 postpartum weeks, $M = 24.56$, $SD = 2.22$). Mothers and fathers completed online measures of positive and negative coparenting and of infant self-regulation at two weeks postpartum before COVID-19 pandemic (between November 2018 and January 2019) and at six months postpartum (between May 2019 and September 2020). Mothers and fathers reported on their infant self-regulation at six months postpartum, before or during COVID-19 pandemic. The group of participants assessed during COVID-19 pandemic included the infants of mothers and fathers that completed the online questionnaires after COVID-19 outbreak was declared a Public Health Emergency of International Concern by WHO on 30 January 2020 (between February and September 2020).

From the mothers and fathers that completed the questionnaires at two weeks postpartum ($N = 206$), 142 mothers and fathers (68.9%) completed a measure of infant self-regulation at six months. The dropout rate did not differ in the groups of mothers and fathers assessed at six months postpartum before (31.0%) or during COVID-19 pandemic (31.2%), $\chi^2 = 0.81$, $p = .549$.

Measures

Socio-demographic questionnaire. Information about the infants and their mothers and fathers was collected using a socio-demographic questionnaire.

Coparenting. The Portuguese version of the Coparenting Relationship Scale (CRS; Feinberg et al., 2012; Lamela et al., 2018) was used to assess positive and negative coparenting. The CRS is a 35-item self-report scale scored on a seven-point Likert-type scale designed to assess the four domains of coparenting proposed by Feinberg (2003) and comprises six subscales: (1) coparenting agreement subscale (four items) that assesses the degree that each parent agrees with matters related to the infant's education, (2) coparenting closeness subscale (five items) that assesses the degree to which coparenting enhanced intimacy and strengthened the couple's relationship; (3) exposure to conflict subscale (five items) that assesses the degree that parents expose the infant to conflicts related to their education; (4) coparenting support subscale (six items) that assesses the perception of coparenting support from the other parent; (5) coparenting undermining subscale (six items) that assesses the perception that coparenting is regulated by critics, guilt and competition between the parents; and (6) endorse partner parenting subscale (seven items) that assesses one's own positive attitude toward the other parent's parenting.

The Portuguese version of the CRS showed good internal consistency in mothers and fathers (Lamela et al., 2016; Lamela et al., 2018). In the present sample, Cronbach's alphas ranged from .80 to .92 (α 's range = .80 – .88 in mothers; α 's range = .84 – .92 in fathers). Composite scores for mother and father's positive and negative coparenting were calculated by standardizing each scale, summing the positive (agreement, closeness, support, and endorse partner parenting) and negative (exposure to conflict, undermining) subscales and dividing by the number of subscales, respectively.

Infant self-regulation. The orienting regulation dimension of the Infant Behavior Questionnaire - Revised short form (IBQ-R; Gartstein & Rothbart, 2003; Putnam et al., 2014) was used to assess infant self-regulation. The IBQ-R short form comprises 91 items in 14 scales, scored in a seven-point Likert-type scale, related to the frequency of occurrence of the infants' behaviors in several specific situations during the previous week or two weeks. The orienting dimension is comprised the mean scores of four scales: low-intensity pleasure (seven items), cuddliness (six items), duration of orienting (six items) and soothability (seven items) scales.

The orienting regulation dimension of the IBQ-R Portuguese version showed good internal consistency (α 's = .60 - .80; Costa & Figueiredo, 2018; Dias et al., 2021). In the present sample, Cronbach's alphas ranged from .68 to .70 (α = .70 in mothers; α = .68 in fathers). Although both mothers and fathers reported on their infant self-regulation, only the orienting regulation scores reported by the primary caregiver were included in the analysis (mostly mothers; see Table 27).

Data analysis

To analyze the impact of previous positive and negative coparenting on infant self-regulation during COVID-19 pandemic, two moderation models were tested using multiple and hierarchical linear regressions, according to Baron and Kenny guidelines (1986). The models included (1) mother and father's previous positive (model one) and negative (model two) coparenting (at two weeks postpartum), (2) COVID-19 pandemic (during COVID-19 pandemic = 1; before COVID-19 pandemic = -1), and (3) the interaction between mother and father's previous positive (model one) or negative (model two) coparenting (at two weeks postpartum) and COVID-19 pandemic as independent variables and infant self-regulation at six months as dependent variable. The models were adjusted for mother and father's positive (model one) and negative (model two) coparenting at six months postpartum. The significant interactions between the independent variables and the moderator were graphed using one standard deviation above and below the mean as high, medium, and low values. Conditional effects were tested to compare the impact of mother and father's previous positive and negative coparenting on self-regulation in the group of infants assessed at six months during *versus* before COVID-19 pandemic. The statistical assumptions regarding linear regressions were analyzed and multicollinearity was determined. Statistical significance was considered at $p < .05$. Statistical analyses were performed using SPSS version 26.0 (SPSS Inc., USA).

Results

Preliminary analysis

Descriptive statistics of the studied variables are presented in Table 28. No differences were noted between the group assessed at six months postpartum during COVID-19 pandemic and the group assessed at six months postpartum before COVID-19 pandemic on mother, $F(1,141) = 0.03, p = .889$, and father's previous positive coparenting at two weeks postpartum, $F(1,141) = 0.02, p = .909$, and on mother, $F(1,141) = 0.75, p = .602$, and father's previous negative coparenting at two weeks postpartum, $F(1,141) = 0.62, p = .639$. Likewise, no differences were found on infant self-regulation at two weeks, $t(70) = 0.66, p = .748$.

Differences were found between the infants allocated in the group assessed during COVID-19 pandemic and the infants allocated in the group assessed before COVID-19 pandemic on self-regulation at six months, $t(70) = 2.89, p = .006$. Infants assessed at six months during COVID-19 pandemic presented lower self-regulation than infants assessed at six months before COVID-19 pandemic (see Table 28).

The impact of mother and father's previous positive and negative coparenting at two weeks postpartum on infant self-regulation six months

Results indicated that mother and father's previous positive coparenting at two weeks postpartum significantly predicted infant self-regulation, accounting for 13% of the variance. Higher levels of previous positive coparenting reported by mothers, $\beta = 0.32, p = .017$, and fathers, $\beta = 0.41, p = .005$, predicted more infant self-regulation at six months (see Table 29). Likewise, mother and father's previous negative coparenting at two weeks postpartum significantly predicted infant self-regulation, accounting for 7% of the variance. Higher levels of previous negative coparenting reported by mothers, $\beta = -0.29, p = .041$, and fathers, $\beta = -0.32, p = .025$, predicted less infant self-regulation at six months (see Table 30).

The impact of COVID-19 pandemic on infant self-regulation at six months

Significantly increasing the variance explained by the first linear regressions of the two tested models, the second linear regressions for infant self-regulation at six months were statistically significant ($p < .001$) and explained 14% to 16% of the variance. Infants assessed at six months postpartum during COVID-19 pandemic presented less self-regulation than infants assessed at six months postpartum before COVID-19 pandemic, β range = -0.31 - -0.32, p range = .021- .027 (see Table 29 and Table 30).

The moderator role of the presence of COVID-19 pandemic in the impact of mother and father's previous positive or negative coparenting at two weeks postpartum on infant self-regulation at six months

Significantly increasing the variance explained by the second linear regression in the model including mother and father's previous positive coparenting at two weeks postpartum as predictors, the third linear regression for infant self-regulation at six months was statistically significant ($p < .001$) and explained 20% of the variance. The interaction between mother's report of previous positive coparenting at two weeks postpartum and COVID-19 pandemic significantly predicted infant self-regulation at six months, $\beta = -1.17$, $p = .014$. Likewise, the interaction between father's report of previous positive coparenting at two weeks postpartum and COVID-19 pandemic significantly predicted infant self-regulation at six months, $\beta = -1.34$, $p = .002$ (see Table 29 and Figure 9).

Table 28

Descriptive statistics of the study's variables

	Before COVID-19 pandemic		During COVID-19 pandemic		<i>F/t</i>	Total	
	<i>n</i> = 35		<i>n</i> = 36			<i>N</i> = 71	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		<i>M</i>	<i>SD</i>
Mother's positive coparenting at two weeks postpartum	25.02	4.41	24.99	4.49	.03	25.01	4.43
Father's positive coparenting at two weeks postpartum	25.89	9.19	25.80	9.66	.02	25.85	9.77
Mother's negative coparenting at two weeks postpartum	2.74	1.15	2.77	1.12	.75	2.76	1.13
Father's negative coparenting at two weeks postpartum	2.57	1.54	2.59	1.53	.62	2.58	1.53
Infant self-regulation at two weeks	5.19	0.69	5.20	0.70	.66	5.20	0.70
Infant self-regulation at six months	5.71	0.48	5.27	0.61	2.89**	5.47	0.59

Notes. *M* = Mean; *SD* = Standard deviation.

***p* < .05

Table 29

The moderator role of the presence of COVID-19 pandemic in the impact of mother and father's previous positive coparenting on infant self-regulation at six months

<i>Infant self-regulation</i>	<i>R² (R²Aj)</i>	<i>F</i>	<i>β</i>	<i>p</i>	<i>R² change</i>
<i>First linear regression</i>	.15 (.13)	4.80**			
Mother's positive coparenting at two weeks postpartum			0.32	.017	
Father's positive coparenting at two weeks postpartum			0.41	.005	
<i>Second linear regression</i>	.17 (.16)	7.33**			.02*
COVID-19 pandemic			-0.31	.021	
<i>Third linear regression</i>	.21 (.20)	8.18***			.04**
Mother's positive coparenting at two weeks postpartum x COVID-19 pandemic			-1.17	.014	
Father's positive coparenting at two weeks postpartum x COVID-19 pandemic			-1.34	.002	

Notes. The model was adjusted for mother and father's positive coparenting at six months postpartum.

* $p < .05$; ** $p < .01$; *** $p < .005$

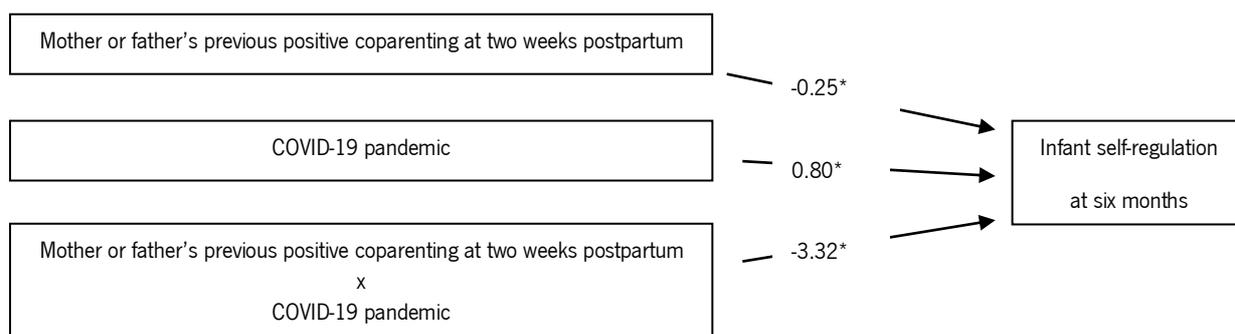


Figure 9. Model to test the moderator role of the presence of COVID-19 pandemic in the impact of mother and father's previous positive coparenting at two weeks postpartum on infant self-regulation at six months.

The plot of the interactions revealed that the impact of mother and father’s previous positive coparenting at two weeks postpartum on self-regulation was higher in infants assessed at six months during COVID-19 pandemic than in infants assessed at six months before COVID-19 pandemic (see Figure 10).

In the model including mother and father’s previous negative coparenting at two weeks postpartum as predictors, the third linear regression for infant self-regulation at six months was not significant. The interaction between mother’s report of previous negative coparenting at two weeks postpartum and COVID-19 pandemic did not predict infant self-regulation at six months, $\beta = -0.20$, $p = .955$. Likewise, the interaction between father’s report of previous negative coparenting at two weeks postpartum and COVID-19 pandemic did not predict infant self-regulation at six months, $\beta = -0.52$, $p = .741$ (see Table 30).

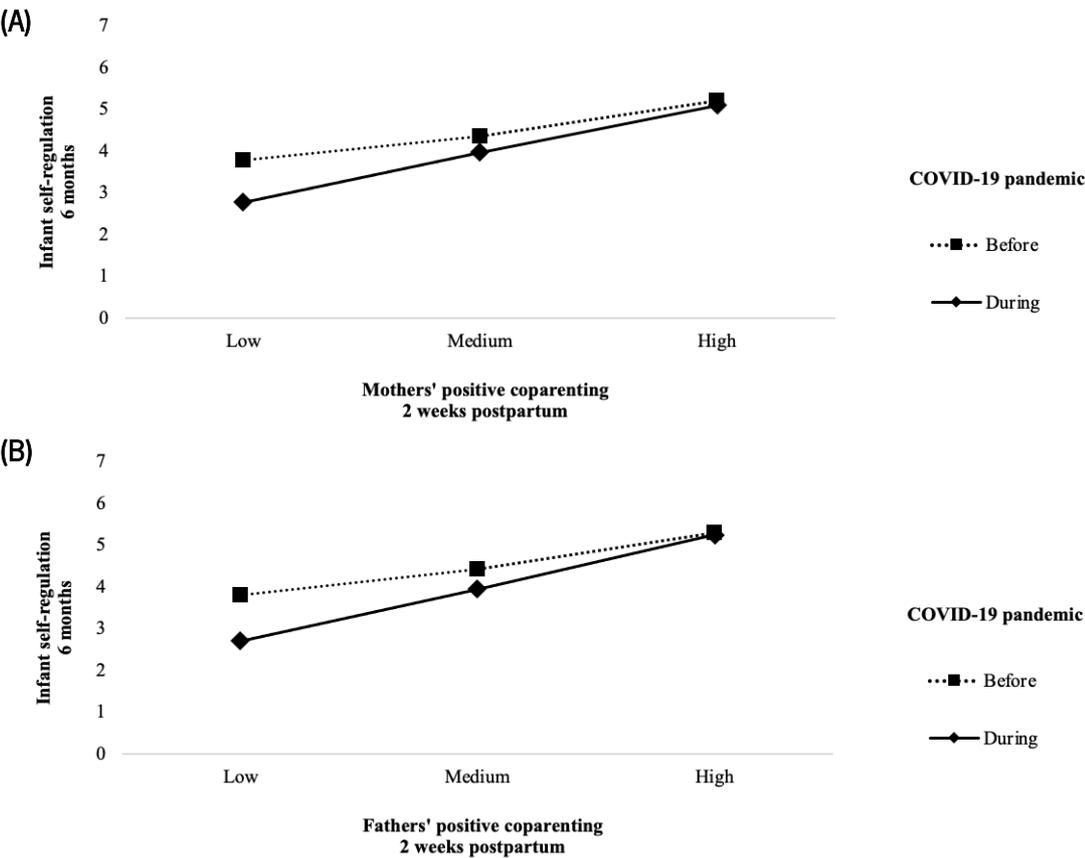


Figure 10. The moderator role of the presence of COVID-19 pandemic in the impact of mother (A) and father’s (B) previous positive coparenting at two weeks postpartum on infant self-regulation at six months.

Table 30

The moderator role of the presence of COVID-19 pandemic in the impact of mother and father's previous negative coparenting on infant self-regulation at six months

<i>Infant self-regulation</i>	<i>R² (R²Aj)</i>	<i>F</i>	<i>β</i>	<i>p</i>	<i>R² change</i>
<i>First linear regression</i>	.08 (.07)	4.40*			
Mother's negative coparenting at two weeks postpartum			-0.29	.041	
Father's negative coparenting at two weeks postpartum			-0.32	.025	
<i>Second linear regression</i>	.15 (.14)	6.01**			.07**
COVID-19 pandemic			-0.32	.027	
<i>Third linear regression</i>	.15 (.14)	3.27*			.00
Mother's negative coparenting at two weeks postpartum			-0.20	.955	
x COVID-19 pandemic					
Father's negative coparenting at two weeks postpartum			-0.52	.741	
x COVID-19 pandemic					

Notes. The model was adjusted for mother and father's negative coparenting at six months postpartum.

* $p < .05$; ** $p < .01$

Discussion

This study analyzed the impact of previous positive and negative coparenting (assessed before COVID-19 pandemic) on infant self-regulation in the presence of an adverse condition – COVID-19 pandemic. Findings provided evidence on the impact of COVID-19 pandemic on infant self-regulation. Although not presenting differences when assessed before COVID-19 pandemic, infants facing COVID-19 pandemic presented less self-regulation at six months than infants that not faced COVID-19 pandemic. Findings from the present study are congruent with those of a previous study (Wang et al., 2020) and suggested that COVID-19 pandemic is a major adverse condition for infant self-regulation during early development. COVID-19 pandemic may be an adverse condition for infant self-regulation development, through the adverse impact on mother and father's mental health (Pinto & Figueiredo, 2020; Provenzi et al., 2021; Zanardo et al., 2020) and on parents-infant interaction (Chivers et al., 2020; Kusin & Choo, 2021) during the postpartum period. COVID-19 pandemic can increase feelings of isolation in mothers and fathers and decrease the support from family and friends in childcare, while increasing the demands of parenting during the postpartum period (Chivers et al., 2020; Kusin & Choo, 2021; Kwong et al.,

2021), which can increase mother and father's mental health problems and disrupted parent-infant interaction (Chivers et al., 2020; Kusun & Choo, 2021), and consequently infant self-regulation problems (Granat et al., 2017; Sun et al., 2020; Væver et al., 2020).

Findings provided evidence on the impact of mother and father's previous positive and negative coparenting at two weeks postpartum on infant self-regulation at six months. Higher levels of previous positive coparenting reported by both mothers and fathers predicted more infant self-regulation at six months. Contrarily, higher levels of previous negative coparenting reported by both mothers and fathers predicted less infant self-regulation at six months. Findings are congruent with those of previous studies (e.g., Feinberg et al., 2009; Moore, 2010; Porter et al., 2003) and supported the view that positive coparenting can be a development-enhancing environment for infant self-regulation, while negative coparenting can be a risk-promoting environment for infant self-regulation that can increase the risk of self-regulation problems.

Findings provided evidence that previous positive coparenting can be a development-enhancing environment for infant self-regulation, with higher impact in the presence of COVID-19 pandemic. Results revealed that the presence of COVID-19 pandemic moderates the impact of mother and father's previous positive coparenting on infant self-regulation at six months, while the impact of mother and father's previous negative coparenting was not moderated by the presence of COVID-19 pandemic. The impact of mother and father's previous positive coparenting on self-regulation was higher in infants facing COVID-19 pandemic, than in infants that not faced COVID-19 pandemic, when controlling for mother and father's positive and negative coparenting at six months postpartum. Considering the reported adverse impact on COVID-19 pandemic on parenting (Chivers et al., 2020; Kusun & Choo, 2021), this allowed us to consider the possible adverse impact of COVID-19 pandemic on coparenting, while ensuring that the impact of previous positive and negative coparenting on infant self-regulation during COVID-19 pandemic was not due to the concurrent impact of positive or negative coparenting on infant self-regulation, as mothers and fathers reporting more previous positive coparenting could be those reporting more positive coparenting during COVID-19 pandemic.

The development of infant self-regulation during the first year of life are supported by and developed through parents–infant co-regulation (e.g., Calkins & Hill, 2007; Moore et al., 2009). The positive dimensions of coparenting (cooperation, support) may provide repeated experiences of positive emotional arousal, thus improving cohesive, secure, and coordinated parent-infant interaction and co-regulation (Busuito & Moore, 2017; Calkins & Hill, 2007; Moore et al., 2009). The positive dimensions of coparenting may be particularly important to enhance the development of self-regulation in infants

facing COVID-19 pandemic. Mothers and fathers presenting more cooperation and support may present more cohesive, secure, and coordinated interactions with their infant (Busuito & Moore, 2017) before COVID-19 pandemic and may be those who better deal with the adverse conditions associated with COVID-19 pandemic, presenting higher resilience to face COVID-19 pandemic. This could promote parents-infant co-regulation (Calkins & Hill, 2007; Moore et al., 2009), enhance the development of infant self-regulation in the presence of COVID-19 and increase infant resilience when facing this adverse condition. The resilience model (Rutter, 1985) suggests that protective factors usually have a greater impact on mental health in the presence of adversity. These findings are framed with and provide evidence to the resilience model (Rutter, 1985) by suggesting that previous positive coparenting can be a protective factor to the development of infant self-regulation, with higher impact in the presence of an adverse condition – COVID-19 pandemic.

Strengths and limitations

The main strength of this study is the use of a longitudinal cohort where all the infants and their mothers and fathers were recruited and assessed before COVID-19 pandemic, with one group of infants assessed at six months during COVID-19 pandemic and another group assessed before COVID-19 pandemic. This allowed to analyze the impact of previous positive and negative coparenting – assessed before COVID-19 pandemic – on infant self-regulation during COVID-19 pandemic.

However, the use of a longitudinal cohort that was not collected aiming to assess the impact of COVID-19, also leads to some limitations. Major variables that could confound or explain the higher impact of previous positive coparenting on the infant self-regulation during COVID-19 pandemic were not collected. This includes the presence of SARS-CoV-2 infection in the infant, the mother, the father, or other family member, specific symptoms related with the fear of COVID-19, and the family socioeconomic strains associated with the COVID-19 pandemic.

Additionally, a higher sample size would have allowed to conduct more complex models, namely including both positive and negative previous coparenting in the same regression models.

Implications for clinical practice and research

This study findings have major implications for clinical practice. Findings suggested that previous positive coparenting can buffer self-regulation problems in infants facing adverse conditions, such as COVID-19 pandemic. Interventions aiming to reduce infant developmental problems in the presence of adversity should target coparenting, promoting a positive coparenting during the postpartum period. Coparenting-focused interventions have demonstrated high efficacy to promote mother and father's mental health, positive parenting, and infant development (Feinberg et al., 2016). Coparenting-focused interventions can be adapted using e-technology to support families during COVID-19 pandemic and in future adverse conditions.

Implications for future research are also pointed out. Future studies should analyze the impact of positive coparenting on infant self-regulation in highly vulnerable families to the adversity, namely, families in condition of poverty, and with previous physical and/or mental health problems. To explore the explaining factors by which positive coparenting can buffer self-regulation problems in infants facing COVID-19 pandemic is also a major contribution to the literature in this field.

Conclusion

Findings suggested that previous positive coparenting can be a development-enhancing environment for infant self-regulation, with higher impact in the presence of an adverse condition. Positive coparenting can buffer self-regulation problems in infants facing adverse conditions.

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DISCUSSION

Aiming to contribute to the literature on mother and father's perinatal mental health, family processes, and infant development, the present doctoral thesis includes two interrelated main aims with different contributes to the field. The **main aim 1** intended to analyze the impact of mother's prenatal depressive symptoms and coparenting on infant self-regulation, considering the role of FHRV in the impact of both mother's prenatal depressive symptoms and coparenting on infant self-regulation. **Paper I** systematically reviewed the measures used to assess infant self-regulation during the first 12 months of life, which supported the selection of the measure used to assess infant self-regulation. Three empirical studies (**Paper II, Paper III, and Paper IV**) comprising this thesis responded to the three specific objectives of **main aim 1**: (1) to analyze the moderator role of positive and negative coparenting in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months (**Paper II**). (2) to analyze the mediator role of FHRV in the impact of mother's prenatal depressive symptoms on infant self-regulation at three months (**Paper III**); and (3) to analyze the moderator role of FHRV in the impact of positive and negative coparenting on infant self-regulation at three months (**Paper IV**).

The **main aim 2** intended to analyze the impact of COVID-19 pandemic on mother and father's postnatal mental health, couple's relationship quality, and infant self-regulation. Three empirical studies (**Paper V, Paper VI, and Paper VII**) comprising this thesis responded to the three specific objectives of **main aim 2**: (1) to analyze the impact of COVID-19 pandemic on mother and father's postnatal depressive and anxiety symptoms, couple's relationship quality, and on infant self-regulation (**Paper V and Paper VII**); (2) to analyze the protective and risk impact of previous couple's positive and negative interaction (assessed before COVID-19 pandemic) on mother and father's postnatal depressive and anxiety symptoms in the presence of an adverse condition - COVID-19 pandemic (**Paper VI**); and (3) to analyze the impact of previous positive and negative coparenting (assessed before COVID-19 pandemic) on infant self-regulation in the presence of an adverse condition - COVID-19 pandemic (**Paper VII**).

In the discussion section, an integrative analysis of the results provided by the seven papers is performed. Throughout this discussion section, considerations are made on (1) the key findings drawn from the seven papers; (2) the integrative discussion of the seven papers; (3) the limitations and strengths of the studies; (4) the implications for practice and research; and (5) an overall conclusion.

Key findings from the studies

The key findings from the papers addressing the **main aim 1** have revealed the following:

(1) The measures used to assess infant self-regulation during the first 12 months of life are generally selected according to the study design, the sample size, and mainly the infant age. Studies targeting younger infants used physiological measures and studies targeting older infants used behavioral measures, with observational measures used with younger infants and parental-reported measures used with older infants during the first year of life (**Paper I**);

(2) Higher levels of mother's prenatal depressive symptoms and higher levels of mother and father's report of negative coparenting at two weeks postpartum predicted lower infant self-regulation at three months. Negative coparenting at two weeks postpartum accentuated the impact of mother's prenatal depressive symptoms on infant self-regulation at three months (Specific objective I, **Paper II**);

(3) FHRV predicted infant self-regulation and mediated the impact of mother's prenatal depressive symptoms on infant self-regulation at three months (Specific objective II, **Paper III**); and

(4) FHRV moderated the impact of mother and father's negative coparenting at two weeks postpartum on infant self-regulation at three months. Infants with low FHRV presented higher self-regulation when mothers or fathers reported less negative coparenting, while lower self-regulation when mothers or fathers reported more negative coparenting, than infants with high FHRV. (Specific objective III, **Paper IV**).

The key findings from papers addressing the **main aim 2** revealed the following:

(1) Significant impact of COVID-19 pandemic on mother and father's depressive symptoms and couple's negative interactions at six months postpartum, and on infant self-regulation at six months. Mothers and fathers facing COVID-19 pandemic reported more depressive symptoms and more couple's negative interactions at six months postpartum than mothers and fathers that not faced COVID-19 pandemic (Objective I, **Paper V**). Likewise, infants facing COVID-19 pandemic presented less self-regulation at six months than infants that not faced COVID-19 pandemic (Specific objective I, **Paper VII**);

(2) Significant impact of the interaction between previous couple's positive interaction and COVID-19 pandemic on mothers and fathers' postpartum depressive symptoms. Previous couple's positive interaction at the first trimester of pregnancy was associated with less postpartum depressive symptoms only in mothers and fathers facing COVID-19 pandemic (Specific objective II, **Paper VI**); and

(3) The presence of COVID-19 pandemic moderated the impact of mother and father's previous positive coparenting on infant self-regulation at six months, while the impact of mother and father's

previous negative coparenting was not moderated by the presence of COVID-19 pandemic. The impact of mother and father's previous positive coparenting on self-regulation was higher in infants facing COVID-19 pandemic, than in infants that not faced COVID-19 pandemic (Specific objective III, **Paper VII**).

Integrative discussion of the results from the included papers

The measures used to assess infant self-regulation during the first 12 months of life were provided in **Paper I**. Several measures were identified: (1) behavioral versus physiological measures, and (2) observational versus parent-reported behavioral measures. Infant self-regulation is mainly assessed using (1) behavioral measures (instead physiological measures) and using (2) observational measures (instead of parent-reported measures). Contrasts were identified when comparing (1) studies using behavioral or physiological measures, regarding the study design, the sample size, and the infant age. Studies with a longitudinal design, comprising larger samples, and aiming to assess infant self-regulation later in infancy, mostly used behavioral measures instead of physiological measures. Contrasts were also identified when comparing (2) behavioral studies using observational or parent-reported measures, namely regarding the sample size and infant age. Studies comprising lower samples and aiming to assess infant self-regulation earlier in infancy, mostly used observational than parent-reported measures. Despite different, both observational and parent-reported measures provide key information to assess infant self-regulation (e.g., Rothbart & Bates, 2006). Observational measures assess infant self-regulation during a specific situation, while parent-reported measures allow the assessment of infant self-regulation in daily routine situations across a variety of contexts where parents have more opportunities to observe the infant. Observational measures can be more adequate to assess infant-self-regulation during a stressful situation, while parent-reported measures can be more adequate to assess self-regulation during and across the days of the infant's life. Combining both observational and parent-reported measures could provide a broader assessment of infant self-regulation.

On the other hand, studies aiming to assess self-regulation earlier in infancy tend to use observational measures. This could be due to the fact that there are no parent-reported measures designed to be applied in infants less than three months of age. Although infant self-regulation is conceptually defined as a multidimensional and complex construct (Rothbart et al., 2011), it is important to note that most of the reviewed studies used only one measure to assess infant self-regulation.

Paper I also identified the behavioral and physiological measures most used to assess infant self-regulation. Regarding behavioral measures, the NNS (Lester & Tronick, 2004) and the NBAS (Brazelton

& Nugent, 1995) were identified as the observational measures most used to assess self-regulation in younger infants. While the FFSF (Tronick et al., 1978) and the BSID-II (Bayley, 1993) were identified as the observational measures most used to assess self-regulation in older infants. The IBQ-R (Gartstein & Rothbart, 2003) and the ASQ:SE (Squires et al., 2001) were identified as the parent-reported measures most used to assess infant self-regulation. Regarding physiological measures, infant's vagal regulation through RSA was identified as the measure mainly applied to assess infant self-regulation.

Paper I supported the empirical and methodological background of the study, providing evidence to design the empirical studies, namely when selecting the measure to assess infant self-regulation. Evidence was provided that the measures used to assess infant self-regulation during the first 12 months of life are generally selected according to the study design, the sample size, and mainly the infant age. Studies targeting younger infants used physiological measures and studies targeting older infants used behavioral measures, with observational measures used with younger infants and parental-reported measures used with older infants during the first year of life.

The results found on **Paper II** allowed us to respond to the **first specific objective** of the **main aim 1** of this thesis. Results showed that experiences provided by negative coparenting interactions reported by mothers and fathers, accentuated the adverse impact of mother's prenatal depressive symptoms on infant self-regulation development, increasing the risk of self-regulation problems. Mother and father's negative coparenting moderated the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. Results specifically showed that mother's prenatal depressive symptoms were more strongly associated with lower infant self-regulation when mothers or fathers reported higher negative coparenting at two weeks postpartum. Findings suggested that the impact of mother and father's negative coparenting on infant self-regulation is higher in infants of mothers with higher prenatal depressive symptoms.

These results are supported and brought empirical evidence to the developmental psychopathology conceptual model (Rutter & Sroufe, 2000; Sroufe, 1997) by showing evidence on the interaction impact between the prenatal (mother's prenatal depressive symptoms) and postnatal (coparenting) environments on infant development (self-regulation). Although the prenatal environment plays a major role in the development of self-regulation (e.g., Henrichs & Van den Bergh, 2015), infants' regulatory capacities during the first year of life are supported by and developed through parents–infant co-regulation (e.g., Calkins & Hill, 2007; Moore et al., 2009). Findings supported the view of negative coparenting as risk-promoting environment for infant self-regulation (e.g., Moore, 2010; Porter et al., 2003). Mother and father's negative coparenting (e.g., exposure to conflict) may negatively impact infant

self-regulation development by exposing the infant to repeated negative experiences of emotional arousal (e.g., Busuito & Moore, 2017). Moreover, mother and father's negative coparenting (e.g., undermining) may negatively impact infant self-regulation by increasing disrupted parenting, leading to disrupted parents-infant interaction and co-regulation (e.g., Calkins & Hill, 2007; Moore et al., 2009). Due to delayed self-regulation maturation associated with mother's prenatal depressive symptoms (e.g., Davis et al., 2011; Figueiredo et al., 2017; Martini et al., 2017), infants of mothers with higher levels of prenatal depressive symptoms could present higher susceptibility to the adverse impact of negative coparenting. The negative experiences provided by negative coparenting interactions may accentuate the adverse impact of mother's prenatal depressive symptoms on infant self-regulation and may increase the risk of self-regulation problems. Findings from this study advance the literature on mother and father's perinatal mental health, family processes, and infant development by suggesting (1) the adverse impact of mother's prenatal depressive symptoms (assessed at the first trimester of pregnancy) on infant self-regulation; and (2) negative coparenting during the early postpartum period as a risk-promoting environment that can accentuate the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. Findings from **Paper II** also raised two major questions on (1) why infants of mothers with higher levels of prenatal depressive symptoms can present lower self-regulation and (2) how they could be more susceptible to the impact of negative coparenting. Thus, **Paper III** and **Paper IV** were designed to address these major questions by analyzing the role of FHRV in the impact of both mother's prenatal depressive symptoms (**Paper III**) and coparenting (**Paper IV**) on infant self-regulation.

The results found on **Paper III** allowed us to respond to the **second specific objective** of the **main aim 1** of this thesis and addressed the first major question provided by the findings of **Paper II** on why infants of mothers with higher levels of prenatal depressive symptoms presented lower self-regulation. **Paper III** suggested FHRV as an early precursor of infant self-regulation that underlies the adverse impact of mother's depressive symptoms on infant self-regulation. It is important to highlight that this study controlled for mother's postnatal depression symptoms, considering the association between mother's postnatal depressive symptoms and both prenatal depressive symptoms and infant self-regulation (Figueiredo et al., 2007; Fisher et al., 2016; Granat et al., 2017; Manian & Bornstein, 2009). Results provided evidence of the association between FHRV and infant self-regulation. Higher FHRV predicted higher levels of infant self-regulation at three months. This finding is congruent with previous studies (e.g., DiPietro et al., 2007; DiPietro et al., 2018; Howland et al., 2020; Werner et al., 2007) and supports the idea that FHRV is an early precursor of infant self-regulation (Appelhans & Luecken, 2006; van den Bergh, 2020). FHRV has been suggested to be an early marker of the ANS development (DiPietro et al., 2007;

DiPietro et al., 2015; Porges, 2007). Namely, significant stability of HRV has been shown from the fetal period to the first year of infant life (DiPietro et al., 2007). The ANS is associated with infant capacity for behavioral and autonomic regulation (DiPietro et al., 2015; Porges, 2007). Likewise, infant's vagal regulation was associated with higher levels of self-regulation during infancy (Bazhenova et al., 2001; Ham & Tronick, 2006; Stifter & Corey, 2001), as well as in later ages (El-Sheikh et al., 2009; Graziano & Derefinko, 2013).

Results also provided evidence that FHRV mediated the impact of mother's prenatal depressive symptoms on infant self-regulation at three months. In the present study, the fetuses of mothers with higher levels of prenatal depressive symptoms showed lower HRV, which predicted lower levels of infant self-regulation at three months. This result is congruent with a previous study (Figueiredo et al., 2017) and suggests lower FHRV as an early precursor of infant self-regulation that underlies the adverse impact of mother's depressive symptoms on infant self-regulation. Infants of mothers with higher levels of prenatal depressive symptoms could be at risk of self-regulation problems, partially due to their lower FHRV. These findings are framed and provide support to the DOHAD hypothesis (Barker et al., 1989; Gluckman & Hanson, 2004) proposing that the exposure to mother's prenatal depression may have developmental programming effects on infant self-regulation. According to the DOHAD hypothesis (Barker et al., 1989; Gluckman & Hanson, 2004), higher levels of prenatal depressive symptoms may lead to a dysregulation of the mother's hypothalamic-pituitary-adrenal (HPA) axis and its hormonal end products, altering the embryotic environment (Szpunar & Parry, 2018; van den Bergh 2011), and consequently altering the neurodevelopment of the fetus (Raikkonen et al., 2011; van den Bergh 2011). Infants of mothers with higher levels of prenatal depressive symptoms may have alterations in the development of their ANS that can lead to lower levels of self-regulation. Lower FHRV may reflect an ANS dysfunction and a decreased ability of the sinus node of the heart to respond to external signals and a reduced ability to respond to the demands of the environment (Lazinski et al., 2008), which could difficult the development of infant self-regulatory mechanisms (Bell & Deater-Deckard, 2007). Findings from this study advance the literature on mother's perinatal mental health and infant development by suggesting FHRV as an early precursor of infant self-regulation that underlies the adverse impact of mother's prenatal depressive symptoms on infant self-regulation.

The results found on **Paper IV** allowed us to respond to the **third specific objective** of the **main aim 1** of this thesis and addressed the second major question provided by the findings of **Paper II** on how infants of mothers with higher levels of prenatal depressive symptoms could be more susceptible to the impact of negative coparenting on self-regulation. **Paper IV** suggested lower FHRV as a prenatal

endophenotypic susceptibility marker that increases the impact of negative coparenting on infant self-regulation. Results provided evidence that FHRV moderates the impact of mother and father's negative coparenting at two weeks postpartum on infant self-regulation at three months. Results showed that infants with low FHRV presented (1) higher levels of self-regulation when mothers or fathers reported less negative coparenting, while (2) lower levels of self-regulation when mothers or fathers reported more negative coparenting, than infants with high FHRV. In infants with high FHRV, the impact of mother and father's negative coparenting on self-regulation was smallest. These findings are framed and provided evidence to DST (Belsky, 2005; Belsky & Pluess, 2009; Ellis et al., 2011) by suggesting lower FHRV as a prenatal endophenotypic susceptibility marker that may increase the impact of negative coparenting on infant self-regulation. According to DST, infants with lower FHRV may be more susceptible to the impact of negative coparenting due to their higher neurobiological plasticity that may already be present during their fetal development. Infants with lower FHRV may better develop their self-regulatory mechanisms in the presence of less negative coparenting interactions, while they may be at high risk of self-regulation problems in the presence of more negative coparenting interactions. This may suggest that infants with lower FHRV are more susceptible to the negative experiences provided by negative coparenting interactions. Specifically, infants with lower FHRV may be more susceptible to the repeated negative experiences of emotional arousal (Busuito & Moore, 2017) provided by mother and father's negative coparenting interactions (e.g., conflict). Additionally, infants with low FHRV may also be more susceptible to the increased disrupted parents-infant interaction and co-regulation (Calkins & Hill, 2007; Moore et al., 2009), associated with mother and father's negative coparenting (e.g., undermining). According to the "for better and for worse" hypothesis provided by DST (Belsky, 2005; Belsky & Pluess, 2009; Ellis et al., 2011), infants with lower FHRV may have increased capacity to deploy self-regulatory mechanisms during early development in the presence of less negative coparenting interactions, which can promote their further development (Williams et al., 2016). These infants may be more susceptible to the cohesive, secure, and coordinated parent-infant interaction and co-regulation, associated with positive coparenting interactions. However, infants with lower FHRV may be at increased risk of self-regulation problems in the presence of more negative coparenting interactions and can be those who are more susceptible to present further developmental problems, as self-regulation problems were associated with more adjustment problems, including internalizing and externalizing problems, impaired social skills, and disrupted physiological regulation to stress in later ages (Eisenberg et al., 2004; Perry et al., 2016). Findings from this study advance the literature on family processes and infant development by suggesting lower FHRV

as a prenatal endophenotypic susceptibility marker that may increase the impact of negative coparenting on infant self-regulation.

Considering the adversity associated with COVID-19 pandemic, **Paper V**, **Paper VI**, and **Paper VII** were designed to analyze the association between mother and father's perinatal mental health, family processes, and infant development in the presence of an adverse condition. The results found on **Paper V** allowed us to respond to the **first specific objective** of the **main aim 2** of this thesis. Results provided evidence on the negative impact of COVID-19 pandemic on mother and father's depressive symptoms and couple's negative interactions at six months postpartum. Mothers and fathers facing COVID-19 pandemic reported more depressive symptoms and more couple's negative interactions at six months postpartum than mothers and fathers that not faced COVID-19 pandemic. These results are in line with a previous study that found more postpartum depressive symptoms in mothers facing COVID-19 pandemic (Zanardo et al., 2020), and with previous studies showing an increase of domestic violence during COVID-19 pandemic (Campbell, 2020; Sediri et al., 2020). This study's findings advance the ones of previous studies by analyzing the impact of COVID-19 pandemic on both mother and father's anxiety and depressive symptoms, and couple's relationship quality during the postpartum period. To our knowledge, this is the first study analyzing the impact of COVID-19 pandemic on father's mental health and couple's relationship quality during the postpartum period. It is important to highlight that gender was considered in the tested models and no impact of the interaction between COVID-19 pandemic and gender were found on mother and father's depressive symptoms, and couple's negative interactions at six months postpartum. This result may suggest that COVID-19 pandemic equally impacts mothers and fathers, in terms of their mental health and couple's relationship quality during the postpartum period.

The confinement measures associated with COVID-19 pandemic may have a negative impact on mother and father's mental health and couple's relationship quality during the postpartum period. Both mothers and fathers have to make several adjustments in order to address the demands of parenting during the postpartum period (Cowan & Cowan, 2012; Demick, 2002; Figueiredo et al., 2018), which can increase the risk for postpartum mental health problems (Don et al., 2014; Figueiredo & Conde, 2011; Underwood et al., 2016), as well as the risk for a deterioration of couple's relationship (Doss et al., 2009; Figueiredo et al., 2018; Lawrence et al., 2008).

Any situation that places human life at risk activates a set of concerns, with specific disturbing concerns for mothers and fathers during the postpartum period. In addition to the difficulty in dealing with the adversity associated with the fear of COVID-19, the confinement measures associated with COVID-19 pandemic may increase the demands of parenting both in mothers and fathers. COVID-19 pandemic

adds a set of restrictions to parents, potentially requiring several changes on infant care, mother/father-infant relationship, and parenting practices, that have to be managed with teleworking and financial burden associated with the layoff situation (Chivers et al., 2020; Kusin & Choo, 2021). This challenging context can raise disagreements between the couple, increasing couple's negative interactions and increasing mother and father's depressive symptoms during the postpartum period. Findings from this study advance the literature on mother and father's perinatal mental health, family processes, and infant development by suggesting the adverse impact of COVID-19 pandemic on mother and father's postpartum depressive symptoms and couple's relationship quality. Findings from **Paper V** also raised two major questions on if family processes can act as protective or risk factors (1) for mother and father's perinatal mental health and (2) for infant development in the presence of an adverse condition – COVID-19 pandemic. Thus, **Paper VI** and **Paper VII** were designed to address these major questions by analyzing the impact of previous couple's positive and negative interaction and previous positive and negative coparenting on mother and father's postnatal depressive and anxiety symptoms (**Paper VI**) and on infant self-regulation (**Paper VII**) in the presence of COVID-19 pandemic.

The results found on **Paper VI** allowed us to respond to the **second specific objective** of the **main aim 2** of this thesis and addressed the first major question provided by the findings of **Paper V** on if family processes can act as protective or risk factors for mother and father's perinatal mental health in the presence of an adverse condition – COVID-19 pandemic. **Paper VI** provided evidence on the protective impact of previous couple's positive interaction on postpartum depressive symptoms, specifically in mothers and fathers facing COVID-19 pandemic, while no impact of previous couple's negative interaction was found. Mothers and fathers with previous high couple's positive interaction facing COVID-19 pandemic reported lower depressive symptoms at six months postpartum than mothers and fathers with previous low couple's positive interaction at the first trimester of pregnancy facing COVID-19 pandemic. While no significant impact of previous couple's positive interaction was found on depressive symptoms in mothers and fathers that not faced COVID-19 pandemic. These findings align with previous research suggesting that previous positive couple's relationship is a protective factor against mental health problems in mothers and fathers facing different adverse situations (e.g., Chen et al., 2016; Tseng et al., 2017; Rosand et al., 2012). The protective role of previous couple's positive interaction on mothers and fathers' postpartum depressive symptoms can be due to several factors, for example a higher support between the couple during the transition to parenthood (e.g., Don & Mickelson, 2012; Stapleton et al., 2012). Couple's positive interaction includes better communication within the couple, which could help them to adjust to their new roles as parents. The supportive aspect of couple's relationship may explain

why previous couple's positive interaction has a protective effect on postpartum depressive symptoms and not on postpartum anxiety symptoms, as high couple's positive interaction is associated with higher support between the couple, which can specifically decrease depressive symptoms (e.g., Illes et al., 2011). Findings of the present study are framed with and provide support to resilience models proposing that protective factors usually have a greater impact on mental health in the presence of adversity (Rutter, 1985).

Findings also provided evidence that the protective impact of previous couple's positive interaction on postpartum depressive symptoms is similar in both mothers and fathers facing COVID-19 pandemic. No significant interaction between previous couple's positive interaction, COVID-19 pandemic, and gender was found on mothers and fathers' postpartum depressive symptoms. This result is in line with previous research (e.g., Rosand et al., 2012) and suggests that previous couple's positive interaction can have a protective impact on both mother and fathers' postpartum depressive symptoms. As such, previous couple's positive relationship is a major source of support for both parents, helping them to deal with the adversity of COVID-19 pandemic. Mothers and fathers with previous high couple's relationship quality assessed before COVID-19 pandemic may easily support each other when facing the increased demands of parenting due to COVID-19 pandemic. Findings from this study advance the literature on mother and father's perinatal mental health and family processes by suggesting the protective impact of previous couple's positive interaction on postnatal depressive symptoms in mothers and fathers facing a major adversity condition, COVID-19 pandemic.

The results found on **Paper VII** allowed us to respond to the **first and the third specific objective** of the **main aim 2** of this thesis. **Paper VII** provided evidence on the impact of COVID-19 pandemic on infant self-regulation (**first specific objective**). Although not presenting differences when assessed before COVID-19 pandemic, infants facing COVID-19 pandemic presented less self-regulation at six months than infants that not faced COVID-19 pandemic. Findings from this study are congruent with those of a previous study (Wang et al., 2020) and suggested that COVID-19 pandemic is a major adverse condition for infant self-regulation during early development. COVID-19 pandemic may be an adverse condition for infant self-regulation development, through the adverse impact on mother and father's mental health (Provenzi et al., 2021; Zanardo et al., 2020) and on parents-infant interaction (Chivers et al., 2020; Kusin & Choo, 2021) during the postpartum period. COVID-19 pandemic can increase feelings of isolation in mothers and fathers and decrease the support from family and friends in childcare, while increasing the demands of parenting during the postpartum period (Chivers et al., 2020; Kusin & Choo, 2021; Kwong et al., 2021), which can increase mother and father's mental health problems and disrupted parent-infant

interaction (Chivers et al., 2020; Kusun & Choo, 2021), and consequently infant self-regulation problems (Granat et al., 2017; Sun et al., 2020; Væver et al., 2020).

Paper VII also addressed the second major question provided by the findings of **Paper V** on if family processes can act as protective or risk factors for infant development in the presence of an adverse condition – COVID-19 pandemic. **Paper VII** provided evidence that previous positive coparenting can be a development-enhancing environment for infant self-regulation, with higher impact in the presence of COVID-19 pandemic (**third specific objective**). Results revealed that the presence of COVID-19 pandemic moderates the impact of mother and father's previous positive coparenting on infant self-regulation at six months, while the impact of mother and father's previous negative coparenting was not moderated by the presence of COVID-19 pandemic. The impact of mother and father's previous positive coparenting on self-regulation was higher in infants facing COVID-19 pandemic, than in infants that not faced COVID-19 pandemic, when controlling for mother and father's positive and negative coparenting at six months postpartum. Considering the reported adverse impact on COVID-19 pandemic on parenting (Chivers et al., 2020; Kusun & Choo, 2021), this allowed us to consider the possible adverse impact of COVID-19 pandemic on coparenting, while ensuring that the impact of previous positive and negative coparenting on infant self-regulation during COVID-19 pandemic was not due to the concurrent impact of positive or negative coparenting on infant self-regulation, as mothers and fathers reporting more previous positive coparenting could be those reporting more positive coparenting when facing COVID-19 pandemic.

As previously described, parents–infant co-regulation plays a major role in the development of infant self-regulation during the first year of life (e.g., Calkins & Hill, 2007; Moore et al., 2009). The positive dimensions of coparenting (cooperation, support) may provide repeated experiences of positive emotional arousal, thus improving cohesive, secure, and coordinated parent-infant interaction and co-regulation (Busuito & Moore, 2017; Calkins & Hill, 2007; Moore et al., 2009). The positive dimensions of coparenting may be particularly important to enhance the development of self-regulation in infants facing COVID-19 pandemic. Mother and fathers presenting cooperation and support may present more cohesive, secure, and coordinated interactions with their infant (Busuito & Moore, 2017) before COVID-19 pandemic and may be those who better deal with the adverse conditions associated with COVID-19 pandemic, presenting higher resilience to face adversity. This could promote parents-infant co-regulation (Calkins & Hill, 2007; Moore et al., 2009), enhance the development of infant self-regulation in the presence of COVID-19 and increase infant resilience when facing this adverse condition. The resilience model (Rutter, 1985) suggests that protective factors usually have a greater impact on mental health in the presence of adversity. These findings are framed with and provide evidence to the resilience model

(Rutter, 1985) by suggesting that previous positive coparenting can be a protective factor to the development of infant self-regulation, with higher impact in the presence of an adverse condition – COVID-19 pandemic. Findings from this study advance the literature on family processes and infant development by suggesting (1) the adverse impact of COVID-19 pandemic on infant self-regulation development and (2) previous positive coparenting as a development-enhancing environment for infant self-regulation, with higher impact in the presence of an adverse condition.

Altogether, the findings of the six empirical papers included in the present thesis can provide a major contribute to the literature on mother and father's perinatal mental health, family processes, and infant development. The findings of the three empirical papers addressing the **main aim 1** of the present thesis (**Paper II, Paper III, and Paper IV**) provided evidence that specifically enlarge the comprehension on the way that mother and father's perinatal mental health problems and negative family processes can interact during early pregnancy and the postpartum and can adversely impact the development of their offspring early in the fetal period and later during infancy. Moreover, the evidence provided on the fetal endophenotypic characteristics (FHRV) that can be adversely affected by mother's prenatal mental health problems (higher depressive symptoms) and later, in infancy, can lead to a differential impact of negative family processes (negative coparenting) on infant development (self-regulation) is another main contribute to this field.

Following the unexpectable emergence of an adverse condition, the presence of COVID-19 pandemic was used as an empirical laboratory and was integrated as the **main aim 2** of the present thesis to enlarge the contribute to the literature provided by the findings of the papers addressing the **main aim 1**. The findings of the empirical papers addressing the **main aim 2** of the present thesis (**Paper V, Paper VI, and Paper VII**) provided evidence that specifically enlarge the comprehension on the impact of adversity (COVID-19 pandemic) on mother and father's postnatal mental health (anxiety and depression symptoms), family processes (couple's relationship quality), and infant development (self-regulation). Moreover, the evidence provided on the family processes previous to the presence of adversity (positive couple's interaction and positive coparenting) that could increase resilience and then promote mother and father's postnatal mental health, and infant development in the presence of an adverse condition is another main contribute to this field.

Limitations and strengths

The studies that comprise this thesis present some limitations. The first limitation concerns to the voluntary nature of the participation in the study that may have led to a selection bias. Mothers and fathers who agreed to participate may be those who feel more involved and satisfied with the pregnancy and the postpartum experience. However, in all the papers comprising the current thesis, no differences were found between mothers and fathers who completed all the assessment waves and those who did not. A higher sample size would also have allowed conducting more complex statistical analyses, incorporating all the studied variables. The generalization of findings should also be taken with caution, as the sample included in these studies comprises mothers and fathers with low socioeconomic risk (e.g., high socioeconomic level, employed, and highly educated).

As independent and dependent variables were generated by the same informants, a common-method variance may have inflated the links between the study variables. Specifically, infant self-regulation was assessed with a parent-reported measure. However, previous literature found an association between parent-reported and observational measures of infant self-regulation, suggesting that parents are reliable informants of their infant's behaviors when they are their primary caregiver (e.g., Rothbart et al., 2011). Considering this association, in this study, the reports of self-regulation were provided by the infant's primary caregiver. Literature also suggests that postnatal depressive symptoms can negatively bias parents' perceptions of their infant's behavior (Field et al., 1993; Rothbart et al., 2011). Considering this, postnatal depressive symptoms were controlled in the statistical analysis. Parent-report measures allow the assessment of infant self-regulation in daily routine situations across a variety of contexts where parents have more opportunities to observe the infant than an observer (Rothbart et al., 2011). Moreover, infant self-regulation was assessed with the IBQ-R short form, a parent-reported measure designed to assess infant temperament. However, as self-regulation is a process that serves to modulate temperamental reactivity (Rothbart et al., 2011), the IBQ-R has been pointed out as a useful self-reported measure to assess infant self-regulation (results from **Paper I**). Infant HRV was not considered in this study, which does not allow to assure that the observed impacts on infant self-regulation are only due to FHRV (results from **Paper III** and **Paper IV**).

Specific limitations of the studies that addressed the **main aim 2** should also be considered. Major relevant information that could explain the study findings was not collected, as this cohort was not collected aiming to assess the impact of COVID-19 pandemic on mother and father's postpartum mental health, family processes, and infant development. This includes the presence of SARS-CoV-2 infection in

the mother, the father, the infant or other family member, specific symptoms related to the fear of COVID-19, the changes in the perinatal care due to COVID-19 pandemic, family-teleworking balance, and the economic burden associated with the layoff situation. Additionally, potential confounders unrelated to COVID-19 pandemic may have interfered in the observed findings. However, the mothers, fathers, and infants assigned in the group assessed during COVID-19 pandemic were similar to the mothers, fathers, and infants assigned in the group assessed before COVID-19 pandemic on their sociodemographic and biometric characteristics, as well as on their levels of anxiety and depressive symptoms, couple's relationship quality, coparenting, and self-regulation before the presence of COVID-19 pandemic.

The studies of this thesis also present major strengths that should be highlighted. First, the studies enclosed a longitudinal design, with mothers, fathers and infants followed from early pregnancy to the postpartum period, within five assessment waves. Additionally, all the studied variables were selected considering its relevance regarding perinatal mental health, family processes, and infant development. Second, the studies used gold-standard measures to assess all the studied variables. Namely, mother and father's depressive and anxiety symptoms were assessed with validated and internationally used instruments to assess and screen for prenatal and postpartum depressive and anxiety symptoms (Eastwood et al., 2012; Mao et al., 2011; Milgrom et al., 2008). Coparenting and couple's relationship quality were assessed with empirically based measures, including the assessment of both positive and negative dimensions (Feinberg et al., 2012; Figueiredo et al., 2008). A validated and widely used measure was also used to assess infant self-regulation (e.g., Davis et al., 2007; Gartstein & Robarh, 2003; Gustafsson et al., 2018). This measure was selected considering the systematically reviewed evidence in **Paper 1**. Additionally, all these measures demonstrated its validity in Portuguese samples (Costa & Figueiredo, 2018; Dias et al., 2021; Figueiredo & Conde, 2011a,b; Figueiredo et al., 2017; Figueiredo et al., 2018; Lamela et al., 2016; Tendais et al., 2014), as well as in the studies of the present thesis.

Specific strengths of the included papers are also provided. **Paper II, Paper IV, and Paper VII** included father's reports of coparenting when studying the impact of coparenting on infant self-regulation. In **Paper III and Paper IV**, FHRV was assessed using a gold standard procedure of fetal monitoring (Ayres-de-Campos et al., 2008).

The main strength of **Paper V, Paper VI, and Paper VII** was the use of a longitudinal cohort where all the mothers, fathers, and infants were recruited before COVID-19 pandemic, with one group of mothers, fathers, and infants assessed at six months postpartum during COVID-19 pandemic. This allowed to analyze (1) the impact of COVID-19 pandemic on mother and father's anxiety and depressive

symptoms, couple's relationship quality, and infant self-regulation, considering participants baseline levels, before the presence of COVID-19 pandemic; (2) the protective and risk impact of previous couple's positive and negative interactions – assessed before COVID-19 pandemic – on postpartum depressive and anxiety symptoms in mothers and fathers facing COVID-19 pandemic; and (3) the impact of previous positive and negative coparenting (assessed before COVID-19 pandemic) on self-regulation in infants facing COVID-19 pandemic.

Implications for practice and research

The findings of the studies comprising this thesis enclose important implications for practice on mother and father's perinatal mental health, family processes, and infant development. Findings provide several cues to interventions targeting mother and father's perinatal mental health problems, negative family processes, and infant mental health and development problems. These interventions should start early in pregnancy, last to the postpartum period, and include both mothers, fathers, and infants. Delivering interventions with such multi-factor approach are feasible, and couple-focused interventions across pregnancy and the postpartum period have demonstrated a positive impact on parental mental health, family processes, and infant development (e.g., Feinberg et al., 2009; Feinberg et al., 2016).

Results from the papers that addressed **main aim 1** provided evidence (1) on the measures mostly used to assess infant self-regulation during the first year of life (**Paper I**); (2) that infants in families of mothers with elevated prenatal depressive symptoms and with high levels of negative coparenting may be at high risk of self-regulation problems (**Paper II**); (3) that infants of mothers with higher levels of prenatal depressive symptoms could be at risk of self-regulation problems, partially due to their lower FHRV (**Paper III**); and (4) that infants with lower FHRV may be more susceptible to the impact of negative coparenting and can be those who better develop their self-regulatory mechanisms in the presence of less negative coparenting interactions, while can be those at high risk of self-regulation problems in the presence of more negative coparenting interactions (**Paper IV**).

Paper I provided evidence that it is important to consider the infant age when measuring self-regulation, in order to fit the measure procedures with the infant self-regulation development level, which is how self-regulation is established and manifested. This evidence could assist both researchers and clinical practitioners in selecting adequate measures to assess infant self-regulation. **Paper II** provided evidence that reducing negative coparenting interactions during the early postpartum period could help to prevent self-regulation problems, particularly in infants at higher risk of self-regulation problems,

associated with mother's prenatal symptoms. **Paper III** provided evidence that screen and intervene on mothers with higher levels of depressive symptoms during early pregnancy could help to prevent delayed fetal neurodevelopment, and consequently, later self-regulation problems in the infant. The monitoring of fetuses with lower HRV could also allow following those infants at risk of self-regulation problems, and those who may need intervention early in infancy. **Paper IV** provided evidence that reducing negative coparenting interactions during the early postpartum period can contribute to promote the development of self-regulation and help to prevent self-regulation problems, particularly in infants with lower FHRV. According to the "for better and for worse" hypothesis provided by DST (Belsky, 2005; Belsky & Pluess, 2009; Ellis et al., 2011), infants with lower FHRV may also be those more susceptible to the positive impact of interventions targeting coparenting quality during early development.

Findings from the papers that addressed **main aim 2** provided several cues to interventions targeting mother and father's perinatal mental health problems, family processes, and infant development in the presence of adverse conditions. Results provided evidence that (1) COVID-19 pandemic may increase the risk of mother and father's postpartum mental health problems, negative couple's relationship during the postpartum period, and of infant self-regulation problems (**Paper V** and **Paper VII**); (2) previous couple's positive interaction can help to reduce postpartum depressive symptoms in mothers and fathers facing adverse conditions, such as COVID-19 pandemic (**Paper VI**); and (3) previous positive coparenting can buffer self-regulation problems in infants facing adverse conditions, such as COVID-19 pandemic (**Paper VII**).

Paper V and **Paper VII** provided evidence that supports the need to (1) screen mothers and fathers with perinatal mental health problems and negative couple's relationship, and infants with self-regulation problems in the presence of adverse conditions; and (2) design new strategies to reduce mother and father's perinatal mental health problems, negative couple's relationship, and infant self-regulation problems in the presence of adverse conditions. **Paper VI** provided evidence that psychological interventions aiming to reduce mother and father's perinatal mental health problems in the presence of adverse conditions should target couple's relationship since early pregnancy, promoting couple's positive interactions. **Paper VII** provided evidence that interventions aiming to reduce infant developmental problems in the presence of adversity should target coparenting, promoting a positive coparenting interactions during the postpartum period.

Couple-focused interventions should be adapted using e-technology to support both mothers, fathers, and infants during COVID-19 pandemic and in future adverse conditions. Additionally, interventions to promote mother and father's mental health, positive family processes, and infant

development during adverse conditions should address parents' concerns, supporting parental decisions and offering strategies to increase feelings of security and parenting self-efficacy, and to promote cooperation and support between the parents in the care of their infant. This could be achieved by decreasing mother and father's feelings of isolation and negative couple interactions, while increasing their positive communication and their social, emotional, and instrumental support.

The findings of the studies comprising this thesis also enclose important implications for further research on mother and father's perinatal mental health, family processes, and infant development. Specifically, the results from the papers that addressed **main aim 1** provided several implications to the literature on the impact of mother's prenatal depressive symptoms and coparenting on infant self-regulation. **Paper II** suggested that mother and father's negative coparenting increases the adverse impact of mother's prenatal depressive symptoms on infant self-regulation at three months. Following the developmental psychopathology conceptual model, future research should further explore the mechanisms underlying the impact of mother's prenatal depressive symptoms that could explain why infants of mothers with higher levels of prenatal depressive symptoms are more susceptible to the impact of negative coparenting. Future studies should also explore the underlying mechanisms (e.g., infant vagal reactivity) and the processes (e.g., disrupted parents-infant interaction) that could explain the adverse impact of negative coparenting on infant self-regulation.

Paper III suggested that FHRV is an early precursor of infant self-regulation that underlies the adverse impact of mother's prenatal depressive symptoms on infant self-regulation. Considering the low variance explained by the mediation model, future research should explore possible prenatal (e.g., maternal-fetal HPA axis dysregulation) and postnatal (e.g., infant HRV and reactivity) mechanisms that can underlie the adverse impact of mother's prenatal depressive symptoms on both FHRV and infant self-regulation. Future research could also be conducted to clarify the potential long-term adverse impact of mother's prenatal depressive symptoms on FHRV and infant self-regulation, examining the impact of duration, timing, and severity of depressive symptoms on self-regulation across development.

Paper IV provided evidence on lower FHRV as a prenatal endophenotypic susceptibility marker that may increase the impact of negative coparenting on infant self-regulation. Integrating developmental and family psychopathology conceptual models and DST, future research should explore the underlying mechanisms that can explain why infants with lower FHRV are more susceptible to the impact of negative coparenting. To analyze mother, father, and infant's psychophysiological processes (e.g., vagal tone and vagal reactivity) during triadic interactions, considering the role of FHRV, can contribute to explain why infants with lower FHRV are more susceptible to the impact of negative coparenting on self-regulation.

Results from the papers that addressed **main aim 2** provided evidence to the literature on the adverse impact of COVID-19 pandemic on mother and father's postpartum mental health problems, negative couple's relationship during the postpartum period, and on infant self-regulation. **Paper V** and **Paper VII** provided evidence on the adverse impact of COVID-19 pandemic on mother and father's postpartum depressive symptoms and negative couple's relationship during the postpartum period, and on infant self-regulation during early development. **Paper VI** provided evidence on the protective impact of previous couple's positive interaction on postpartum depressive symptoms in mothers and fathers facing an adverse condition - COVID-19 pandemic. **Paper VII** provided evidence that previous positive coparenting can be a development-enhancing environment for infant self-regulation, with higher impact in the presence of an adverse condition – COVID-19 pandemic.

Further research should analyze the role of mother, father, or infant's SARS-CoV-2 infection when studying the impact of COVID-19 pandemic on mother and father's mental health and couple's relationship quality during the transition to parenthood, and on infant self-regulation during early development. Exploring the explaining factors (mediators) of COVID-19 pandemic impact on mother and father's mental health problems and negative couple's relationship during the postpartum period, and on infant self-regulation could also be a major contribution to the literature in this field. Several psychological and socioeconomic factors can explain the impact of COVID-19 pandemic and should be considered by future studies. Namely, specific symptoms related to the fear of COVID-19, the changes in the perinatal care due to COVID-19 pandemic, family-teleworking balance, and the economic burden associated with the layoff situation.

Future studies should also analyze the protective role of previous couple's positive interaction and coparenting on the mental health and development in highly vulnerable groups of mothers, fathers, and infants facing COVID-19 pandemic. Namely, families in situation of poverty, mothers and/or fathers infected with SARS-CoV-2, working as health care professionals, and with previous physical and/or mental health problems. To explore the explaining factors by which previous couple's positive interaction and positive coparenting can protect both mothers and father's postpartum mental health and infant self-regulation development in the presence of COVID-19 pandemic is also a major contribution to the literature in this field.

Overall conclusion

The present thesis contributes to the literature on mother and father's perinatal mental health, family processes, and infant development by providing evidence on (1) the impact of mother's prenatal depressive symptoms and negative coparenting on infant self-regulation, considering the role of FHRV in the impact of both mother's prenatal depressive symptoms and negative coparenting on infant self-regulation (**main aim 1**); and (2) the adverse impact of COVID-19 pandemic on mother and father's postnatal mental health, couple's relationship quality, and infant self-regulation (**main aim 2**).

Papers that addressed **main aim 1** specifically contribute to the literature on mother and father's perinatal mental health, family processes, and infant development by suggesting that (1) it is important to consider the infant age when measuring self-regulation, in order to fit the measure procedures with the infant self-regulation development level, that is how self-regulation is established and manifested (**Paper I**); (2) negative coparenting can be a risk-promoting environment, increasing the adverse impact of mother's prenatal depressive symptoms on infant self-regulation (**Paper II**); (3) FHRV is an early precursor of infant self-regulation that underlies the adverse impact of mother's prenatal depressive symptoms on infant self-regulation (**Paper III**); and (4) lower FHRV is a prenatal endophenotypic susceptibility marker that may increase the impact of negative coparenting on infant self-regulation (**Paper IV**).

Papers that addressed **main aim 2** specifically contribute to the literature on the impact of adversity on mother and father's perinatal mental health, family processes, and infant development by suggesting (1) the adverse impact of COVID-19 pandemic on mother and father's postpartum depressive symptoms, couple's negative interaction, and on infant self-regulation (**Paper V** and **Paper VII**); (2) the protective impact of previous couple's positive interaction on postpartum depressive symptoms in mothers and fathers facing COVID-19 pandemic (**Paper VI**); and (3) that previous positive coparenting can be a development-enhancing environment for infant self-regulation, with higher impact in the presence of COVID-19 pandemic (**Paper VII**).

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APPENDIX



Universidade do Minho

SECVS

Subcomissão de Ética para as Ciências da Vida e da Saúde

Identificação do documento: SECVS 042/2016

Título do projeto: *Psychophysiological processes involved on Breastfeeding and Infant Self-regulation*

Investigador(a) responsável: Professora Barbara Figueiredo, da Escola de Psicologia da Universidade do Minho

Subunidade orgânica: Escola de Psicologia, Universidade do Minho

PARECER

A Subcomissão de Ética para as Ciências da Vida e da Saúde (SECVS) analisou o processo relativo ao projeto intitulado "*Psychophysiological processes involved on Breastfeeding and Infant Self-regulation*".

Os documentos apresentados revelam que o projeto obedece aos requisitos exigidos para as boas práticas na experimentação com humanos, em conformidade com o Guião para submissão de processos a apreciar pela Subcomissão de Ética para as Ciências da Vida e da Saúde.

Face ao exposto, a SECVS nada tem a opor à realização do projeto.

Braga, 29 de setembro de 2016.

A Presidente

MARIA CECÍLIA
DE LEMOS
PINTO ESTRELA
LEÃO

Digitally signed by MARIA CECILIA DE LEMOS PINTO ESTRELA LEÃO
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Maria Cecília de Lemos Pinto Estrela Leão

Emitido
em 5.12.17

Data: 28 de Novembro de 2017

Nossa referência: 99/2017

Relator: Paulo Silva

A. Figueiredo,
L. Guilherme
5/12/17**Parecer emitido em reunião plenária de 28 de Novembro de 2017**

Nos termos dos Nº 1 e 6 do Artigo 16º da Lei Nº 21/2014, de 16 de Abril, a Comissão de Ética para a Saúde do Hospital de Braga (CESHB) em relação ao estudo "Depressão, Coparentalidade e Autorregulação do bebé – o papel da reatividade endofenotípica e fenotípica fetal-infantil" de que é investigador principal o Dr. Tiago Pinto, aluno do 1º ano de Doutoramento em Psicologia Aplicada da Escola de Psicologia da Universidade do Minho, orientadora a Profª. Drª. Bárbara Figueiredo, Professora Associada com Agregação da mesma Escola, e que decorrerá no âmbito do Serviço de Obstetrícia do Hospital de Braga, emite o seguinte parecer:

- a) O estudo apresenta como objetivo principal a análise do efeito da depressão materna pré-natal e da coparentalidade no desenvolvimento da autorregulação do bebé. Desta forma, pretende analisar o efeito da interação entre a depressão materna pré-natal e a coparentalidade na autorregulação do bebé; o papel mediador-moderador da reatividade cardíaca fetal no efeito da depressão materna pré-natal e da coparentalidade na autorregulação do bebé; o papel mediador-moderador da reatividade neuroendócrina e comportamental do bebé no efeito da depressão materna pré-natal e da coparentalidade na autorregulação do bebé; e o papel mediador da reatividade neuroendócrina do bebé como moderador da reatividade comportamental do bebé no efeito da coparentalidade na autorregulação do bebé. Trata-se de um estudo longitudinal, de carácter prospetivo;
- b) A colheita de dados será efetuada em 4 momentos de avaliação: 3º trimestre de gravidez (28-32 semanas de gestação), 3 a 6 dias pós-parto, 3 meses pós-parto e 6 meses pós-parto.

No 3º trimestre de gravidez, cada membro do casal irá preencher individualmente *online* um questionário sociodemográfico para recolher informação sociodemográfica, obstétrica e fetal, e uma escala para avaliar os sintomas de depressão (*Edinburgh Postnatal Depression Scale*). A variabilidade cardíaca fetal será avaliada durante a cardiocografia fetal (CTG) de rotina, por uma obstetra (Dr^a. Cristina Nogueira Silva), que se configura como elo de ligação com o Hospital.

Aos 3-6 dias pós-parto, cada membro do casal irá preencher individualmente *online* um questionário sociodemográfico para recolher informação sociodemográfica, obstétrica, fetal e neonatal, e uma escala para avaliar os sintomas de depressão (*Edinburgh Postnatal Depression Scale*); . O tónus e a reatividade vagal do bebé serão medidos durante o exame de Guthrie (EG). O tónus vagal do bebé será medido nos 5 minutos anteriores ao início do EG e a reatividade vagal do bebé será medida durante todo o procedimento através do VU-AMS5fs (*Ambulatory Monitoring System*). A reatividade comportamental do bebé será avaliada através do choro durante todo o procedimento, pelo investigador. Aos 3 meses pós-parto, os casais serão visitados em casa e observados durante uma interação triádica estruturada (mãe-pai-bebé) que será filmada e cotada para avaliar a coparentalidade. Serão codificadas as seguintes dimensões numa escala tipo *Likert* de 5 pontos: aprovação, carinho, cooperação, desaprovação e competição. Os vídeos serão eliminados após a sua cotação.

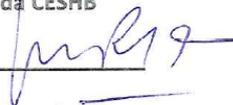
Cada membro do casal irá preencher individualmente um questionário sociodemográfico e uma escala para avaliar os sintomas de depressão (*Edinburgh Postnatal Depression Scale*). Aos 6 meses pós-parto, cada membro do casal irá preencher individualmente *online* um questionário sociodemográfico, uma escala para avaliar os sintomas de depressão (*Edinburgh Postnatal Depression Scale*), e medidas para avaliar a latência e o período mais longo do sono (*Infant Sleep Chronogram*), e a regulação do temperamento do bebé (*Infant Behavior Questionnaire – Revised*).

Neste contexto, e atendendo ao constrangimento causado pela presença reiterada de um elemento externo à tríade numa fase tão delicada na vida de uma família (ainda que com o consentimento do casal), reitera-se a necessidade de um particular cuidado por parte do investigador na abordagem e acompanhamento das famílias participantes no estudo;

- c) O protocolo é adequado estando os planos de divulgação dos resultados do estudo implícitos ao Doutoramento em Psicologia Aplicada da Escola de Psicologia da Universidade do Minho;
- d) O investigador principal e a orientadora possuem aptidão para a realização do estudo;
- e) Existem condições materiais e humanas necessárias à realização do estudo clínico;
- f) O estudo será aparentemente financiado pela Fundação para a Ciência e Tecnologia no âmbito do Projeto de Doutoramento do investigador principal;
- g) A população alvo serão casais heterossexuais primíparos e respetivos bebés, seguidos no Hospital de Braga (3º trimestre de gravidez), sendo que se prevê que a amostra inclua cerca de 150 participantes, excluindo-se indivíduos não capazes de ler / escrever português, multiparidade, gestações múltiplas, gravidez com problemas obstétricos, pais divorciados e recém nascidos prematuros.
- h) Não foram referidas situações de conflito de interesses;
- i) Não haverá acompanhamento clínico dos participantes para além dos 6 meses pós-parto;
- j) Existe um adequado procedimento de obtenção de consentimento informado, incluindo as informações a prestar aos participantes. Existe o compromisso de que os dados recolhidos serão tratados de forma anónima, e que será garantida a sua confidencialidade ao longo de todo o processo.

Concluindo, o estudo cumpre as normas da Bioética e nada há a opor à sua realização.

O Presidente da CESHB



(Dr. Juan Garcia)