Exposure to parents’ negative emotions in early life as a developmental pathway in the intergenerational transmission of depression and anxiety

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Exposure to Parents’ Negative Emotions in Early Life as a Developmental Pathway in the Intergenerational Transmission of Depression and Anxiety

INVITATION

Invitation to attend the Public Defense of The Thesis

Exposure to Parents’ Negative Emotions in Early Life as a Developmental Pathway in the Intergenerational Transmission of Depression and Anxiety

On Wednesday, 3rd of February at 12:00
At Agnietenkapel, Oudezijds Voorburgwal 229-231 Amsterdam
Followed by the reception

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voor het bijwonen van de openbare verdediging van het proefschrift

Exposure to Parents' Negative Emotions in Early Life as a Developmental Pathway in the Intergenerational Transmission of Depression and Anxiety

op woensdag 3 februari
om 12:00
in de Agnietenkapel,
Oudezijds Voorburgwal 229-231
Amsterdam
Receptie na afloop

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Evin Aktar
Exposure to Parents’ Negative Emotions in Early Life as a Developmental Pathway in 
the Intergenerational Transmission of Depression and Anxiety

ACADEMISCH PROEFSCHRIFT

ter verkrijging van de graad van doctor
aan de Universiteit van Amsterdam
op gezag van de Rector Magnificus
Prof. dr. D.C. van den Boom
ten overstaan van een door het College voor Promoties ingestelde 
commissie, in het openbaar te verdedigen in de Agnietenkapel
op woensdag 3 februari 2016, te 12:00 uur

door
Evin Aktar
geboren te Istanbul, Turkije
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Faculteit der Maatschappij-en Gedragswetenschappen
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GENERAL INTRODUCTION
The evidence on the effects of early adversity in maltreated children has been bitter illustrations of how the effects of early experiences can extend to later functioning and constitute vulnerability for the development of psychopathology (Cicchetti & Toth, 1995; Cicchetti & Toth, 2005). The focus of this dissertation is on less severe, but more prevalent forms of deviations in infants’ early socio-emotional environment: depression and anxiety in parents. The main goal of the thesis is to investigate how exposure to clinical and non-clinical forms of parental depression and anxiety in the early years of life may affect infants’ socio-emotional development.

Depression and anxiety disorders are among the most prevalent psychopathology in childhood (Kashani & Orvaschel, 1990) and adulthood (Bijl, Ravelli, & Van Zessen, 1998; Kessler, Chiu, Demler, & Walters, 2005). Depression and anxiety aggregate in families: the presence of a diagnosed parent is linked to two-to-six-fold increase in the risk of depression and anxiety disorders in the offspring (Beardslee, Gladstone, & O’Connor, 2011; Beidel & Turner, 1997; England & Sim, 2009; Hettema, Neale & Kendler, 2001). Along with the inherited biological/genetic dispositions, environmental exposure to parents’ anxious and depressed behavior in daily interactions contributes to the intergenerational transmission of depression and anxiety (Goodman & Gotlib, 1999; Murray, Creswell & Cooper, 2009). The current dissertation focuses on exposure to parents’ negative emotions as a developmental pathway in the intergenerational transmission of depression and anxiety.

Vulnerabilities that co-occur on the side of the parents and of the offspring make the early years of life a key developmental phase in the investigation of exposure effects within the context of intergenerational transmission of depression and anxiety. Becoming a parent is a major developmental transition that requires reorganization and reconstruction of parents’ life around the needs of the new member of the family (Selder, 1989). Due to the new demands and responsibilities, the early years of parenthood may be experienced as an overwhelming and stressful time (Nyström, & Öhrling, 2004). This explains why this is a vulnerable period for the development, maintenance or relapse of depression and anxiety disorders in parents (O’Hara & Swain; 1996; Matthey, Barnett, Howie, & Kavanagh, 2003; Ross & McLean, 2006). In turn, the rapid rate of experience-dependent development in the infant brain explains why the impact of early environmental adversity, including exposure to depressed and/or anxious moods of parents, would be most pronounced on the offspring’s adaptation in the early years of life (Goodman & Gotlib, 1999; Heim & Nemeroff, 1999; Kaufman, Plotsky, Nemeroff, & Charney, 2000; Leppänen, 2011; Leppänen & Nelson, 2009). The current dissertation focuses on the early years of life to investigate exposure effects in the intergenerational transmission of depression and anxiety.
Parents’ expressions of emotion constitute the basis for infants’ expression and regulation of emotion in early parent-infant interactions, while the specific function of parents’ emotional expressions seem to change from dyadic parent-infant interactions in the first half-year to triadic parent-infant-object interactions in the second half-year. Parents’ expressions of positive affect serve as a ‘frame’ for infants’ expression and regulation of affect in early dyadic parent-infant interactions (Als, Tronick, & Brazelton, 1979; Cohn & Tronick, 1987; Tronick, 1989). Infants learn to initiate and reciprocate positive affect by tuning to parents’ expressions of positive affect. In turn, parents’ emotional expressions and reactions serve as safety/threat signals in the face of novel/ambiguous stimuli in triadic parent-infant-object interactions (so-called social referencing, Feinman, 1982). In contrast to previous evidence that predominantly focused on the effects of mothers’ psychopathology in early development, the current dissertation addresses infants’ early exposure to emotional expressions both from mothers and fathers as the most prominent and influential figures in infants’ environment.

Infants’ temperament, defined by withdrawn, fearful, or distressed responses to ambiguous/novel stimuli (Fox, Henderson, Marshall, Nichols, & Ghera, 2005) constitutes a biologically determined source of individual differences in infants’ emotional expressions, reactivity and arousal in early interactions. Negative temperamental dispositions are more common in the offspring of parents with (vs. without) depression and anxiety, and depression and anxiety are more common among children with (vs. without) negative temperamental dispositions (Biederman, Rosenbaum, Chaloff, & Kagan, 1995; Bruder-Costello et al., 2007; Rosenbaum et al., 1993). Moreover, temperamental dispositions are considered to constitute vulnerability for the effects of adverse rearing environments on later outcomes (Ingram & Luxton, 2005; Nigg, 2006). This dissertation addresses the effect of infants’ temperamental dispositions as a potential moderator of the link between exposure to parents’ depression and anxiety and infant outcomes.

Three aspects of early socio-emotional development are the focus of the current dissertation. These are infants’ (I) emotional expressions, (II) behavioral and emotional reactions to novelty, and (III) attention to emotional stimuli. These three aspects are relevant to the investigation of the effects of exposure to parents’ depression and anxiety, as increases in negative expressions and reactions (American Psychiatric Association [APA], 2013), and in attention/vigilance to negative emotion characterizes childhood and adulthood forms of depression and anxiety disorders (Leppänen, 2006; Van Bockstaele et al., 2004). The current dissertation addresses depression- and/or anxiety-related alterations in infants’ interactive behavior (emotional expressions and reactions), and in their attention to emotional stimuli as early outcomes that may be potentially linked to later forms of psychopathology.
General introduction

Outline of The Thesis
The central aim of this dissertation is to investigate how exposure to parents’ depression and anxiety, and infants’ temperament are linked to infants’ emotional and behavioral reactions in early interactions with parents, and to their attention to emotional expressions.

First, the links between parents’ and infants’ emotional expressions and behavioral reactions were examined in naturalistic observations of parent-infant and parent-infant-object interactions (Chapter 1, 2, 3, & 4) in infants and parents with vs. without anxiety and/or depression. Next, the links between infants’ attention to emotional stimuli (Chapter 1, 5, & 6) and parents’ depression and anxiety symptoms were examined.

The dissertation starts with a literature review in Chapter 1 on the effects of exposure to parental depression and anxiety in the first postnatal year. The aim of this review was to provide an overview of available evidence on the associations between exposure to parental negative emotions in the first year of life and offspring’s socio-emotional development.

Chapter 2 describes a study investigating the effect of parental depression and anxiety and infants’ negative temperament on parents’ and infants’ expressions of emotions in parent-infant face-to-face interactions. First-born infants ($n=101$) were observed at 4-months of age during naturalistic parent-infant face-to-face interactions with mothers and fathers with and without lifetime depression and/or anxiety diagnoses. Parents’ lifetime depression and anxiety diagnoses and symptoms were assessed prenatally via semi-structured clinical interviews, while infants’ negative temperamental dispositions were investigated when the infants were 4 months old via standardized observational paradigms.

Chapter 3 is an observational study investigating the associations of maternal and paternal anxiety (expressed parental anxiety as well as lifetime anxiety disorders) and of infants’ temperament with 12-month-old infants’ fear and avoidance during encounters with social and nonsocial novel stimuli in a social referencing paradigm. The sample consisted of 122 mothers and fathers (with and without social and/or other types of anxiety) and their infants. Parents’ expressions of anxiety and infants’ fear and avoidance were observed during confrontations with a stranger and a remote-control robot toy. Parents’ lifetime depression and anxiety diagnoses and symptoms were assessed prenatally via semi-structured clinical interviews, while infants’ negative temperamental dispositions were investigated via standardized observational paradigms at 12 months.

Chapter 4 is a follow-up study of the sample investigated in Chapter 3 in toddlerhood (i.e., at 30 months). This study investigated the cross-sectional and longitudinal associations of maternal and paternal anxiety (expressed parental anxiety at 12 and
30 months and lifetime anxiety disorders) and of temperament at 12 months with children’s fear/avoidance at 30 months ($n = 117$). Parents’ expressions of anxiety and infants’ fear/avoidance of novelty were observed during encounters with social and nonsocial novel stimuli (i.e., a stranger and a remote-control robot toy) at 30 months in a social referencing paradigm.

Chapter 5 describes a study investigating the associations of infants’ sad and fearful temperament and of parents’ depression and anxiety with 13-to-16-month old infants’ attention allocation to facial expressions of emotion in typical development. Infants’ ($n = 57$) attention was measured during the presentation of fearful, sad, angry, and happy (vs. neutral) facial expressions with an eye-tracker. The duration of infants’ fixations to positive and negative facial expressions was used as a behavioral index of infants’ attention, while infants’ pupil responses to positive and negative expressions were used as a physiological index of attention and arousal in this study. Information on parents’ negative affect, depression and anxiety, and infants’ temperament was obtained via questionnaires filled in by both parents.

Chapter 6 is a study investigating the associations of infants’ sad and fearful temperament and of parents’ negative affect, depression and anxiety with 14-to-17-month old infants’ attention to unfamiliar objects paired with positive and negative (vs. neutral) facial expressions. Infants’ pupil responses ($n = 57$) were measured with an eye tracker during the presentation of unfamiliar objects alone, before and after being paired with sad, fearful, and happy (vs. neutral) expressions heading/gazing towards (vs. away) from the object. Negative affect, depression and anxiety in parents, sad and fearful temperament in infants were measured via questionnaires filled in by both parents.

The dissertation ends with a discussion and integration of the research findings from the Chapters 1 through 6, followed by limitations, future directions and clinical implications.
CHAPTER 1

Exposure to parents’ negative emotions as a developmental pathway in the family aggregation of depression and anxiety in the first year of life

Evin Aktar
Susan M. Bögels

This chapter is based on Aktar, E., & Bögels, S. M. (in preparation). Exposure to parents’ negative emotions as a developmental pathway in the family aggregation of depression and anxiety in the first year of life. *Clinical Child and Family Psychology Review.*
ABSTRACT

Background: Depression and anxiety run in families. A developmental psychopathology perspective highlights the diversity in developmental pathways that lead to parent-to-child transmission of depression and anxiety. The current study aims to consolidate the developmental psychopathology perspective by providing a review on the effects of exposure to parents’ depression and anxiety in the first year as an early developmental pathway in the intergenerational transmission. We address the continuity between normative and maladaptive development by addressing exposure effects in typically developing infants and in infants of depressed and/or anxious parents. Methods: To discuss how exposure to parents’ negative emotions may alter infants’ socio-emotional development and contribute to the family aggregation of depression and/or anxiety, we focus on infants’ expressions of emotion, and reactions to novelty in their early interactions with parents, and on their attention to others’ expressions of emotion as early markers of psychopathology. We first review the evidence on the associations between infants’ and parents’ emotional expressions in dyadic parent-infant interactions, and between infants’ and parents’ reactions to novelty in triadic parent-infant-object interactions. Next, we review evidence on the associations between infants’ exposure to parents’ emotional expressions, and attention to others’ emotional facial expressions in dyadic person-infant and triadic person-infant-object contexts. Results: Infants’ emotional expressions and behavioral reactions to novelty echo parents’ expressions and reactions in dyadic and triadic interactions. Moreover, infants exposed to high levels of negative emotions from the parent seem to attend less to negative emotions in others’ facial expressions. The associations hold across community and clinically depressed and/or anxious parent samples, and with mothers and fathers. Conclusions: Early exposure to parental depression and anxiety is linked to alterations in infants’ socio-emotional development, and may be related to later psychological outcomes in infants of parents with depression and anxiety.
INTRODUCTION
Depression and anxiety disorders are among the most prevalent psychopathology in children (Kashani & Orvaschel, 1990) and adults (Bijl, Ravelli, & Van Zessen; 1998; Jacobi et al., 2004; Kessler, Chiu, Demler, & Walters, 2005). Anxiety and depression aggregate in families, thus parents' depression and anxiety disorders constitute risk for the development of depression and anxiety in the offspring (Beardslee, Gladstone, & O'Connor, 2011; Beidel & Turner, 1997; Goodman & Gotlib, 1999; Turner, Beidel, & Costello, 1987). Infants born to depressed or anxious parents not only inherit a significant genetic vulnerability (Hettema, Neale, & Kendler, 2001; Tsuang & Faraone, 1990) that predisposes them to depression and anxiety but they also grow in socio-emotional environments marked by alterations in exposure to parents' emotional expressions during daily interactions (Goodman & Gotlib, 1999; Murray, Creswell, & Cooper, 2009). Despite the significant family loading, and the associated risk for the development of psychopathology in the offspring, some of children with depressed/anxious parents never develop depression/anxiety, and for those who do, there is a high variability in the outcomes. A developmental psychopathology (DP) perspective on the intergenerational transmission of depression and anxiety embraces the diversity in the developmental pathways that lead to parent-to-offspring transmission of depression and anxiety (Cicchetti & Toth, 1998; Vasey & Dadds, 2001). Differently from previous work that aimed to address the diversity of the developmental pathways that may contribute to the intergenerational transmission of depression and anxiety (Creswell & Waite, 2015; Goodman & Gotlib, 1999; Murray et al., 2009), the current review aims to consolidate the developmental psychopathology perspective by specifically focusing on exposure to parents' negative emotions as an early developmental pathway in the intergenerational transmission of depression and anxiety. We attempt to answer the question of how exposure to parental negative emotions in the first year of life may alter offspring's socio-emotional development in infancy and be related to subsequent psychopathology.

From a developmental psychopathology perspective, both adaptation and maladaptation arise from complex and dynamic transactions across psychological, biological, and social mechanisms that operate both at the intrapersonal, and the interpersonal levels (Cicchetti & Dawson, 2002; Rutter & Sroufe, 2000; Sroufe 1990; Sroufe & Rutter, 1984). The biological mechanisms that received attention in the context of intergenerational transmission include inherited genetic dispositions for depression and anxiety, and innate dysfunction in early neuro-regulatory systems in the offspring of depressed and anxious parents (Goodman & Gotlib, 1999). Environmental mechanisms include other stressors and difficulties in family and couple functioning that relate to parents' psychopathology, together with exposure to parents' negative affect, cognition and behavior. It is therefore important to keep in mind that exposure effects that constitute the main scope of the current
Chapter 1

review are only one among many developmental pathways that contribute to the development of depression and anxiety. Isolated consideration of exposure effects can therefore not be sufficient to explain the variation in the outcomes, or emergence of psychopathology in the offspring of depressed and anxious parents. Instead, a better understanding of the intergenerational transmission of depression and anxiety requires the consideration of how multiple transactions between infants’ exposure to parental depression and anxiety and other characteristics of the parents and the infant, and of the early parent-infant environment dynamically determine the range of outcomes in the offspring (Goodman & Gotlib, 1999; Murray et al., 2009).

The developmental models of parent-to-child transmission of depression (Goodman & Gotlib, 1999) and anxiety (Murray et al., 2009) propose that children’s repeated exposure to parents’ depressed and anxious moods is a potential mechanism that contribute to risk for the development of psychopathology. Goodman and Gotlib (1999) suggested five inter-related components in the exposure effects in the intergenerational transmission of maternal depression. We suggest that these components can be extended to anxiety disorders and to fathers. First, depression and anxiety in parents are defined by heightened duration, frequency and intensity of negative emotions, moods and behaviors (see American Psychiatric Association [APA], 2013). Depressed parents experience increased levels of flat and negative affect (sadness, irritability, anger, and guilt) in their interactions in everyday life. Anxious parents experience and express excessive fear, anxiety and worry that may remain specific to certain situations (e.g., in the case of social anxiety and specific phobias), or generalize across situations (in the case of generalized anxiety disorder). Second, due to their negative behaviors and moods, depressed and anxious parents are less than optimal social partners, and they may not be able to provide the optimal interpersonal environment for children’s emotional and social development. Third, the lack of an optimal interpersonal environment will adversely affect children’s emotional and social development. Fourth, as a result of these adverse effects, children will acquire negative behaviors and moods that look similar to negative behaviors and moods of depressed parents. Finally, acquisition of these negative behaviors and moods will put infants at risk for the development of anxiety and depression. In their review, Goodman & Gotlib (1999) provide an overview of evidence supporting these components in children, and highlight the importance of considering the specific characteristics of the developmental stages at which exposure effects take place in childhood. The current review aims to address the role of exposure to parental negative emotions on infants’ early socio-emotional development and functioning in depth as a developmental pathway underlying the intergenerational transmission of depression and anxiety in the first postnatal year.
Parents’ negative emotions and infants’ socio-emotional development

Why is it important to specifically focus on the early years of life to discuss exposure as a developmental mechanism? High prevalence of depression and anxiety disorders in the postnatal period reveals that early years of parenthood may be a vulnerable period for the development, maintenance or relapse of depression and anxiety in parents (Matthey, Barnett, Howie, & Kavanagh, 2003; O’Hara & Swain, 1996; Ross & McLean, 2006). On the other hand, the rapid experience-dependent development of emotional brain systems in the first year of life seems to make infants particularly vulnerable to the effects of exposure to parental depression and anxiety (Leppänen, 2011; Leppänen & Nelson, 2009). Goodman and Gotlib (1999) suggest that the time of exposure to parents’ depression and anxiety determines the strength of the associations on child outcomes, with early years of life constituting the most vulnerable period in development. Exposure to emotional expressions most often takes place within the immediate family environment with parents in early years. Findings from exposure effects in the non-emotional aspects of face processing in typically developing infants illustrate the important role that extensive exposure to primary caregivers’ faces may have on shaping infants’ attention (Slater et al., 2010). For example, as a result of exposure to mothers’ faces, infants who are cared for by mothers show enhanced attention to mothers’ (vs. stranger) neutral faces (3-to-6 months, De Haan & Nelson, 1997; De Haan & Nelson, 1999; Montague & Walker-Andrews, 2002). Moreover, infants’ exposure to mothers’ faces seems to shape their attention to strangers’ faces. For example, 3-month-old infants look longer to stranger faces if the gender of the stranger matches the gender of their primary caregiver (Quinn & Slater, 2003; Quinn, Yahr, Kuhn, Slater, & Pascalis, 2002). Thus, exposure to parents’ faces seems to tune infants’ attention towards caregiving parents’ faces, and towards strangers that look like parents, ensuring enhanced processing of the most relevant and most frequently encountered stimuli in the environment. Leppänen and colleagues suggest that exposure to parents’ expressions of emotion during daily parent-infant interactions plays an essential role in the neural fine-tuning of infants’ attention to emotional stimuli in typical development in early years (Leppänen, 2011; Leppänen & Nelson, 2009). They therefore predict that the influence of an atypical emotional environment provided by depressed and/or anxious parents in the early years would be especially detrimental for later development of emotion processing abilities (Leppänen, 2011, p. 185).

Evidence on the effects of parental depression and anxiety in the postnatal year on later psychopathology in childhood and beyond has only started to accumulate in the last decades. Although research in this area is limited by a number of issues (such as reliance on mothers’ report of infants’ functioning, and lack of control for prenatal or concurrent depression), it provides preliminary support for the idea that parents’ depression and anxiety may have prolonged effects on offsprings’ functioning and psychopathology. For example, longitudinal positive associations have been found...
Chapter 1

between mothers' depressive symptoms in the first year and child behavioral and/or emotional problems at 2 (Avan, Richter, Ramchandani, Norris, & Stein, 2010), and 5 (Murray, Sinclair, Cooper, Ducournau, & Turner, 1999) years of age. Evidence also demonstrates a significant overall increase in the risk of psychopathology at the age of 11 in children of postnatally depressed mothers (Pawlby, Sharp, Hay, & O'Keane, 2008), as well as a more specific increase in depression and anxiety diagnoses at the age of 13 (Halligan, Murray, Martins, & Cooper, 2007) and 16 (Murray et al., 2011). More recent research sheds light on the effects of fathers' depression. Similar to maternal depression, paternal depression is linked to an increase in behavioral and emotional problems in later childhood (Ramchandani et al., 2008; Ramchandani & Psychogiou, 2009). Moreover, there is also some evidence suggesting that paternal depression may have effects on child outcomes that are specific and independent of mothers' depression (Ramchandani, Stein, Evans, & O'Connor, 2005). The available evidence on effects of postnatal maternal anxiety reveals similar links to negative psychological outcomes in childhood (Glasheen, Richardson, & Fabio, 2010) and adolescence (Glasheen et al., 2013), while the effects of exposure to paternal anxiety on later child outcomes remain to be investigated. Despite the preliminary evidence on a longitudinal link between parents' depression and anxiety in the postnatal year and offsprings' later functioning and psychopathology, we know little about how specific developmental pathways contribute to the emergence of psychopathology in the offspring at specific stages of development. For the time being, it is difficult to delineate the separate and joint contributions of the diverse developmental pathways -including exposure to parental negative emotions and other genetic and environmental factors- to maladaptive child outcomes.

From a developmental psychopathology perspective, failures of adaptation in certain developmental processes precede the emergence of psychopathology, and serve as early markers that are probabilistically linked to the development and course of psychopathology (Sroufe, 1990). In our current discussion on the early effects of exposure to parental depression and anxiety, we focus on three aspects of infants' socio-emotional development as developmental processes that may potentially serve as early markers of psychopathology in preverbal infants. These are infants' expressions of emotion, emotional and behavioral reactions in their early interactions with parents and their attention to facial expressions of emotion. Infants' early interactions with parents, and their attention to emotional stimuli are not only important indices of preverbal infants' socio-emotional functioning, but they also correspond to the core aspects of dysfunction in depression and anxiety. Depression and anxiety disorders by definition imply alterations in emotional expressions, and emotional and behavioral reactions in daily interactions of affected individuals (APA, 2013). Infants' emotional expressions, and emotional and behavioral reactions in early interactions with parents are an important early outcome that may improve
Parents' negative emotions and infants' socio-emotional development

our understanding of early effects of exposure on infants' adaptation. Attention to emotional stimuli is another important aspect of early socio-emotional functioning with potential links to the later attention biases characterizing depression and anxiety. Information processing in depression and anxiety is marked by enhanced attention/vigilance to negative emotions in children and adults (Leppänen, 2006; Van Bockstaele et al., 2014). Attention biases have been assigned an important role in cognitive theories on the development and maintenance of depression and anxiety disorders (e.g., Beck & Clark, 1988; Beck & Perkins, 2001). Behavioral and physiological indices of infants' attention allocation may therefore constitute an important early outcome in preverbal infants that may be useful in detecting early effects of exposure and risk for later psychopathology.

There are two milestones in infants' socio-emotional development in the first year of life that are important to consider for a discussion on the effects of exposure to parental negative emotions (Striano & Reid, 2006). The first milestone is the onset of dyadic parent-infant face-to-face interactions following the emergence of infants' social smile and gaze following abilities (D’Entremont, Hains, & Muir, 1997; Messinger & Fogel, 2007). Mothers' positive affect and contingent responding to infants' expressions of emotion in these early face-to-face interactions are essential for infants' expression and regulation of emotions in the interpersonal domain (Als, Tronick, & Brazelton, 1979; Cohn & Tronick, 1987; Tronick, 1989). The second milestone is the onset of triadic parent-infant-object interactions where the parent and infant communicate affective states regarding an external object, person, situation or event in the environment (i.e., joint attention in the second half of the first year; Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998). Between 10 and 14 months, infants start to actively use adults' -most frequently parents'- emotional signals to regulate their behavioral reactions to ambiguous/novel aspects of the environment (so called social referencing [SR]; Feinman, 1982; Feinman, Roberts, Hsieh, Sawyer, & Swanson, 1992). Parents' emotional expression in dyadic parent-infant interactions and triadic parent-infant-object interactions are important in the current discussion as they serve as a basis for infants' expression and regulation of emotions.

Infants show a negativity bias in SR situations, that is, they change their reactions more strongly when the referee expresses negative as compared to positive emotions (for a review see Vaish, Grossmann, & Woodward, 2008). A negativity bias also emerges in infants' attention to emotional facial expressions in the second half of the first year. Studies investigating behavioral and physiological correlates of infants' attention to emotional expressions consistently reveal a negativity bias in 7-month-old infants' attention to emotional expressions (e.g., De Haan, Belsky, Reid, Volein, & Johnson, 2004; Geangu, Hauf, Bhardwaj, & Bentz, 2011; Hoehl, Palumbo, Heinisch, & Striano, 2008; Kotsoni, De Haan, & Johnson, 2001; Peltola, Hietanen, Forssman, & Leppänen, 2013). Infants’ enhanced processing of negative emotional expressions is functional
in this period as it increases the survival chances of crawling/walking infants who may come across potential dangers while exploring the distant environment (Bertenthal & Campos, 1990; Boyer & Bergstrom, 2011; Campos et al., 2000; Leppänen, 2011). However, repeated exposure and enhanced attention to depressed and/or anxious parents’ negative emotions may at the same time influence emerging negativity bias (Vaish et al., 2008), and constitute risk for parent-to-infant transmission of negative emotions in this period. Vaish et al. (2008) suggested that early exposure to positive facial expressions in the first year may be necessary to skew the distribution of infants’ exposure to faces towards the positive end to ensure that negative faces are perceived as more novel and more salient in the second half of the first year, where infants shift their attention from positive to negative expressions. Thus, changes in exposure to parents’ positive and negative affect in the first year may influence the distribution of infants’ overall exposure to positive and negative emotions, and later negativity bias in infants’ attention and behavior.

The current discussion incorporates child temperamental dispositions in the discussion of early exposure effects to parental anxiety and depression. Child temperamental predispositions constitute a biologically determined source of individual variation in infants’ emotional reactivity, expressions and arousal. Infants with a negative temperamental predisposition (also referred to as negative reactivity in infancy or behavioral inhibition [BI] from toddlerhood onwards) are more likely to react to change or novelty in the environment with fearful, withdrawn, shy and avoidant responses than infants without such a predisposition (Fox, Henderson, Marshall, Nichols, & Ghera, 2005; Kagan & Snidman, 1999; Rothbart, 2007). Children of depressed and anxious parents are more likely to be behaviorally inhibited than children of reference parents, and behaviorally inhibited children are more likely to develop depression and anxiety (Biederman, Rosenbaum, Chaloff, & Kagan, 1995; Bruder-Costello et al., 2007; Rosenbaum et al., 1993). Furthermore, infants’ temperamental characteristics may determine the impact of early environmental adversity on current and later outcomes. Diathesis-stress (Zuckerman, 1999) and vulnerability-stress (Ingram & Luxton, 2005; Nigg, 2006) models suggest that negative temperamental traits may constitute a predisposition to the effects of environmental adversity. A recent extension of these models, i.e., the “differential susceptibility to environmental influences hypothesis” (Belsky, Bakermans-Kranenborg, & Van Ijzendoorn, 2007; Belsky & Pluess, 2009) suggests that highly inhibited children are not only more susceptible to adversity, but they also benefit more from adaptive rearing environments. Thus behavioral inhibition would make them more open to the effects of the environment “for better and for worse”. These models predict that infants with negative temperamental dispositions may be more vulnerable to the effects of exposure to depression and anxiety from parents, while differential susceptibility to environmental influences hypothesis additionally stresses the buffering role of an adaptive rearing environment for infants at risk for psychopathology.
Our discussion on exposure effects focuses on the evidence on infants’ exposure to emotional expressions from mothers and fathers as the most commonly exposed figures in infants’ environment. In line with a developmental psychopathology perspective, current discussion on the effects of exposure encompasses the expression of negative emotions in clinically depressed and/or anxious, and non-clinical parent samples to address the continuity between normative development and deviations from it. In line with the multi-component model of exposure effects by Goodman and Gotlib (1999), we review evidence on the depression- and anxiety-related alterations in parents’ expressions of negative emotion in early parent-infant interactions, together with links of these alterations to infants’ emotional expressions, emotional and behavioral reactions, and attention to others’ emotional expressions. In the first section, we review evidence on the links between infants’ exposure to parents’ facial expressions of emotion, and infants’ facial expressions of emotion during their face-to-face interactions with their parents. In the second section, we review the evidence on the links between exposure to parental emotional expressions in triadic parent-infant-object interactions and infants’ emotional and behavioral reactions to novel stimuli (e.g., objects or a stranger). In the third section, we review evidence on the associations between infants’ overall exposure to parents’ emotional facial expressions and infants’ attention to others’ emotional facial expressions in dyadic person-infant and triadic person-infant-object contexts. The review finishes with a discussion on potential links between exposure to parental depression and/or anxiety in the first postnatal year and later psychopathology in the offspring, followed by a discussion of mechanisms, future directions and clinical implications.

EXPOSURE TO PARENTS’ FACIAL EXPRESSIONS, AND INFANTS’ FACIAL EXPRESSIONS IN DYADIC PARENT-INFANT INTERACTIONS

Typically Developing Infants

Observations of mother-infant face-to-face interactions reveal that mothers’ facial expressions are predominantly positive, and rarely negative in face-to-face interactions (e.g., Kaye & Fogel, 1980; Malatesta & Haviland, 1982). Available evidence on fathers’ expressions of affect, and on infants’ facial expressions with fathers revealed that mothers are more positive than fathers, and that infants are more positive with their mother than with their father dyadic parent-infant face-to-face interactions (Belsky, Gilstrap, & Rovine, 1984; Forbes, Cohn, Allen, & Lewinsohn, 2004). One study reported similar positive associations between infants’ and mothers’, and infants’ and fathers’ positive affect at 6 months. This finding shows that the differences in infants’ expressions of positive affect in the interactions with mother (vs. father) can be accounted for by higher levels of exposure to positive affect from mothers, rather than qualitative differences related to parents’ gender (Forbes et al., 2004). Thus, it seems that infants’ expressions of positive affect in dyadic face-to-face interactions
get tuned to the moment-to-moment differences in mothers’ and fathers’ interactive styles. In line with this, experimental manipulations of naturalistic face-to-face situations where parents are asked to switch to a depressive interactive style by maintaining a neutral facial expression for a few minutes (i.e., still-face; Tronick, Als, Adamson, Wise, & Brazelton, 1978) before switching back to regular interactions, reveal that infants experience stress, and decrease positive affect in response to such decreases in mothers’ and fathers’ positive affect expressions (Braungart-Rieker, Garwood, Powers, & Notaro, 1998).

Infants of Depressed and Anxious Parents
The evidence from observational studies investigating depressed parents’ expressions of emotions in dyadic face-to-face situations reveals that maternal depression interferes with mothers’ expressions of positive affect to their infant, and is associated with an increase in flat and negative facial expressions (Beck, 1995; Murray, Haligan, & Cooper; 2010; Stanley, Murray, & Stein, 2004). Like their depressed mothers who are overall less positive and more negative in their affect than non-depressed mothers, infants of mothers with depression express less positive and more negative emotion in dyadic face-to-face interactions with the mother than infants of non-depressed mothers (e.g., Campbell, Cohn, & Meyers, 1995; Cohn, Campbell, Matias, & Hopkins, 1990; Cohn & Tronick, 1987; Field, 1984). Thus, in line with findings from community samples showing significant associations between parents’ and infants’ expressions of positive affect, infants of mothers with depression tune in their mothers’ depressed interactive style by becoming less positive and more negative like their mother in dyadic parent-infant interactions.

To what extent do infants generalize depressed interactive patterns acquired from depressed parents to the other parent or other adults? Findings from two studies on infants’ expressions of positive affect in dyadic interactions with their depressed (vs. non-depressed) mothers vs. non-depressed fathers revealed that infants of depressed mothers are more positive while interacting with their non-depressed fathers than with their depressed mothers. Edhborg, Lundh, Seimyr, and Widström (2003) compared mother-infant and father-infant interactions when children were 15-to-18-months old, in families with mothers with high levels of depressive symptoms (measured at 2-months postpartum). They reported more positive interactions in non-depressed fathers and infants dyads of mothers with post-partum depression. Likewise, Hossain and colleagues (1994) found that 3-to-6-month-old infants of depressed mothers interact better with their non-depressed fathers. Non-depressed fathers also received better interaction ratings than depressed mothers. In contrast, another study by Chabrol, Bron, & Le Camus (1996) observing mother-infant and father-infant face-to-face interactions in families with mothers experiencing moderate levels of depression (vs. without depression) did not find any significant differences between depressed mother-infant and non-depressed father-infant interactions, suggesting that
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Depressed interactive styles may extend to father-infant interactions in some cases. Moreover, in contrast to findings revealing more positivity in dyadic interactions with fathers, another study by Goodman (2008) revealed that mothers' depression in the post-partum period was related to more depression in fathers, and less optimal interactions with their 2-to-3-month-old infants during dyadic interactions (Goodman et al., 2008). Thus mothers' depression may in some cases adversely affect fathers' psychological functioning and interactions with their infant.

One study investigating infants' interactions with other partners reported an increase in positive affect expressions of infants during interactions with their nursery teachers (Pelaez-Nogueras, Field, Cigales, Gonzalez, & Clasky, 1994), who were more positive than depressed mothers during the interaction. In contrast, another study by Field and colleagues (1988) investigating 3-to-6-month-old infants of depressed vs. non-depressed mothers in interaction with their mothers vs. non-depressed female strangers revealed no differences in infants' positive affect, or activity level during their interactions with the strangers (vs. mothers). Note that no significant differences were found also between the positive affect of depressed mothers and non-depressed strangers in this study.

Taken together, it seems that infants show more positive affect in dyadic interactions with other familiar partners such as fathers and teachers. This occurs in the context of fathers and teachers expressing more positive affect than the depressed mother. In this sense, fathers and other familiar figures may compensate for the depression of the mother by giving the child the opportunity to interact in a more positive manner during early face-to-face interactions on a regular basis. However, the results also reveal that fathers who have a partner with depression are themselves more likely to be depressed. Thus, maternal depression may interfere with fathers' ability to compensate for mothers' depression in face-to-face interactions via its positive association with paternal depression. As a result, depressed interaction styles in mother-infant interactions may generalize to father-infant interactions, and to infants' interaction with strangers who are not more positive than depressed mothers during the interaction.

Studies testing reactions to parents' still-face in infants of depressed parents reveal significant alterations in infants' reactions to still-face, while the findings concerning exact direction of the effect are mixed. Similar to the effects reported in typically developing samples, Forbes et al. (2004) reported more negative and less positive affect in infants of parents with (vs. without) depression during both mothers' and fathers' still-face. In contrast, other studies found that infants of mothers with depression respond to the mothers' still-face with more positive and less negative affect, and less stress compared to infants of mothers without depression (Field, 1984; Field et al., 2007; Pelaez-Nogueras, Field, Hossain, & Pickens, 1996). Field explains the results.
based on familiarity: Infants of depressed parents may be relatively more familiar to parents’ still-face and therefore react with less negative affect to parents’ still-face in the lab. In contrast to still-face interactions, no studies investigated whether the effects of parental depression on parents’ and infants’ emotional expressions differ for mothers vs. fathers in naturalistic face-to-face interactions.

Compared to parental depression, we also know less about how parental anxiety disorder affects parents’ and infants’ emotional expressions in early dyadic face-to-face interactions. Moreover, the majority of the available evidence comes from parents with comorbid depression and anxiety. For example, depressed mothers with high trait anxiety were found to be less positive than depressed mothers with low trait anxiety, and infants of depressed mothers with high trait anxiety were less positive and more negative than infants’ of non-depressed mothers (Field et al., 2005). Thus, high trait anxiety may be linked to a further decrease in depressed mothers’ and infants’ expressions of positive affect. There is also some evidence showing a decrease in mothers’ facial, vocal and bodily expressions of positive affect when they have high (vs. low) trait anxiety (independent of their depression) in face-to-face play interactions with their 10 and 14-month-olds (Nicol-Harper, Harvey, & Stein, 2007). Due to high comorbidity of anxiety disorder and depression in studied samples, the available evidence revealing more severe alterations in affect expressions of depressed mother-infant dyads cannot disentangle the distinct influences of parents’ depression and anxiety disorder on emotional expressions. Furthermore, because comorbid anxiety diagnosis is linked to greater symptom severity in depressed individuals (Fava et al., 2004; Lamers et al., 2011), it is unclear whether a more pronounced decrease in mothers’ positive affect is specifically related to high trait anxiety, or to overall greater depression symptom severity. In a sample of anxious mothers with low rates of depression diagnoses, Murray, Cooper, Creswell, Schofield, and Sack (2007) observed mothers with social anxiety disorder (SAD) and generalized anxiety disorder (GAD) and their infants in face-to-face interactions. Mothers with SAD were less positively engaged, and more anxious during their interactions, while the effect of maternal GAD was not significant. Infants of mothers with GAD and SAD did not differ from infants of mothers without anxiety disorder.

To our knowledge, three observational studies investigated the effects of maternal anxiety without comorbid depression on infants’ and parents’ facial expressions of emotion during dyadic face-to-face interactions. In a study investigating the effects of maternal panic disorder without comorbid depression, and maternal depression in a still-face paradigm (a still-face interaction preceded and followed by regular face-to-face interactions), no effects of parental panic disorder nor depression were found on parents’ and 3-month-old infants’ expressions of affect (Weinberg, Beeghly, Olson, & Tronick, 2008). In another study investigating the effects of maternal anxiety disorder without comorbid depression on 6-month-old infants’ facial expressions...
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during dyadic interactions (free play, teaching and caregiving episodes), infants of anxious mothers were not less positive than their peers during the regular face-to-face interactions, and the duration of matched positive affect in the dyads did not differ between healthy and anxious mother-infant dyads (Kaitz, Maytal, Devor, Bergman, & Mankuta, 2010). On the other hand, the findings revealed an overall increase in intensity and frequency of gaze, positive affect, verbalizations and acknowledgements of anxious (vs. reference) mothers, referred to as exaggerated behavior. Similar to the results reported by Field (1984) and by Peláez-Nogueras et al. (1996) in infants of depressed mothers, infants of anxious parents less often reacted with negative affect to mothers’ still-face in this study. This suggests that infants of anxious mothers protest less when the mother stops responding.

Taken together, preliminary evidence from these first observational studies on anxiety disorders without comorbid depression does not support an effect of maternal anxiety disorder on mothers’ and infants’ expressions of affect in naturalistic face-to-face interactions, while infants seem to react less negatively when mothers stop responding in still-face interactions. The effects of paternal anxiety disorder remain to be investigated in parents’ and infants’ emotional expressions during dyadic parent-infant interactions.

Section Summary and Conclusions

Evidence on the effects of exposure to parents’ facial expressions in the first postnatal year in typically developing infants’ expressions of emotion in dyadic parent-infant interactions reveals a direct association between infants’ and parents’ expressions of emotions, highlighting the crucial role that exposure to parental positive emotions play in the regulation of infants’ expressions and communication of affect in their face-to-face interactions (e.g., Cohn & Tronick, 1987; Forbes et al., 2004; Malatesta & Haviland, 1982). Surprisingly, studies focusing on the associations between infants’ and parents’ emotional expressions in early dyadic interactions in community samples did not consider the role of infants’ temperamental predispositions, which are known to explain variance in infants’ expressions of emotion (Izard, Libero, Putnam, & Haynes, 1993). Parallel associations between infants’ and mothers’, and infants’ and fathers’ expressions of positive affect in typical development reveal that infants’ expressions of positive affect adapt to the differences in mothers’ vs. fathers’ moment-to-moment expressions of positive affect in dyadic face-to-face interactions (Forbes et al., 2004). In line with the findings suggesting that parents’ expressions of positive affect in this period have a direct influence on typically developing infants’ expressions of positive affect (Braungart-Rieker et al., 1998; Forbes et al., 2004), infants of mothers with clinical depression seem to copy their depressed mother’s dysphoric interaction style, and become less positive, more flat and more negative in dyadic interactions with their mother (Beck, 1995; Campbell et al., 1995; Cohn et al., 1990; Murray et al., 2010; Stanley et al., 2004). In turn, the effect of fathers’ depression on fathers’
and infants’ facial expressions remains to be addressed in future studies. Available evidence comparing mother-infant and father-infant face-to-face interactions in families where the mother is depressed reveals that infants are more positive in their interactions with fathers, and with familiar figures when the partner expresses more positive affect than the depressed mother. The fathers, and other familiar figures may thus compensate for mothers’ depression in face-to-face interactions (Edhborg et al., 2003; Hossain et al., 1994; Peláez-Nogueras et al., 1994) and provide the infant with a more positive early interactive environment. However, findings also reveal that due to its positive association with paternal depression, maternal depression may in some cases interfere with father-infant interactions and fathers’ ability to compensate for mothers’ depression in face-to-face interactions (Chabrol et al., 1996; Goodman, 2008).

The available evidence on the affect expressions of parents with depression suggests that the alterations in parents’ positive affect expressions in early dyadic interactions are more pronounced in the case of comorbid anxiety disorders (Field et al., 2005), while the findings from mothers with anxiety disorders and without comorbid depression suggest that anxiety disorders alone do not alter parents’ and infants’ expressions of positive affect in everyday face-to-face interactions, even in the case of generalized anxiety disorder (Kaitz et al., 2010; Murray et al., 2007; Weinberg et al., 2008). Thus, the increase in the expressions of negative emotions in the case of maternal anxiety disorders may not be visible in everyday dyadic parent-infant interactions, and be rather specific to certain anxiety-provoking objects/events/persons in triadic parent-infant-object interactions (like being videotaped in interaction with a stranger in the case of maternal SAD, Murray et al., 2007; 2008). To our knowledge, no studies investigated how paternal anxiety alters fathers’ expressions of affect, and infants’ expressions of affect with fathers in early face-to-face interactions.

**EXPOSURE TO PARENTS’ EMOTIONAL EXPRESSIONS, AND INFANTS’ REACTIONS TO NOVELTY IN TRIADIC PARENT-INFANT-OBJECT INTERACTIONS**

**Typically Developing Infants**

The effects of mothers’ positive and negative emotional expressions on infants’ behavioral and emotional reactivity have been extensively studied in social referencing (SR) situations where infants are confronted with strangers, unfamiliar toys and visual cliff situations at the end of the first year (see Feinman et al., 1992 for a review). Findings from these observational studies provide support for a direct influence of parents’ expressions of negative emotions at the end of the first year on infants’ affect and behavior: Infants interact with novel stimuli less, and manifest more negative affect (i.e., fear) and more avoidance when the referee expresses negative (vs. positive) emotions to these stimuli.
Two studies investigated the effect of parents’ anxious signals in SR situations on infants’ behavior in typically developing infants to understand early mechanisms fear learning from anxious parents in infancy. De Rosnay, Cooper, Tsagaras, and Murray (2006) investigated the effects of mothers’ expressions of anxiety towards a stranger on infants’ stranger anxiety. Parents without anxiety disorders were trained to behave in socially anxious ways in a stranger SR paradigm. In this paradigm, a stranger first engages the parent in a conversation about parenthood while the infant is watching the interaction. At the end of the parent-stranger interaction, the stranger makes a gradual approach towards the infant, and picks him/her up from the high chair. Findings from this study revealed that expressions of maternal anxiety towards the stranger can trigger infants’ avoidance of the stranger. This effect was moderated by infants’ fearful temperament, that is, the link between maternal negative reactions and infants’ avoidance of the stranger was stronger for infants with high levels of fearful temperament (De Rosnay et al., 2006). The second observational study investigated the associations of mothers’ and fathers’ expressions of anxiety and infants’ fear and avoidance in the visual cliff (Möller, Majdandžić, & Bögels, 2014). In the visual cliff paradigm, infants are placed on the shallow end of the cliff, and are encouraged to crawl towards their parent who stands at the deep end of the cliff (Sorce, Emde, Campos, & Klinnert, 1985). Möller and colleagues (2014) found that fathers’, but not mothers’ anxious signals predict temperamentally fearful infants’ avoidance of the visual cliff. Taken together, findings from both studies reveal an interplay between parents’ expressions of anxiety and infants’ fearful temperament in SR situations. In line with diathesis-stress (Zuckerman, 1999) and vulnerability-stress (Ingram & Luxton, 2005; Nigg, 2006) models, the findings show that temperamentally fearful infants are more vulnerable to the expressions of parents’ anxiety in SR contexts.

Regarding effects of mothers’ vs. fathers’ emotional signals in SR situations, an earlier study did not find a significant difference on infants’ reactions to novel toys with mothers and fathers (Hirshberg & Svejda, 1990), while the findings of Möller et al. (2014) suggest that fathers’ but not mothers’ expression of anxiety predict avoidance of the cliff. This discrepancy in the findings may possibly be related to the testing of SR processes in situations that involve qualitatively different types of threat (i.e., falling vs. being harmed by an ambiguous object or by a stranger). Nevertheless, findings from both studies suggest that both parents’ emotional expressions in SR situations is directly linked to infants’ reactions towards novel/ambiguous aspects of the environment.

Infants of Depressed and Anxious Parents

Probably due to the specific relevance of SR situations for infants’ fear acquisition, SR studies in clinical samples have focused on the effects of anxious parents’ expressions of fear and anxiety, rather than the effect of depressed parents’ dysphoric style during triadic parent-infant-object interactions. Although the associations between parents’
emotional signals and infants’ reaction to novelty have not been investigated in the context of SR, an earlier study investigating infants’ object exploration and emotional expressions reported that daughters (but not sons) of depressed (vs. non-depressed) parents express less positive and more negative affect than infants of non-depressed mothers in triadic parent-infant-object interactions (Hart, Field, Del Valle, & Peláez-Nogueras, 1998). Moreover, infants of depressed mothers were less likely to explore the toy objects. The findings from this earlier study reveal that maternal depression may affect parents’ and infants’ facial expressions similarly in dyadic parent-infant and triadic parent-infant-object interactions. Furthermore, it shows that exposure to parental depression may be linked to a decrease in infants’ exploring of the novel stimuli in the environment. In a recent discussion Peláez, Virues-Ortega, Field, Amir-Kiaei, and Schnierch (2013) suggested that flat affect in depressed parents limits the availability of the parents to provide threat/safety signals to their infants in SR situations. Gewirtz and Peláez-Nogueras (1992) further suggest that as a result of parents’ unavailability/non-responsivity in SR situations, infants will be less likely to use the mother as a source of information in SR situations. This idea awaits further investigation in SR situations in infants of parents with depression.

The first studies focusing at the effect of anxiety disorder on parents’ and infants’ expressions of negative emotion in SR situations investigated the associations between socially anxious parents’ expressions of anxiety and infants’ fear and avoidance of strangers to shed light on the early intergenerational transmission of social anxiety (Aktar, Majdandžić, De Vente, & Bögels, 2013; Murray et al., 2008). Murray and colleagues investigated SR processes in a longitudinal design with socially anxious (vs. reference) mothers and their infants at 10 and 14 months in the stranger SR paradigm. Socially anxious mothers expressed more anxiety than reference mothers both at 10 and 14 months. Furthermore, highly behaviorally inhibited infants of mothers with social anxiety disorder showed a longitudinal increase in avoidance of strangers in SR situations from 10 to 14 months. In a later replication and extension of this study to nonsocial SR situations and to parents with nonsocial types of anxiety disorders, Aktar et al. (2013) found that parents’ expressions of anxiety in the SR situations predict 12-month-old infants’ avoidance in SR situations (in interaction with infants’ behavioral inhibition), rather than parental lifetime (social and nonsocial) anxiety diagnoses. This finding shows that 12-month-old infants’ avoidance of novelty is related to their environmental exposure to anxious responses in the SR situations, rather than parents’ dispositions for anxiety disorders. Consistent with previous evidence (De Rosnay et al., 2006; Murray et al., 2008), there was a positive association between parents’ expressions of anxiety and infants’ avoidance of novelty for infants with moderate-to-high levels of fearful temperament. However, parents’ expressions of anxiety in the situation did not predict infants’ avoidance when infants had low levels of behavioral inhibition, and when parents expressed low levels of anxiety.
In a follow-up study of this sample at 30 months in SR situations, parental social anxiety diagnosis (with or without comorbid nonsocial anxiety diagnoses) rather than parents' expressions of anxiety predicted toddler's fear/avoidance of strangers, suggesting that the link between parents' expressions of anxiety and children's fearful/avoidant reactions may be specific to SR situations at the end of first year of life (Aktar, Majdandžić, De Vente, & Bögels, 2014). Moreover, there were positive associations between expressions of anxiety of parents with comorbid social and other anxiety diagnoses at 12 months and children's fear/avoidance at 30 months. Thus, exposure to expressions of anxiety from parents with comorbid social and other anxiety diagnoses in SR situations at the end of first year may prospectively influence offsprings' avoidance of novelty in toddlerhood. At 12 and 30 months, no significant differences were found in this sample in the associations between mothers' and fathers' expressions of anxiety, indicating that fathers' emotional expressions are as important as mothers' for infant's fear learning. Taken together, the available evidence from clinical samples suggest that exposure to parental expressions of anxiety in SR situations at the end of first year may concurrently and prospectively increase infants' avoidance of novelty, and thereby contribute to parent-to-infant transmission of anxiety.

Section Summary and Conclusions
The evidence reviewed above suggests that infants' exposure to parents' expressions of emotion towards novel objects/people/events in the environment have a direct effect on infants' avoidance of these novel stimuli at the end of the first year both in community samples and in clinical samples (Aktar et al., 2013; De Rosnay et al., 2006; Möller et al., 2014; Murray et al., 2008). Increases in parents' expressions of anxiety towards certain stimuli can lead to the intergenerational transmission of fear/anxiety in this period as infants use parents' situation-specific expressions of fear and anxiety in SR situations as signals for safety/threat (Aktar et al., 2013; Murray et al., 2008). Because clinically anxious parents experience and express excessive levels of anxiety/worry in response to certain stimuli in SR situations, infants of anxious parents are likely to be repeatedly exposed to high levels of parental anxiety expressions at the end of first year. Evidence showing a pronounced increase in anxiety expressions of mothers and fathers with social anxiety disorder in the stranger SR paradigm supports this idea (Aktar et al., 2013; Murray et al., 2008).

Findings from experimental and semi-experimental SR studies in community samples and in clinical samples consistently suggest that infants' own temperamental dispositions (i.e., behavioral inhibition) moderate the effects of exposure to parents' expressions of anxiety on infants' emotional and behavioral responses to ambiguity in SR situations (Aktar et al., 2013; De Rosnay et al., 2006; Möller et al., 2014; Murray et al., 2008). Consistent with the predictions of diathesis-stress, vulnerability-stress and differential susceptibility models (Belsky & Pluess, 2009; Ingram & Luxton, 2005;
Nigg, 2006), temperamentally inhibited/difficult/fearful infants are more vulnerable to the effects of exposure to parents’ negative emotions in triadic contexts at the end of first year. Moreover, exposure to parents’ expressions of anxiety at 12 months from parents with comorbid social and other anxiety diagnoses predict infants’ responses to strangers 18 months later (Aktar et al., 2014). Thus, exposure to anxiety expressions from parents with more severe forms of anxiety disorders at the end of first year may have prolonged effects in the offsprings’ later avoidance of novelty in toddlerhood.

EXPOSURE TO PARENTS’ FACIAL EXPRESSIONS AND INFANTS’ ATTENTION TO OTHERS’ EMOTIONAL EXPRESSIONS IN DYADIC AND TRIADIC CONTEXTS

Typically Developing Infants
To our knowledge, only one study tested the links between infants’ exposure to parents’ emotional expressions and infants’ attention to others’ facial expressions of emotion in typical development. De Haan et al. (2004) studied the associations of maternal positive and negative affect, and of infants’ fearful temperament with 7-month-old infants’ looking preferences and event-related potentials (ERP) to fearful and happy faces. Mothers reported their experience of positive (e.g., interest, excitement, pride) and negative (e.g., irritability, guilt, nervousness, stress, fear) emotions, as well as infants’ fearful and positive temperament. The findings revealed that infants showed a negativity bias in their looking preferences (i.e., they attended more to fearful than happy faces). Moreover, the negativity bias in infants’ attention was moderated by mothers’ positive (but not negative) affect. Only infants of mothers with high levels of positive affect looked longer to fearful faces, while infants of mothers with low positive affect did not show a looking preference. Thus, it seems that there is a negative association between exposure to mothers’ happy facial expressions and infants’ interest in happy faces at 7-month-old infants. ERP correlates of infants’ attention revealed that temperamentally fearful infants devoted more attention (larger Nc component) to fearful than happy facial expressions. Moreover, temperamentally positive infants of highly positive mothers also allocated more attention (larger Nc) to fearful than happy facial expressions, while maternal negative affect did not predict infants’ attention. Thus, it seems that infants who experience more positive emotions show a decrease in ERP indices of attention allocation to happy faces when they have been more frequently exposed to it from their mothers. Findings from this first study on the effects of exposure on infants’ attention allocation to facial expressions are in line with the idea that the variation in infants’ exposure to parents’ positive affect, together with infant temperament predict infants’ attention allocation to emotional stimuli in typical development.
Parents' negative emotions and infants' socio-emotional development

Jones, Slade, Pascalis, and Herbert (2013) investigating infants' attention (or interest) in mothers' neutral facial expressions as a function of parents' depression, anxiety and stress levels revealed that higher levels of anxiety (but not depression or stress) are linked to less interest to mothers' (but not to strangers') neutral faces from the infants. Thus, previous findings indicating a lower likelihood of negative reactions to mothers' still-face in infants of anxious parents (Kaitz et al., 2010) may be related to an overall decrease in attention to mothers' neutral face. It is difficult to explain why anxiety but not depression predicted infants' interest to mothers' neutral faces, but the findings suggest that heightened exposure to parents' negative emotional expressions in the case of anxiety is linked to less interest to mothers' neutral expressions. It remains to be investigated how infants' exposure to parental depression and anxiety alters their attention to positive and negative (vs. neutral) facial expressions.

Infants of Depressed and Anxious Parents

In line with the evidence on a significant role of exposure to parents' positive emotion on infants' emotional processing in typical development, studies in infants of clinically depressed mothers reveal significant associations between exposure to mothers' depressive moods and infants' attention to facial expression of emotion. Infants of depressed parents show differences in behavioral correlates of attention to sad and happy faces that are indicative of an increased familiarity to sad vs. happy faces in dyadic person-infant contexts (see Field, Diego, & Hernandez-Reif, 2009 for a review). Differently from their peers who allocate enhanced attention to sad facial expressions (probably due to its novelty), 3- and 6-months-old infants of depressed mothers spend less time looking at sad faces as compared to infants of non-depressed mothers (Field, Pickens, Fox, Gonzales, & Nawrocki, 1998). Infants of depressed parents are also more likely to attend to mothers' happy facial expressions in face-to-face interactions (Striano, Brennan, & Vanman, 2002), and habituate more slowly to happy facial expressions as compared to infants of non-depressed mothers (Hernandez-Reif, Field, Diego, Vera, & Pickens, 2006). Unlike typically developing infants, infants of depressed mothers fail to discriminate happy from neutral faces following habituation (from 3 to 6 months; Bornstein, Arterberry, Mash, & Manian, 2011), and show less interest to both happy and sad faces, independent of who (mother vs. stranger) poses the expressions (at 5 months, Diego et al., 2004). Taken together, the evidence from infants of depressed parents in dyadic contexts reveals a negative association between infants' exposure to mothers' sad faces and infants' attention to sad faces. In contrast to normally developing infants who are most familiar with happy facial expressions, infants of clinically depressed parents seem to be more familiar with sad faces. It remains to be investigated how exposure to parents' depression alters infants' attention allocation to emotions other than joy and sadness.
The first evidence on the effect of parental anxiety disorders on infants’ attention has come from Creswell and colleagues (Creswell et al., 2008; 2011) who investigated the effects of parental social anxiety disorder on infants’ attention allocation to low vs. high intensity negative facial expressions (fear and anger) in a clinical sample. Creswell et al. (2008) compared the differences in initial orientation, and total looking time to fearful and angry facial expressions in infants of mothers with (vs. without) social anxiety disorder. Infants of socially anxious mothers were more likely to orient, and to look at low (vs. high) intensity fearful faces at 10 weeks of age while infants of reference mothers showed the opposite pattern, that is, a bias for high intensity fearful faces. There were no group differences in infants’ interest to anger: all infants, independent of parents’ social anxiety showed more looking to high (vs. low) intensity faces. Interestingly, observations of infants’ temperament and of parents’ expressions of anxiety with a stranger did not account for differences in infants’ visual interest to fearful faces. In a follow-up of this sample, a preference for high intensity fear faces at 10 weeks predicted higher anxiety symptoms in the offspring of mothers with social anxiety disorders, while a preference for low intensity fear faces predicted less anxiety at 2 years (Creswell et al., 2011). Infants of index mothers showed the opposite pattern with a preference for high intensity fearful faces being associated with less anxiety at 2 years. This study is not only the first evidence revealing directly links between early attention and later anxiety outcomes in the offspring of socially anxious mothers, but it also suggests that the associations of offspring’s early attention to facial expressions to later anxiety may differ as a function of maternal anxiety diagnoses. It seems that the adaptive and maladaptive attention trajectories in infants’ emotion processing may be different in the presence of an anxious mother, that is, avoidance of high intensity (i.e., a preference for low intensity) fearful faces seems to be an adaptive response in infants of socially anxious mothers, while a preference for high intensity fearful faces is adaptive in typical development. The effect of exposure to parents’ anxiety disorders on infants’ attention allocation awaits to be further explored both in dyadic and triadic contexts to disentangle the differences in developmental trajectories of infants with or without a parent with anxiety disorder.

Section Summary and Conclusions
Evidence reviewed above on the association between exposure to parents’ facial expressions in the first postnatal year and infants’ attention to emotional expressions highlights the crucial role that parental positive emotions have in shaping infants’ attention to parents’ faces, and to emotional expressions from strangers. First, the normal variation in infants’ exposure to positive emotions from parents in this period seems to influence infants’ attention to positive emotions expressed by strangers (De Haan et al., 2004). Increases in infants’ exposure to mothers’ happy emotions seem to be associated with decreases in infants’ attention allocation to happy (vs. fear) facial
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expressions, and an increase in attention to strangers’ fearful expressions at 7 months.

Similarly, the significant increase in infants’ exposure to mothers’ sad emotions in the case of clinical maternal depression seems to be associated with decreases in infants’ attention allocation to sad (vs. happy) facial expressions, and an increase in attention to happy facial expressions (Field et al., 1998; Striano et al., 2002). In contrast to typically developing infants who are most familiar with happy facial expressions, infants of clinically depressed parents seem to be more familiar to sad faces, and perceive the happy faces as more novel. This finding is in line with Vaish and colleagues’ (2008) suggestion that the distribution of infants’ overall exposure to emotional facial expressions would be less positively skewed towards the positive end when mothers express more negative emotions, which makes negative expressions more familiar, and less interesting for infants of clinically depressed parents.

Higher levels of maternal anxiety (but not depression or stress) was found to be related to less interest to mothers’ (but not to strangers’) neutral faces in a community sample, while how exposure to parental anxiety may alter infants’ attention to mothers’ and others’ negative facial expressions remains to be investigated (Jones et al., 2013). The only longitudinal evidence reveals that the links of offspring’s early attention to facial expressions to later anxiety may be moderated by the presence of social anxiety diagnosis in mothers. A preference for high intensity fearful faces in infancy seems to be linked to less anxiety in normally developing samples, while a preference for low intensity fearful faces seems to be linked to less anxiety when the mother has social anxiety disorder.

To sum up, the studies from typically developing infants and infants of depressed mothers consistently reveal a negative association between infants’ exposure to specific facial expressions from parents and their attention allocation to these emotional expressions from strangers, while findings from mothers with social anxiety disorder reveal a negative association between parental anxiety disorders and infants’ interest to high intensity fearful faces. Taken together, the findings support the idea that alterations in infants’ exposure to parents’ positive and negative emotions in early interactions are linked to infants’ familiarity and attention to emotional facial expressions of others.

**DISCUSSION**

In the present article, we reviewed evidence for the associations between infants’ exposure to parents’ emotional expressions and socio-emotional development in the first postnatal year by focusing on infants’ emotional expressions, and reactions during interactions with parent, and their attention to others’ facial expressions. The evidence on the links between infants’ exposure to parents’ negative emotional
expressions and infants’ own negative emotional expressions and behavioral reactions to novelty in early interactions consistently reveals significant positive associations. In other words, infants’ emotional and behavioral reactions seem to directly relate to their parents’ emotional and behavioral reactions in the first year. For example, 2-to-6-month-olds become more negative and less positive when exposed to more negative and less positive affect from parents in face-to-face interactions, (e.g., Forbes et al., 2004; Campbell et al., 1995; Cohn et al., 1990). Similarly, when exposed to parents’ fearful expressions directed to a novel stimulus in SR situations, 10-to-14-month-olds become more avoidant of the novel stimulus (Aktar et al., 2013; De Rosnay et al., 2006; Möller et al., 2014; Murray et al., 2008). Although infants’ fine-tuning to parents’ expressions of emotion in this period is essential for the infants’ survival, socio-emotional development, and socialization, the evidence reviewed in the current article indicates that it appears to create a vulnerability for the effects of exposure in the offspring of parents with clinical depression and anxiety. Thus it seems that in the first year of life, infants may already take over depressed and anxious interaction patterns from their parents via repeated exposure to parents’ depressed and anxious moods.

Our review on the effects of exposure to parental depression and/or anxiety on emotional expressions and reactivity in everyday situations suggests distinct influences of mothers’ depression and anxiety diagnoses on mothers’ and infants’ expressions of negative emotions in their interactions, while the effect of fathers’ depression and anxiety awaits to be investigated in future studies. Infants of depressed mothers are exposed to less positive, and more negative and neutral affect from mothers in early interactions (Campbell et al., 1995; Cohn et al., 1990). In contrast, expressions of affect in mothers with anxiety disorders (without comorbid depression), and in infants of mothers with anxiety disorders do not seem to differ from reference parents (Kaitz et al., 2010; Murray et al., 2007; Weinberg et al., 2008). One explanation for the lack of evidence that anxiety-disordered mothers would expose their infants to more negative emotions, is the specificity of anxious parents’ expressions of negative emotions to their confrontations with anxiety-provoking stimuli during triadic parent-infant-object interactions (Aktar et al., 2013; Murray et al., 2008).

Although parents’ depressed affect was suggested to have a distinct influence in SR situations due to diminished availability of depressed parents as referees in SR situations (Peláez et al., 2013), and to the resulting decrease in infants’ frequency of using the parents as referees (Gewirtz & Peláez-Nogueras, 1992), the effect of a depressed affect in SR situations awaits to be explored with mothers and fathers. If the effects of exposure in the case of parental depression extend to the triadic parent-infant-object interactions like suggested, this would reveal continuity in the effects of exposure to parental depression between dyadic parent-infant and triadic parent-infant-object interactions in the first year. In contrast, if exposure to

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parents’ depression does not affect triadic parent-infant-object interactions, it may mean that exposure effects in the case of depression and anxiety in the first year may be dynamically changing within the first year across the two milestones of socio-emotional development (i.e., onset of dyadic and triadic interactions). For a better understanding of specific influences of exposure to parental depression and anxiety in infants’ early socio-emotional development, it is important that future studies test the effects of exposure in the first year in longitudinal designs that incorporate the dyadic parent-infant and triadic parent-infant-object interactions in community and clinical samples of anxious and depressed parents.

The evidence on the links between infants’ exposure to parents’ facial expressions of emotions and their processing of emotional facial expressions revealed that infants’ exposure to mothers’ positive affect predict their attention to strangers’ positive vs. negative emotions (De Haan et al., 2004), while the effect of infants’ exposure to paternal positive and negative affect has not yet been investigated. The negative association between infants’ exposure to a certain emotion from the mothers and their attention to others’ expressions of that emotion seems to hold across infants of mothers from clinical and non-clinical samples. That is, typically developing infants who have been exposed to high levels of maternal positive affect in everyday life attend less to the happy (vs. fearful) facial expressions (De Haan et al., 2004), while infants’ of depressed mothers who are exposed to increased levels of negative emotions seem to attend less to sad (vs. happy) facial expressions (Field et al., 1998; Field et al., 2009; Hernandez-Reif et al., 2006; Striano et al., 2002). Thus, depression-related increases in infants’ exposure to maternal negative emotions seem to decrease infants’ attention to negative emotions due to increased familiarity/decreased novelty of negative emotional expressions in infants’ emotional environment. It is important to note that the links of infants’ attention to their exposure to negative emotions suggest a pattern that is reverse to the findings suggesting enhanced attention to negative facial expression in parents and children with depression and anxiety (Leppänen, 2006; Van Bockstaele et al., 2014).

In summary, we conclude that the variation in infants’ exposure to parents’ positive and negative facial expressions resulting from parental depression and anxiety is positively associated with infants’ expressions of positive and negative emotions, and emotional reactivity to novelty in daily interactions while it is negatively associated with infants’ attention allocation to positive and negative emotional expressions. This conclusion on effects of exposure to parental negative emotions in typical development and in infants of depressed and/or anxious parents is limited by the little evidence available on exposure effects in infancy. It is important to note that most of the work reviewed in the current article is simply correlational and cross-sectional. The available longitudinal work is confined to short-term prospective designs that, most of the time did not directly assess clinical outcomes.
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Nevertheless, the available evidence on the exposure effects in the first year of life is in line with the multi-component model by Goodman and Gotlib (1999). Namely, it shows that parents with depression and anxiety express more negative and flat emotional expressions in everyday interactions with their infants. Due to experience-dependent nature of early socio-emotional development, and parents’ heightened negative affect expressions, depression and anxiety diagnoses make parents and the interpersonal environment that they provide less than optimal for children’s socio-emotional development. The evidence revealing more negative and flat expressions of affect, and less attention to others’ negative emotion in infants of depressed and anxious parents reveals that this suboptimal interpersonal environment may affect infants’ socio-emotional development. The links between parents’ and infants’ expressions of affect, and behavioral reactivity in everyday interactions confirm the idea that children will acquire negative and avoidant interactive styles that look similar to negative behaviors and moods of depressed and anxious parents. On the other hand, the links between infants’ overall exposure to parental negative emotion and attention to others’ emotional expressions reveal a negative, rather than a positive association (when exposed to high levels of a certain emotion from the parent, infants seem to attend less to that emotion in others’ facial expressions). Thus, exposure to parents’ negative emotions does not necessarily have only adverse effects on infants’ development, but it can also desensitize infants to others’ negative emotions, thus alter infants’ processing towards the non-anxious, non-depressed information processing style. Alternatively, infants’ lower attention to negative emotional faces when being exposed frequently to negative parental emotions could be considered as avoidance, and may constitute the basis of an avoidant style in life and in relationships. The associations between exposure-related alterations in infants’ emotional and behavioral reactions in daily parent-infant interactions, and in infants’ attention to others’ emotion remain to be investigated in future multi-method longitudinal studies combining the observation of everyday interactions with experimental studies measuring infants’ attention to emotional stimuli. In contrast to the components summarized above, the current review does not allow any evidence-based conclusions on the last component of the model by Goodman and Gotlib (1999), i.e., on the links of exposure-related alterations in infants’ socio-emotional development and the development of anxiety disorders and depression in childhood or adolescence. It remains unknown whether the increase in flat and negative affect expressions of infants resulting from exposure to parental anxiety and depression predisposes the offspring for the development of depression and anxiety. It is therefore crucial to investigate the specific contributions of these early exposure-related alterations in the emotional and behavioral reactions and attention in infancy to later depression and anxiety. This is attainable via longitudinal designs incorporating the measurement of socio-emotional development together with the diagnostic measurements that identify depression and anxiety in the offspring. In the
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next section, we put the findings in the context of intergenerational transmission by addressing potential mechanisms that may link exposure effects in infants’ emotional expressions, behavioral reactions and infants’ attention to the intergenerational transmission of depression and anxiety in infancy.

Intergenerational Transmission of a Depressive Interpersonal Style From Parents in Infancy

The findings consistently show that depressed mothers trigger a depressed interaction style characterized with less positive and more negative affect from their infants in early interactions. Field and colleagues (Field, 1984; Field et al., 1998) suggested that repeated exposure to alterations in these first early dyadic interactions may generalize to infants’ expression of emotion in their interactions with other adults, and contribute to a less positive and more negative affective tone from the infant, and correspondingly trigger less positive affect from others in dyadic interactions. The environmental transmission of this depressive interpersonal style from parents to infants may contribute to the intergenerational transmission of parental depression in these early dyadic interactions.

The association between an increase in exposure to parents’ depressed mood and an increase in infants’ attention allocation to happy (vs. sad) expressions from strangers imply a different influence of exposure to parental depression on infants’ attention allocation (Field et al., 1998; 2009; Hernandez-Reif et al., 2006; Striano et al., 2002). That is, infants of depressed parents attend to others’ positive facial expressions rather than negative emotions that they are already familiar with from their interactions with mothers. Infants of depressed parents also show more interest to mothers’ happy facial expressions (Striano et al., 2002). More attention to positive expressions may be adaptive for infants of depressed parents as biases towards the positive emotions would increase infants’ chances for exposure to more positive emotions, and would serve to diminish deviations in infants’ distribution of overall exposure to emotions. In other words, infants’ increased attention to happy expressions in this period may be a protective mechanism that shields the infants from increases in exposure to negative or flat emotional expressions of the mothers with depression by directing their attention to mothers’ and others’ positive expressions (and away from mothers’ and others’ negative expressions).

Mechanisms of transmission

Field (1984) suggested two potential mechanisms behind exposure to parental depression and the early transmission of a depressive interpersonal style from depressed parents to children in infancy. First, infants may acquire a dysphoric interaction style by mirroring parents’ expressions of emotion during dyadic face-to-face interactions. In line with this idea, positive associations were reported not only between infants’ and mothers’ expressions of specific emotions, but also between
infants’ and mothers’ use of eye and brow muscles while expressing these emotions during face-to-face interactions (Malatesta & Haviland, 1982). Second, the decreased positivity of depressed parents may render the dyadic interactions less arousing, exposing infants to lower than optimal levels of stimulation (Field, 1984). In addition to a decrease in positive arousal specifically stemming from the decreased positivity in parents’ emotional expressions in early interactions that was the scope of the current discussion, depressed parents seem to provide a less stimulating environment for infants’ development. For example, depressed mothers are less likely to tell stories, while depressed fathers are less likely to play, and sing to their infant (Paulson, Dauber, & Leiferman, 2006), supporting the idea of decreased positive arousal in interactions of depressed parents with their infants as a potential mechanism of intergenerational transmission of depression.

Intergenerational Transmission of Anxious/Avoidant Reactivity Patterns from Parents in Infancy

The findings consistently reveal a significant effect of exposure to parental expressions of anxiety on infants’ emotional expressions and emotional reactivity to novel/ambiguous stimuli at the end of the first year (Aktar et al., 2013; De Rosnay et al., 2006; Möller et al., 2014; Murray et al., 2008). The related increase in infants’ expressions of fear and behavioral avoidance towards novel stimuli was found to be more pronounced in infants with a temperamental disposition for fear. Thus, inherited temperamental dispositions exacerbate the effects of exposure to parental anxiety. The interplay between infants’ temperamental dispositions and exposure to parental anxiety may be contributing to the intergenerational transmission of parental anxiety in these early dyadic interactions (Fisak & Grills-Taquechel, 2007; Murray et al., 2009; Rapee, 2001).

Mechanisms of transmission

The mechanisms explaining the links between repeated exposure to fearful/anxious expressions from parents with anxiety disorders and the resulting increase in infants’ fear/avoidance responses in infancy have been operationalized within the framework of fear acquisition models (Fisak & Grills-Taquechel, 2007; Murray et al., 2009; Rachman, 1977). Together with the learning experiences that involve direct confrontations with threat (i.e., classical conditioning), indirect acquisition of fear via verbal or non-verbal forms of social learning are among the major pathways for fear acquisition (Olsson & Phelps, 2007; Rachman, 1977), and for early social transmission of fear from parents in SR situations at the end of the first year (Askev & Field, 2008; Rapee, 2001). Classical conditioning and observational learning precede language (and instructional learning) in our evolutionary history and seem to rely on the same emotional brain systems (i.e., amygdala-mediated fear learning pathways, Olsson & Phelps, 2007). In line with this, vicarious learning is often conceptualized as a form of classical conditioning where a fearful/anxious signal from the parent act as an unconditional
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stimulus, triggering fearful/anxious reactions from the infant when paired with the ambiguous stimuli like objects or strangers in the environment (see Askew & Field, 2008 for a review). Following the pairing, the ambiguous stimuli become conditioned stimuli, evoking fearful/anxious reactions from the child. For infants of parents with anxiety disorders, who by definition have more frequent and intense experiences of anxiety triggered by innocuous cues (rather than actual threat; APA, 2013), these pathways may be mediating the increase in infants' reactivity to ambiguous/novel stimuli and contribute to parent-to-infant transmission of anxiety. In addition to fear responses, infants’ observational learning of anxious parents’ anxious/avoidant behavioral styles via repeated exposure, and the resulting increase in infants' overall perception of threat in the environment were suggested to contribute to the social transmission of anxiety from parents with anxiety disorders (Fisak & Grills-Taqueuechel, 2007; Rapee, 2001). Finally, anxious parents’ reinforcement of infants’ anxious/avoidant behaviors has been stressed as a form of operant conditioning. Fisak and Grills-Taqueuechel (2007) suggest that differently from reference parents who reinforce approach and exploration of novelty with their infants, parents with anxiety disorder can reinforce anxious/avoidant coping styles due to their own excessive reactions, or to previous aversive experiences in anxiety-provoking situations.

The findings revealing decreased interest to mothers’ neutral expressions in community samples of anxious mothers (Jones et al., 2013), and a preference for low-intensity negative expressions in infants of parents with social anxiety disorder (Creswell et al., 2008; 2011) may serve to decrease exposure to parents’ anxiety. Thus, infants’ decreased attention to high intensity negative faces, and mothers’ neutral faces when mothers have anxiety may be part of a protective mechanism that shields the infant from increases in exposure to fearful/anxious expressions of the mothers with anxiety by directing the attention away from mothers’ faces, and from mothers’ and others’ high intensity negative emotions. Less exposure to emotional affect from mothers, and to low intensity negative faces from others may help bringing the distribution of overall exposure to positive and negative affect in infants of anxious parents closer to the distribution of typically developing infants.

Exposure to the Other Parents’ Emotional Expression as a Moderator of Exposure to Depression and Anxiety

Considering that effects of exposure to parents’ emotional expressions mostly happen together in development, and jointly determine the distribution of infants’ overall exposure to emotions, it is also important to look at the joint effects of infants’ exposure to emotions from mothers and fathers. Two important aspects determine whether the influence of exposure to the other parents' emotional expressions is a risk or a buffer (see Goodman & Gottlib, 1999): The other parents’ involvement in infant care and the other parents’ depression and/or anxiety. The other parents’ involvement is a measure of the frequency of infants’ exposure to the parents’ expressions of
emotion, while parents’ depression and anxiety determine the proportion of exposure to positive vs. negative emotions from the other parent. Fathers’ availability and mental health appear as a moderator of exposure to mothers’ depression in the developmental model of intergenerational transmission of depression by Goodman and Gotlib (1999). In accordance with this model, we suggest that exposure to the other parents’ emotions can become a risk factor in infancy when higher frequencies of exposure to the other parent co-occur with depression and anxiety in the other parent. Thus, when the other parent is highly involved in the infants’ care and has a depression and/or anxiety diagnosis, the other parent may exacerbate the effect of depression and anxiety in one parent. Note that due to assortative mating, parents with depression and anxiety disorders are more likely to choose partners that do have similar types of psychopathology, resulting in significant associations between couples’ depression and anxiety diagnoses (Goodman, 2004; Matthey et al., 2003), and in higher risk for psychopathology in the offspring (Merikangas, Prusoff, & Weissman, 1988; Merikangas, Weissman, Prusoff, & John, 1988). Psychopathology in the other parent not only contributes to a more pronounced genetic and biological risk for intergenerational anxiety, but also to more pronounced alterations in the overall distribution of infants’ exposure to parental emotions when the other parent is highly involved in care. In line with this idea a study in a clinical sample of depressed mothers revealed that exposure to postpartum maternal depression is linked to later internalizing and externalizing problems in the offspring in the toddlerhood only in the presence of paternal psychopathology (Dietz, Jennings, Kelley, & Marshal, 2009). Furthermore, a community study reported that exposure to fathers’ depression in infancy strengthens the association between early exposure to mothers’ depression in infancy and children’s behavioral problems in the kindergarten only if the father is involved in care (Mezulis, Hyde, & Clark, 2004). These findings suggest that the other parents’ depression, together with his/her involvement can create more pronounced alterations in infants’ exposure, and lead to poorer outcomes. Similarly, when both the mother and the father have anxiety disorders, and are involved in infants’ care, a higher frequency of exposure to parental expressions of anxiety in anxiety-provoking situations would be expected to be associated with worse outcomes than in the case of a single parent having anxiety disorder.

Alternatively, in cases where the other parent has no diagnosis of depression or anxiety, and is involved in infant care, exposure to the other parents’ emotional expression may provide the infants the opportunity to interact more positively with the other parent on a regular basis, which may help to bring the distribution of infants’ overall exposure closer to the typically developing infants’ exposure. The findings suggesting that fathers compensate for mothers’ depression by expressing more positive affect than their depressed partners in their face-to-face interactions with the infant support this idea (Edhborg et al., 2003; Hossain et al., 1994). Other
findings revealing no differences in the interactions of depressed mothers and non-depressed fathers with their infants (Chabrol et al., 1996) and less optimal interactions in non-depressed fathers when the mother is depressed (Goodman, 2008) show that the other parent may not always be able to compensate for depression and anxiety in his partner. Thus, the other parent’s ability to compensate may depend on a number of factors including his/her own depression and the negative influences of living with a depressed partner on the other parent’s own functioning and on the marital relationship quality. More recent evidence on the links between maternal depression and the other parents’ involvement in child care has revealed that fathers’ ability to compensate for mother by increasing involvement may be dynamically changing within the first postnatal year (Goodman, Lusby, Thompson, Newport, & Stowe, 2014). More specifically, maternal depression in the first 6 months was linked to higher levels of compensatory involvement from fathers, while maternal depression in the second half of the first year was linked to less involvement from fathers. Thus, fathers’ ability to compensate may decrease in cases where maternal depression continues across the first year. Likewise, the other parents’ availability and ability to compensate for the effects of exposure to the anxious parent’s anxiety was suggested to constitute a buffer for infants’ exposure to the expressions of anxiety from the anxious parent (see Bögels & Perroti, 2011; Bögels & Phares, 2008).

**Exposure to Parental Depression and Anxiety and Infants’ Socio-Emotional Development: Future Directions**

Based on our review on the associations between exposure to parents’ emotional expressions and infants’ socio-emotional development in the first year of life, we suggest that the following issues should be given priority in future research. First, it is important to notice that previous investigations of exposure to parental emotion effects in daily interactions, and in infants’ attention did not include measurements of purely genetic and biological influences. It is therefore unclear to what extent the associations in parents’ and infants’ expressions of emotions and reactions to novel stimuli are explained by environmental exposure after controlling for genetic and biological vulnerabilities in the offspring of parents with depression and anxiety. The studies investigating the links between overall exposure to parents’ depression/anxiety and infants’ attention has relied on mothers’ report of negative affect, depression and anxiety. Observations of parents’ negative emotions may constitute a more objective index of infants’ actual exposure, and therefore must be considered in future studies. Second, exposure effects have not been investigated longitudinally or cross-sectionally across the developmental transitions signaling the onset of dyadic parent-infant and triadic parent-infant-object associations. For example, although we know that mothers with depression are less positive and more flat during parent-infant interactions in the first half year of life, we don’t know whether these parents also express less positive emotion during infants’ exploration of objects in triadic
parent-infant-object interactions that emerge later in the second half year of life. Future longitudinal investigations of the exposure effects should take into account the transitions in infants’ socio-emotional development in the investigation of effects of exposure to parents’ emotions, depressed and/or anxious moods. The third issue concerns the associations between behavioral and physiological correlates of infants’ emotional reactivity and of attention allocation. Further research should aim at elucidating the links between infants’ emotional expressions, behavioral reactions and attention to emotion for a more complete picture of infants’ socio-emotional development in different levels of analysis. The final issue is the inclusion of fathers. Previous evidence reviewed above on exposure effects in typically developing infants and in infants of depressed and/or anxious parents predominantly comes from mothers. For a more complete understanding of the exposure effects in the family contexts in early years, it remains essential to investigate differential and interactive effects of exposure to mothers’ and fathers’ negative moods in everyday interactions on infants’ socio-emotional development. Inclusion of fathers is important to understand the compensating or exacerbating effect that the secondary caregiver can have in case of a depressed and/or anxiety disordered mother.

Transactions Between Exposure and Other Mechanisms in the Intergenerational Transmission of Depression and Anxiety: Future Directions

How does exposure to parental depression and anxiety in the first year of life interact with inherited genetic/biological predispositions, and other environmental mechanisms to determine depression and anxiety outcomes in the offspring? Inherited genetic markers for depression and anxiety and innate dysfunction in early neuro-regulatory systems in the offspring of prenatally depressed and anxious parents (Goodman & Gotlib, 1999) may create additional vulnerabilities, and strengthen the effect of the deviations related to exposure effects on later psychopathology. For example, both depression and anxiety disorders in mothers show high continuity between the prenatal and postnatal years, infants of depressed mothers are therefore likely to have already been exposed to mothers’ depression prenatally (Heron, O’Connor, Evans, Golding, & Glover, 2004). Newborns of prenatally depressed mothers show altered biochemical/physiological responses (e.g., lower levels of dopamine, higher levels of cortisol levels, and lower vagal tone) that resemble their mothers’ responses (Field, Diego, Hernandez-Reif, 2006). The observed effects of exposure may therefore be partially explained by these biochemical/physiological alterations. Alternatively, the link between exposure to parents’ negative emotions and later psychopathology may be stronger in children of prenatally depressed mothers due to these early biochemical/physiological vulnerabilities. Likewise, other environmental mechanisms are at work during and after the first year of life including low marital quality/satisfaction, parenting stress, and socioeconomic disadvantages may diminish/exacerbate exposure effects.
It is therefore important to incorporate other environmental, biological and genetic mechanisms that operate in intrapersonal and interpersonal levels before, during, and after infancy together with exposure to parental emotional expressions in the intergenerational transmission of depression and anxiety disorders. Considering the diversity of child outcomes in the offspring of anxious and depressed parents, parallel longitudinal measurements of other environmental and genetic factors, in addition to exposure effects are crucial in delineating the effects of environmental exposure on concurrent socio-emotional development and subsequent development of depression and anxiety in childhood and adolescence. Family, twin and adoption studies investigating these mechanisms in the intergenerational transmission of anxiety from a developmental psychopathology perspective may provide important insights to how exposure-related vulnerabilities in infancy cross-sectionally and longitudinally interact with other genetic or environmental vulnerabilities to determine offsprings’ socio-emotional development and psychopathology. This requires a shift from reliance on self-report measures to the integration of different methodologies allowing the assessment of environmental, biological and genetic mechanisms in future family, twin and adoption studies addressing intergenerational transmission of depression and anxiety.

Clinical Implications
The findings reviewed above on the effects of exposure to parental depression and/or anxiety on infants' socio-emotional development highlight the importance of interventions targeting mood and anxiety disorders in the first years of parenthood to decrease the early risk posed by exposure to parents’ negative moods. Although interventions targeting maternal depression are efficient in decreasing parents’ experience of negative emotions (like stress), they may not be always enough to reestablish the typical interaction patterns in early parent-infant interactions (Forman et al., 2007). Studies testing the effects of interventions targeting parent-infant interaction in addition to mother’s depressive symptoms revealed promising results, although the outcomes were related to other aspects of dyadic functioning (like parental responsivity) than emotional expressions (see Poobalan et al., 2007). Thus, it remains to be investigated whether the interventions targeting parent-infant dyad can reestablish the typical emotional expression and reactivity patterns in early parent-infant interactions, and buffer the offspring from exposure effects. Not only the effect of parental depression interventions, but also the effect of parental anxiety interventions on parent-child-object interactions in anxiety-specific contexts in the postnatal year is an important issue that needs to be addressed in future studies. Interventions that aim to shield the infant from exposure to negative parental emotions in the postnatal year should consider and target the negative effects of partners’ depression on the functioning, parenting stress and psychopathology of the other parent, and in his/her relationship with the offspring in addition to depression and anxiety diagnosis in one parent.
CONCLUSIONS

The first major conclusion of the current review is that the extent to which parents express negative emotions with their infants has a direct link to infants’ expressions of emotion in their early interactions with parents. Infants’ expression of emotion echoes their parents’ expression of emotion in early interactions in typically developing infants of non-diagnosed parents and in infants of parents with depression and/or anxiety diagnoses. Thus, infants’ repeated exposure to clinically depressed parents’ flat and negative interaction styles in dyadic parent-infant interactions may contribute to the transmission of a similar depressed interaction style from parents to children in the first year of life and constitute risk for the development of depression. Likewise, repeated exposure to fearful and anxious interaction styles from parents with anxiety disorders in triadic parent-infant-object interactions may contribute to infants’ learning of fear and contribute risk for early intergenerational transmission of anxious reactivity patterns from anxious parents to offspring, and to the development of child anxiety.

The second conclusion of the current review is that the extent of exposure to parents’ positive and negative emotions is linked to infants’ attention allocation to others’ positive and negative expressions. Increased exposure to a certain emotion from the parent in the early months seems to be related to a decrease in infants’ attention allocation to that emotional expressions both in typically developing infants, and in infants of depressed parents. Infants of non-diagnosed parents allocate more attention to fearful facial expressions, rather than to happy expressions that their mothers have frequently exposed them in their interactions. In contrast, infants of clinically depressed parents allocate more attention to happy facial expressions, rather than to sad expressions that their mothers have frequently exposed them in their interactions. As suggested above, an increase in attention to others’ positive expression in infants of depressed parents may be a protective mechanism that may help bringing the distribution of infants’ overall exposure to positive and negative affect closer to those of the typically developing infants by increasing the chances of positively interacting with others. Likewise, the decreased interest to mothers’ faces in infants of anxious mothers and to high intensity negative emotional expressions in infants of mothers with social anxiety disorder may help bringing the distribution of infants’ overall exposure to negative affect closer to those of the typically developing infants by decreasing the chances of exposure to mothers’, and to others’ high intensity negative expressions.
CHAPTER 2

How do infants’ temperament, and parents’ depression and anxiety alter parent-infant face-to-face interactions?

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ABSTRACT

The present study investigated infants’ and parents’ facial expressions in dyadic face-to-face interactions to explore the effects of mothers’ and fathers’ lifetime depression and anxiety diagnoses, and infants’ negative temperament on parents’ and infants’ facial expressions of emotion, and synchrony. We observed 4-month-old infants’ ($N = 101$), and their parents’ facial expressions during 4-minute dyadic face-to-face interactions. Parental diagnosis groups consisted of parental lifetime anxiety (without depression, $n = 61$), lifetime depression (alone and comorbid with anxiety disorders, $n = 49$) and no diagnosis ($n = 89$). Infants’ negative temperament was measured via observations. Mothers (but not fathers) with depression were less positive than mothers without diagnosis, while parental depression diagnosis, and infants’ temperament did not predict infants’ facial expressions or synchrony. Parental anxiety diagnoses did not predict parents’ or infants expressed emotion, or synchrony. The study adds to previous evidence by showing that maternal lifetime depression diagnosis is linked to less positive affect from mothers during face-to-face interactions, while revealing that this link may be specific to maternal depression and mothers’ expressions, and may not generalize to anxiety, to fathers’, or to infants’ facial expressions.
INTRODUCTION

The emergence of gaze and social smile towards the second month of life marks the beginning of socio-emotional communication in infancy (Messinger & Fogel, 2007). Henceforth, infants' increasing social skills in communicating and reciprocating affect enable dyadic forms of affect sharing during face-to-face interactions with the caregiver (Als, Tronick, & Brazelton, 1979; Tronick, 1989). Mothers' facial expressions are known to be predominantly positive, and rarely negative in face-to-face interactions in typical development (Cohn & Tronick, 1987; Malatesta & Haviland, 1982). Mothers' expressions of positive affect constitute a 'frame' for typically developing infants' expression and regulation of affect in early interactions (Als et al., 1979; Cohn & Tronick, 1987; Tronick, 1989). Mothers' positive affect serves to elicit, or maintain positive affect expressions from the infants. The synchronous timing of parents' positive affect expressions are considered to be important determinants of the quality of early parent-child interactions that is known to be associated with infants' current and later social, emotional and psychological functioning (Feldman, 2007; Leclère et al., 2014). The present study investigates the effect of parents' depression and anxiety, and infants' negative temperament on parents' and infants' expressions of emotions during parent-infant face-to-face interactions.

Depression and anxiety are highly prevalent in early years of parenthood (Bijl, Ravelli, & Van Zessen; 1998; Jacobi et al., 2004; Kessler, Chiu, Demler, & Walters, 2005), and exposure to parents' depression and anxiety in early life is linked to negative emotional, behavioral and psychological outcomes in infancy and beyond (e.g., Glasheen, Richardson, & Fabio, 2010; Halligan, Murray, Martins, & Cooper, 2007; Murray et al., 2011; Pawlby, Sharp, Hay, & O'Keane, 2008). Both depression and anxiety run in families, thus the presence of a depressed and/or anxious parent increases the risk of later psychopathology in the offspring (Beardslee, Gladstone, & O’Connor, 2011; Beidel & Turner, 1997; Goodman, & Gotlib, 1999; Turner, Beidel, & Costello, 1987). Both depression and anxiety are characterized by increases in the duration, frequency and intensity of negative emotions (American Psychiatric Association [APA], 2013). Depressed parents express more flat and negative affect in everyday life. Anxious parents express more fear, anxiety and worry in certain situations (or in general, in the case of generalized anxiety disorder). High comorbidity of depression and anxiety symptoms and the associated increase in severity (e.g., Klein Hofmeijer-Sevink et al., 2012; Lamers et al., 2011) reveal that the offspring is often simultaneously exposed to parents' depression and anxiety. Exposure to parents' negative affect during daily interactions was suggested to be an important mechanism in the parent-to-infant transmission of depression and anxiety disorders, alone and in interaction with inherited genetic vulnerabilities and/or temperamental predispositions (Goodman & Gotlib, 1999; Murray, Creswell, & Cooper, 2009).
Investigating how the range of deviations in the levels of early exposure to parents’ positive emotions in infants’ of depressed and anxious parents relate to the range of current socio-emotional development and later psychological outcomes in the offspring remains crucial for a better understanding of parent-to-infant transmission of depression and anxiety. Maternal depression is known to interfere with positive emotional interactions during early mother-infant face-to-face interactions (Beck, 1995). Less is known about the effect of parental anxiety, and infant temperament, as well as the differences between fathers and mothers. Considering high prevalence of depression and anxiety disorders in the first years of parenthood (e.g., Bijl et al., 1998; Jacobi et al., 2004; Kessler et al., 2005), and the evidence pointing to prolonged effects of early exposure to parents’ anxious and depressed moods on children’s functioning and psychopathology (e.g., Glassheen et al., 2010; Halligan et al., 2007; Murray et al., 2011), it is important to better understand how infants’ early exposure to parents’ depressed and anxious moods alters their expressions of affect in early interactions and constitute risk for the development of child psychopathology.

Field (1984) proposed that infants of depressed mothers may mirror their mother’s dysphoric interaction style, characterized by lower levels of positive affect and arousal in their early face-to-face interactions, and extend it to their interactions with others. Likewise, infants’ repeated exposure to, and modeling of parents’ negative (anxious) emotional reactions was suggested to be an important mechanism in the parent-to-infant transmission of anxiety. In the current study, we investigated how mothers’ and fathers’ anxiety and depression, and infants’ negative temperament affect parents’ and infants’ facial expressions and synchrony during face-to-face interactions in a Dutch sample of infants and parents.

Because the majority of observational studies of parent-infant face-to-face interaction in typically developing samples were conducted only with mothers, less is known about mother-father differences in parents’ and infants’ expressions of affect and synchrony during face-to-face interactions. Available evidence suggest that although fathers are equally able to sensitively respond to their infant (Braungart-Rieker, Garwood, Powers, & Notaro, 1998), mothers are more positive than fathers, and infants are more positive with their mother than with their father (Belsky, Gilstrap, & Rovine, 1984; Colonnesi, Zijlstra, Van der Zande, & Bögels, 2012; Field, Vega-Lahr, Goldstein, & Scafidi, 1987; Forbes, Cohn, Allen, & Lewinsohn, 2004). One study revealed that the differences in infants’ expressions of positive affect with mothers vs. fathers were accounted by parents’ expressions of emotion during face-to-face interactions (Forbes et al., 2004). This finding suggests that infants tune to mothers’ and fathers’ moment-to-moment expressions of positive affect, rather than communicating with fathers vs. mothers in qualitatively different ways. In addition to parents’ moment-to-moment expressions, the differences in overall exposure to the mother vs. father in everyday life may explain infants’ expressions of affect in face-to-face interactions.
Parent-infant face-to-face interactions

Studies observing depressed mothers in face-to-face interaction with their infant have revealed that depression affects mothers’ and infants’ behavior during face-to-face interactions by interfering with mothers’ ability to synchronously respond to, and to positively engage with their infant (Beck, 1995; Murray, Halligan, & Cooper, 2010; Stanley, Murray, & Stein, 2004). Mothers with depression and their infants are less positive and more negative than reference mothers and their infants during face-to-face interactions (e.g., Campbell, Cohn, & Meyers, 1995; Cohn, Campbell, Matias, & Hopkins, 1990). Furthermore, a negative association between maternal depression and mother-infant emotional synchrony (Feldman, 2003) was reported, suggesting that maternal depression may also impair mothers’ and infants’ contingent responding to each others’ affect.

To our knowledge, only two studies compared the effect of maternal and paternal depression on the expressions of affect in face-to-face interactions (Feldman, 2003; Forbes et al., 2004). Feldman (2003) found a negative association between parental depression and parent-infant synchrony for mothers, but not for fathers at 5 months. Forbes et al. (2004) found that 3-month-old infants of parents with lifetime depression were less positive and more negative during the mother’s, but not the father’s, still-face than infants of reference parents, while the effect of parental depression was no longer significant at 6 months. However, the analysis of parental depression was limited to still-face interactions in this study, where parents watched their child with a neutral face. In the current study, the effect of paternal and maternal depression on infants’ and parents’ expressions of affect was studied in naturalistic face-to-face interactions.

Compared to parental depression, less is known about how parental anxiety affects parents’ and infants’ facial expressions and synchrony during face-to-face interactions. The available evidence makes it difficult to distinguish the effects of parental anxiety from depression, and is limited to infants’ interactions with mothers. Weinberg and Tronick (1998) reported higher levels of negative affect in infants of a mixed sample of mothers with depression or anxiety. In another study by Field et al. (2005) depressed mothers with high trait anxiety were found to show less positive affect (i.e., smiling) and less exaggerated faces in face-to-face interactions at 3 months than depressed mothers with low trait anxiety. Infants of depressed mothers with high trait anxiety were also less positive and more negative than infants of depressed mothers with low trait anxiety. Nicol-Harper, Harvey and Stein (2007) reported reduced sensitivity and emotional tone in mothers with high (vs. low) trait anxiety in face-to-face play interactions with their 10 and 14-month-olds. Comparisons of high (vs. low) trait anxiety groups with similar levels of depression revealed that the effects of parental anxiety held independent of parents’ depression. In a sample of mothers with low rates of depression, Murray, Cooper, Creswell, Schofield, and Sack (2007) observed mothers with social anxiety disorder (SAD) and generalized anxiety disorder (GAD)
and their infants in face-to-face interactions. Mothers with SAD were less positively engaged, and more anxious during the interactions, while they were equally sensitive as control mothers. The effect of maternal GAD was not significant.

Relatively little evidence is available on the effects of maternal anxiety without comorbid depression on infants’ and parents’ facial expressions, synchrony and sensitivity during dyadic face-to-face interactions. Weinberg, Beeghly, Olson, and Tronick (2008) investigated the effects of maternal panic disorder without comorbid depression, and maternal depression on 3-month-olds’ and their mothers’ interactions in a still-face paradigm (a still-face interaction preceded and followed by regular face-to-face interactions). Parental psychopathology groups did not differ on infants’ and parents’ affect, or on synchrony. Kaitz, Maytal, Devor, Bergman and Mankuta (2010) investigated the effects of maternal anxiety without depression on 6-month-old infants’ facial expressions and parents’ sensitivity during dyadic interactions including still-face paradigm, free play, teaching, and caregiving episodes. In this study, anxious mothers displayed more exaggerated behavior, but they were not less sensitive than mothers without diagnosis during teaching and free play interactions with their 6-month-olds. Because mother’s positive affect was not separately analyzed, no conclusions can be made about the effect of parental anxiety on parent’s expressions of affect, while the duration of matched positive affect did not differ between healthy and anxious mother-infant dyads in this study. Infants of anxious mothers were not less positive than their peers during the regular face-to-face interactions.

In line with the dyadic nature of parent-infant interactions, it is important to include the effect of infant temperament when studying parents’ and infants’ emotional expressions during face-to-face interactions. In support for a bidirectional influence, prenatal maternal anxiety and depression seem to predict an increase in infants’ difficult temperament (Austin, Hadzi-Pavlovic, Leader, Saint, & Parker, 2005), while neonatal irritability seems to predict increased postnatal maternal depression, but not the quality of the mother’s early face-to-face interactions (Murray, Stanley, Hooper, King, & Fiori-Cowley, 1996). The reciprocal relation between the effect of parents’ and infants’ negative dispositions on parents’ and infants’ expressions of affect provides a route whereby parents’ and infants’ depressed/sad and anxious/fearful predispositions shape parents’ and infants’ behavior.

In the present study, we investigated the effects of mothers’ and fathers’ lifetime depression and anxiety and infants’ negative temperament on infants’ and parents’ facial expressions, and emotional synchrony during face-to-face interactions at 4 months. Parental diagnosis groups consisted of parental lifetime anxiety, lifetime depression (alone and comorbid with anxiety disorders) and no diagnosis. Infants’ negative temperament was assessed via standardized observations.
First, we investigated inter-parental differences in face-to-face interactions. Based on previous evidence (Belsky et al., 1984; Colonnesi et al., 2012; Forbes et al., 2004), we expected mothers to be more positive than fathers, and infants to be more positive with mothers than with fathers. In an additional step, we also tested whether the differences in infants’ expressions of affect with mothers vs. fathers are accounted by parents’ expressions of positive affect during the face-to-face interactions, and by infants’ overall frequency of exposure to mothers vs. fathers (number of days that the infant was cared by mother vs. father). Second, we investigated the effect of lifetime parental anxiety and/or depression diagnoses on mothers’, fathers’, and infants’ facial expressions and synchrony. Based on previous evidence (Campbell, et al. 1995; Cohn et al., 1990), we expected parents with lifetime depression, and their infants to express less positive affect, more neutral/negative affect, and less synchrony than reference parents and their infants. Third, we investigated whether infant negative temperament predicts parents’ and infants’ facial expressions, alone and in interaction with parental diagnoses and infant gender. Finally, we explored the effect of infant gender, as previous studies on the differences between daughters’ and sons’ face-to-face interactions with mothers and fathers during face-to-face interactions revealed inconsistent findings (e.g., Belsky et al., 1984; Malatesta & Haviland, 1982; Weinberg et al., 2008).

METHOD

Participants
Participants were 101 couples with their 4-month-old first-born infant. Socio-demographic characteristics are presented in Table 1. The families are part of a larger group of participants in an ongoing longitudinal study on social development recruited from the normal population (for the details about the recruitment, see Colonnesi et al., 2012). A sub-sample of infant data ($n = 66$) was previously analyzed to investigate infants’ ability to coordinate emotional expressions with gaze and vocalizations with mothers and fathers (Colonnesi et al., 2012).

Materials and Procedure

Face-to-Face interaction
Face-to-face interactions were recorded during the lab visits that each parent made separately with his/her 4-month-old infant. The infant was placed in a bouncer mounted on a table, and the parent sat on a chair, facing the infant. The experimenter asked the parent to interact with his/her infant as he/she would normally do, and left the dyad alone for 5 minutes. Infants’ and parents’ facial expressions (duration and frequency) were coded in 1-s intervals in the first 4 minutes of the interaction, via Observer XT 10.5 and 11.5 (Noldus, Trienes, Hendriksen, Jansen, & Jansen, 2000) together with gaze and vocalizations (not used in this study). The original infant protocol from Colonnesi and colleagues (2012) was adapted for the coding of parents’ behavior.
Table 1. Sociodemographic characteristics of the sample

<table>
<thead>
<tr>
<th></th>
<th>Mothers M (SD, range)</th>
<th>Fathers M (SD, range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parents’ age</td>
<td>31.17 (4.35, 19-42)</td>
<td>34.08 (5.48, 23-60)</td>
</tr>
<tr>
<td>Infants’ age in months</td>
<td>4.15 (0.35, 3.49-5.43)</td>
<td>4.29 (0.41, 3.39-5.30)</td>
</tr>
<tr>
<td>for each visit</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dutch origin</td>
<td>91 %</td>
<td>93.88 %</td>
</tr>
<tr>
<td>Educational level$^a$</td>
<td>6.99 (1.20, 1-8)</td>
<td>6.58 (1.62, 2-8)</td>
</tr>
<tr>
<td>Professional level$^b$</td>
<td>8.57 (2.16, 2-11)</td>
<td>8.17 (2.66, 3-11)</td>
</tr>
<tr>
<td>Monthly income$^c$</td>
<td>4.12 (1.31, 1-7)</td>
<td>4.59 (1.28, 1-7)</td>
</tr>
<tr>
<td>Days in child care (per week)</td>
<td>2.18 (1.35, 0-5.50)</td>
<td>0.66 (0.77, 0-5.00)</td>
</tr>
<tr>
<td>HK</td>
<td>2.08</td>
<td>1.02</td>
</tr>
<tr>
<td>PT</td>
<td>77.08</td>
<td>23.47</td>
</tr>
<tr>
<td>FT</td>
<td>9.38</td>
<td>71.43</td>
</tr>
</tbody>
</table>

$^a$ Measured with an 8-point scale from 1 (primary education) to 8 (university).
$^b$ Measured with an 11-point scale from 1 (manual labor for which no education is required) to 11 (labor for which a university degree is required).
$^c$ Measured with a 7-point scale from 1 (< 500 euros/month) to 7 (> 5000 euros/month).

Parents’ and infants’ facial expressions were coded into three categories consisting of positive, negative and neutral facial expressions (see Table 2) based on descriptions of Ekman and Friesen (1978). Two separate groups of observers were trained for coding infants’ and parents’ expressions. Observers were blind to the parents’ diagnostic status and infants’ temperament. For inter-observer reliability, a master coder recorded 19 % of the infant and 20 % of the parent recordings. The average Cohen’s kappa was .86 (SD = .17) for parents’ and .83 (SD = .16) for infants’ facial expressions.

Consistent with previous studies (Forbes et al., 2004; Kaitz et al., 2010), the majority (63 %) of the parents never displayed a negative facial expression during the interaction. When this happened, negative facial expressions were usually less than 2 seconds, and seemed to be part of parents’ attempts to imitate or empathize with their baby’s negative mood. Hence, parental negative expressions were excluded from further analysis.
**Parent-infant face-to-face interactions**

*Parents’ diagnostic status*
To assess parents’ diagnoses without the postnatal influence of infant characteristics on parental psychopathology (Murray et al., 1996), the Anxiety Disorder Interview Schedule (ADIS; Di Nardo, Brown, & Barlow, 1994) was conducted with both parents at the prenatal measurement (in average 4.99 months \(SD = 1.94\) before the 4-month measurement for mothers, and for fathers 5.24 months \(SD = 1.45\) before the 4-month measurement where the face-to-face interactions took place). The ADIS is a semi-structured clinical interview based on DSM-IV (APA, 1994). Parents in the study were assigned to three diagnosis groups based on lifetime diagnoses (i.e., current and lifetime diagnoses during pregnancy) of depression and anxiety. The choice of including the lifetime diagnoses was motivated by previous evidence revealing that lifetime depression diagnoses may be a stronger predictor of the interaction patterns characterizing depressed mother-infant dyads in face-to-face interactions than current depression diagnoses (Forbes et al., 2004), and by findings revealing prolonged effects of parental depression on parents’ sensitivity despite a decrease in depressive symptoms after treatment (Forman et al., 2007). Parental depressive disorders in the current sample included major depressive disorder and dysthymia, and parental anxiety disorders included social anxiety disorder, generalized anxiety disorder, panic disorder, post-traumatic stress and acute stress disorder. Lifetime diagnoses groups (current diagnoses indicated in parentheses) were: Parents with anxiety disorders only (30 (28) mothers and 31(20) fathers), parents with depression (30 mothers and 19 fathers [8(0) mothers and 8(1) fathers with depression only, and 22 (1) mothers and 11 (0) fathers with comorbid anxiety], and parents without lifetime or current diagnosis (40 mothers and 49 fathers). 16 mothers and 8 fathers in the anxiety disorder group had two or more comorbid lifetime anxiety diagnoses. The mean of parents’ clinician rated severity scores (obtained by summing the severity [range: 2 to 8] of each of parents’ existing lifetime depression and/or anxiety diagnoses) was 7.98 \(SD = 4.29\) in the parental depression (with or without comorbid anxiety) group, and 7.81 \(SD = 3.95\) in the parental anxiety group. Two interviewers recoded 10 % of the interviews in the prenatal measurement. Inter-observer agreement, based on the presence/absence of a diagnosis, ranged from 90 % to 100 % \((M = 97.71, SD = 2.97)\).

*Infant temperament*
To measure infants’ temperamental dispositions, their negative reactivity was observed in response to four unfamiliar stimuli during mother’s visit of the 4-month measurement, and the negative reactivity was coded following Kagan and Snidman (1991). For the current study, negative emotionality scores, obtained by averaging infants’ standardized emotion scores on negative facial expressions (e.g., a crying or fearful face), protest (e.g., whining, fussing), and crying across these tasks, were used as an index of negative temperament.
Table 2. Descriptives for infant’s temperament, and percentage duration of infants’ and parents’ facial expressions

<table>
<thead>
<tr>
<th>Parents Diagnostic Status</th>
<th>% Duration of parent facial expressions</th>
<th>% Duration of infant facial expressions</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Positive expressions</td>
<td>Neutral expressions</td>
</tr>
<tr>
<td>Parents with no diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>89.65 (8.59)</td>
<td>8.71 (7.97)</td>
</tr>
<tr>
<td>N</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>Boys</td>
<td>87.07 (16.44)</td>
<td>12.26 (16.27)</td>
</tr>
<tr>
<td>N</td>
<td>25</td>
<td>25</td>
</tr>
<tr>
<td>Father</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>68.92 (23.53)</td>
<td>30.01 (23.43)</td>
</tr>
<tr>
<td>N</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Boys</td>
<td>70.37 (28.56)</td>
<td>29.13 (28.41)</td>
</tr>
<tr>
<td>N</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Parents with anxiety disorder</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mother</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>79.22 (13.93)</td>
<td>20.27 (13.63)</td>
</tr>
<tr>
<td>N</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Boys</td>
<td>89.30 (10.80)</td>
<td>9.56 (10.21)</td>
</tr>
<tr>
<td>N</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td>Father</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls</td>
<td>70.44 (26.88)</td>
<td>28.39 (27.10)</td>
</tr>
<tr>
<td>N</td>
<td>17</td>
<td>17</td>
</tr>
<tr>
<td>Boys</td>
<td>70.64 (26.85)</td>
<td>28.52 (26.87)</td>
</tr>
<tr>
<td>N</td>
<td>14</td>
<td>14</td>
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<tr>
<td>Parents with depression</td>
<td>Mother</td>
<td>Girls</td>
</tr>
<tr>
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<tr>
<td>Boys</td>
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<tr>
<td>Father</td>
<td>Girls</td>
<td>M(SD)</td>
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<td>Boys</td>
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<tr>
<td>Parents with comorbid depression and anxiety</td>
<td>Mother</td>
<td>Girls</td>
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<tr>
<td>Boys</td>
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<tr>
<td>Father</td>
<td>Girls</td>
<td>M(SD)</td>
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<td>Boys</td>
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</table>

Parents with depression

Parents with comorbid depression and anxiety
The tasks consisted of three nonsocial (visual, auditory and olfactory) stimuli from Kagan and Snidman (1991) and one social stimulus (a stranger). The infant was placed in a bouncer mounted on a table, and the parent sat on a chair behind the infant during the tasks. The visual stimuli were three mobiles with hanging balls with flashing lights, each presented twice in increasing intensity (with one, three and seven balls) in six consecutive trials of 20-s intervals with 10-s breaks between trials. The olfactory stimuli were distilled water, water with a low (.001 %), and high (.002 %) concentration of butanol, each presented twice in increasing intensity in 6 trials of 5 s, with 5-s breaks between trials. In each trial, the experimenter held the q-tip with the olfactory stimuli 3 cm away from the child’s nose for 5 s. The auditory stimuli were three tones of increasing intensity (55 (+/-) dB, the 65 (+/-) dB and 75 (+/-) dB), each presented twice in 6 consecutive trials of 10-s intervals, with 10-s breaks between trials. The social stimulus was a male stranger who gradually approached the infant while greeting him/her and picked him/her up from the chair (4 intervals lasting 5 to 15 s each). The task started when the stranger knocked on the door and entered the observation room (5 s). After standing close to the door for 10 s, he gradually walked towards the infant (10 s), stopped and greeted him/her: “Hello (name of the child), I come a bit closer”. Next, the stranger approached the baby until he was 30 cm away from the bouncer. He kneeled down and talked to the infant for 15 s with a friendly but neutral attitude. The stranger then stood up, approached the table and said to the infant: “I am now going to pick you up”. Finally, the stranger picked up the baby and held him/her on his arm for 15 s while looking at him. The task finished with the stranger putting the baby back in the bouncer and leaving the room. Two observers were trained to code infants’ behaviors. Observers were blind to parents’ diagnostic status. To test inter-observer reliability of obtained scores, 19 % of the infant recordings were double-coded. Average inter-rater reliabilities (ICC) across the four tasks was .80 (SD = .08) for negative facial expressions, .68 (SD = .32) for protest, and .97 (SD = .06) for crying. The internal consistency of emotion scores across the four tasks was .60.

Data Analysis

Outcome variables

Outcome variables for singular occurrences were the durations (in seconds) of parents’ (positive vs. neutral) facial expressions, and of infants’ (positive, and negative vs. neutral) facial expressions (see Table 2 for descriptives). The outcome variables for consecutive occurrences (sequential synchrony) were parents’ and infants’ frequencies of following each other’ expressions with synchronous (i.e., positive with positive, and non-positive with non-positive) vs. with asynchronous (i.e., positive with non-positive, and non-positive with positive) expressions. These were obtained via lag-sequential analyses (consecutive occurrences defined as within the following 2-s time lag after the onset of the recipients’ behavior).
Parent-infant face-to-face interactions

Preliminary analyses
The associations between continuous predictors (i.e., parents’ depressive and anxiety symptoms, infants’ temperament, the number of days that parents spend on child care) and the continuous outcome variables (i.e., duration of parents’ positive and neutral expressions, and duration of infants’ positive, negative, and neutral expressions) were first inspected via zero-order correlations, and next with partial correlations after controlling for infants’ gender.

Main analyses
Hypotheses on the durations of parents’ and infants’ expressions of affect were tested with multilevel models. The structure of the multilevel model for the duration of parents’ facial expressions as the outcome consisted of the repeated observations of emotion (duration of positive vs. neutral expressions for parents) nested within parent gender (mother vs. father), nested within family. The structure of the multilevel model for the duration of infants’ facial expressions as the outcome consisted of the repeated observations of emotions (duration of positive and negative vs. neutral expressions for parents) nested within visits (mother vs. father visit), nested within family. Inspection of distributions for the durations indicated sufficient normality; skewness and kurtosis of all variables were < |2|, except for infants’ negative reactivity. Four outliers (> 2.5 SD) were replaced by the next most extreme value at to the end of the distribution. Scores on all continuous variables were standardized. The intercept was a fixed effect, along with other predictors. Emotion was dummy-coded with neutral facial expressions as reference. Child gender, parent gender, and parental diagnoses were dummy-coded with girls, mothers, and parents without diagnosis as the reference group respectively.

Duration of infants’ and parents’ facial expressions was first analyzed with a main effects model including the main effect of emotion (consisting of the repeated observations of durations of positive, negative and neutral expressions for infants, and of positive and neutral expressions for parents), parent gender and infant gender, lifetime parental depression and anxiety diagnoses, and infant negative temperament. Theoretically relevant interactions were then added one-by-one to both models. Significant interaction terms were kept in the model. The effects of continuous predictors are interpreted with the 95 % confidence bands representing continuously plotted confidence intervals (Preacher, Curran, & Bauer, 2006). First, the interaction between parent gender and emotion was included in the models to investigate the differences between mother-infant vs. father-infant face-to-face interactions. Second, to test the differences between fathers and mothers with and without lifetime diagnoses, the interaction between parent gender and lifetime diagnoses was included. Third, the two-way interactions of emotion with parental diagnoses, and with infants’ negative temperament were tested to see if infants’ and parents’ expressions change as a function of parental diagnoses or infant negative
temperament. Fourth, to test differences between same-sex vs. opposite-sex dyads the cross-level interaction between parent gender and infant gender was included. Finally, the two-way interactions of infant gender with parental diagnoses, and with infant temperament were included to explore whether the association of parental depression and anxiety diagnoses and of infant temperament with parents’ and infants’ expressions of emotions differ between girls and boys. In the analyses of the duration of infants’ expressions of affect, we tested two other predictors in an additional step. These were the duration of parents’ facial expressions and the number of days infants were cared by mothers and fathers as predictors of infants’ expressions of affect. In addition to main effects, the two-way interactions of these variables with emotion were tested to see whether the associations differ across emotion categories.

Hypotheses on the frequencies for infants’ and parents’ sequential synchrony were analyzed via multilevel models. The structure of the multilevel model for the frequencies for infants’ and parents’ synchrony as the outcome consisted of (repeated observations of synchronous vs. asynchronous expressions) nested within visits (with mother vs. father), nested within family. A negative binomial distribution was used, as the distributions were highly skewed to the right and 63 % of parents’ and 56 % of infants’ frequencies of following each other’s facial expressions was 0 during the interaction. Predictors were the main effects and two-way interactions of synchrony (synchronous vs. asynchronous), parent gender and parental diagnoses. The significance of the effects was evaluated at $p \leq .05$.

**Exploratory Analyses**

In addition to the main analyses outlined above, we were interested in exploring one additional research question concerning parents’ lifetime depression and anxiety. To test the specificity of the effects of parental lifetime disorders on parents’ expressions of emotion, it is necessary to include parents’ lifetime diagnoses as categorical variables in the current analyses. However, dichotomizing parental psychopathology results in the loss of variance that may explain individual differences in parents’ and infants’ expressions of emotion. To address this issue, we repeated the same multilevel analyses and tested the same interactions on the durations of facial expressions (described above) with lifetime symptom counts of depression and anxiety instead of categorical variables of parents’ diagnostic status.
RESULTS

Preliminary Analyses
None of the raw and partial correlations between infants’ expressions of affect and the continuous predictors (i.e., parents’ depressive and anxiety symptoms, infants’ temperament, the number of days that parents spend on child care) were significant, except for the association between fathers’ depressive symptoms and infants’ expressions of positive affect after controlling for infants’ gender ($r = -.21, p = .048$). Infants of fathers with more depressive symptoms were less positive during father-infant interactions.

Among the raw associations between parents’ expressions of affect and the predictors, the correlation between maternal depressive symptoms and mothers’ expressions of positive affect ($r = -.38, p < .001$), and between maternal depressive symptoms and maternal expressions of neutral affect ($r = .38, p < .001$) were significant. Mothers with more depressive symptoms were less positive and more neutral during their interactions. Both of the associations remained significant after controlling for infant gender. The associations of infant temperament with fathers’ expressions of positive affect ($r = -.21, p = .046$), and with fathers’ expressions of neutral effect ($r = .21, p = .042$) were significant only after controlling for infants’ gender. Fathers of infants with a more negative temperament were less positive and more neutral during face-to-face interactions. None of the raw or partial associations between continuous predictors were significant, except for the positive association between parents’ depressive and anxiety symptoms both for mothers and fathers ($r = .36, p < .001$, and $r = .21, p = .043$ respectively).

Main Analyses
The findings from the multilevel models are presented below under separate headings for each outcome variable. Although infants’ temperament was initially included in the models, neither main effect nor the two-way interactions of this variable with parental diagnoses, infant gender, or with emotion were significant in the current models. This variable is therefore not further considered in the models.
Table 3. Multilevel regressions of the percentage duration of parents’ expressions of affect (outcome) on parent gender and infant gender, and parental lifetime diagnoses (3.a) or symptoms (3.b).

<table>
<thead>
<tr>
<th></th>
<th>3.a (N = 101, R^2 = .63)</th>
<th></th>
<th>3.b (N = 101, R^2 = .64)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>SE</td>
<td>P</td>
</tr>
<tr>
<td>Intercept</td>
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<td>.07</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Positive</td>
<td>2.05</td>
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<td>&lt; .001</td>
</tr>
<tr>
<td>Parent gender</td>
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<td>.10</td>
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</tr>
<tr>
<td>Infant gender</td>
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<td>.00</td>
<td>.365</td>
</tr>
<tr>
<td>Parental anxiety diagnosis</td>
<td>0.04</td>
<td>.08</td>
<td>.644</td>
</tr>
<tr>
<td>Parental depression diagnosis</td>
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<td>.09</td>
<td>.067</td>
</tr>
<tr>
<td>Positive * Parent gender</td>
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<td>&lt; .001</td>
</tr>
<tr>
<td>Positive * Parental anxiety diagnosis</td>
<td>-0.08</td>
<td>.16</td>
<td>.647</td>
</tr>
<tr>
<td>Positive * Parental depression diagnosis</td>
<td>-0.33</td>
<td>.18</td>
<td>.065</td>
</tr>
</tbody>
</table>

*Note: Positive = positive (vs. neutral) emotion, negative = negative (vs. neutral) emotion.

Duration of parents’ facial expressions
The model for parents’ facial expressions is presented in Table 3.a. Among theoretically relevant interactions, only the two-way interaction of emotion with parent was significant in this model. While both parents were more positive than neutral, mothers were significantly more positive than fathers. Infant gender did not predict parents’ expressions of affect during the face-to-face interaction. The two-way interaction between emotion and parental depression revealed a trend towards less positive affect from parents with lifetime depression. To further inspect this interaction, we performed analyses stratified on parent gender. Analyses of separate effects in mothers’ and fathers’ expressions of affect revealed a significant interaction between parental depression and emotion for mothers (β = -0.54, SE = .21, p = .013) but not for fathers (β = -0.22, SE = .42, p = .957). Mothers (but not fathers) with depression were less positive than mothers without diagnosis. The effect of parental anxiety was not significant.
To explore the effects with lifetime depression and anxiety symptoms instead of diagnoses, we repeated the same model with parents’ lifetime depression and anxiety symptoms. This model appears in Table 3.b. The results were similar to the model presented above, except that the interaction between emotion and parents’ depression was significant in this model ($\beta = -0.25$, $SE = .07$, $p = .001$). Analyses of separate effects in mothers’ and fathers’ expressions of affect however, revealed a significant interaction between parental depression and emotion for mothers ($\beta = -0.10$, $SE = .03$, $p < .001$) but not for fathers ($\beta = -0.04$, $SE = .06$, $p = .499$). Thus, mothers, but not fathers with more depressive symptoms were less positive during face-to-face interaction.

### Table 4. Multilevel regressions of the percentage duration of infants’ expressions of affect (outcome) on parent and infant gender, and parental lifetime diagnoses (4.a) or symptoms (4.b).

<table>
<thead>
<tr>
<th></th>
<th>4.a ($N = 101$, $R^2 = .65$)</th>
<th>4.b ($N = 101$, $R^2 = .66$)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\beta$</td>
<td>SE</td>
</tr>
<tr>
<td>Intercept</td>
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<td>.07</td>
</tr>
<tr>
<td>Positive</td>
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</tr>
<tr>
<td>Negative</td>
<td>-1.76</td>
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<tr>
<td>Parent gender</td>
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<td>.08</td>
</tr>
<tr>
<td>Infant gender</td>
<td>0.00</td>
<td>.05</td>
</tr>
<tr>
<td>Parental anxiety diagnosis</td>
<td>0.00</td>
<td>.06</td>
</tr>
<tr>
<td>Parental depression diagnosis</td>
<td>0.00</td>
<td>.06</td>
</tr>
<tr>
<td>Positive * Parent gender</td>
<td>-0.26</td>
<td>.12</td>
</tr>
<tr>
<td>Negative * Parent gender</td>
<td>0.05</td>
<td>.12</td>
</tr>
<tr>
<td>Positive * Parental anxiety symptoms</td>
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</tr>
<tr>
<td>Negative * Parental anxiety symptoms</td>
<td>0.14</td>
<td>.06</td>
</tr>
<tr>
<td>Positive * Parental depression symptoms</td>
<td>-0.21</td>
<td>.06</td>
</tr>
<tr>
<td>Negative * Parental depression symptoms</td>
<td>-0.11</td>
<td>.06</td>
</tr>
</tbody>
</table>

*Notes: Positive = positive (vs. neutral) emotion, negative = negative (vs. neutral) emotion.*
Duration of infants’ facial expressions

The model for infants’ facial expressions with parental diagnoses is presented in Table 4.a. Among theoretically relevant interactions that were tested, the two-way interaction between parent gender and positive emotion was significant in this model: Infants were more positive with mothers than with fathers. The effects of parental diagnoses, and of infant gender were not significant.

To explore the effects with lifetime depression and anxiety symptoms we ran the same model with parents’ lifetime depression and anxiety symptoms instead of diagnoses. This model appears in Table 4.b. In addition to the interaction between parent gender and positive emotion revealing that infants express more positive affect with mothers than with fathers, the two-way interactions between emotion and parental depression, and between emotion and parental lifetime anxiety disorders were significant in this model. More depressive symptoms predicted less positive affect from infants, while more anxiety symptoms predicted more positive and more negative affect. In the following steps, parents’ expressions of positive emotion, and the number of days that each parent spends in care per week were included as additional predictors to the models presented in Table 4. The days spent in care did not significantly predict the duration of infants’ facial expressions, while parents’ durations of positive affect did.

The models after the inclusion of this variable appear in Table 5 (in 5.a with lifetime diagnoses and in 5.b with symptoms of depression and anxiety). The interaction between the duration parents’ positive affect and emotion was significant in both models, revealing that infants were less negative when parents were more positive. The model with parental diagnoses additionally revealed that infants were more positive when the parents were more positive. After the inclusion of this effect, the interaction between parents’ gender and emotion became non-significant in both models, revealing that the differences in infants’ expressions of positive affect with mothers vs. fathers are accounted for by the differences in mothers’ and fathers’ duration of positive affect during the interaction. Note that more depressive symptoms in parents predicted less positive and less negative affect from infants in this model.

Parents’ and infants’ sequential synchrony of facial expressions

The models for the frequency of parents’ (N = 101) and infants’ (N = 101) following of facial expressions revealed significant main effects of synchrony (marginally significant in infants’ model) and of parent, while no other effect was significant. The main effect of synchrony showed that parents more frequently followed infants with synchronous (M = 0.76, SD = 1.22) than with asynchronous (M = 0.49, SD = 0.83) facial expressions (β = .45, SE = .16, p = .005). Fathers (M = 0.90, SD = 1.46) followed more frequently (β = .48, SE = .17, p = .005) with synchronous facial expressions than mothers (M = 0.62,
Table 5. Multilevel regressions of the percentage duration of infants’ expressions of affect (outcome) on parent and infant gender, and parental lifetime diagnoses (5.a) or symptoms (5.b) after the inclusion of parents’ percentage duration of positive affect.

<table>
<thead>
<tr>
<th></th>
<th>β</th>
<th>SE</th>
<th>p</th>
<th></th>
<th>β</th>
<th>SE</th>
<th>p</th>
</tr>
</thead>
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<td>Intercept</td>
<td>1.09</td>
<td>.06</td>
<td>&lt; .001</td>
</tr>
<tr>
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<td>.09</td>
<td>&lt; .001</td>
<td>Positive</td>
<td>-1.59</td>
<td>.09</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Negative</td>
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<td>.09</td>
<td>&lt; .001</td>
<td>Negative</td>
<td>-1.69</td>
<td>.09</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Parent gender</td>
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<td>.09</td>
<td>.289</td>
<td>Parent gender</td>
<td>0.10</td>
<td>.09</td>
<td>.261</td>
</tr>
<tr>
<td>Infant gender</td>
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<td>.998</td>
<td>Infant gender</td>
<td>0.00</td>
<td>.05</td>
<td>.998</td>
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<tr>
<td>Parental anxiety diagnosis</td>
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<td>.988</td>
<td>Parental anxiety symptoms</td>
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<td>.005</td>
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<td>Parental depression diagnosis</td>
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<td>.06</td>
<td>1.000</td>
<td>Parental depression symptoms</td>
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<td>Positive * Parent gender</td>
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<td>.13</td>
<td>.103</td>
</tr>
<tr>
<td>Negative * Parent gender</td>
<td>-0.09</td>
<td>.13</td>
<td>.453</td>
<td>Negative * Parent gender</td>
<td>-0.10</td>
<td>.13</td>
<td>.445</td>
</tr>
<tr>
<td>Parents’ % duration of positive affect</td>
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<td>.04</td>
<td>.662</td>
<td>Positive * Parental anxiety symptoms</td>
<td>0.19</td>
<td>.06</td>
<td>.002</td>
</tr>
<tr>
<td>Positive * Parents’ % duration of positive affect</td>
<td>0.13</td>
<td>.06</td>
<td>.046</td>
<td>Negative * Parental anxiety symptoms</td>
<td>0.18</td>
<td>.06</td>
<td>.004</td>
</tr>
<tr>
<td>Negative * Parents’ % duration of positive affect</td>
<td>-0.18</td>
<td>.06</td>
<td>.004</td>
<td>Positive * Parental depression symptoms</td>
<td>-0.19</td>
<td>.06</td>
<td>.003</td>
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<tr>
<td>Positive * Parental anxiety symptoms</td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Negative * Parental depression symptoms</td>
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<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Parents’ % duration of Positive Affect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Positive * Parents’ % duration of positive affect</td>
<td></td>
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<td></td>
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<td></td>
</tr>
<tr>
<td>Negative * Parents’ % duration of positive affect</td>
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<td></td>
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</tr>
</tbody>
</table>

Note: Positive = positive (vs. neutral) emotion. negative = negative (vs. neutral) emotion.
In line, infants more often followed parents (marginally significant, $\beta = .29$, $SE = .15$, $p = .053$) with synchronous ($M = 0.92$, $SD=1.29$) than asynchronous affects ($M= 0.69$, $SD = 1.11$), while they more frequently synchronized ($\beta = .39$, $SE = .15$, $p = .007$) with father’s ($M = 1.07$, $SD = 1.60$) than with mother’s ($M = 0.84$, $SD = 1.23$) affect. Parental lifetime diagnoses did not predict sequential synchrony.

## DISCUSSION

The present study investigated infants’ and parents’ facial expressions during face-to-face interactions at 4 months, and explored for the first time the effects of maternal and paternal lifetime diagnoses and symptoms of depression and anxiety (without comorbid depression), along with infants’ negative temperament.

### Parents’ and Infants’ Facial Expressions and Synchrony

Although both parents were predominantly positive, mothers were more positive than fathers during the interaction. Infants also expressed more positive affect with mothers than with fathers. In line with previous observations (Belsky et al., 1984; Forbes et al., 2004), our findings reveal more positive affect in mother-infant than in father-infant dyads.

Although both parents and infants seem to more frequently follow each other with synchronous than asynchronous affects, a higher frequency of interactive synchrony occurred during the father-infant interactions than during the mother-infant interactions, and more stable but positive interaction were observed during the mother-infant interactions compared to the father-infant interactions. Similar variation and dynamicity in infant-father interactions was found in Feldman’s study (2003) where mother-infant interactions were characterized by cyclical patterns of low or moderate levels of positive arousal, while father-infant interactions were characterized by several unpredictable peaks of high positive arousal. Feldman suggested that inter-parental differences in mother-infant and father-infant interactions may be related to the different patterns of affective sharing and positive arousal patterns that mothers and fathers show with their infant. Similarly, Kokkinaki and Vasdekis (2015) found that infant-father interactions were characterized by a stronger emotional matching (when one partner is expressing the same facial expression during the other partners’ expression) and by a stronger emotional attunement (when one partner matches the shifts of emotional intensity of the other partner). The present study provides further evidence on these differences between fathers’ and mothers’ interactional style that seem to reflect two different modes to express sensitivity, which is more regulatory and soothing in the case of the mother, and more stimulating and dynamic in the case of the father.
Parent-infant face-to-face interactions

Parallel findings in infants’ and parents’ expression/synchronization of affect reveal that infants’ tune in to moment-to-moment differences in parents’ expression and synchronization of affect. Previously, it was reported that the positive association between infants’ and parents’ expressions of positive affect accounts for the differences in infants’ expressions of positive affect with mothers vs. fathers (Forbes et al., 2004). In contrast, the current findings revealed less negative affect when parents express more positive affect. In line with the findings of Forbes and colleagues, this association accounted for the differences in infants’ expressions of positive affect with mothers vs. fathers in the current study. The differences in infants’ overall exposure to mothers’ vs. fathers’ (measured by the number of days in child care) however, did not predict infants’ facial expressions of emotions. Thus, it seems that infants’ moment-to-moment exposure to parents’ expressions of positive affect during the interaction, rather than infants’ overall frequency/duration of exposure to mothers and fathers determines the dynamics of the early affective exchanges.

The Effect of Parental Lifetime Diagnoses/Symptoms and Infants’ Negative Temperament

Consistent with previous evidence (Campbell, et al. 1995; Cohn et al., 1990), mothers with lifetime depression diagnoses (and with more depressive symptoms) were less positive than mothers without diagnosis in the current study. In contrast, paternal lifetime depression did not affect fathers’ expressions of positive affect during the interaction. Depression may be more salient in the duration of mothers’ than fathers’ facial expressions of emotion during the interaction because positive affect is more salient in facial expressions of mother-infant than in father-infant interactions.

In line with previous studies, current findings support the idea that depression interferes with mothers’ facial expressions of positive affect in face-to-face interactions. Thus, interventions aiming at increasing positive facial expressions in depressed mothers during mother-infant face-to-face interactions may be crucial in the prevention of mother-to-infant transmission of depression (Bureau, Easterbrooks, & Lyons-Ruth, 2009). These interventions need to be considered in addition to treatments targeting depressive symptoms, as treating symptoms does not seem to necessarily improve depressed parents’ decreased sensitivity during mother-infant face-to-face interactions or the quality of the parent-child relationship (Forman et al., 2007). In contrast to previous findings (Campbell, et al. 1995; Cohn et al., 1990), lifetime depression diagnosis did not influence infants’ expressions of affect, and infants’ or parents’ sequential synchrony, revealing that the effect of maternal lifetime depression diagnosis may not always be visible in infants’ expressions of affect and infants and parents’ synchrony in face-to-face interactions. Nevertheless, once depressive symptoms were considered, more depression symptoms in parents predicted less positive affect in infants. After controlling for parents’ expressions
of positive affect, infants of parents with depression expressed less negative, and less positive affect. Thus, it seems that infants of parents with more severe forms of depression are more likely to express more neutral affect after controlling for parents’ positive affect.

It is important to note that the current finding pointing to a lack of depression-related alterations in the facial expressions of positive affect in the father-infant dyad does not preclude the possibility that depression-related alterations occur in other aspects of the father-infant interactions, for example, in the vocal or physical domain. Considering unique and distinct associations of mothers’ and fathers’ depression with later emotional and behavioral outcomes (Bureau, et al., 2009; Ramchandani, Stein, Evans, & O’Connor, 2005), and distinct patterns of positive arousal regulation by mothers and fathers in early interactions (Feldman, 2003), it is important to further investigate depression-related alterations in father-infant interactions by incorporating the intensity together with the duration and frequency of affect, and by considering the vocal and physical aspects of the positive affective exchanges in addition to facial expressions.

Neither maternal nor paternal anxiety diagnoses/symptoms predicted parents’ expressions of affect or synchrony. Taken together with the previous evidence by Kaitz et al. (2010), findings suggest that anxiety diagnoses without comorbid depression do not affect parents’ positive affect expression and parent-infant synchronization in dyadic face-to-face interactions. The clinician-rated lifetime severity was comparable between parents with depression (with and without anxiety disorders) and anxiety diagnoses (alone) --due to high comorbidity of anxiety disorder subtypes--, thus the difference in the effects of depression and anxiety does not seem to be caused by group differences in severity of psychopathology. We therefore suggest that flat/neutral affect, which is characteristic of depression but not of anxiety, may be mediating the link between parental diagnoses and parents’ expressions of affect in early dyadic parent-infant interactions. Because anxious responses of parents are specific to certain external stimuli, the increase in anxious parents’ negative emotion expressions may be more salient in the presence of anxiety-provoking stimuli in triadic parent-infant-object interactions (e.g., Aktar, Majdandžić, De Vente, & Bögels, 2013; De Rosnay, Cooper, Tsigaras, Murray, 2006; Murray et al., 2008) than in face-to-face interactions. During triadic interactions that emerge later in the first year, the parent and infant express/share affect in response to an external stimulus (person, object, or event) in the environment.

Lifetime diagnoses of anxiety did not predict infants’ expressions of affect, while higher levels of anxiety symptoms in parents were linked to more positive and more negative affect in infants. Thus, in contrast to infants of parents with depression, infants of parents with anxiety were more emotionally reactive/less emotionally
stable than infants of parents without diagnoses in the early interactions. In addition, infants’ negative temperament did not predict their affective expressions. Thus, it seems that infants’ affective reactions to ambiguous/potentially threatening stimuli in the environment may not always match their expressions of affect in the safety of everyday face-to-face interactions.

The findings of the current study should be interpreted considering the following limitations: First, the non-experimental design of the study precludes any causal inferences on the effect of parental diagnoses and infant temperament on facial expressions during parent-infant face-to-face interactions. Second, the effect of parents’ and infants’ negative dispositions were analyzed separately on parents’ and infants’ affect while the bidirectionality of influences in parent-infant interactions was not simultaneously analyzed. Third, because the prevalence of lifetime parental depression without anxiety diagnosis was low in the current sample, the study was underpowered to examine parental depression effects without anxiety. Fourth, parent psychopathology was measured prenatally, while face-to-face interactions were assessed at four-month postpartum. Because parents’ psychopathology was measured before the interactions, the effect of current depression and anxiety diagnoses could not be examined in the current sample. Finally, the current study utilized a highly educated, higher middle class Dutch sample (Henrich, Heine & Norenzayan, 2010), thus the findings may not represent the general population of parents with depressive and anxiety disorders, and may differ in other cultures (Carra, Lavelli, Keller, & Kärtner, 2013).

CONCLUSIONS

The present study provides insight into parent-infant early emotional interactions, and the effect of parental psychopathology. While mother-infant interactions are characterized by more positive emotionality, father-infant interactions appear to be more synchronous and dynamic. The study adds to previous evidence by showing that maternal lifetime diagnoses of depression are linked to less positive affect from mothers during face-to-face interactions with their infant, while revealing that this link may be specific to maternal depression diagnoses and mothers’ expressions, and may not generalize to anxiety diagnoses, and to fathers.
CHAPTER 3

The interplay between parents’ expressions of anxiety and infants’ temperament predicts infant avoidance in a social referencing paradigm

Evin Aktar
Mirjana Majdandžić
Wieke De Vente
Susan M. Bögels

This chapter is based on Aktar, E., Majdandžić, M., De Vente, W., & Bögels, S. M. (2013). The interplay between expressed parental anxiety and infant behavioral inhibition predicts infant avoidance in a social referencing paradigm. Journal of Child Psychology and Psychiatry, 54, 144-156.
ABSTRACT

Background: Anxiety aggregates in families. Environmental factors such as modelling of anxious behaviors are assumed to play a causal role in the development of child anxiety. We investigated the predictive value of paternal and maternal anxiety (lifetime anxiety disorders and expressed parental anxiety) on infants’ fear and avoidance during encounters with social and nonsocial novel stimuli in a social referencing (SR) paradigm. Methods: A total of 122 12-month old infants participated in this study separately with their fathers and mothers (parents with lifetime: social anxiety disorders \( n = 47 \), other types of anxiety disorders \( n = 33 \), comorbid social and other types of anxiety disorders \( n = 52 \), and without anxiety disorders \( n = 112 \)). Infants were confronted with a stranger and a mechanical dinosaur as novel stimuli in two SR situations. Infants’ avoidance as well as fear and parents’ expressed anxiety were observed. Infants’ behavioral inhibition (BI) was separately observed in structured tasks. Results: Parental lifetime anxiety disorders did not significantly predict infant fear or avoidance. Expressed parental anxiety interacted with BI to significantly predict infant avoidance, revealing a positive association between expressed parental anxiety and infant avoidance among infants with moderate-to-high BI. The association between infant avoidance and expressed parental anxiety was not significantly different for mothers and fathers, pointing to an equally important role of fathers at this young age. Infant fear was significantly predicted by infant BI but not by expressed parental anxiety. Conclusions: Infants with a temperamental disposition for anxiety (BI) may learn from both paternal and maternal anxious signals and become avoidant towards novelty when their parents express anxiety. This link between expressed parental anxiety and infant avoidance for moderate and high BI children, that seems to hold across contexts and to be independent of lifetime parental anxiety disorders, may be a mechanism explaining early intergenerational transmission of anxiety.
INTRODUCTION

Anxiety disorders are one of the most prevalent psychiatric conditions in adults (Kessler, Chiu, Demler, & Walters, 2005) and children (Kashani & Orvaschel, 1990). Evidence supports the view that anxiety disorders in parents contribute to the development of anxiety in children. In addition to moderate and non-specific genetic influences (Eley, 2001; Hettema, Neale, & Kendler, 2001), environmental influences seem to be more pronounced for the intergenerational transmission of anxiety (Bögels & Brechman-Toussaint, 2006; Murray, Creswell, & Cooper, 2009). Anxious parents may contribute to the development of childhood anxiety via anxious modelling and a lack of positive reinforcement on approaching unfamiliar or potentially threatening situations (i.e., encouragement; Fisak & Grills-Taquechel, 2007; Murray et al., 2009).

Evidence of early environmental influences of parental anxiety relies on the infants’ emerging social referencing (SR) skills towards the end of the first year (Carpenter, Nagell, Tomasello, Butterworth, & Moore, 1998). SR occurs when infants make use of the adults’ emotional signals to determine how to act when confronted with unfamiliar people, objects or situations (Feinman, 1982). SR may be a mechanism contributing to the early learning of fear from parents via observational learning and modelling: infants of anxious parents are more likely to be provided with expressions of parental anxiety (Muris, Steerneman, Merckelbach, & Meesters, 1996) during SR and may model anxious coping strategies (e.g., avoidance) from their parents (Fisak & Grills-Taquechel, 2007; Murray et al., 2009; Rapee, 2001).

Infant characteristics may also influence SR. Behavioral inhibition (BI), a biologically driven avoidant, fearful and withdrawn attitude towards novelty (Fox, Henderson, Marshall, Nichols, & Ghera, 2005; Kagan & Snidman, 1999; Rubin, Coplan, & Bowker, 2009) and a temperamental predisposition for childhood anxiety, has been found to moderate the effects of parental anxiety on infants’ avoidance during SR situations (Murray et al., 2008). Infants with high BI are at risk for developing anxiety disorders (Biederman, Rosenbaum, Chaloff, & Kagan, 1995; Rosenbaum et al., 1993), especially of the social type (Rubin et al., 2009). Studies have reported increased levels of BI in children of anxious parents (Rosenbaum et al., 1993).

The interplay between BI and modelling of parental anxiety via SR may play an important role in the development of child anxiety disorders. As suggested by diathesis-stress (Zuckerman, 1999) and vulnerability-stress models (Ingram & Luxton, 2005; Nigg, 2006), the temperamental predisposition of BI may constitute vulnerability for the effects of adverse rearing environments. The “differential susceptibility to environmental influences hypothesis” (Belsky & Pluess, 2009) is a recent extension of those models on the effects of positive rearing: highly inhibited children are not only assumed to be more susceptible to adverse rearing environments, but also to
benefit more from adaptive rearing environments, making them more open to the effects of the environment and parenting “for better and for worse” (Belsky & Pluess, 2009). All three models predict that high BI children may be the highest risk group with respect to the effects of anxious parenting via SR. The differential susceptibility to environmental influences hypothesis further predicts that high BI children would benefit the most from encouraging parenting.

To investigate the effects of anxious maternal reactions on child behavior via SR in an experimental design, mothers’ behavior towards novel social and nonsocial stimuli has been manipulated either through direct instructions or by training anxious responses (Bradshaw, Goldsmith, & Campos, 1987; De Rosnay, Cooper, Tsigras, & Murray, 2006; Dubi, Rapee, Emerton, & Schniering, 2008; Gerull & Rapee, 2002). Results from these studies provide support for a link between parental anxiety and child fear/avoidance: even a relatively brief negative (fear or disgust) reaction (range: 30 s to 1 min) from the mother may be enough for the toddlers to become fearful and avoidant towards a novel toy (Gerull & Rapee, 2002). The SR processes have also been experimentally investigated in response to strangers (De Rosnay et al., 2006), and the results provide evidence for the vulnerability of high BI infants to the negative influence of anxious maternal reactions.

Only one study has investigated SR processes with clinically anxious mothers. Murray et al. (2008) examined the transmission of anxiety among mothers with \( n = 79 \) and without \( n = 77 \) social anxiety disorder at 10 and 14 months to investigate whether the co-emergence of SR and stranger anxiety (Sroufe, 1977) during late infancy makes infants vulnerable to parental social anxiety. This SR paradigm allowed the infant to observe the mother in interaction with a stranger who subsequently approached the infant and interacted with him/her. The paradigm enabled studying the link between maternal anxiety and simultaneous and subsequent infant fear/avoidance towards the stranger. Socially anxious mothers showed more anxiety than reference mothers at both assessments. Murray et al. (2008) also observed a longitudinal change with high BI children of socially anxious mothers becoming more avoidant from 10 to 14 months, supporting the central assumption of vulnerability-stress models. Furthermore, the interplay between parental social anxiety disorder and infant BI was accounted for by lower levels of encouragement in mothers with social anxiety disorders.

Murray et al. (2008) provided the first evidence of early transmission of anxiety with clinically anxious mothers via SR. Nevertheless, several aspects of this transmission await further investigation. First, information on paternal effects is absent. Recent models on the development of anxiety (Bögels & Perotti, 2011; Bögels & Phares, 2008) assign fathers an essential role in the development of anxiety based on their greater evolutionary experience in exploring the external world. Therefore, the inclusion of fathers with and without anxiety disorders on infant SR studies is needed.
Expressed parental anxiety and infant behavioral inhibition

Second, it remains unknown whether the transmission only occurs from socially anxious mothers or also from healthy mothers or mothers with other types of anxiety disorders. Third, it remains unclear whether the transmission occurs only in contexts that provoke social anxiety, or whether it also applies to other, nonsocial contexts.

In this study, we observed 12-month-old infants’ responses to novelty in SR situations. Firstly, we aimed to extend the current knowledge of SR processes by exploring the fathers’ role in the intergenerational transmission of anxiety via SR. We expected that fathers would be as important as mothers in the transmission of anxiety. On the basis of previous evidence with mothers, infants were expected to show more fear/avoidance if they were highly behaviorally inhibited, if their parents had a lifetime anxiety disorder or if their parents had high levels of expressed anxiety during the task. Second, in light of the differential susceptibility hypothesis, a larger negative influence of expressed parental anxiety, and a larger positive influence of parental encouragement on infant fear/avoidance was expected for high BI infants in both SR situations. Third, to explore diagnosis dependency and anxiety subtype specificity in the transmission of anxiety, we included infants of parents with lifetime social anxiety disorder, with other types of anxiety disorders, with comorbid social and other types of anxiety disorders and parents without anxiety disorders. If parental expressions of anxiety are diagnosis-dependent, one would expect higher levels of expressed anxiety among parents with lifetime anxiety disorders (vs. parents without lifetime anxiety disorders). If parental expressions of anxiety are diagnosis-specific, then one would expect that the link between lifetime anxiety disorders and expressed parental anxiety would differ as a function of the type of parental lifetime anxiety disorders. Similarly, if the transmission of anxiety is diagnosis-dependent, one would expect higher levels of fear/avoidance among infants of parents with (vs. without) lifetime anxiety disorders. If the transmission of anxiety is diagnosis-specific, then one would expect that the link between lifetime anxiety disorders and the infant fear/avoidance would differ as a function of the type of parental lifetime anxiety disorders. Fourth, to explore context specificity in the transmission of anxiety, we observed SR processes in response to a novel social (a stranger) or nonsocial (a remote control dinosaur) stimulus. If parental expressions of anxiety are context-specific, then one would expect that the link between lifetime anxiety disorders and expressed parental anxiety would differ between the social and nonsocial SR situations. Similarly, if the transmission of anxiety is context-specific, then one would expect that the link between expressed parental anxiety and infant fear/avoidance would be different in social versus nonsocial SR situations.
Chapter 3

METHODS

Participants
The sample consisted of 122 couples with their 12-month-old first-born infant. The families are part of a larger group of participants recruited from the general population for an ongoing longitudinal study on social development from infancy to middle childhood, which includes a prenatal measurement (see below) and a 4-month measurement (not used in this study). Couples expecting their first child were recruited via advertisements in magazines and on parenting websites, or via flyers provided by midwives, pregnancy courses, and baby shops. The project was approved by the ethics committee of the Department of Psychology. Participants provided written informed consent prior to their participation.

The SR tasks were completed by 120 mothers and 122 fathers. Age and sociodemographic characteristics of the sample are presented in Table 1.

Table 1. Sociodemographic characteristics of the sample

<table>
<thead>
<tr>
<th></th>
<th>Mothers</th>
<th>Fathers</th>
<th>Girls</th>
<th>Boys</th>
</tr>
</thead>
<tbody>
<tr>
<td>N</td>
<td>122</td>
<td>122</td>
<td>67</td>
<td>55</td>
</tr>
<tr>
<td>Age M (SD)</td>
<td>31.78 (4.20)</td>
<td>34.64 (5.33)</td>
<td>1.03 (0.06)</td>
<td>1.00 (0.04)</td>
</tr>
<tr>
<td>Dutch origin</td>
<td>90.98 %</td>
<td>95.08 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dutch parental origin</td>
<td>M 90.16 %</td>
<td>94.26 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>F 84.43 %</td>
<td>93.44 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Educational level a M (SD)</td>
<td>7.06 (1.13)</td>
<td>6.62 (1.53)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Professional level b M (SD)</td>
<td>8.73 (2.09)</td>
<td>8.17 (2.66)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current working status c HK</td>
<td>3.40 %</td>
<td>1.80 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PT 77.60 %</td>
<td>26.30 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>FT 10.30 %</td>
<td>67.50 %</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monthly income d M (SD)</td>
<td>4.11 (1.41)</td>
<td>4.61 (1.33)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


a Parental educational level was assessed with an 8-point scale ranging from 1 (primary education) to 8 (university).
b Parental professional level was assessed with an 11-point scale ranging from 1 (manual labour for which no education is required) to 11 (labour for which a university degree is required).
c Parental income was assessed with a 7-point scale from 1 (less than 500 euros/month) to 7 (more than 5000 euros/month).
Materials and Procedure
Each parent visited the lab separately when his/her infant was 12-month-old: 54 % of the infants visited with their mother first, and 46 % with their father. The order of the parental visits was included in the analyses as a control variable. Measurements of infant BI and SR were conducted and recorded during these visits (three additional BI tasks were conducted during a home visit). BI tasks were conducted before the SR tasks during the visits.

Parental anxiety status
Each parent’s anxiety status was obtained via the Anxiety Disorder Interview Schedule (ADIS; Di Nardo, Brown, & Barlow, 1994). The ADIS is a semi-structured clinical interview based on DSM-IV criteria and was conducted at the prenatal measurement by four trained and experienced interviewers (psychology/educational sciences graduates) to assess the parent’s current and lifetime anxiety disorder status. Agreement about difficult cases was obtained by post-hoc consultation of an expert in anxiety disorders (SB). To establish inter-observer reliability, a trained psychologist recoded 10 % of the interviews that were videotaped in the prenatal measurement. The percentage inter-observer agreements for all ADIS diagnoses were based on the presence or absence of the specific anxiety disorder. The percentage inter-observer agreements ranged from 90 % to 100 % per anxiety disorder with a mean of 97.55 % (SD = 2.95).

As our theoretical interest was on the predispositions of parental anxiety, rather than expressed parental anxiety (that was separately observed during the task), we assigned parents to the following parental anxiety groups based on the current and/or lifetime anxiety diagnoses as measured in the prenatal interview: ‘social anxiety disorder’, ‘other types of anxiety disorders’, ‘comorbid social and other type(s) of anxiety disorders’ and ‘no anxiety disorder’ groups. None of the mothers were in treatment, whereas one father in the comorbid group was in treatment for anxiety problems. The sample sizes for each group are summarized in Table 2.

SR tasks
Stranger SR task. In phase I, a female stranger entered the room and engaged the parent in a 2-minute conversation about his/her experiences of parenthood, while the infant was watching the interaction from a high chair. In phase II, the stranger told the parent that she would pick up the infant and asked the parent to inform the infant. In phase III, the stranger gradually approached the infant, picked him/her up, lifted him/her in the air and put him/her on the floor (for more information, see Murray et al., 2008). The strangers maintained a neutral attitude during the SR task. Different strangers were used for the mother and father visits.
Table 2. Prevalence of lifetime anxiety diagnoses in the parent sample

<table>
<thead>
<tr>
<th></th>
<th>Mother</th>
<th></th>
<th></th>
<th>Father</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SA</td>
<td>OA</td>
<td>SA&amp;OA</td>
<td>None</td>
<td>TOTAL</td>
<td>TOTAL</td>
</tr>
<tr>
<td>Mother</td>
<td>5</td>
<td>5</td>
<td>7</td>
<td>7</td>
<td>24 (16)</td>
<td></td>
</tr>
<tr>
<td>Father</td>
<td>0</td>
<td>5</td>
<td>3</td>
<td>4</td>
<td>12 (7)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4</td>
<td>11</td>
<td>4</td>
<td>21 (8)</td>
<td></td>
</tr>
<tr>
<td>None</td>
<td>16</td>
<td>7</td>
<td>10</td>
<td>32</td>
<td>65</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>23 (14)</td>
<td>21 (16)</td>
<td>31 (15)</td>
<td>47</td>
<td>122</td>
<td></td>
</tr>
</tbody>
</table>

Notes: SA: Social anxiety disorder, OA: other types of anxiety disorders, SA&OA: social anxiety disorder and at least one other anxiety disorder, None: no anxiety disorder. Parental anxiety disorder groups were formed on the basis of current and/or past anxiety disorders. Information is provided on mothers and fathers separately as totals (in bold) and on how their disorders relate to each other as couples (parents of the same infant). For example, there are 7 mothers without anxiety diagnosis who have a partner with social anxiety disorder. The numbers in parentheses indicate the number of parents only with the current anxiety disorders.

Dinosaur SR task. A remote-control dinosaur was placed 2 m from the infant, and displayed a pattern of movements and noises. In phase I, parents remained neutral. In phase II, parents were instructed to talk about the dinosaur. In phase III, parents actively encouraged the infant to approach the dinosaur. Two different dinosaurs were used and counterbalanced between the mother and father visits. The order of tasks was fixed for each visit: first stranger, then dinosaur.

Murray et al.’s (2008) coding protocol was used to code parental and infant behavior in the stranger SR task. We developed a parallel coding scheme for the dinosaur SR task. All behavioral dimensions from parents and infants (see below) were rated on each time interval (coding units within a phase) as a single rating. The ratings were made on a 5-point scale unless stated otherwise.

Parent behavior during SR tasks
1. Expressed parental anxiety during SR tasks was based on facial (e.g., anxious, frozen faces), bodily (e.g., fidgeting, rigid posture) and verbal expressions of anxiety.
2. Parental encouragement involved encouragement of infant positive engagement with the stranger and of approach to the dinosaur through smiles and looks, or simple comments. This behavior was rated on a 3-point scale.
3. Parental overcontrol involved parental attempts to control or intervene during
SR situation (e.g., gesturing to the infant and signaling for the infant's attention when the infant has not sought attention, or making specific attributions on behalf of the infant.)

Infant behavior during SR tasks
1. Infant fear was based on facial (e.g., wide eyes, cry face), bodily (e.g., sunken-in posture, decrease in activity) and vocal (e.g., whining, crying) expressions of fear.
2. Infant avoidance involved behaviors like looking/turning away, hiding behind the parent, or ignoring the stimulus.
3. Infant approach to the stranger involved positive engagement: smiling, laughing to the stranger, positive vocalizations, and approach to the dinosaur: active attempts to approach or touch the dinosaur.
4. Infant baseline negativity was based on facial, bodily, and vocal expressions of negative emotional tone. It was rated in the last minute before the task started and used as a control variable as infants varied in their initial negativity before the SR tasks.
5. Infant’s looks at the parent were a count of the number of times the infant looked at the parent during SR situations. Looks at the parent are indicative of active information seeking and serve as a preliminary measure of the extent to which social referencing occurs during the SR tasks.

For the coding of infant and parent behavior, each phase was divided into 1-min or 30-s time intervals. In the stranger SR task, the time intervals in the second and third phases were determined by a given action of the stranger. Final scores in each dimension were obtained by averaging the interval scores. Two pairs of observers were trained to code either infant or parent behavior during SR. Observers were blind to parents’ diagnostic status and infants’ BI. To prevent potential carryover effects stemming from the observation of mother-infant and father-infant dyads of the same family, each observer in both pairs coded either the father (or the infant with father) or the mother (or infant with mother) of a family except for 20 % of the SR data that was double-coded for inter-observer reliability. The final scores for the double coded data were obtained by averaging the ratings of the two observers.

The inter-observer reliabilities for the parent and infant variables (intraclass correlations, ICC) were .78 for parental anxiety, .77 for parental encouragement, .90 for infant fear, .65 for infant avoidance, .75 for infant approach, .78 for infant baseline negativity, and .94 for looks at the parent. Parental overcontrol was not reliably coded and was only observed in 4.19 % of the measurements. This variable was not considered further.
Chapter 3

BI tasks

Infant BI was measured via 11 social and nonsocial tasks from several well-known standard BI laboratory instruments. Three tasks were from the Laboratory Temperament Assessment Battery (LAB-TAB; Goldsmith & Rothbart, 1996): stranger approach (a male stranger approached and picked up the infant), unpredictable mechanical toy (a large, remote controlled toy train drove across the table), and masks (the experimenter appeared from behind a curtain successively showing three masks). Three unpredictable mechanical toy tasks were modelled after Rothbart (1988): buzzing animal (a small vibrating animal toy was placed within arm’s reach distance of the infant), ambulance (a toy ambulance with light and sound rode towards the infant), and horse (a neighing toy horse approached the infant). Four discomfort tasks developed by Kochanska, Coy, Tjebkes, and Husarek (1998) were used: ice (an ice cube was held against the foot and the neck of the infant), lemon (the infant was given two spoons of diluted lemon juice), spray (water was sprayed on the infant’s face), and blender (the infant was exposed to the noise of a blender). Finally, the truck task (Calkins, Fox, & Marshall, 1996; Fox, Henderson, Rubin, Calkins, & Schmidt, 2001) was used: a female stranger came into the room, played with a toy truck with blocks, and invited the infant to join.

The BI tasks of unpredictable mechanical toy, stranger approach, and masks were administered in the mother’s visit, whereas truck and the four discomfort tasks were conducted in the father’s visit. Buzzing animal, ambulance, and horse were conducted during a home visit with both parents present. Parents sat behind the infant and remained neutral during the BI tasks. The order of the BI tasks was fixed for all infants.

For each BI task, several indices of infant behavior were coded, such as facial fear, bodily fear, escape, distress vocalizations, the latency to touch the toy, the latency of the first fear reaction, startle response, and proximity to parent (see Goldsmith & Rothbart, 1996).

The scores were first averaged across epochs (coding intervals), then standardized and averaged for each BI task, and then aggregated into a single BI score. Six observers were trained by a master coder (MM) to code the 11 BI tasks. To establish inter-observer reliability, the master coder coded 20% of each observer’s data pool. Average inter-observer reliability of coded variables was .83 (ICC ranged from .60 to .93, (SD = .11) per task, and from .39 to .99 (SD = .16) per variable). Among nineteen observed variables, two showed little variance and were not reliably coded: The first variable concerned the extent to which infants talked to the stranger in the truck task (ICC = .39; 79.68% of the infants did not talk.). The second variable was the startle response in the spray task (ICC = .56; 77.47% of the infants showed a startle response.). The internal consistency of the total score across the 11 BI tasks was .79.
Expressed parental anxiety and infant behavioral Inhibition

Statistical Analyses
The design consisted of two SR tasks (stranger and dinosaur) that were repeated with both parents, giving rise to a hierarchical data structure with four observations per infant. A two-level regression model (consisting of task and parent's gender) was fitted for each outcome variable (i.e., infant fear, infant avoidance, and expressed parental anxiety). The significance of the effects was evaluated at $p \leq .05$. Scores on continuous outcome and predictor variables were standardized. For each analysis, the levels task and parent gender, along with other predictors, and the intercept were analyzed using a fixed-effects model. Parental anxiety disorders were dummy-coded with parents without anxiety disorders as the reference group. Infant BI, expressed parental anxiety, parental encouragement, and looks at the parent were entered as continuous variables in the models. Inspection of distributions indicated sufficient normality for all variables except infant baseline negativity. As infants were neutral in the majority of the cases, this variable was categorized (0: neutral, 1: negative).

To check the assumptions of multilevel models, the distributions of residuals were checked for normality and linearity following the main analyses and found to be satisfactory. Maximum likelihood was the estimation method. Multilevel models were analyzed using PASW IBM Statistics 18, Release Version 18.0.3 (IBM, Somers, NY, USA).

Infant’s fear and avoidance were analyzed in separate multilevel models. Initially each model consisted of main effects (of parent gender, SR task, parental lifetime anxiety disorders, expressed parental anxiety during SR, parental encouragement, infant BI, looks at the parent, infant baseline negativity, and order of the visits) only. Subsequently, theoretically relevant interactions were added one by one to the main-effects model. Interaction terms were kept in the model or removed based on likelihood ratio tests and $t$-tests.

For the models of fear and avoidance, we first included the cross-level interaction between infant and parent gender to investigate whether boys’ and girls’ expressions of fear/avoidance differed between mother and father visits. Second, the cross-level interaction between parent gender and infant BI was included to investigate whether the link between infant BI and fear/avoidance differed across mothers and fathers. Third, we included the cross-level interaction between parent gender and expressed parental anxiety to investigate whether the link between infant fear/avoidance and expressed parental anxiety differed between mothers and fathers. Fourth, the cross-level interaction between parent gender and parental encouragement was included in the model to investigate whether the link between infant fear/avoidance and parental encouragement differed between mothers and fathers. Fifth, we tested the differential susceptibility hypothesis in the transmission of anxiety by adding the cross-level interactions between expressed parental anxiety and infant BI, and between parental encouragement and infant BI to the main effects model, to explore how the links of infant fear/avoidance with expressed parental anxiety,
and with parental encouragement differed as a function of infant BI. Finally, to test the context specificity in the transmission of anxiety, we included the interaction between expressed parental anxiety and the task in the models.

To investigate the link between parental lifetime anxiety disorders and expressed parental anxiety we regressed expressed parental anxiety on parental lifetime anxiety disorders in a multilevel model. The interactions of parental lifetime anxiety disorders with the task were entered in subsequent steps to test context specificity of expressed parental anxiety.

RESULTS

Preliminary Analyses

In the study by Murray et al. (2008), infant fear and avoidance during the stranger SR situation were treated as separate outcome measures, as there was no significant association between them and different patterns of results emerged with fear versus avoidance. In the current study, we first calculated the raw associations of fear and avoidance for separate SR tasks with each parent (see Table 3). There were moderate associations between them (with the exception of the fathers during the dinosaur SR task), with fear and avoidance sharing approximately 25-30 % of their total variances. Given the findings of Murray et al. (2008), we treated fear and avoidance as two distinct outcome measures despite their positive association. Second, infant approach was negatively associated with both fear and avoidance, but was not considered in this study due to the theoretical priority of negative reactions.

Third, to explore the role of looks at the parent as a potential mechanism for the transmission of anxiety, we computed the correlations between infant BI and looks at the parent. There was only a weak positive association between infant BI and looks at the parent in the stranger SR task in the mother visit, indicating that higher BI infants looked more often to their mother in the stranger SR. Fourth, we calculated the raw correlations between expressed parental anxiety and BI to test the overlap between expressed parental anxiety and BI in parent-infant dyads. This correlation seemed to indicate relatively stronger links between expressed maternal anxiety (vs. paternal) and BI, which may be reflecting greater maternal (vs. paternal) sensitivity to infant BI. Fifth, the correlation between expressed parental anxiety and parental encouragement was investigated following the previous findings of Murray et al. (2008) who found that anxious mothers encouraged their infants less. The correlation was only significant for the fathers in the dinosaur SR task.
Expressed parental anxiety and infant behavioral inhibition

Table 3. Raw correlations between infant measures of fear, avoidance and approach, between looks at the parent and infant BI, between expressed parental anxiety and infant BI, and between expressed parental anxiety and parental encouragement.

<table>
<thead>
<tr>
<th></th>
<th>Mother visit</th>
<th></th>
<th>Father visit</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SSR</td>
<td>DSR</td>
<td>SSR</td>
<td>DSR</td>
</tr>
<tr>
<td>r (infant fear, infant avoidance)</td>
<td>.53</td>
<td>.55</td>
<td>.24</td>
<td>.50</td>
</tr>
<tr>
<td>p</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>.009</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>r (infant approach, infant fear)</td>
<td>-.42</td>
<td>-.43</td>
<td>-.42</td>
<td>-.49</td>
</tr>
<tr>
<td>p</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>r (infant approach, infant avoidance)</td>
<td>-.31</td>
<td>-.30</td>
<td>-.34</td>
<td>-.30</td>
</tr>
<tr>
<td>p</td>
<td>.001</td>
<td>.001</td>
<td>&lt;.001</td>
<td>.001</td>
</tr>
<tr>
<td>r (looks at the parent, infant BI)</td>
<td>.196</td>
<td>-.129</td>
<td>.018</td>
<td>.078</td>
</tr>
<tr>
<td>p</td>
<td>.034</td>
<td>.168</td>
<td>.846</td>
<td>.395</td>
</tr>
<tr>
<td>r (expressed parental anxiety, infant BI)</td>
<td>.26</td>
<td>.23</td>
<td>.17</td>
<td>.11</td>
</tr>
<tr>
<td>p</td>
<td>.004</td>
<td>.012</td>
<td>.058</td>
<td>.212</td>
</tr>
<tr>
<td>r (expressed parental anxiety, parental encouragement)</td>
<td>-.04</td>
<td>-.17</td>
<td>-.11</td>
<td>-.32</td>
</tr>
<tr>
<td>p</td>
<td>.661</td>
<td>.073</td>
<td>.250</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Note: SSR: stranger social referencing, DSR: dinosaur social referencing, BI: behavioral inhibition.

Main Analyses

The standardized parameter estimates, standard errors and p values for the fear and avoidance models are shown in Table 4. Although looks at the parent (per interval, $M = 1.20$, $SD = .78$, range: 0.00-4.06) and the interaction between looks at the parent and infant BI were initially included in the models to investigate the potential mechanisms behind the transmission of anxiety, they did not significantly predict infant fear or avoidance in any of the models. Therefore, they are not further reported in the analyses. Similarly, the interactions between infant and parent gender, between parent gender and BI, and between expressed parental anxiety and SR task were included in the main effects models of fear and avoidance but they did not reveal any significant associations. Therefore, these interactions are not further reported in the analyses.
Table 4. Parameter estimates for the multilevel models of infant fear and avoidance regressed on parent and infant variables

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Fear Model</th>
<th></th>
<th></th>
<th></th>
<th>Avoidance Model</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>β</td>
<td>SE</td>
<td>p</td>
<td>β</td>
<td>SE</td>
<td>p</td>
<td></td>
</tr>
<tr>
<td>Intercept</td>
<td>-.46</td>
<td>.10</td>
<td>&lt; .001</td>
<td>.13</td>
<td>.13</td>
<td>.345</td>
<td></td>
</tr>
<tr>
<td>Order of the visits (0:first with mother, 1: first with father)</td>
<td>-.03</td>
<td>.06</td>
<td>.654</td>
<td>-.17</td>
<td>.08</td>
<td>.051</td>
<td></td>
</tr>
<tr>
<td>Infant baseline negativity (0: no, 1:yes)</td>
<td>.48</td>
<td>.08</td>
<td>&lt; .001</td>
<td>.15</td>
<td>.09</td>
<td>.106</td>
<td></td>
</tr>
<tr>
<td>Parent (0: mother, 1: father)</td>
<td>.06</td>
<td>.07</td>
<td>.380</td>
<td>.02</td>
<td>.09</td>
<td>.847</td>
<td></td>
</tr>
<tr>
<td>Task (0: SSR, 1: DSR)</td>
<td>.74</td>
<td>.10</td>
<td>&lt; .001</td>
<td>-.26</td>
<td>.10</td>
<td>.009</td>
<td></td>
</tr>
<tr>
<td>Infant Gender</td>
<td>-.15</td>
<td>.09</td>
<td>.098</td>
<td>.06</td>
<td>.11</td>
<td>.601</td>
<td></td>
</tr>
<tr>
<td>Parent lifetime social anxiety disorder</td>
<td>-.08</td>
<td>.10</td>
<td>.436</td>
<td>-.12</td>
<td>.13</td>
<td>.336</td>
<td></td>
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<tr>
<td>Parent lifetime other anxiety disorder(s)</td>
<td>-.03</td>
<td>.11</td>
<td>.801</td>
<td>.09</td>
<td>.15</td>
<td>.548</td>
<td></td>
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<tr>
<td>Parent lifetime comorbid anxiety disorder(s)</td>
<td>.08</td>
<td>.10</td>
<td>.452</td>
<td>-.01</td>
<td>.13</td>
<td>.973</td>
<td></td>
</tr>
<tr>
<td>Expressed parental anxiety</td>
<td>.07</td>
<td>.04</td>
<td>.109</td>
<td>.17</td>
<td>.07</td>
<td>.014</td>
<td></td>
</tr>
<tr>
<td>Parental encouragement</td>
<td>-.01</td>
<td>.04</td>
<td>.728</td>
<td>-.04</td>
<td>.06</td>
<td>.542</td>
<td></td>
</tr>
<tr>
<td>Infant BI</td>
<td>.26</td>
<td>.05</td>
<td>&lt; .001</td>
<td>.15</td>
<td>.06</td>
<td>.007</td>
<td></td>
</tr>
<tr>
<td>Parent gender * Expressed parental anxiety</td>
<td>-.11</td>
<td>.09</td>
<td>.201</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parent gender * Parental encouragement</td>
<td>.21</td>
<td>.08</td>
<td>.014</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expressed parental anxiety * Infant BI</td>
<td>.12</td>
<td>.05</td>
<td>.011</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: SSR: stranger social referencing, DSR: dinosaur social referencing, BI: behavioral inhibition.
Expressed parental anxiety and infant behavioral Inhibition

For the model with infant fear as the outcome measure, a main-effects-only model was first fit (-2log = 1145.92, AIC = 1189.92, BIC = 1281.51). The interaction between parent gender and expressed parental anxiety, aiming at exploring differences between parents in the transmission of anxiety, reached marginal significance (β = .13, SE = .07, p = .059), but failed to significantly improve the fit of the model (-2log = 1142.51, AIC = 1188.51, BIC = 1284.27). The inclusion of the other theoretically relevant interactions did not reveal any significant effects and did not significantly improve the model. The main-effects model explained 21.62% of the variance in infant fear.

The final model (see Table 4) revealed that infants showed significantly more fear in the dinosaur SR task (M = 2.30, SD = .98) than in the stranger SR task (M = 1.78, SD = .83). Infant BI significantly predicted infant fear during the SR tasks, with increased levels of BI predicting increased fear. Infant fear did not significantly differ between the mother and father visits or between boys and girls. Neither parental anxiety disorders nor expressed parental anxiety significantly predicted infant fear. The association between parental encouragement and infant fear was not significant either.

The fit of the initial main-effects model for infant avoidance was -2log = 1260.85, AIC = 1304.85, BIC = 1396.44. The main-effects model explained 8.59% of the variance in infant avoidance. Several theoretically relevant interactions (previously described on page 79) were significant and improved this model. First, the inclusion of the interaction between parent gender and expressed parental anxiety was initially significant (β = -.22, SE = .08, p = .007) and improved the fit (-2log = 1253.96, AIC = 1299.96, BIC = 1395.71) indicating a stronger effect for mothers. However, the interaction was no longer significant (β = -.15, SE = .09, p = .098) after including the interaction between parent gender and parental encouragement. The interaction between parent gender and parental encouragement further improved the fit of this model (-2log = 1249.89, AIC = 1297.89, BIC = 1397.81) and indicated a stronger association between infant avoidance and parental encouragement for fathers than for mothers (the association was in the opposite direction than expected, see Figure 1). Third, the interaction between expressed parental anxiety and infant BI was significant (-2log = 1243.75, AIC = 1293.75, BIC = 1397.84) confirming an increased role of expressed parental anxiety for high BI children. The three-way interaction between parent gender, expressed parental anxiety and infant BI was also tested in an additional step and found to be significant (β = -.19, SE = .09, p = .026). However, further inspection of the plot revealed significant leverage caused by four mothers with expressed anxiety scores 2.5 SD above the mean in five observations. Once these observations were removed, the three-way interaction between parent gender, expressed parental anxiety and infant BI was no longer significant (β = -.14, SE = .09, p = .113), therefore the three-way interaction was not included in the final model. The two-way interactions between expressed parental anxiety and infant BI, and between parent gender and parental encouragement remained significant after the removal of the leverage. The interaction between infant
BI and parental encouragement was only marginally significant ($\beta = .09$, $SE = .05$, $p = .060$) and did not significantly improve the fit ($-2\log = 1240.28$, $AIC = 1292.28$, $BIC = 1400.52$), and therefore was not included in the final model. The final model (see Table 4) explained 10.11% of the variance in infant avoidance.

The main effects in the final avoidance model (see Table 4) revealed that infants showed significantly less avoidance in the dinosaur SR task ($M = 1.61$, $SD = .63$) than in the stranger SR task ($M = 1.79$, $SD = .57$). Lifetime parental anxiety diagnoses did not significantly predict infant avoidance. Infant avoidance did not significantly differ between boys and girls.

The interactions between parent gender and parental encouragement and between expressed parental anxiety and infant BI were significant in the final model. To investigate how the association between parental encouragement and infant avoidance differed between parents, we first inspected the confidence bands (Preacher, Curran, & Bauer, 2006, see Figure 1(i)) representing continuously plotted confidence intervals for the simple outcome slope across levels of parental encouragement. The inspection of the confidence intervals revealed that paternal encouragement had its largest impact on infant avoidance with the most and the least encouraging parents. Next, we plotted the association between parental encouragement and infant avoidance in separate lines for mothers and fathers. Confidence intervals cannot be computed for dichotomous variables such as parent gender, therefore we based our interpretations on the visual inspection of the interaction plot (shown in Figure 1(ii)). There was a positive association between parental encouragement and infant avoidance for fathers, with higher levels of encouragement by the father being associated with higher levels of avoidance by the infant. Maternal encouragement however, had a negligible relation with infant avoidance (see Figure 1(ii)).

To investigate how the association between expressed parental anxiety and infant avoidance differed across BI levels, we first inspected the confidence bands (see Figure 2(i)) representing continuously plotted confidence intervals for the simple outcome slope across levels of infant BI. The inspection of the confidence intervals revealed that there was a significant association between expressed parental anxiety and infant avoidance for moderate-to-high BI infants. Next, we inspected the confidence bands (see Figure 2(iii)) representing continuously plotted confidence intervals for the simple outcome slope across levels of expressed parental anxiety. The inspection of the confidence intervals revealed that there was a positive association between expressed parental anxiety and infant avoidance for moderate-to-high levels of expressed parental anxiety. Finally, we plotted the association between expressed parental anxiety and infant avoidance as a function of infant BI (see Figure 2(iii)). The association between expressed parental anxiety and infant avoidance was positive for moderate and high BI infants.
Expressed parental anxiety and infant behavioral inhibition

Figure 1. The interaction effect between parent gender and parental encouragement on infant avoidance
(i) The black line is the distribution of simple outcome slope (on the y-axis) continuously plotted across levels of parental encouragement (standardized scores on the x-axis). The confidence bands (the area bounded by red curves) represent the 95% confidence intervals. When the confidence interval does not include $y = 0$ for a given level of the parental encouragement, the effect is interpreted as being significant at that level (i.e., $p \leq .05$). The light horizontal line at $y = 0$ shows the zero point for the slope (i.e., no association). The association between parental encouragement and infant avoidance was significant among the most encouraging parents ($z \geq 1.11$) and the least encouraging parents ($z \leq -1.6$). (ii) The interaction between parent gender and parental encouragement. Lines represent the association between parental encouragement (standardized scores on the x-axis) and infant avoidance (standardized scores on the y-axis) with separate lines for mothers and fathers. The association between parental encouragement and infant avoidance was positive only for fathers whereas maternal encouragement had a negligible relation with infant avoidance.
Figure 2. The interaction effect between infant BI and expressed parental anxiety on infant avoidance

(i) The black line is the distribution of simple outcome slope (on the y-axis) continuously plotted across levels of infant BI (standardized scores on the x-axis). The confidence bands (the area bounded by red curves) represent the 95% confidence intervals. When the confidence interval does not include y = 0 for a given level of infant BI, the effect is interpreted as being significant at that level (i.e., \( p \leq .05 \)). The light horizontal line at y = 0 shows the zero point for the slope (i.e., no association). The three vertical lines represent the mean slopes of infants with low, moderate and high levels of infant BI. Moderate, low and high levels of infant BI were determined as mean, 2 SD below and 2 SD above the mean, respectively. There was a significant positive association between infant BI and infant avoidance among infants with moderate to high levels of BI (\( z \geq -.03 \)).

(ii) The black line is the distribution of the simple outcome slope (on the y-axis) continuously plotted across levels of expressed parental anxiety (standardized scores on the x-axis). The confidence bands (the area bounded by red curves) represent the 95% confidence intervals. When the confidence interval does not include y = 0 for a given level of expressed parental anxiety, the effect is interpreted as being significant at that level (i.e., \( p \leq .05 \)). The light horizontal line at y = 0 shows the zero point for the slope (i.e., no association). Moderate, low and high levels of expressed parental anxiety were determined as mean, 2 SD below and 2 SD above the mean, respectively. Expressed parental anxiety significantly predicted infant avoidance for parents with moderate-to-high levels of expressed parental anxiety (\( z \geq -.03 \)).

(iii) The interaction effect between expressed parental anxiety and infant BI. Lines represent the association between expressed parental anxiety (standardized scores on the y-axis) and infant avoidance (standardized scores on the y-axis) with separate lines for the high, moderate and low BI infants. As indicated in Figure 2 (i), moderate, low and high levels of infant BI were determined as mean, 2 SD below and 2 SD above the mean, respectively. There was a significant positive association between expressed parental anxiety and infant avoidance for moderate-to-high BI infants.
To investigate the link between lifetime parental anxiety disorders and expressed parental anxiety, we regressed expressed parental anxiety on parental lifetime anxiety disorders (\( -2\log = 1124.37, \ AIC = 1142.37, \ BIC = 1179.88 \)). None of the interactions between task and parental lifetime anxiety disorders were significant, or improved the model. Parents with lifetime social anxiety (\( \beta = .27, \ SE = .14, \ p = .053 \)) and parents with lifetime comorbid social and other anxiety disorders (\( \beta = .27, \ SE = .14, \ p = .054 \)) tended to express more anxiety than parents without anxiety disorders. Expressed parental anxiety did not differ between parents with other anxiety disorders and parents without anxiety disorders. Mothers and fathers expressed similar levels of anxiety, and both parents expressed more anxiety (\( \beta = -.85, \ SE = .05, \ p < .001 \)) in the stranger task \( (M = 2.34, \ SD = .49) \) than in the dinosaur task \( (M = 1.87, \ SD = .52) \).

To investigate the possibility that the lack of significant associations between parental anxiety disorders and infant fear/avoidance was caused by the inclusion of both current and lifetime anxiety disorders, we conducted the same analyses only with the current anxiety diagnoses of the parents. The conclusions were similar except that infants of parents with other types of anxiety disorders tended to be more avoidant during SR tasks (\( \beta = .32, \ SE = .16, \ p = .053 \)) than infants of parents without current anxiety disorders. Another difference emerged with respect to the link between parental anxiety diagnoses and expressed parental anxiety: parents with a current social anxiety disorder expressed significantly more anxiety than parents without anxiety disorders (\( \beta = .36, \ SE = .16, \ p = .024 \)), whereas parents with current other anxiety disorders and current comorbid social and other anxiety disorders expressed similar levels of anxiety as the parents without anxiety disorders.

**DISCUSSION**

The central finding of this study is that expressed parental anxiety interacted with infant BI to significantly predict 12-month-old infants’ avoidance in response to a novel stranger and toy. The effect of expressed parental anxiety on infant avoidance was significant for infants with moderate-to-high BI and for parents with moderate-to-high levels of expressed anxiety, whereas the association was not significant for infants with low BI and parents with low levels of expressed anxiety. The findings support the idea that infants may be differentially susceptible to anxious parental rearing based on their level of BI (Belsky & Pluess, 2009; Nigg, 2006). This study replicates previous findings showing increased vulnerability of high BI infants to the effects of parental anxiety during SR (De Rosnay et al., 2006; Murray et al., 2008).

On the other hand, no evidence was found in favour of increased susceptibility of high BI infants to the beneficial effects of parental encouragement. This may be partially due to the instructions of encouragement in the dinosaur SR task (see below).
The second major finding of the study is that the link between infant avoidance and expressed parental anxiety did not significantly differ between mothers and fathers, indicating that fathers may be as important as mothers in the transmission of anxiety via SR. Although the analyses initially indicated a stronger link between infant avoidance and expressed parental anxiety for mothers, the interaction was no longer significant once the differences between the parents on parental encouragement were controlled for in the model.

Contrary to the previous evidence indicating an association between more maternal encouragement and less infant avoidance (Murray et al., 2008), maternal encouragement had a negligible relation with infant avoidance in this study, whereas more paternal encouragement was associated with more infant avoidance. The raw correlations between parental encouragement and expressed anxiety revealed that more encouragement in fathers, but not in mothers, was associated with less expressed parental anxiety in the dinosaur SR task (see Table 3). It is important to note that the instruction to actively encourage the infant in the last minute of the dinosaur SR task may have increased the occurrence of parental encouragement while leaving the expressions of parental anxiety intact since some parents (especially mothers, who tend to be more sensitive to infant signals; Barnett, Deng, Mills-Koonce, Willoughby, & Cox, 2008) may prefer not to actively encourage their infant to approach the dinosaur. This may explain the lack of associations between maternal encouragement and expressed maternal anxiety. In turn, in line with previous evidence (Barnett et al., 2008), highly encouraging fathers may be encouraging their infant in a less sensitive way as compared to mothers during SR situations, reversing the positive effects of encouragement, triggering further avoidance of the dinosaur. Alternatively, fathers may simply be encouraging more when their infant becomes aviodant in the situation. Further research is needed to discover the mechanisms that account for the positive link found between encouragement from fathers and infant avoidance. The present findings reveal that parental encouragement may not always help infants to decrease their avoidance in face of ambiguous stimuli.

In contrast to infant avoidance, infant fear was only predicted by infant BI. The more behaviorally inhibited infants were, the more fear they showed during SR, pointing to a moderate effect of this temperamental predisposition on infant fear. This finding may provide support for the role of the early temperamental trait of BI in the acquisition/learning of fear (Rosenbaum et al., 1993). Expressed parental anxiety was not significantly associated with infant fear, indicating that infant’s own fearful disposition, and not his/her parents’ anxiety was important for fear expression in the SR tasks. It is important to note that observed infant BI was considered to be a measure of ‘trait’ fear in the present study, whereas infant fear in SR situations was considered to reflect the infant’s ‘state’ reaction to one social and one nonsocial novelty, in the presence of parental feedback. However, in light of the definitional
Expressed parental anxiety and infant behavioral inhibition

and methodological overlap between fear and the temperamental predisposition of anxiety (Fox et al., 2005; Rothbart, 2007), one may suggest that the procedures of infant BI and infant fear were similar, leading to the conclusion that the present model on infant fear reflected an absence of significant parental effects (i.e., expressed parental anxiety) on infant fear reactions which were mainly consistent from BI to SR situations. Since infant BI was measured in a range of situations in the present study, (i.e., at home and in two different lab visits), using 11 well-known standardized tasks, and in the absence of parental feedback, we consider our BI measure distinct enough from the fear measure to warrant the present conclusions about state and trait fear.

The third major finding of the study is that lifetime and current parental anxiety disorders were not significantly related to infant fear or avoidance during SR tasks, with the exception of a current diagnosis of other types of anxiety. It is difficult to understand why infants of parents with other (nonsocial) anxiety disorders, but not those with social or with comorbid social and other anxiety disorders were more avoidant than infants of parents without anxiety disorder. Taken together, the findings do not support the diagnosis specificity hypothesis for the early transmission of anxiety. Although the lack of association between parental lifetime anxiety diagnoses and infant avoidance seems in contrast to Murray et al. (2008) who reported more avoidance in infants of mothers with social anxiety disorder, it should be kept in mind that the parental anxiety diagnoses were analyzed in the present models simultaneously with expressed parental anxiety. It is important to note that parental anxiety diagnoses, measured via the ADIS were considered to be a measure of parental ‘trait’ anxiety in the present study, whereas observations of expressed parental anxiety in SR situations were considered to reflect the parent’s ‘state’ reaction to these situations. The models of infant fear and avoidance in the present study could not differentiate between parents with and without anxiety disorders independently from expressed parental anxiety.

With respect to expressed parental anxiety, parents with lifetime and current diagnoses of social anxiety disorders and with lifetime comorbid social and other anxiety disorders did express more anxiety than parents without anxiety disorders during SR situations. The expressions of parental anxiety were thus specific to parents with social anxiety disorders. This makes sense given that being aware that one is being filmed is an experience that is especially likely to trigger socially anxiety. However, parents with a lifetime or current diagnosis of other anxiety disorders and parents with current diagnoses of comorbid social and other anxiety disorders expressed similar levels of anxiety as parents without anxiety disorders during SR situations.

Several explanations can be offered for the lack of association between infant avoidance and parental anxiety disorders. Parents may be able to mask their anxiety disorders when helping their infants approach a novel stimulus, either because the
Chapter 3

anxiety disorder is not triggered enough in the SR tasks, or because some parents with anxiety disorders are able to hide their anxiety from their infant. Expressed parental anxiety predicted infant avoidance over and above the effects of lifetime anxiety disorders, implying that the way a parent acts in response to novel stimuli in the presence of the infant matters more than his/her predisposition towards an anxiety disorder.

The fourth major finding of the present study is that neither the expressions of parental anxiety, nor their effect on infant behavior were found to be context-specific. Parents’ behavior influenced infants’ behavior similarly in social and nonsocial SR contexts. The association between expressed parental anxiety and parental anxiety disorders did not significantly differ between SR contexts, providing evidence against context specificity in the transmission of anxiety.

Infants were less fearful and more avoidant in the stranger SR task than in the dinosaur SR task. No gender difference was detected between the boys’ and girls’ expressions of fear and avoidance, and/or between the mothers’ and fathers’ expressions of anxiety, suggesting that the transmission of anxiety may be occurring similarly from mothers and fathers to girls and boys. The link between BI and infant fear/avoidance did not significantly differ between mother and father visits, implying a similar influence of infant temperamental characteristics on infant reactions with mothers and fathers.

The number of times the infant looked at the parent was not significantly associated with infant fear or avoidance in the SR situations in the multilevel models, whereas the raw correlations between BI and looks at the parents indicated a positive association in the stranger SR task of the mother’s visit. Although the number of looks is an indicator of active visual information seeking, it is certainly not the only valid proxy in the naturalistic setting of the present SR tasks. Infants were provided with multimodal (visual and auditory) signs of expressed parental anxiety. Previous studies comparing visual and auditory modalities in SR situations (Mumme, Fernald, & Herrera, 1996) suggest that, in fact, auditory (versus visual) information may be a stronger channel for fearful expressions during SR situations. Additionally, multimodal input can enhance early emotional information processing (Flom & Bahrick, 2007).

Findings of this study should be interpreted in the light of some limitations. First, the study focused on the predictive value of expressed parental anxiety on infant fear and avoidance and did not consider the opposite direction of effects (i.e., infant fear/avoidance on expressed parental anxiety). Parents’ expressed anxiety during SR situations may partly result from the simultaneous fear/avoidance of the infant in that situation. Second, the reliability of the infant avoidance was slightly lower than conventionally acceptable levels for observational measures. This may partly
stem from the structure of the stranger SR task where the infants were restrained in a high chair. As a result, the avoidant behavior, which is defined as increasing the distance between self and the ambiguous stimulus was manifest in less obvious ways, possibly resulting in lower levels of the inter-observer agreement. Third, the study had a single-age non-experimental design, therefore the present conclusions preclude any prospective or causal inferences about the effect of expressed parental anxiety on infant fear or avoidance. It is important to follow up the present sample to investigate the prospective effects of expressed parental anxiety on infant behavior in a SR paradigm.

CONCLUSIONS

This study supports the notion that infants who show a temperamental disposition for anxiety learn from maternal and paternal anxious signals during confrontations with novelty and become avoidant towards novel stimuli when their parents express anxiety. Consistent with previous evidence, the findings suggest that moderate and high levels of BI constitute a temperamental vulnerability for the effects of expressed parental anxiety.

This was the first study to our knowledge comparing fathers’ and mothers’ effects on their infants in SR tasks. The association between infant avoidance and expressed parental anxiety was not significantly different for mothers and fathers, pointing to an equally important role of fathers at this young age. Contrary to the previous evidence showing negative associations between maternal encouragement and infant avoidance, the association was only significant for fathers in the present study and it was positive, that is, infants of highly encouraging fathers showed higher levels of avoidance.

The present study did not find evidence in favour of diagnosis or context specificity of the intergenerational transmission of anxiety via SR. The association between expressed parental anxiety and infant fear/avoidance was found to be independent of the presence of anxiety disorders in parents, and similar in social versus nonsocial SR contexts.
CHAPTER 4

Parental social anxiety disorder prospectively predicts toddlers’ fear/avoidance in a social referencing paradigm

Evin Aktar
Mirjana Majdandžić
Wieke De Vente
Susan M. Bögels

Chapter 4

ABSTRACT

Background: Anxiety runs in families. Observational learning of anxious behavior from parents with anxiety disorders plays an important role in the intergenerational transmission of anxiety. We investigated the link between parental anxiety (parental lifetime anxiety disorders and expressed parental anxiety) and toddler fear/avoidance during social referencing (SR) situations. Method: Toddlers (n = 117) participated with both parents (with lifetime social anxiety disorder, other nonsocial anxiety disorders, lifetime comorbid social and other anxiety disorders, or without anxiety disorders) in a longitudinal study. Behavioral inhibition (BI) was measured at 12 months via observational tasks. At 30 months, children were confronted with a stranger and a remote-control robot in SR situations, separately with each parent. Children’s fear and avoidance, and parents’ expressions of anxiety, encouragement and overcontrol were observed. Results: Toddlers of parents with lifetime social anxiety disorder (alone and comorbid with other anxiety disorders) showed more fear/avoidance in SR situations than toddlers of parents without anxiety disorders, while the effect of other anxiety disorders alone was not significant. Although expressed parental anxiety at 30 months in SR situations did not significantly predict toddlers’ fear/avoidance, higher levels of expressed anxiety at 12 months in SR situations by parents with lifetime comorbid social and other anxiety disorders predicted higher levels of fear/avoidance. BI at 12 months predicted toddlers’ fear/avoidance only with mothers, but not with fathers. Conclusions: Parental lifetime social anxiety disorders may be a stronger predictor of children’s fear/avoidance than parents’ expressions of anxiety in SR situations in toddlerhood. End of infancy may be a sensitive time for learning of anxiety from parents with comorbid lifetime social and nonsocial anxiety disorders in SR situations. Fathers are as important as mothers in the transmission of anxiety via SR. Furthermore, children may act relatively free of their early temperament in SR situations with fathers.
INTRODUCTION

Anxiety aggregates in families, passing from generation to generation and putting children of anxious parents at risk for the development of anxiety disorders (Beidel & Turner, 1997; Turner, Beidel & Costello, 1987). Genetic factors partially explain the intergenerational transmission of anxiety with moderate effect sizes (Eley, 2001; Hettema, Neale, & Kendler, 2001). Environmental factors also play an important role, both alone and in interaction with genetic predispositions (Fisak & Grills-Taquechel, 2007). In this study, we investigated the role of social referencing (SR) as an early mechanism for the transmission of anxiety from parents (with and without anxiety disorders) to toddlers.

Given the family aggregation of anxiety disorders and the prominent role of parents in the construction of the child’s environment in early years, it is important to understand how children learn from parents who have anxiety disorders and who are highly likely to experience irrational fear in the presence of their child. From a learning perspective, modeling (observational learning) of parental behavior may contribute to children’s learning of anxiety from parents (Fisak & Grills-Taquechel, 2007; Murray, Creswell, & Cooper, 2009). Children of parents with anxiety disorders may adopt anxious responses and become fearful/avoidant because they are frequently exposed to parental expressions of anxiety (Muris, Steerneman, Merckelbach, & Meesters, 1996) and to avoidant coping strategies (Barrett, Rapee, Dadds, & Ryan, 1996). Furthermore, parental anxiety may impair parents’ ability to positively reinforce (encourage) their child’s attempts to approach novelty (Fisak & Grills-Taquechel, 2007; Murray et al., 2009) and is assumed to give rise to parental overcontrol, which increases child anxiety (Rapee, 2001). Meta-analytic studies report a medium effect size association between parental control and child anxiety (McLeod, Wood, & Weisz, 2007; Van der Bruggen, Stams, & Bögels, 2008) and a low effect size association between parental anxiety disorder and parental control (Van der Bruggen et al., 2008).

Considerable attention has been given to the role of child temperamental predispositions in the link between parental and child anxiety. Behavioral inhibition (BI) is a biologically based temperamental characteristic defined by fearful, withdrawn and avoidant responses to ambiguity (Fox, Henderson, Marshall, Nichols, & Ghera, 2005; Kagan & Snidman, 1999). Highly inhibited children are more likely to develop anxiety disorders (Rosenbaum et al., 1993), especially social anxiety (Clauss & Blackford, 2012) than those with low BI, and are more likely to have parents with anxiety disorders (Rosenbaum et al., 1991). Furthermore, as stated by diathesis stress (Zuckerman, 1999) and vulnerability-stress (Ingram & Luxton, 2005; Nigg, 2006) models, temperamental traits may constitute a predisposition to the effects of adverse rearing environments, and thereby to the development of psychopathology. Thus,
infant BI may moderate the link between child and parental anxiety, rendering highly inhibited infants more vulnerable to the effects of anxious modeling and thereby to the development of anxiety disorders (Degnan, Almas, & Fox, 2010).

As infants begin to use SR at the end of the first year, they start to utilize adults’ emotional signals and behaviors to determine how to behaviorally and emotionally respond in ambiguous/novel situations (Feinman, 1982; Feinman, Roberts, Hsieh, Sawyer, & Swanson, 1992). In early experimental studies of SR, affective messages provided by adults (most often mothers) in the face of ambiguity in SR situations have been manipulated to investigate its effect on infant behavior (Feinman et al., 1992). The novel stimuli utilized in these studies, were most often a robot toy (e.g., Blackford & Walden, 1998; Walden & Ogan, 1988), a stranger (e.g., Feinman & Lewis, 1983), or visual cliff (e.g., Sorce, Emde, Campos & Klinnert, 1985). The findings from these studies support the idea that infant behavioral and affective reactions change in line with the affective and behavioral state expressed by parents (for a review see Feinman et al., 1992). More recently, scientific interest has grown on how parents with anxiety disorders may contribute to infants’ learning of anxiety and avoidance via social referencing in daily life. At around the same time as SR, infants start to show increased wariness to unfamiliar people (Sroufe, 1977). The co-emergence of stranger wariness and SR at the end of infancy has raised the question of whether this time is a sensitive period for the learning of social anxiety, especially for children of parents with social anxiety disorder and/or highly inhibited children (De Rosnay, Cooper, Tsigaras, & Murray, 2006; Murray et al., 2008).

The studies investigating learning of anxiety from parents via SR at the end of infancy consistently reveal an important role of the interplay between infants’ BI and parental anxiety in determining infant avoidance in response to novelty. However, the precise learning mechanism for how these factors work together is unclear. Murray et al. (2008) found that highly inhibited infants who had a mother with social anxiety disorder (SAD) became more avoidant from 10 to 14 months in a social SR task. In this task, a female stranger engaged the parent in a 2-minute conversation while the infant was watching, and subsequently approached the infant, and picked him/her up. The effect was accounted for by less encouragement from mothers with SAD to highly inhibited infants. Additionally, it has recently been shown that 12-month-old infants’ level of BI and their parents’ expressed anxiety during SR tasks interact to predict infants’ avoidance behavior in SR situations (Aktar, Majdandžić, de Vente, & Bögels, 2013). This link is such that moderate-to-highly inhibited infants with parents who expressed moderate-to-high levels of anxiety during SR were more avoidant. Contrary to Murray et al. (2008), parental encouragement did not account for this interaction. Notably, parental anxiety diagnoses did not predict infants’ fear or avoidance behavior, indicating that at 12 months, parents’ expressions of anxiety in the situation are more influential than their lifetime anxiety diagnoses. This finding
is complemented by an experimental SR study (De Rosnay et al., 2006) where the expressions of parental anxiety were manipulated to be anxious or non-anxious. The interplay between 12-to-14 month-old infants’ BI and maternal expressions of anxiety was found to predict increased infant avoidance in the anxious condition. This finding provides strong confirmation of a causal role for mothers’ anxious messages about strangers on children’s avoidance behavior in infancy, an effect moderated by an infant’s level of BI.

The studies investigating how children learn from parents with anxiety disorders via SR have been conducted at an age where infants’ SR behavior is assumed to be most ‘salient’ (i.e., 10-14 months; Emde, 1992). According to Feinman et al. (1992), children’s reactions in SR situations closely match parental reactions in this period, indicating that parental appraisals of the situation have a direct influence on infants’ reactions to novelty. Much less is known about how parental anxiety links to children’s fear/avoidance in SR situations later in development, for example in toddlerhood. Early studies with toddlers of healthy mothers have revealed that as children gain more experience in dealing with novelty in the environment, the effect of parental reactions on children’s reactions in SR situations becomes more complex and indirect (see Feinman et al., 1992). Although parents’ influence may change as children grow older and build confidence in approaching novel situations, it is likely that parents still have a pronounced role in constructing toddlers’ environment, particularly for behaviorally inhibited children who have more difficulty in approaching novel situations.

Moreover, the role of fathers in SR has been rarely studied. Nevertheless, recent models on the development of anxiety (e.g., Bögels & Perotti, 2011; Bögels & Phares, 2008) assign fathers a unique and essential role in the development of anxiety based on their greater evolutionary experience in exploring the external world. It was recently found that fathers’ expressed anxiety in SR situations is as influential as mothers’ at 12 months (Aktar et al., 2013). In view of an increasing number of encounters with the external world from infancy to toddlerhood, it may be hypothesized that father’s role becomes more influential as children grow older (Bögels & Perotti, 2011; Bögels & Phares, 2008).

The majority of SR studies on anxiety have been conducted with parents with and without SAD in social SR paradigms (e.g., De Rosnay et al., 2006; Murray et al., 2008), whereas the effect of other types of parental anxiety disorders or of other contexts is not well understood. Thus, it is not clear whether the transmission of anxiety is diagnosis or context specific. That is, does it only occur when a parent has SAD, or also when the parent has another anxiety disorder or no anxiety disorder? Additionally, is the transmission specific to social situations, or does it also occur in nonsocial SR situations? The inclusion of a nonsocial SR situation in addition to a social SR situation, enables the assessment of child reactions and parental dynamics via SR in a more
comprehensive manner in typical SR contexts, and allows the investigation of context specificity in the transmission of anxiety. In a recent study addressing these questions with social and nonsocial SR tasks at 12 months, we found that parental expressions of anxiety may influence infant reactions in response to both social and nonsocial types of novelty, and from parents with and without lifetime anxiety diagnoses indicating that the transmission occurs similarly in social and nonsocial contexts, and independent of parental anxiety disorders (Aktar et al., 2013).

In the present study, we observed toddlers’ reactions to ambiguous stimuli in SR situations at 30 months to address the following issues: First, based on previous findings (Aktar et al., 2013; Murray et al., 2008) we expected toddlers to be more fearful/avoidant if their parents had an anxiety disorder (parental trait anxiety), and/or if their parents expressed higher levels of anxiety in SR situations (parental state anxiety). Second, we investigated the role of both parents by having toddlers participate to both SR tasks once with their mother and once with their father, thus with both their parents separately. Based on theories about the importance of father’s role in the prevention or maintenance of child anxiety (e.g., Bögels & Perotti, 2011; Bögels & Phares, 2008; Möller, Majdandžić, de Vente, & Bögels, 2013), and on previous evidence (Aktar et al., 2013), we hypothesized that fathers are at least as important referees as mothers in SR situations. Third, we included an early measure of child temperament to explore whether children who showed high BI at 12 months (trait anxiety) were more fearful/avoidant in SR situations at 30 months. Furthermore, based on vulnerability models, we explored the effect of the interplay between parents’ expressed anxiety and children’s early BI on their fear/avoidance at 30 months. Fourth, we explored anxiety subtype and context specificity in the transmission of anxiety by confronting toddlers of parents without anxiety disorders, with social anxiety disorder, with other types of nonsocial anxiety disorders and with comorbid social and nonsocial types of anxiety disorders in one social and one nonsocial SR context.

METHOD

Participants
The present sample consisted of 117 couples with their 30-month-old toddler (64 girls, 53 boys). The families are participants of an ongoing longitudinal study on social development (see Aktar et al., 2013). Testing phases have included a prenatal (see below), a 4-month (not used in this study), a 12-month, and a 30-month measurement. Sociodemographic characteristics of the parents are presented in Table 1. The study was approved by the ethics committee of the University of Amsterdam. Parents provided informed consents for participation.
Table 1. Sociodemographic characteristics of the sample

<table>
<thead>
<tr>
<th></th>
<th>Mothers</th>
<th>Fathers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age M (SD)</td>
<td>33.98 (4.34)</td>
<td>34.02 (4.18)</td>
</tr>
<tr>
<td>Dutch origin</td>
<td>90.60 %</td>
<td>94.02 %</td>
</tr>
<tr>
<td>Educational level a M (SD)</td>
<td>7.07 (1.12)</td>
<td>6.63 (1.57)</td>
</tr>
<tr>
<td>Professional level b M (SD)</td>
<td>8.69 (2.14)</td>
<td>8.24 (2.67)</td>
</tr>
<tr>
<td>Current working status (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HK</td>
<td>2.56</td>
<td>0.86</td>
</tr>
<tr>
<td>PT</td>
<td>76.06</td>
<td>23.93</td>
</tr>
<tr>
<td>FT</td>
<td>5.98</td>
<td>64.10</td>
</tr>
</tbody>
</table>

Notes. M: mother; F: father; HK: housekeeper; PT: part-time; FT: full-time.

a Parental educational level was assessed with an 8-point scale (1: primary education, 4: higher secondary education, 8: university).
b Parental professional level was assessed with an 11-point scale (1: manual labor for which no education is required, 5: white-collar work at primary or secondary professional education level and not in an executive function, 11: labor for which a university degree is required).

Materials and Procedure

At 30 months, toddlers visited the lab twice, once with their father (n = 115), and once with their mother (n = 117) (53 % of toddlers visited with mother first and 47 % with father first.), and completed both the social and the nonsocial SR tasks at each visit. Thus, each toddler completed the social and the nonsocial SR task once with each of his/her parents. The order of the visits was included in the analyses to control for learning effects. BI tasks were administered at the 12-month measurement occasion.

Parental anxiety status

Parents’ current and lifetime anxiety disorder status was measured via the Anxiety Disorder Interview Schedule (ADIS; Di Nardo, Brown, & Barlow, 1994) at the prenatal measurement by four experienced interviewers. A trained psychologist recoded 10 % of the interviews. Inter-interviewer agreement for all ADIS diagnoses (based on the presence/absence of each anxiety disorder) ranged from 90 % to 100 % for each anxiety disorder with a mean of 97.55 % (SD = 2.95).

Each parent was assigned to the following four groups based on his/her current and lifetime anxiety diagnoses: ‘SAD’ (n = 43, 21 mothers and 22 fathers), ‘other types of nonsocial anxiety disorders’ (n = 34, 20 mothers and 14 fathers), ‘comorbid social and other nonsocial type(s) of anxiety disorders’ (n = 53, 32 mothers and 21 fathers) and ‘no anxiety disorder’ (n = 104, 44 mothers and 60 fathers).
BI tasks
The toddler’s level of BI was assessed at the 12-month measurement occasion via 11 well-known BI laboratory tasks (Calkins, Fox, & Marshall, 1996; Goldsmith & Rothbart, 1996; Kochanska, Coy, Tjebkes, & Husarek, 1998; Rothbart, 1988). Details on procedures and coding can be found in Aktar et al., 2013. For each BI task, several indices of infant behavior were coded such as facial, bodily and vocal fear, escape, and latency until the first fear reaction (see Goldsmith & Rothbart, 1996). The BI score was a standardized average across these behaviors (see Aktar et al., 2013). Average inter-observer reliability of BI tasks was .83, SD = .11.

SR tasks
Social SR task
The parent and toddler were seated at a low table in a way that enabled the toddler to see the parent-stranger interaction. In phase I, a female stranger entered the room, sat on a sofa 2 m away from the table, and engaged the parent in a 2-min conversation about his/her daily activities with his/her child. In phase II, the stranger explained to the parent that she would like to read a book with the toddler on the sofa and asked the parent to inform the toddler. In phase III, the parent asked the toddler to join the stranger on the sofa. This phase terminated when the child sat next to the stranger. If the toddler was unwilling to approach the stranger, the parent and the stranger encouraged the child. If the toddler did not approach the stranger, the stranger moved to be next to the toddler to read the story. In phase IV, the stranger read stories to the child for 2 minutes from a colorful book. The stranger maintained a neutral but friendly attitude towards the toddler and the parent. Different strangers conducted the task during the mother and father visits.

Nonsocial SR task
A remote-control robot dog was placed 2 m from the toddler and displayed a pattern of movements and noises. Parents were instructed to remain neutral in phase I, to talk about the robot in phase II, and to actively encourage the toddler to approach the robot in phase III. Two different robot dogs were counterbalanced between the mother and father visits. We expected the nonsocial SR task to inherently evoke more intense negative reactions from toddlers than the social task due to differences in previous exposure. By 30 months, children would have already gained some experience in interacting with strangers in daily life. The robot dog however, was less likely to be familiar, and therefore more likely to trigger negative reactions. To minimize potential dropouts due to intense negative reactions to the robot, the order of SR tasks was kept fixed, with the social task first and then the nonsocial task. A previously used coding scheme was used to code the toddler and parent behavior (see Aktar et al., 2013; Murray et al., 2008). All the behaviors were coded on 5-point scales unless stated otherwise.
Parent behavior during SR tasks.
(i) Expressed parental anxiety was based on facial (e.g., anxious, frozen faces), bodily (e.g., fidgeting, rigid posture) and verbal expressions of anxiety.

(ii) Parental encouragement (3-point scale) involved encouragement of toddler’s positive engagement with the stranger and of approach to the robot through smiles, looks or simple comments.

(iii) Parental overcontrol involved attempts to control or intervene (e.g., interfering in the stranger-toddler interaction during the social task, or controlling toddler’s attempts to explore the robot in the nonsocial task).

Toddler behavior during SR tasks.
(i) Toddler fear was based on facial (e.g., wide eyes, cry face), bodily (e.g., sunken-in posture, decrease in activity) and vocal (non-verbal, e.g., whining, crying, and verbal, e.g., ‘go away!’) expressions of fear. Toddler avoidance involved behaviors such as looking/turning away, hiding behind the parent or refusing to approach the stimulus.

(ii) Toddler baseline negativity was based on facial, bodily, and vocal expressions of negative emotional tone. It was rated in the last minute before the task started and used as a control variable.

(iii) Toddlers’ looks at the parent were counted and served as a preliminary measure of the extent to which social referencing occurs during the tasks.

For the coding, each phase was divided into time intervals and final scores of each behavior were obtained by averaging scores across intervals. Two pairs of observers were trained to code either the toddler’s or the parent’s behavior. Observers were blind to parents’ diagnostic status and toddlers’ BI.

Inter-observer reliability for parent and toddler variables was good (intraclass correlations, ICC: parental anxiety .88, parental encouragement .85, parental overcontrol .95, toddler fear .93, toddler avoidance .93, toddler baseline negativity .99, and looks at the parent .97).

Preliminary Analyses
The families in the present sample had participated in similar social and nonsocial SR tasks previously at the 12-month measurement occasion (reported in Aktar et al., 2013). First, the correlations between the scores at 12 and 30 months were computed separately per task and parent. The two-tailed significance of the associations was inspected at $p \leq .05$. The associations of child fear and avoidance scores between 12 and 30 months were not significant, implying that children’s behavior in SR situations at 30 months could not be predicted by their behavior at 12 months. Therefore, we separately analyzed the data for 30 months, and excluded infants’ fear/avoidance at
12 months from further analysis. On the other hand, parental expressions of anxiety showed some stability from 12 to 30 months: there were modest but significant positive associations between expressions of parental anxiety at 12 and 30 months, with the exception of mothers in the social SR task (Pearson correlations for the significant effects, were: $r = .20, p = .045$ for mothers in the nonsocial SR task, and $r = .30, p = .001$, and $r = .24, p = .014$ for fathers in the social and the nonsocial SR tasks, respectively). None of the associations between parenting at 12 and 30 months were significant, with the exception of maternal overcontrol in the social SR task ($r = .30, p = .001$). The lack of associations in parenting variables between 12 and 30 months suggests that parenting dynamics may change over time as child capabilities change and as parents gain more experience in adapting to their child's behavior in the toddlerhood years.

Correlations between child fear and avoidance were highly positive at 30 months ($r = .59$ and .73 for measurement with the mother and .62 and .81 for measurement with the father in the social and nonsocial tasks, respectively, all $p < .001$), indicating that expressions of fear and avoidance co-occur frequently at 30 months. Therefore, fear and avoidance were aggregated into a single variable.

The raw associations between observed parental expressions of anxiety and parenting variables at 30 months revealed that the correlations of expressed parental anxiety with parental encouragement were only significant and negative in the nonsocial SR task: ($r = -.20, p = .037$, for mothers and $r = -.37, p < .001$, for fathers, respectively), whereas none of the associations between expressed parental anxiety and parental overcontrol were significant. The negative association between parents’ encouragement and expressed parental anxiety supports the idea that parental anxiety can impair parents’ ability to encourage their child to approach the robot, while parental overcontrol seems to be unrelated to the expressions of parental anxiety.

Statistical Analyses

Hypotheses were tested with fixed-effects multilevel regression models consisting of the toddler, and the observations (repeated in social and nonsocial SR tasks and with mothers and fathers) as levels. The significance of the effects was inspected at $p \leq .05$. Scores on continuous outcome and predictor variables were standardized. Parental anxiety disorders were dummy-coded with parents without anxiety disorders as the reference group. Expressed parental anxiety, parental encouragement, parental overcontrol and toddler’s BI and looks at the parent at 30 months were entered as continuous variables. As toddlers were neutral in the majority of the cases, baseline negativity was dichotomized (0: neutral, 1: negative).
Predicting expressed parental anxiety at 30 months
Expressed parental anxiety was analyzed with a main effects model that included parental lifetime anxiety disorders (i.e., lifetime parental social, nonsocial, and comorbid social and nonsocial anxiety disorders), parent gender, and task.

Predicting toddler fear/avoidance at 30 months
Toddler fear/avoidance was analyzed first with a main effects model including order of the visits (first visiting parent vs. second visiting parent), toddler baseline negativity, parent gender, task, toddler gender, parental lifetime anxiety disorders, expressed parental anxiety, parental encouragement and BI as predictors. Theoretically relevant interactions were then added one-by-one. Interaction terms were kept in the model or removed based on likelihood ratio tests and t-tests.

First, the interaction between parent gender and toddler gender was tested to investigate whether toddler expressions of fear/avoidance differed between mother and father visits and between boys and girls. Second, the interaction between parent gender and children’s BI was tested to investigate whether fear/avoidance differed across mothers and fathers based on the infants’ level of BI. Third, the interactions between parent gender and expressed parental anxiety, between parent gender and parental encouragement, and between parent gender and parental overcontrol were tested to investigate whether the associations of toddler fear/avoidance with parental behavior differ between mothers and fathers. Fourth, the interaction between expressed parental anxiety and BI at 12 months was included to test the vulnerability models predicting a larger influence of parental anxiety on highly inhibited children. Next, we tested the interactions of parenting variables with BI to explore whether the associations of parental overcontrol and of parental encouragement with child fear/avoidance differ across BI levels. Finally, the interaction between expressed parental anxiety and type of task was included to test the context specificity in the transmission of anxiety.

RESULTS

Main Analyses
Predicting expressed parental anxiety at 30 months
The main effects model explained 18 % of the variance in expressed parental anxiety and revealed that parents with lifetime social ($\beta = .33, SE = .14, p = .021$) and with comorbid social and nonsocial anxiety disorders ($\beta = .36, SE = .13, p = .007$) expressed more anxiety during SR situations than parents without anxiety disorders. Parents expressed more anxiety in the social SR task than in the nonsocial SR task ($\beta = -.78, SE = .06, p < .001$). Mothers and fathers expressed similar levels of anxiety in the SR situations.
Chapter 4

Predicting toddler fear/avoidance at 30 months with parental behavior at 30 months

The standardized parameter estimates, standard errors and \( p \)-values for the toddler fear/avoidance model are shown in Table 2. Looks at the parent and parental overcontrol were initially included in the models but neither the main effects of these variables, nor their interactions with parent gender and with early BI reached significance. Since these variables did not predict child fear/avoidance in any of the models, they were not considered further.

Among theoretically relevant interactions that were tested, only the interaction between parent gender and infant BI improved the fit of the model and was included. In view of the main effects of lifetime parental social, and comorbid social and nonsocial anxiety diagnoses, we additionally explored the interactions of parental anxiety diagnoses with parent gender, and with BI in subsequent steps. None of these effects were significant.

Table 2. Parameter estimates for the multilevel model of toddler fear/avoidance

<table>
<thead>
<tr>
<th>Parameter</th>
<th>( \beta )</th>
<th>( SE )</th>
<th>( p )</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-.39</td>
<td>.11</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Order of the visits (0: first visiting parent, 1: second visiting parent)</td>
<td>-.18</td>
<td>.06</td>
<td>.001</td>
</tr>
<tr>
<td>Toddler baseline negativity (0: no, 1: yes)</td>
<td>.31</td>
<td>.14</td>
<td>.025</td>
</tr>
<tr>
<td>Parent gender (0: mother, 1: father)</td>
<td>.14</td>
<td>.06</td>
<td>.017</td>
</tr>
<tr>
<td>Task (0: social, 1: nonsocial)</td>
<td>.65</td>
<td>.11</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Toddler gender (0: girl, 1: boy)</td>
<td>-.06</td>
<td>.12</td>
<td>.635</td>
</tr>
<tr>
<td>Parent lifetime social anxiety disorder</td>
<td>.22</td>
<td>.10</td>
<td>.025</td>
</tr>
<tr>
<td>Parent lifetime other anxiety disorder(s)</td>
<td>-.06</td>
<td>.11</td>
<td>.613</td>
</tr>
<tr>
<td>Parent lifetime comorbid social and other anxiety disorder(s)</td>
<td>.21</td>
<td>.10</td>
<td>.039</td>
</tr>
<tr>
<td>Expressed parental anxiety</td>
<td>.01</td>
<td>.04</td>
<td>.813</td>
</tr>
<tr>
<td>Parental encouragement</td>
<td>.08</td>
<td>.04</td>
<td>.054</td>
</tr>
<tr>
<td>Behavioral inhibition (BI)</td>
<td>.12</td>
<td>.06</td>
<td>.055</td>
</tr>
<tr>
<td>Parent gender * Infant BI</td>
<td>-.13</td>
<td>.06</td>
<td>.015</td>
</tr>
</tbody>
</table>
The final model explained 19% of the variance in toddler fear/avoidance, and revealed that toddlers of parents with SAD alone ($\beta = .22, SE = .10, p = .025$) or comorbid social and nonsocial anxiety disorders ($\beta = .21, SE = .10, p = .039$) showed higher levels of fear/avoidance than toddlers of parents without anxiety disorders. Parental diagnoses of other nonsocial anxiety disorders alone did not significantly predict toddlers’ fear/avoidance. Expressed parental anxiety did not significantly predict toddlers’ fear/avoidance - also when parental lifetime anxiety diagnoses were excluded from the model. Toddlers were more fearful/avoidant in the nonsocial SR task than in the social SR task ($\beta = .65, SE = .11, p < .001$). Higher levels of parental encouragement were marginally associated with higher levels of toddlers’ fear/avoidance ($\beta = .08, SE = .04, p = .054$). The plot of the significant interaction between parent gender and BI ($\beta = -.13, SE = .06, p = .015$) revealed that higher levels of BI at 12 months predicted higher levels of fear/avoidance at 30 months in the mother’s visit, whereas early BI had a negligible impact on toddler fear/avoidance in the father’s visit. Inspection of confidence bands (continuously plotted confidence intervals) for the simple outcome slope across levels of BI at 12 months revealed that this effect was more pronounced for children with low-to-moderate levels of BI.

**Post-hoc Analyses**

*Predicting toddler fear/avoidance at 30 months with parental behavior at 12 months*

To investigate early learning mechanisms that may explain the current findings in the model, we additionally explored the longitudinal effects of parental behavior in SR tasks at 12 months on toddlers’ fear/avoidance at 30 months. We included the standardized average scores of expressed parental anxiety and parental encouragement (observed at 12 months in similar SR situations with a similar protocol, see Aktar et al. 2013) as predictors in the fear/avoidance model (Table 2). Parental overcontrol showed little variance at 12 months, therefore we excluded this variable from further analysis.

First, to investigate the prospective associations of parental encouragement at 12 months with child fear/avoidance at 30 months, we included the main effects of parental encouragement at 12 months in the final toddler fear/avoidance model. This association was not significant. Second, to see whether the associations between parental encouragement at 12 months and toddlers’ fear/avoidance at 30 months differ between mothers and fathers, and across levels of BI, the interactions of parent gender and of infant BI with parental encouragement were subsequently entered one-by-one in the model. None of these interactions were significant, indicating that toddlers’ fear/avoidance at 30 months was not predicted by parental encouragement at 12 months, neither alone nor as a function BI or parent gender.
Furthermore, the association between expressed parental anxiety at 12 months and toddler fear/avoidance at 30 months was tested to investigate whether parents’ anxious behavior at this potentially sensitive time for learning via SR has an effect on child fear/avoidance in similar SR situations at 30 months. First, the main effect of expressed parental anxiety at 12 months was included in the final fear/avoidance model at 30 months. The effect was not significant. Second, to test whether the association between expressed parental anxiety at 12 months and child fear/avoidance at 30 months changes as a function of task, we included the interaction of expressed parental anxiety at 12 months with task, this effect was also not significant. Third, based on vulnerability models, we tested whether the association between expressed parental anxiety at 12 months and child fear/avoidance at 30 months changes as a function of BI by including the interaction of expressed parental anxiety at 12 months with BI in the model, this effect was also not significant. Finally, to test whether the associations between expressed parental anxiety at 12 months and child fear/avoidance at 30 months change as a function of parental lifetime anxiety disorder, we included the interactions of expressed parental anxiety at 12 months and child fear/avoidance at 30 months with parental lifetime diagnoses of social, nonsocial, and comorbid social and nonsocial anxiety disorders in the final fear/avoidance model. Only the interaction between parental lifetime comorbid social and other anxiety disorders, and expressed parental anxiety at 12 months ($\beta = .20, SE = .09, p = .026$) revealed a significant association. Inspection of the interaction plot revealed that higher levels of expressed anxiety by parents with comorbid social and other anxiety disorders at 12 months predicted higher levels of child fear/avoidance at 30 months, while this association was not significant for toddlers of parents without anxiety diagnoses. Inspection of confidence bands (continuously plotted confidence intervals) for the simple outcome slope across levels of expressed parental anxiety revealed that the effect of comorbid lifetime parental anxiety disorders was more pronounced for toddlers of parents who expressed moderate-to-high levels of anxiety in SR situations at 12 months.

The model after the inclusion of this interaction ($n = 112$) is presented in Table 3. The interaction between parent gender and infant BI was marginally significant ($\beta = -.11, SE = .06, p = .057$) and the association between parental encouragement and fear/avoidance was significant ($\beta = .10, SE = .04, p = .026$) after the inclusion of the interaction between comorbid social and other nonsocial anxiety diagnoses and expressed parental anxiety at 12 months in the model, and the remaining effects were similar to the model presented in Table 2.
Table 3. Parameter estimates for the multilevel model of toddler fear/avoidance after the inclusion of the interaction between parental lifetime comorbid anxiety disorders and expressed parental anxiety in SR at 12 months

<table>
<thead>
<tr>
<th>Parameter</th>
<th>$\beta$</th>
<th>SE</th>
<th>$p$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.40</td>
<td>0.11</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Order of the visits (0: first visiting parent, 1: second visiting parent)</td>
<td>-0.20</td>
<td>0.06</td>
<td>.001</td>
</tr>
<tr>
<td>Toddler baseline negativity (0: no, 1: yes)</td>
<td>0.30</td>
<td>0.15</td>
<td>.043</td>
</tr>
<tr>
<td>Parent gender (0: mother, 1: father)</td>
<td>0.15</td>
<td>0.06</td>
<td>.018</td>
</tr>
<tr>
<td>Task (0: social, 1: nonsocial)</td>
<td>0.60</td>
<td>0.11</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Toddler gender (0: girl, 1: boy)</td>
<td>0.00</td>
<td>0.11</td>
<td>.982</td>
</tr>
<tr>
<td>Parent lifetime social anxiety disorder</td>
<td>0.21</td>
<td>0.10</td>
<td>.045</td>
</tr>
<tr>
<td>Parent lifetime other anxiety disorder(s)</td>
<td>-0.05</td>
<td>0.12</td>
<td>.685</td>
</tr>
<tr>
<td>Parent lifetime comorbid anxiety disorders</td>
<td>0.20</td>
<td>0.10</td>
<td>.061</td>
</tr>
<tr>
<td>Expressed parental anxiety at 12 months</td>
<td>-0.02</td>
<td>0.06</td>
<td>.749</td>
</tr>
<tr>
<td>Expressed parental anxiety at 30 months</td>
<td>-0.01</td>
<td>0.04</td>
<td>.910</td>
</tr>
<tr>
<td>Parent lifetime social anxiety disorder * Expressed parental anxiety at 12 months</td>
<td>0.01</td>
<td>0.10</td>
<td>.943</td>
</tr>
<tr>
<td>Parent lifetime other anxiety disorder(s) * Expressed parental anxiety at 12 months</td>
<td>-0.13</td>
<td>0.12</td>
<td>.283</td>
</tr>
<tr>
<td>Parent lifetime comorbid anxiety disorders * Expressed parental anxiety at 12 months</td>
<td>0.20</td>
<td>0.09</td>
<td>.026</td>
</tr>
<tr>
<td>Parental encouragement at 30 months</td>
<td>0.10</td>
<td>0.04</td>
<td>.026</td>
</tr>
<tr>
<td>Behavioral Inhibition (BI)</td>
<td>0.09</td>
<td>0.06</td>
<td>.158</td>
</tr>
<tr>
<td>Parent gender * Infant BI</td>
<td>-0.11</td>
<td>0.06</td>
<td>.057</td>
</tr>
</tbody>
</table>

Finally, we further explored the possibility that the positive association between expressions of parental anxiety by parents with comorbid social and other anxiety disorders at 12 months and toddlers’ fear/avoidance at 30 months is explained by higher severity of lifetime parental anxiety disorders in the comorbid social and other anxiety disorders group (than lifetime other anxiety disorder(s) only, and than social lifetime anxiety disorder only). As an index of severity, we used the sum of parents’
interference scores for each anxiety diagnosis. First, we compared severity across the three parental anxiety disorder groups (i.e., parental lifetime social anxiety disorders, parental other nonsocial anxiety disorder(s) and parental comorbid social and nonsocial anxiety disorders) with a one way between-subjects ANOVA which revealed a significant effect of parental anxiety disorder group on severity \( F(2, 125) = 43.97, p < .001, \eta^2_p = .41 \). Pairwise comparisons revealed that the severity was significantly higher in comorbid social and other nonsocial anxiety disorders group (\( M = 14.92, SD = 5.50 \)), while there was no significant difference in severity between social anxiety disorder group (\( M = 5.74, SD = 2.34 \)), and other anxiety disorder(s) group (\( M = 7.53, SD = 6.52 \)). Second, we included the severity scores in the multilevel model (presented in Table 3) as a predictor of toddlers’ fear/avoidance at 30 months in SR situations, after removing parental anxiety diagnoses. There was a positive association between parents’ anxiety disorder severity and toddlers’ fear/avoidance (\( \beta = .09, SE = .04, p = .040 \)). The association between parental encouragement and of toddlers’ fear/avoidance was not significant in this model, while the remaining effects were similar to the model presented in Table 2.

DISCUSSION

This study investigated the links between parental trait anxiety (lifetime anxiety disorders), parental state anxiety (observed expressed anxiety at 12 and 30 months in SR situations) and toddlers’ fear/avoidance in SR situations at 30 months, and explored the influence of early temperamental dispositions of child trait anxiety (i.e., BI measured with observational tasks at 12 months) as well as of current and previous parenting behavior in SR tasks (i.e., parental encouragement at 12 and 30 months and parental overcontrol at 30 months).

The central finding is that toddlers’ fear/avoidance in SR situations was predicted by parental anxiety disorder rather than by expressed parental anxiety in the SR situations at 30 months. Note that this was specifically the case for social anxiety disorder, as children of parents with SAD diagnoses (with and without other nonsocial comorbid anxiety diagnoses) were more fearful/avoidant than children of parents without anxiety diagnosis, whereas children of parents with other nonsocial anxiety diagnoses alone expressed similar levels of anxiety as children of parents without anxiety diagnosis. Parental diagnosis of SAD (with and without other nonsocial comorbid anxiety diagnoses) also predicted higher levels of expressed parental anxiety compared to parents without anxiety diagnosis in the SR situations. These findings suggest that parental lifetime social anxiety diagnosis increased both the parents’ and the toddlers’ anxiety in novel situations.

Although at 30 months, expressed parental anxiety did not significantly predict child fear/avoidance in the SR tasks, higher levels of expressed parental anxiety at
Parental Social Anxiety Disorder and Toddler Fear/Avoidance

12 months by parents with lifetime comorbid social and other anxiety diagnoses, predicted higher levels of child fear/avoidance at 30 months. The positive association implies that these children may have already learned to be anxious in SR situations from their parents at 12 months. That is, children of parents with comorbid social and other anxiety disorders may have already internalized parental responses to novel stimuli at 12 months, and, as a result, they may rely on their own judgment (that seems to include parents’ previously expressed anxiety) rather than on their parent’s current behavior. Additional checks on the predictive role of severity of parental lifetime anxiety disorder(s) revealed that this longitudinal effect of expressed parental anxiety by comorbid parents may be explained by a significantly higher severity of anxiety disorders in parents with comorbid social and other anxiety disorders. These findings provide preliminary support for the idea that the end of first year may be a sensitive period for learning of anxiety via SR from parents with comorbid social and nonsocial lifetime anxiety diagnoses.

The finding that expressed parental anxiety at 12 months did not significantly predict toddler fear/avoidance for toddlers of parents with lifetime social anxiety disorder only or with nonsocial anxiety disorder(s) only, has raised the question of whether the transmission of anxiety at 12 months is only happening from parents with relatively more severe forms of parental anxiety disorders. The severity analyses revealing significantly higher severity in parents with comorbid social and other nonsocial anxiety disorders confirmed this idea in the current sample. The longitudinal effects of learning via SR at 12 months on children’s fear/avoidance at later ages remain to be studied.

In contrast to the hypothesized vulnerability of highly inhibited infants (e.g., Ingram & Luxton, 2005; Nigg, 2006; Zuckerman, 1999), the interplay of infants’ BI with parental (trait and state) anxiety, did not predict toddler fear/avoidance at 30 months. Interestingly, BI at 12 months prospectively predicted toddler fear/avoidance in SR situations at 30 months with mothers but not with fathers, indicating a differential influence of early temperamental predispositions on fear/avoidance in the presence of mother versus father. It seems that with their mother, toddlers’ reactions to novelty were more consistent with their early temperamental predispositions, whereas with their father, toddlers seemed to respond relatively free of their early temperamental predispositions. Thus, it can be speculated that fathers’ presence stimulates their toddlers to approach novel, ambiguous situations without a priori hesitation, consistent with their hypothesized role of stimulating exploration (e.g., Bögels & Perotti, 2011).

With respect to the influence of mothers vs. fathers in SR at 30 months, no other difference was observed between mothers’ and fathers’ effects during SR situations. The associations of child fear/avoidance with parental state and trait anxiety did not significantly differ across parents, indicating that in toddlerhood (like in infancy,
Aktar et al., 2013), fathers are as important as mothers. No support was found for the idea that fathers’ expressed anxiety may be more influential than mothers’ as children get older (Bögels & Perotti, 2011; Bögels & Phares, 2008) in toddlerhood. The lack of gender differences in toddlers’ expressions of fear/avoidance and in parents’ anxiety indicate that SR processes operate similarly across parent and child gender at this age, in line with our previous findings at 12 months (Aktar et al., 2013).

The present findings suggest that the transmission of anxiety in SR situations is not context specific. The interplay of expressed parental anxiety at 12 and 30 months with task (social versus nonsocial) did not significantly predict child fear/avoidance indicating a lack of differential effects of expressed parental anxiety on children’s fear/avoidance across SR tasks.

Higher levels of parental encouragement were associated with more fear/avoidance in the SR situations in the regression models. This is inconsistent with previous evidence on maternal encouragement predicting lower avoidance at 14 months (Murray et al., 2008), but consistent with the negative association we found at 12 months between child avoidance and parental encouragement (Aktar et al., 2013). Because parents were asked to actively encourage their child to approach the stimuli, the likely explanation is that fearful/avoidant children needed -and received- more encouragement. Note that although parental encouragement is associated with more child fear/avoidance on the spot, it may help children overcome fears of novelty in the long term. In contrast to previously reported meta-analytic associations between overcontrolling parenting and child anxiety (McLeod et al., 2007; Van der Bruggen et al., 2008), in the present study parental overcontrol at 30 months was unrelated to toddler fear/avoidance. However, keep in mind that very few studies have examined this association at this age. The lack of association between parental state anxiety and overcontrol is however, in accordance with the low meta-analytic effect size as reported by Van der Bruggen et al. (2008). Post-hoc analyses on the prospective effect of parents’ encouraging behavior at 12 months on child fear/avoidance at 30 months did not reveal any significant associations, indicating that child reactions at 30 months were unrelated to previous parental encouragement in SR contexts. To conclude, our findings do not support the generally held idea that parents transmit their anxiety to their children through overprotective or lack of encouraging parenting, neither cross-sectionally nor longitudinally. However, higher levels of previously expressed anxiety during SR tasks by parents with lifetime comorbid social and other anxiety disorders did predict higher levels of anxiety/avoidance at 30 months, suggesting that social referencing in infancy contributes to the intergenerational transmission of anxiety in children of parents with comorbid social and other anxiety disorders.

The findings should be interpreted with consideration of the following limitations. First, measures of parental anxiety diagnoses were obtained in the prenatal...
Parental Social Anxiety Disorder and Toddler Fear/Avoidance

assessment, thus information on parents’ current diagnostic status was not available. Still, the findings revealed that prenatal diagnostic anxiety status prospectively predicted child behavior in SR situations. Second, a concurrent measure of BI was not available at 30 months. The existing literature on the stability of temperament suggests that BI may be relatively less stable from infancy to toddlerhood (e.g., Lemery, Goldsmith, Klinnert, & Mrazek, 1999), and more stable from toddlerhood onwards (Fox et al., 2005). Still, higher levels of BI at 12 months predicted higher fear/avoidance with mothers, suggesting that with mothers, toddlers rely on their early temperamental predisposition in approaching novel situations. Third, because the order of SR tasks was fixed, potential carryover effects couldn’t be excluded. Fourth, families were from a relatively higher socioeconomic background than the general population, limiting the generalizability of the findings.

CONCLUSIONS

The findings of the present study investigating toddler and parent behavior in SR situations provide evidence that social anxiety aggregates in families. Children of parents with lifetime SAD (both alone and comorbid with other anxiety disorders) showed higher levels of fear/avoidance in response to novelty in SR situations than children of parents without anxiety disorder. Although parents with lifetime SAD expressed more anxiety during the SR situations, expressed parental anxiety at 30 months was not associated with child fear/avoidance, indicating that in toddlerhood, anxiety may not be (any longer) transmitted via SR. Expressed parental anxiety at 12 months by parents with comorbid lifetime social and other nonsocial anxiety diagnoses did predict children’s fear/avoidance significantly at 30 months, indicating that end of first year may be an especially sensitive period for learning of anxiety from parents with comorbid social and other anxiety disorders. No evidence was found for an increased vulnerability of highly inhibited infants to the effects of parental state or trait anxiety.

The association between parental state and trait anxiety and toddler fear/avoidance did not significantly differ between mothers and fathers, indicating that at this young age, fathers are as important as mothers in the intergenerational transmission of anxiety. Interestingly, early BI predicted fear/avoidance only with mothers, suggesting that toddlers may act relatively free from their early temperamental predispositions in SR situations with fathers.

This study found evidence in favor a specific link between parental social anxiety diagnosis and higher levels of child fear/avoidance, which did not hold for parental diagnoses of other anxiety disorders alone. No evidence was found supporting context specificity: the association between expressed parental anxiety and toddler fear/avoidance did not significantly differ across social and nonsocial contexts.
CHAPTER 5

Infants’ fearful temperament and mothers’ and fathers’ anxiety symptoms predict infants’ attention to facial expressions of emotion

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Chapter 5

ABSTRACT

Previous evidence from clinical and typically developing samples has revealed links between infants’ exposure to maternal positive and negative emotions and infants’ attention to facial expressions of emotion. This study investigated behavioral and physiological indices of infants’ attention to facial expressions of emotions, and tested the associations of infants’ attention to facial expressions with infants’ negative temperament, and with mothers’ and fathers’ negative affect, depression and anxiety. Infants’ \(N = 57, M_{\text{age}} = 14.26\) months) fixations and pupil responses to 3-s presentations of happy, sad, angry, fearful, and neutral facial expressions were measured with an eye-tracker. Mothers’ and fathers’ negative affect, depression, and anxiety, and infants’ negative temperament were measured with questionnaires. More maternal negative affect, and fearful infant temperament were related to less pupil dilation to emotional (vs. neutral) facial expressions. More maternal and paternal anxiety was related to shorter fixations to emotional (vs. neutral) faces in infants low in fearful temperament, while it was related to longer fixations in infants high in fearful temperament. The current study provides the first evidence for significant associations between infants’ and parents’ emotional dispositions, and infants’ pupil responses to facial expressions of emotion in a typically developing sample.
INTRODUCTION

Detecting and understanding faces in the environment is adaptive in early development (Pascalis & Kelly, 2009). In line with the survival value of face processing in infancy, evolutionary pressures have ensured early functionality and maturation of the emotional brain systems responsible for the detection and processing of faces. Exposure to faces in the environment is known to be essential for the development of emotional brain systems responsible for infants’ face processing skills in the first year (Leppänen, 2011; Leppänen & Nelson, 2009; Pascalis & Kelly, 2009; Slater et al., 2010). Considering that infants are most frequently exposed to their parents’ face in the environment, the variation in the distribution of emotions that the parent expresses in this period can explain individual differences in infants’ attention to faces, alone or in combination with infants’ own emotional dispositions (De Haan, Belsky, Reid, Volein, & Johnson, 2004).

Parental depression and anxiety are highly prevalent forms of psychopathology that are defined by an increase in the experience and expressions of negative emotions in parents (O’Hara, & Swain; 1996; Matthey, Barnett, Howie, & Kavanagh, 2003; Ross & McLean, 2006). The experience-dependent development of infants’ emotional brain systems in the first year of life seems to constitute vulnerability to depression- and/or anxiety-related deviations in early emotional environment (Leppänen, 2011; Leppänen & Nelson, 2009). Considering significant associations of parental depression and/or anxiety in early years with later emotional, behavioral and psychological child outcomes (e.g., Avan, Richter, Ramchandani, Norris & Stein, 2010; Murray, et al., 1999; Pawlby, Sharp, Hay & O’Keane, 2008), it is important to understand how exposure to parents’ negative emotions is linked to emotion processing in infancy. The goals of the current study are two-fold: The first is to investigate fixations and pupil responses to positive and negative (vs. neutral) facial expressions as indices of infants’ attention allocation to emotion, and the second is to explore whether negative temperamental dispositions of typically developing infants and their parents’ negative affect, depression and anxiety explain individual differences in infants’ attention allocation (measured via fixations and pupillary responses) to emotional versus neutral facial expressions.

Typically developing infants start to show a negativity bias in their attention to emotional stimuli between 5 and 7 months of age, that is, they allocate more attention to negative stimuli (for a review see Vaish, Grossmann, & Woodward, 2008). For example, seven-month-old infants look longer at fearful than happy facial expressions in visual paired comparison tasks (De Haan et al., 2004; Kotsoni, De Haan & Johnson, 2001; Nelson & Dolgin, 1985). Further, they are less likely to disengage their attention from fearful than happy faces (Peltola, Hietanen, Forssman, & Leppänen, 2013; Peltola, Leppänen, Palokangas, & Hietanen, 2008). Physiological indices of attention allocation also reveals a negativity bias in infants’ emotion processing. For
example, ERP studies utilizing the Negative Central (Nc) Component as an index of attention allocation reveal enhanced attention to fearful over happy faces (De Haan et al., 2004; Nelson & De Haan 1996, Peltola, Leppänen, Mäki, & Hietanen, 2009). Heart rate studies utilizing heart rate deceleration as an index of attention allocation reveal a stronger deceleration for fearful than happy faces (Peltola et al., 2013). Eye-tracking studies that use pupil dilation as an index of attention allocation reported more dilation to fearful than neutral, or happy facial expressions at 12 and 14 months (Geangu Hauf, Bhardwaj, & Bentz, 2011; Gredebäck, Eriksson, Schmitow, Laeng & Stenberg, 2012).

It has been suggested that the negativity bias is evolutionarily programmed to emerge at this time in infancy to ensure self-preservation in the face of new threats encountered after locomotion (Leppänen & Nelson, 2012; Vaish et al., 2008). Thus, one would expect the negativity bias to be especially salient for negative emotions with threat relevance (i.e., fear and anger). Because the available evidence on negativity bias mainly comes from studies testing fearful (vs. happy) emotions (see Grossmann, 2010), it remains largely unknown whether the negativity bias in infants’ processing is specific to threat-relevant negative emotions (that is, to fearful and angry facial expressions) or generalizes to other negative emotions (such as sad facial expressions). There is some evidence on specific effects for threat-relevant emotions in infants’ scanning of facial expressions. Hunnius, De Wit, Vrins, and von Hofsten (2011) reported a vigilant-avoidant pattern in infants’ visual scanning of facial expressions for anger and fear, but not for sadness. However, this study focused on infants’ visual scanning patterns only, and did not consider any physiological index of attention allocation, such as pupil dilation. In the present study, we tested differences in infants’ attention to happy, fearful, angry and sad faces (in addition to neutral faces) to explore negativity bias in behavioral and physiological measures of infants’ attention.

The main advantage of eye-tracking methods in the investigation of emotion processing is the opportunity to simultaneously assess behavioral and physiological components of attention allocation. In the current study, we used fixations, defined as a series of gaze points clustered on a given location in the visual field, as a behavioral index of attention. Infants’ pupillary responses were used as a physiological index of attention. Although pupil dilation can be both a parasympathetic and a sympathetic response, adult pupil dilation in the context of emotional stimuli is found to reflect sympathetic processing after controlling for light effects (Bradley, Miccoli, Escrig, & Lang, 2008). Pupil dilation has been increasingly used in research with adults (e.g., Bradley et al., 2008; Partala & Surakka, 2003; Kret, Roelofs, Stekelenburg, & de Gelder, 2013; Kret, Stekelenburg, Roelofs, & De Gelder, 2013) and recently with infants (Geangu et al., 2011; Gredebäck et al., 2012) to assess attention (or arousal) to emotional stimuli.
Studies investigating adults’ and infants’ pupil responses to emotion consistently report more pupil dilation (i.e., more attention) to negative vs. neutral emotions (Bradley et al., 2008; Geangu et al., 2011; Gredebäck et al., 2012; Partala & Surakka, 2003; Van Steenbergen, Band, & Hommel, 2011). Geangu et al. (2011) reported significant increases in pupil dilation to negative as compared to both positive and neutral videos of peers at 6 and 12 months. In contrast, Gredebäck et al. (2012), investigating infants’ pupil responses to static images of fearful, happy, and neutral facial expressions of parents or strangers at 14 months, found increased pupil dilation to fearful vs. neutral faces of strangers (and not of parents), while no significant differences were reported between happy and neutral faces in infants cared by both parents (but not by mothers only). In the current study, we included happy facial expressions to test the differences in infants’ attention to positive in addition to negative (vs. neutral) emotions.

In addition to infants’ attention to negative, positive and neutral emotions, the current study investigated how individual variation in infants’ attention to emotional expressions relates to the differences in parents' negative affect, depression and anxiety in typical development. There is evidence on the effects of exposure to parents’ negative emotions on infants’ attention in special populations. Overexposure to parents’ angry faces among maltreated children seems to result in increased attention to angry faces (Pollak, Cicchetti, Hornung, & Reed, 2000), while overexposure to mothers’ sad and flat facial expressions by depressed mothers has been linked to decreased attention to sad faces (Field, Diego, & Hernandez-Reif, 2009; Field, Pickens, Fox, Gonzalez, & Nawrocki, 1998). For example, at 6 months, infants of depressed mothers show less interest (less looking) to sad facial expressions as compared to infants of non-depressed mothers (Field et al., 1998). Infants of depressed mothers also show more interest (looking) in mothers’ positive facial expressions during face-to-face interactions (Striano, Brennan, & Vanman, 2002). In the current study, we indirectly investigated the effects of exposure to parental negative emotions in a typically developing sample by testing mothers’ and fathers’ self-reported negative affect, depression and anxiety as predictors of infants’ attention to facial expressions of emotions.

Along with the environmental effects of exposure to parents’ negative emotions, depression and anxiety, infants’ own negative temperamental dispositions are a relevant source of individual variation in infants’ responses to facial expressions. Negative temperamental dispositions, defined by withdrawn, fearful, or distressed reactions to ambiguous/novel stimuli such as strangers or ambiguous objects (Fox, Henderson, Marshall, Nichols, & Ghera, 2005). Negative temperamental predispositions may constitute vulnerability for the effects of adverse rearing environments on later outcomes (Ingram & Luxton, 2005; Nigg, 2006) and for later child psychopathology.
Infants’ temperamental dispositions are also closely linked to infants’ own expressions of negative emotions (Izard, Libero, Putnam, & Haynes, 1993), and to their physiological reactivity to emotional stimuli. For example, Martinos, Matheson, and De Haan (2012) investigated the association between ERP correlates of infants’ attention allocation (i.e., the Nc component of ERP responses) and negative emotional dispositions in 3-to-13-month old infants and found that infants with higher negative emotionality (parent report) showed a more pronounced Nc response, indicating more attention to happy faces than fearful faces.

To our knowledge, only one study has investigated the links of infants’ temperament and of parents’ negative affect with behavioral and physiological components of infants’ attention to facial expressions of emotion in a typically developing sample: De Haan et al. (2004) measured 7-month-old infants’ looking preferences and ERP responses to fearful and happy facial expressions, and tested mothers’ report of their infants’ positive and fearful temperament and of their own positive and negative emotions as predictors of infants’ attention. They found that when presented with pairs of happy and fearful expressions, infants of mothers with high levels of positive affect looked longer at fearful faces, while infants of mothers with low positive affect did not show a looking preference. Differently from the findings of Martinos et al. (2012) that revealed enhanced attention to happy than fearful faces in temperamentally negative infants, De Haan et al. (2004) found a larger Nc component in infants’ attention (measured via ERP) to fearful than happy faces only in temperamentally fearful infants. This finding reveals that fearful temperamental dispositions may be linked to more attention to fearful faces in ERP indices. While the relationship between maternal negative affect and infants’ ERP activity was not significant in De Haan et al.’s study, temperamentally positive infants of highly positive mothers allocated more attention to fearful faces using ERP indices (Nc component). Taken together, the findings of this study reveal a stronger negativity bias in attention to fearful facial expressions in infants of mothers with more positive affect. The study by De Haan and colleagues provides the first evidence for significant effects of infants’ and mothers’ emotional dispositions on infants’ attention to faces in a typically developing sample. The findings also reveal continuity in the links between exposure to parents’ depressed affect and infants’ attention to sad expressions in infants of clinically depressed mothers, and exposure to parents’ positive affect with infants’ attention to happy expressions in typically developing infants, i.e., a negative association. In other words, infants seem to pay less attention to the emotional facial expressions that they are exposed to relatively more often from mothers in typical development, as well as in the case of parental depression. However, the association...
of parents’ depression and anxiety symptoms with infants’ attention to emotional stimuli remains to be explored in typically developing samples.

In the current study, we investigated 13-to-16-month-old infants’ attention to facial expressions via eye tracking and tested the associations of the duration of infants’ fixations, and pupil responses to emotional facial expressions with mothers’, fathers’ and infants’ negative emotional dispositions. The current age group was of special interest as infants’ understanding of facial expressions, and the negativity bias seem to become more ‘robust’ around this time in development (Vaish et al., 2008). Around 12 months, infants develop the ability to use adults’ expressions of emotions to determine their emotional and behavioral reactions to unfamiliar aspects of the environment (so called social referencing, Feinman, 1982). For example, infants’ exposure to parents’ expressions of anxiety towards unfamiliar stimuli (such as strangers and/or novel toys) is linked to increased behavioral avoidance of these stimuli in infants with moderate and high levels of negative temperamental predispositions (Aktar, Majdandžić, De Vente, & Bögels, 2013; De Rosnay, Cooper, Tsigaras, & Murray, 2006).

Based on previous evidence revealing a negativity bias in infants’ looking preferences to fearful expressions, we expected that the duration of infants’ fixations would be longer in response to fearful (vs. neutral) stimuli. Based on previous infant studies of emotion via pupil dilation, we expected that infants would respond with more pupil dilation to fearful than to neutral expressions. We additionally explored the differences in infants’ attention to fearful, angry, sad and happy (vs. neutral) facial expressions in physiological and behavioral components of infants’ attention allocation to emotion. Thereby, we also addressed threat specificity by comparing infant’s processing of threat-relevant emotions (anger and fear) to the non-threat-relevant emotion (sadness). Based on previous evidence on the links between mothers’ and infants’ emotional dispositions and infants’ attention to emotional expressions (De Haan et al., 2004; Martinos et al., 2012), we expected significant associations between infants’ attention to faces and parents’ negative affect, depression and anxiety, as well as between infants’ attention to faces and infants’ temperament. The direction of these associations, and the moderating role of infants’ temperament were explored for the first time via infants’ fixations and pupil dilation in the current study.

**METHODS**

**Participants**
The sample consisted of 57 infants between the ages of 13 and 16 months (23 girls; $M_{age} = 14.26$ months, $SD = 0.66$, range: 12.45 to 15.61) and their mothers and fathers. Data from 7 infants who participated in the study was missing due to equipment failure, movement and/or fussiness (see Data Reduction). Of the 57 couples that participated with their infant, questionnaire data was available from 52 parents.
Families were part of a larger sample recruited via invitation letters sent by the municipality to a random sample of families who recently became parents. Forty-eight infants visited with their mother, and 9 with their father. Sociodemographic characteristics are presented in Table 1. The study was approved by the ethical committee of the University of Amsterdam. Parents provided written informed consent for participation.

Table 1. Sample characteristics

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Mother</th>
<th>Father</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (M (SD, \text{range}))</td>
<td>34.48 (4.08, 26-45)</td>
<td>37.20 (4.52, 29-50)</td>
</tr>
<tr>
<td>Dutch origin</td>
<td>89.47 %</td>
<td>86 %</td>
</tr>
<tr>
<td>Educational level(a) (M (SD, \text{range}))</td>
<td>7.76 (0.48, 6-8)</td>
<td>7.48 (1.25, 4-8)</td>
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<tr>
<td>Professional level(b) (M (SD, \text{range}))</td>
<td>9.68 (2.01, 2-11)</td>
<td>9.06 (2.18, 2-11)</td>
</tr>
<tr>
<td>Monthly income(c) (M (SD, \text{range}))</td>
<td>3.96 (1.83, 1-7)</td>
<td>5.58 (1.36, 3-7)</td>
</tr>
<tr>
<td>Working hours (per week)</td>
<td>25.96 (12.88, 0-50)</td>
<td>34.69 (12.42, 0-60)</td>
</tr>
</tbody>
</table>

Notes. \(a\) Educational level was assessed with an 8-point scale ranging from 1 (primary education) to 8 (university).
\(b\) Professional level was assessed with an 11-point scale ranging from 1 (manual labour for which no education required) to 11 (labour requiring a university degree).
\(c\) Parental income was assessed with a 7-point scale from 1 (< 500 euros/month) to 7 (> 5000 euros/month).

Materials and Procedure

Stimuli

The stimuli were black-and-white photographs (1280 x 1024 pixels) exhibiting happy, fearful, sad, angry and neutral facial expressions (presented in Figure 1). To avoid the confounding effects of differences in visual properties of different individuals’ faces, we presented facial expressions from a single person in this study. Considering that the mothers are mostly the primary caregiver in this period, and that infants who are mainly cared by mothers show more attention to female faces (Quinn, Yahr, Kuhn, Slater, & Pascalis; 2002) we used facial expressions from a female model. We asked 40 adults (31 females and 9 males, \(M \text{ age} = 25.82, \text{SD} = 3.32, \text{range:} \ 19-35\)) to label the emotion expressed in each picture. The percentage of participants who labeled the emotion correctly was 97.5 % for the happy, 95 % for the angry, 95 % for the fearful, and 97.5 % for the sad face. All the photographs were taken in the same studio with similar light conditions. The contrast, clarity and luminance were further standardized in Adobe Photoshop, along with the size and positions of the face and of the eyes. The remaining variance (\(M = 73.46, \text{SD} = 5.35, \text{range:} \ 65.04 \text{ to} \ 79.39\)) in the mean luminance of the photographs had a weak association with raw pupil scores (\(r = -.04, p < .001\)).
Infants’ attention to faces

Figure 1. Angry, fearful, happy, neutral and sad faces used in the experiment.

Questionnaires

**Parental negative affect.** Both parents completed the Negative Affect Schedule of The Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). The Negative Affect Schedule consists of 10 negative emotions (e.g., distress, irritability or shame), and measures parents’ experience of these emotions in the last two weeks on a 5-point scale. The reliability of the Negative Affect Schedule was (Cronbach’s α) .87 for mothers and .85 for fathers.

**Parents’ depression and anxiety.** Both parents filled in the second edition of the Beck Depression Inventory (BDI-II; Beck, Steer & Brown, 1996), and the adult version of the Screening for Anxiety Related Emotional Disorders (SCARED-A; Bögels & Van Melick, 2004). The BDI-II is a 21-item questionnaire measuring depressive symptoms, and the SCARED-A is a 71-item questionnaire assessing symptoms of anxiety disorders. The reliability (Cronbach’s α) of the BDI-II was .77 for mothers and .91 for fathers, and of the SCARED-A .91 for mothers and .86 for fathers.

**Infant temperament.** The parent visiting the lab with the infant completed the Infant Behavior Questionnaire Revised (IBQ-R; Gartstein & Rothbart, 2003). The IBQ-R consists of 191 items measuring 14 dimensions of infant temperament. Due to their direct link to infants’ experience of negative emotions, the fearful and the sad temperament dimensions were of interest for this study. Parents rated the frequency of infants’ expressions of fear (such as crying, or showing distress) and sadness (e.g., becoming tearful and sad) in a number of occasions (e.g., fear while visiting a new place or meeting a stranger, or sadness after separation from the caregiver) in the last two weeks on a 7-point scale. The reliability (Cronbach’s α) of these scales was .85 and .80, respectively.

**Procedure**

Infants’ fixations and pupil responses were measured via an eye-tracker (Tobii T120) in a dimly illuminated room. Infants were seated in a car seat 60 cm away from the screen. Prior to testing, infants’ gaze was calibrated with a 5-point procedure. During the test, the parent sat on a chair behind the infant and was instructed to remain neutral and not intervene unless the infant became fussy.

Before the experimental blocks, the facial expressions were presented once in a test block with a fixed order starting with neutral and ending with the sad expression (not
used in the analyses). The experiment consisted of 4 blocks of 5 trials. In each block, five facial expressions appeared once in pseudo-random order with the following restrictions: the same emotion could not appear consecutively and all emotions were shown before one was repeated. Each trial started with an attention-getter (a moving chick) followed by 500 ms of blank black screen. Next, the first face was presented for 3 s. An experimenter monitoring infants’ attention from another room repeated the presentation of the attention getter when necessary before the presentation of each facial expression.

Statistical Analyses

Data reduction

Fixations. Fixations were identified using the data-driven algorithm of Mould, Foster, Amano and Oakley (2012) implemented in gaze path package (Van Renswoude & Visser, 2015) in R (R core team, 2014). This speed-based algorithm overcomes problems with standard dispersal algorithms, such as correlations between dependent variables and noise levels (Wass, Forssman, & Leppänen, 2014). A duration threshold of 100 ms was used and the velocity threshold was estimated for each individual on each trial separately to control for the influence of noise. Infants with noisier trials, indicated by a large variance in point of gaze, had more conservative thresholds than infants with cleaner trials, \( r = .60, t(60) = 5.82 \), indicating that the algorithm was performing well. Missing sequences between fixations on the same location were interpolated, leading to 4885 fixations with a mean duration of 436 ms (SD = 135). In average, fixation data were available from 14.00 trials (SD = 5.31) for each infant. The duration and the frequency of fixations to faces were obtained by summing the durations and the frequency of fixations on the face in a given trial.

Pupil responses. First, to account for measurement error, outlying pupil measurements (\(| > |3| \ SD |\)) were removed from each infant’s distribution of pupil scores. Next, missing observations (missing sequences < 500ms) were identified, and replaced via linear interpolation (see Jackson & Sirois, 2009). Following the interpolation, the pupil data was reduced to observations where the infant was looking at the face and was averaged to 60 observation points with 50 ms intervals in the 3 s time window (i.e., picture time). Trials in which children looked at the face for at least 500 ms within the 3-s presentation time were included in the analyses. Infants’ pupil responses to emotional facial expressions were baselined to the pupil size (averaged across 10 observation points with 50 ms intervals) during the 500 ms presentation of the preceding blank black screen via subtraction. In line with adult pupil studies (e.g., Bradley et al., 2008), pupil responses were analyzed following the initial pupillary light reflex (i.e., the last 2 s of 3-s presentation, thus 40 observation points of 50 ms interval were used for analysis). The pupil data was available in average for 14.65 trials (SD = 4.49) across all infants. To explore the associations between the number of available trials and individual differences, we inspected the zero-order correlations.
Infants’ attention to faces

There was a significant positive association between the number of available trials and fathers’ negative affect ($r = .38$, $p = .006$ for pupil, and $r = .32$, $p = .023$ for fixations). Thus there were more trials available when fathers had higher levels of negative affect. To keep as much variance as possible in the models for the investigation of individual differences, we did not exclude any participants based on the overall number of trials where the pupil or fixation data was available. We adjusted our analytic approach accordingly and used multilevel models that are known to accommodate for missing data (Bagiella, Sloan & Heitjan, 2000).

Outcome variables

The duration of fixations was the outcome measure in the analysis of infants’ behavioral attention to emotion. It was analyzed with multilevel regression models consisting of observations across trials nested within infants. The intercept was a random effect, while emotion (i.e., facial expression) and all other predictors were treated as fixed effects. Maximum likelihood was the estimation method, and an auto-regressive covariance structure was used for repeated effects of trials.

Baselined pupil scores were the outcome measure in the analyses of physiological reactivity to emotion (henceforward called ‘differential pupil responses’). Therefore all pupil analyses in this study should be interpreted as a relative change in pupil size from baseline. The pupil data were analyzed with multilevel regression models consisting of observations across picture time within each trial and across trials nested within infants. The intercept and picture time were random effects, while emotion (i.e., facial expression) and all other predictors were treated as fixed effects. Maximum likelihood was the estimation method. An auto-regressive covariance structure was used for repeated effects of picture time.

To test the relation between emotion effects and attention, the neutral expression was used as the reference in both the fixation and the pupil models. Girls were the reference group for child gender. Parental negative affect, infant temperament (i.e., infant fear and sadness), picture time (repeated observations within trial), block and order were entered as continuous variables in the models. Inspection of distributions indicated sufficient normality; skewness and kurtosis of all variables were $< |2|$, except for paternal anxiety scores. The scores from two fathers with outlying values ($> 3$ SD) in the distributions of anxiety scores were replaced by the next most extreme value in the distribution. The scores of parents’ negative affect, depression and anxiety, infants’ temperament, the duration of fixations and pupil responses were standardized in the analyses.
The initial multilevel models for infants’ duration of fixations consisted of the main effects of emotion (i.e., happy, fearful, angry, and sad vs. neutral), and additional control variables (trial order [0 to 19], and block [0 to 3]). The initial multilevel models for infants’ differential pupil responses consisted of the main effects of emotion (vs. neutral), picture time (0 to 39), and additional control variables (trial order, and block). For the analyses of individual differences, first the main effects of mothers’ and fathers’ negative affect, and of infants’ fearful and sad temperament were included in all models. Second, two-way interactions of each of these predictors with emotion were included. Two-way interactions between parents’ negative affect and infants’ temperament were tested in the last step. To probe significant interaction effects in multilevel models, we inspected the interaction plots and regions of significance obtained by continuously plotting confidence intervals for the simple outcome slope across all the values of the moderator using online tools provided by Preacher, Curran, and Bauer (2006).

To explore the associations of infants’ attention with parental depression and anxiety symptoms, we separately analyzed these predictors in additional models. We repeated the same multilevel analyses, and tested the same interactions as the individual difference models described above. We first tested a model for parental depression (including infant temperament, excluding parental negative affect), and next a model for parental anxiety symptoms. All the effects were evaluated at $p \leq .05$.

RESULTS

Preliminary Analyses

Zero-order correlations between predictor variables are presented in Table 2. There were positive associations between mothers’ depression and anxiety, as well as between fathers’ depression and anxiety symptoms, and positive associations between parents’ negative affect and depression symptoms (marginally significant for mothers, $p = .055$). Higher levels of depression (but not anxiety) in mothers and fathers were also associated with higher ratings of infants’ sad and fearful temperament (marginally significant for fathers’ depressive symptoms and infants’ sad temperament, $p = .064$). Mothers’ but not fathers’ negative affect was also marginally associated with infants’ sad temperament, $p = .053$. The associations between infants’ fixation durations and their averaged differential pupil responses (per trial) were not significant ($r = -.02$, $p = .537$).
Infants’ attention to faces

Table 2. Zero-order correlations between infants’ temperamental fear and sadness, parental negative affect, depression and anxiety.

<table>
<thead>
<tr>
<th></th>
<th>Infant fear</th>
<th>Infant sadness</th>
<th>Maternal negative affect</th>
<th>Paternal negative affect</th>
<th>Maternal depression</th>
<th>Paternal depression</th>
<th>Maternal anxiety</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant sadness</td>
<td>.04</td>
<td>.787</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>p</td>
<td></td>
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<td></td>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal negative</td>
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<td>.27</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paternal negative</td>
<td>.18</td>
<td>.10</td>
<td>.17</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>affect</td>
<td>p</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal depression</td>
<td>.29</td>
<td>.33</td>
<td>.28</td>
<td>-.14</td>
<td></td>
<td></td>
<td></td>
</tr>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paternal depression</td>
<td>.33</td>
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<td>.13</td>
<td>.51</td>
<td>.12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>p</td>
<td></td>
<td></td>
<td></td>
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<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal anxiety</td>
<td>.18</td>
<td>.15</td>
<td>.11</td>
<td>-.01</td>
<td>.32</td>
<td>-.03</td>
<td></td>
</tr>
<tr>
<td></td>
<td>p</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paternal anxiety</td>
<td>.24</td>
<td>.21</td>
<td>.04</td>
<td>.19</td>
<td>-.02</td>
<td>.67</td>
<td>-.10</td>
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<td></td>
</tr>
</tbody>
</table>

Main Analyses

The effect of emotion on behavioral and physiological indices of attention

The model with infants’ duration of fixation as the outcome is presented in Table 3.a ($N = 57$). Infants’ fixations were longer for fearful than neutral faces, while the duration of infants’ fixations to happy, sad, and angry faces did not differ from neutral faces.

The model with infants’ differential pupil responses as the outcome is presented in Table 3.b ($N = 57$). Infants’ pupils dilated significantly less from the baseline (i.e., blank screen) for fearful than neutral faces, while infants’ differential pupil responses to happy, sad and angry faces did not differ from neutral faces. Infants’ differential pupil response to emotional expressions increased over picture time.
Table 3. The multilevel-regressions of (3.a) durations of infants’ fixations, and (3.b) differential pupil responses (3.b) to facial expressions on emotion.

<table>
<thead>
<tr>
<th></th>
<th>3.a</th>
<th></th>
<th>3.b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE</td>
<td>p</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.21</td>
<td>0.12</td>
<td>0.088</td>
</tr>
<tr>
<td>Happy</td>
<td>0.13</td>
<td>0.09</td>
<td>0.134</td>
</tr>
<tr>
<td>Fearful</td>
<td>0.33</td>
<td>0.08</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Angry</td>
<td>0.04</td>
<td>0.09</td>
<td>0.665</td>
</tr>
<tr>
<td>Sad</td>
<td>0.09</td>
<td>0.09</td>
<td>0.320</td>
</tr>
<tr>
<td>Order</td>
<td>0.01</td>
<td>0.02</td>
<td>0.627</td>
</tr>
<tr>
<td>Block</td>
<td>-0.09</td>
<td>0.10</td>
<td>0.378</td>
</tr>
<tr>
<td>Picture time</td>
<td>0.03</td>
<td>0.00</td>
<td>&lt; .001</td>
</tr>
</tbody>
</table>

Notes. N = 57, R² = .42

Individual differences in behavioral and physiological indices of infants’ attention to emotions
In the next step, parents’ negative affect, and infants’ negative temperamental dispositions were included in the initial models with duration of fixations (presented in Table 3.a) and differential pupil responses as outcome (presented in Table 3.b) to investigate individual differences in infants’ attention to facial expressions of emotions. In the model with the duration of fixations as the outcome, none of the main effects or interactions of these variables were significant, reducing this model to the model presented in Table 3.a. Thus, infants’ and parents’ negative dispositions were not associated with infants’ duration of fixations to emotional facial expressions. In the model with infants’ differential pupil responses as the outcome, mothers’ and infants’ emotional dispositions predicted infants’ pupil responses. This model is presented in Table 4 (N = 491).

In the final step, we explored the associations of infants’ attention (i.e., duration of fixations and pupil dilation) with parental depression and anxiety symptoms, by separately adding parental depression and anxiety as predictors in the emotion models presented in 3.a and 3.b. Maternal and paternal anxiety (but not depression) symptoms predicted the duration of infants’ fixations in interaction with infants’ fearful temperament. Parents’ depression and anxiety symptoms did not significantly predict infants’ differential pupil responses alone, or in interaction with emotional expression.

1 Among 52 parents who returned the questionnaires, the data on negative affect was missing from 2 fathers, and data on infants’ temperament was missing from 1 father, resulting in the current sample size of the model.
Infants’ attention to faces or with infant temperament. The multilevel model for the duration of fixations after the inclusion of parental anxiety is presented in Table 5 (N = 47²). The interactions between parental anxiety symptoms and infants’ fearful temperament revealed that the direction of the association between parents’ anxiety and infants’ fixation durations changes as a function of infants’ fearful temperament. More maternal and paternal anxiety predicted shorter fixations to emotional faces in infants with low levels of fearful temperament (z < -0.32; and z < -0.09 for mothers and fathers, respectively), while more anxiety in parents predicted longer fixations in infants with high levels of fearful temperament (z > 1.32 and z > 1.93 for mothers and fathers, respectively).

The associations were not significant for infants with moderate levels of fearful temperament. Moreover, the interaction between maternal (but not paternal) anxiety and infants’ fixation to happy (vs. neutral) was significant in this model. Infants of mothers with low levels of anxiety symptoms (z < 0.13) had longer fixations to happy than to neutral facial expressions, while the duration of fixations did not significantly differ between happy and neutral faces for infants of mothers with moderate or high levels of anxiety.

Table 4. Individual differences on infants’ attention to emotion: the multilevel regressions of infants’ differential pupil responses to facial expressions on emotion, infants’ temperamental fear, and sadness, parental negative affect.

<table>
<thead>
<tr>
<th></th>
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</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>-0.56</td>
<td>.12</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Happy</td>
<td>0.03</td>
<td>.08</td>
<td>.670</td>
</tr>
<tr>
<td>Fearful</td>
<td>-0.32</td>
<td>.08</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Angry</td>
<td>-0.08</td>
<td>.08</td>
<td>.296</td>
</tr>
<tr>
<td>Sad</td>
<td>-0.12</td>
<td>.08</td>
<td>.111</td>
</tr>
<tr>
<td>Picture time</td>
<td>0.03</td>
<td>.00</td>
<td>&lt; .001</td>
</tr>
<tr>
<td>Infant fear</td>
<td>-0.23</td>
<td>.11</td>
<td>.039</td>
</tr>
<tr>
<td>Infant sadness</td>
<td>0.10</td>
<td>.10</td>
<td>.329</td>
</tr>
<tr>
<td>Maternal negative affect</td>
<td>-0.20</td>
<td>.10</td>
<td>.051</td>
</tr>
<tr>
<td>Paternal negative affect</td>
<td>0.11</td>
<td>.12</td>
<td>.376</td>
</tr>
<tr>
<td>Order</td>
<td>0.03</td>
<td>.02</td>
<td>.145</td>
</tr>
<tr>
<td>Block</td>
<td>-0.06</td>
<td>.09</td>
<td>.531</td>
</tr>
</tbody>
</table>

Notes. N= 49, $R^2 = .55$

² Among 52 parents who returned the questionnaires, the data on depression was missing from 5 fathers, and 4 mothers resulting in the current sample size of the model.
Table 5. Individual differences on infants’ attention to emotion: the multilevel regression of infants’ duration of fixations to facial expressions on emotion, infants’ temperament, and parental anxiety

<table>
<thead>
<tr>
<th></th>
<th>B</th>
<th>SE</th>
<th>p</th>
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<tbody>
<tr>
<td>Intercept</td>
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<td>0.12</td>
<td>0.015</td>
</tr>
<tr>
<td>Happy</td>
<td>0.21</td>
<td>0.09</td>
<td>0.025</td>
</tr>
<tr>
<td>Fearful</td>
<td>0.36</td>
<td>0.09</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Angry</td>
<td>0.08</td>
<td>0.09</td>
<td>0.410</td>
</tr>
<tr>
<td>Sad</td>
<td>0.16</td>
<td>0.09</td>
<td>0.090</td>
</tr>
<tr>
<td>Infant fear</td>
<td>0.17</td>
<td>0.08</td>
<td>0.052</td>
</tr>
<tr>
<td>Infant sadness</td>
<td>0.13</td>
<td>0.08</td>
<td>0.095</td>
</tr>
<tr>
<td>Maternal anxiety</td>
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<td>0.11</td>
<td>0.229</td>
</tr>
<tr>
<td>Paternal anxiety</td>
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<td>0.09</td>
<td>0.129</td>
</tr>
<tr>
<td>Maternal anxiety * Infant fear</td>
<td>0.28</td>
<td>0.07</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Paternal anxiety * Infant fear</td>
<td>0.20</td>
<td>0.07</td>
<td>0.009</td>
</tr>
<tr>
<td>Maternal anxiety * Happy</td>
<td>-0.20</td>
<td>0.09</td>
<td>0.031</td>
</tr>
<tr>
<td>Maternal anxiety * Fear</td>
<td>-0.17</td>
<td>0.09</td>
<td>0.061</td>
</tr>
<tr>
<td>Maternal anxiety * Angry</td>
<td>-0.05</td>
<td>0.09</td>
<td>0.562</td>
</tr>
<tr>
<td>Maternal anxiety * Sad</td>
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<td>0.09</td>
<td>0.572</td>
</tr>
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</tr>
<tr>
<td>Block</td>
<td>-0.06</td>
<td>0.11</td>
<td>0.589</td>
</tr>
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</table>

Notes. N=47, $R^2 = .40$

DISCUSSION

This study investigated behavioral and physiological correlates of infants’ attention to negative, positive and neutral faces. It also explored the associations between infants’ attention to facial expressions of emotion and parents’ negative affect, depression, anxiety and of infants’ temperament. Below we first address findings on behavioral and physiological components of infants’ attention to facial expressions of emotion, and next we turn to findings on individual differences.

The Effect of Emotion on Fixations and Pupil Dilation

Behavioral and physiological indices of infants’ attention to repeated presentations of fearful, angry, sad, and happy vs. neutral faces revealed differences in infants’ attention to fearful vs. neutral facial expressions, while infants’ attention to angry,
Infants' attention to faces

Sad and happy faces did not differ from neutral faces in the current study. Infants fixated longer to fearful vs. neutral facial expressions. This finding is consistent with previous evidence for a negativity bias in infants’ looking times to fearful facial expressions (De Haan et al., 2004; Kotsoni et al., 2001; Nelson & Dolgin, 1985), and reveals that infants’ negativity bias may be specific to fear, and not generalize to other threat-relevant (i.e., angry) or other negative (i.e., sad) emotions. In contrast, infants’ differential pupil responses were smaller for fearful vs. neutral facial expressions. This finding is not consistent with previous evidence revealing more pupil dilation to fearful than neutral facial expressions in adults (Bradley et al., 2008) and infants (Gredebäck et al., 2012). Greater interest (duration of fixation) to the fearful face, accompanied by smaller changes in pupil dilation reveals an inconsistency between behavioral and physiological indices of attention allocation. A similar inconsistency between a behavioral (i.e., looking time as an index of behavioral approach) and a physiological index (i.e., left frontal EEG activation as an index of approach tendencies) was reported by Field et al. (1998) in response to sad facial expressions in infants of non-depressed mothers. Keep in mind that differently from this study that reported a negative association between physiological and behavioral indices of approach, the raw association between differential pupil responses and fixation durations were not significant in the current study. Field and colleagues suggest that this mixed/ambivalent pattern of response towards negative stimuli may be related to wariness towards negative emotions, or to an empathic response to sad expressions. Alternatively, behavioral and physiological indices of attention may represent potentially different aspects of infants’ emotional reactions.

Individual Differences in Infants’ Pupil Dilation to Emotions

The current findings on individual differences reveal significant effects of infants’ and parents’ emotional dispositions on infants’ attention to facial expressions of emotion in a typically developing sample. First, more maternal negative affect was marginally related to less dilated pupils to facial expressions of emotion (less attention) in infants. This finding is in line with the previous evidence from clinical samples revealing a negative association between maternal depression and ERP indices of infants’ attention to sad expressions. However, this negative association also generalized to infants’ pupil responses to happy expressions in the current study. Second, higher levels of infants’ own fearful temperament were associated with less dilated pupils (less attention) to emotional (vs. neutral) faces in the current study. It is known that parents with higher levels of anxiety and depression tend to report their child as more temperamentally difficult (Najman et al., 2000), but the raw association between parental negative affect and infants’ fearful temperament was not significant in the current sample. Therefore, we conclude that the effects of maternal negative affect and of infants’ fearful temperament on infants’ pupil responses to emotional (vs. neutral) facial expressions are independent from each other. Previous ERP evidence has shown more attention to fearful (vs. happy) faces in temperamentally fearful
infants at 7 months (De Haan et al., 2004), and more attention to happy (but not fearful) faces in infants with negative temperament at 3 to 13 months (Martinos et al., 2012). In contrast, the current findings suggest that fearful temperament may be related to decreased arousal to both positive and negative (vs. neutral) facial expressions. Because the associations between infants’ ERP and pupil dilation have not yet been studied, it remains unknown whether fearful temperament may have different effects on infants’ physiological reactivity to emotion at the cortical vs. sub-cortical level. Alternatively, the differences may be related to the age of studied samples, as the findings from ERP studies cover the period between 3 and 13 months, while the current study tested the links of fearful temperament to infants’ attention allocation between 13 and 16 months of age.

The current study revealed significant associations of both mothers’ and fathers’ anxiety (but not depression) symptoms with the fixations of infants with low and high levels of fearful temperament. More anxiety symptoms in mothers and fathers predicted longer fixations to emotional faces in infants with a highly fearful temperament, while it predicted shorter fixations (i.e., less attention) in infants with low fearful temperament. Thus, it seems that exposure to higher maternal and paternal anxiety is related to less interest in facial expressions of emotion in infants with low fearful temperament, while it is related to more interest to emotion in infants with high levels of fearful temperament. These results are in line with the behavioral evidence revealing a direct positive association between infants’ exposure to parents’ expressions and avoidance of unfamiliar stimuli in infants with high levels of negative temperamental predispositions (Aktar et al., 2013; De Rosnay et al., 2006), as well as with diathesis-stress models of psychopathology (Ingram & Luxton, 2005; Nigg, 2006). The current findings show that temperamentally fearful infants’ exposure to maternal and paternal anxiety is indirectly related to enhanced interest/attention to emotional (vs. neutral) facial expressions. Considering that enhanced attention to negative emotion is characteristic of information-processing in anxiety disorders (Van Bockstaele et al., 2014), this increased interest to emotional stimuli in infants with high levels of fearful temperament and with anxious parents may constitute a risk factor that relates to later development of childhood anxiety disorders, and is an important finding that needs/warrants further study.

Maternal (but not paternal) anxiety symptoms were also related to infants’ fixations to happy facial expressions. Infants of mothers with low levels of anxiety symptoms had longer fixations to happy (vs. neutral) faces, while infants of mothers with moderate and high levels of anxiety showed similar durations of fixations to happy and neutral faces. Thus, differently from previous evidence suggesting a decrease in the attention to relatively more familiar stimuli (De Haan et al., 2004), infants of parents with low levels of maternal anxiety showed an enhanced interest to happy faces in the present study.
Fathers’ negative affect, parents’ depression and infants’ sad temperament did not predict infants’ fixations or differential pupil responses to facial expressions of emotion. Despite significant associations between parents’ negative affect and depressive symptoms, and between parents’ depression and anxiety symptoms, only anxiety (but not depression, or negative affect) in mothers and fathers predicted the duration of infants’ fixations to facial expressions of emotion; and only mothers’ negative affect predicted infants’ pupil dilation. Behavioral indices of attention seem to be specifically related to the exposure to parents’ expressions of fear/anxiety, and infants’ fearful temperament. Keeping in mind that the current differences in infants’ fixation durations came from their differential response to fearful (vs. neutral) stimuli, it is understandable that the associations that specifically relate to infants’ and parents fear/anxiety dispositions -rather than sadness/depression dispositions- explain significant variance in infants’ attention. In contrast, the associations of physiological indices of attention with mothers’ and infants’ negative emotional dispositions seem to be specific to the non-clinical variation in mothers’ daily negative emotions (rather than depression and anxiety, and fathers’ daily negative emotions).

The findings provide additional support for the idea that exposure to mother’s negative affect, and mothers’ and fathers’ anxiety symptoms may be associated with behavioral and physiological components of infants’ attention to emotional facial expressions not only in special populations (e.g., Pollak et al., 2000; Field et al., 1998), but also in typical development. The joint influence of parents’ anxiety symptoms and infants’ fearful temperament on infants’ fixations illustrate the necessity to consider infants’ temperamental predispositions in the study of early socio-emotional development.

The findings of the current study must be interpreted while considering the following limitations. First, using repeated presentations of facial expressions from a single female is not an uncommon practice in infancy research due to infants’ relatively limited attention span (e.g., Nelson & De Haan, 1996; Young-Browne, Rosenfeld, & Horowitz, 1977) and it provides advantages in minimizing the effects of differences in visual properties of different individuals’ faces on infants’ pupil size and fixations. However, it limits the generalizability of the current findings on infants’ attention to other female, and to male faces. Future studies testing the effects of maternal and paternal negative emotions, depression and anxiety should consider including more than one exemplar, and both female and male facial expressions. Second, parents’ and infants’ negative dispositions were indirectly assessed via questionnaires rather than direct observations. Although questionnaires are suitable to assess trait-like measures of negative affectivity, parents’ perception of infants’ temperament may be biased by parents’ own psychopathology (Najman et al., 2000). Future studies measuring infants’ physiological responses should therefore consider including naturalistic observations of parents’ and infants’ emotional expressions as an additional index.
Chapter 5

of parents’ negative affect and infants’ temperament, in addition to self-report measures. Third, different from the multimodal and dynamic displays of emotion that infants encounter in everyday life, infants’ pupil dilation to emotion was measured with static facial expressions in the current study. Future studies should consider using multimodal dynamic face displays to test the effects of emotion on infants’ emotion processing. Finally, the study had a cross-sectional and non-experimental design, precluding any prospective or causal inference on the effect of parental negative affect, depression, and anxiety, and of infants’ temperament on infants’ attention to facial expressions. Despite these limitations, the current study provides the first eye-tracking evidence for significant associations between infants’ own negative temperamental dispositions as well as parents’ negative affect and anxiety on infants’ attention to facial expressions of emotion in a typically developing sample of 13-to-16-month-olds.
CHAPTER 6

Infants’ temperament, and mothers’ and fathers’ depression predict infants’ attention to objects paired with emotional faces

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**ABSTRACT**

Between 10 and 14 months, infants gain the ability to learn about unfamiliar stimuli by observing others’ emotional reactions to those stimuli, so called social referencing (SR). Joint processing of emotion and head/gaze direction is essential for SR. This study tested emotion and head/gaze direction effects on infants’ attention via pupillometry in the period following the emergence of SR. Fourteen-to-17-month-olds’ \((N = 57)\) pupil responses were measured during computerized presentations of unfamiliar objects alone, before and after being paired with emotional (happy, sad, fearful vs. neutral) faces heading/gazing towards (vs. away from) objects. Additionally, the associations of infants’ temperament, and parents’ negative affect/depression/anxiety with infants’ pupil responses were explored. Both mothers and fathers of participating infants completed questionnaires about their infants’ negative temperament and the parent’s negative affect, depression and anxiety symptoms. Infants allocated more attention (larger pupils) to negative vs. neutral faces when the faces were presented alone, while they allocated less attention to objects paired with emotional vs. neutral faces independent of head/gaze direction. Sad (but not fearful) temperament predicted more attention to emotional faces. Infants’ sad temperament moderated the associations of mothers’ depression (but not anxiety) with infants’ attention to objects. Maternal depression predicted more attention to objects paired with emotional expressions in infants low in sad temperament, while it predicted less attention in infants high in sad temperament. Fathers’ depression (but not negative affect/anxiety) predicted more attention to objects paired with emotional expressions independent of infants’ temperament. We conclude that infants’ own temperamental dispositions for sadness, and their exposure to mothers’ and fathers’ depressed moods may influence infants’ attention to emotion-object associations in social learning contexts.
INTRODUCTION

Learning about dangers in the environment via observing others’ reactions, so-called observational learning, vicarious learning or modeling, is a highly adaptive strategy that tremendously increases one’s chances for survival (Olsson & Phelps, 2007). This is especially true for preverbal infants who know little about the dangers in the environment when they start to actively explore it following locomotion (Campos et al., 2000). Between 10 and 14 months, infants start to actively use adults’ emotional expressions to guide their behavioral reactions to ambiguous/novel stimuli in the environment, so-called social referencing (SR; Feinman, 1982; Feinman, Roberts, Hsieh, Sawyer, & Swanson, 1992; Emde, 1992). Observational SR studies where infants are confronted with ambiguous stimuli like strangers or robot toys have consistently revealed that infants are less likely to interact with ambiguous/novel stimuli, and more likely to manifest negative affect (i.e., fear) and avoidance (Feinman et al., 1992; Vaish, Grossmann, & Woodward, 2008) when the referee expresses negative as compared to positive and neutral emotions. In line with the survival value of observational learning, infants more strongly modulate their behavior in SR situations when the referee expresses negative as compared to positive emotions, so called negativity bias (reviewed in Vaish et al., 2008).

Infants’ biases towards parents’ negative emotional signals in SR situations are adaptive in typical development, while repeated exposure to high levels of negative emotions from parents with psychopathology in SR situations seem to constitute risk for parent-to-infant transmission of negative emotions, and for the development of child psychopathology, especially in infants with negative temperamental dispositions (Aktar, Majdandžić, De Vente, & Bögels, 2013; Murray et al., 2008). Infants’ negative temperamental dispositions are defined by a pattern of negative reactivity characterized by withdrawn, fearful, or distressed reactions to novelty/ambiguity (Fox, Henderson, Marshall, Nichols, & Ghera, 2005). Children of parents with depression and anxiety are more likely to have negative temperamental dispositions as compared to children of parents without psychopathology, and children with negative temperamental dispositions are more likely to develop psychopathology (Biederman, Rosenbaum, Chaloff, & Kagan, 1995; Bruder-Costello et al., 2007; Rosenbaum et al., 1993). Furthermore, negative temperamental predispositions are considered as a vulnerability to the effects of adverse rearing environments (Ingram & Luxton, 2005; Nigg, 2006). Parents with anxiety disorders are known to express more fear/anxiety in the presence of anxiety-provoking stimuli in SR situations (like a stranger in the case of SAD: Aktar et al., 2013; Murray et al., 2008). Temperamentally fearful infants of parents (with and without anxiety diagnoses) show more avoidance of ambiguous stimuli when exposed to more anxious reactions from parents in SR situations (Aktar et al., 2013; De Rosnay, Cooper, Tsigaras, & Murray, 2006). Moreover, high levels of exposure to parental expressions of anxiety in SR situations from
parents with anxiety diagnoses were shown to be linked to a longitudinal increase in temperamentally fearful infants' avoidance of ambiguous stimuli (Murray et al., 2008). Therefore, repeated exposure to parents' expressions of anxiety in the face of anxiety-provoking stimuli in SR was suggested to be an early mechanism in the early modelling of fears, and an early pathway for parent-to-infant transmission of anxiety for temperamentally fearful infants (Murray et al., 2008; Murray, Creswell, & Cooper, 2009). However, the effect of exposure to parents' depression has not yet been investigated in SR situations. Peláez, Virues-Ortega, Field, Amir-Kiaei, and Schnerch (2013) suggest that infants of depressed mothers have limited access to mothers' emotional signals in SR situations due to increased flat affect and decreased availability of depressed parents. Gewirtz and Peláez-Nogueras (1992) further suggest that when the mother has been unavailable/unresponsive, infants will be less likely to use mother as a source of information, and will less frequently seek information from mothers in SR situations.

Considering high prevalence of depression and anxiety disorders in parents in the postnatal year (Matthey, Barnett, Howie, & Kavanagh, 2003; O’Hara & Swain; 1996; Ross & McLean, 2006) and significant associations between early exposure to parental depression and anxiety and offsprings' later behavioral, emotional and psychological functioning (e.g., Avan, Richter, Ramchandani, Norris, & Stein, 2010; Murray et al., 1999; Pawlby, Sharp, Hay, & O'Keane, 2008), it is important to better understand how exposure to parental negative emotions in SR situations in the case of parental depression and anxiety affects infants' reactions. From a developmental psychopathology perspective, a better understanding of the effects of exposure to parents' negative emotions in infancy requires the consideration of continuities and discontinuities between normal vs. clinical parent samples in the effects of exposure to parental negative emotions on infants' reactions to ambiguous stimuli in the behavioral, neural and physiological levels, together with the dynamic interactions between processes operating at the intrapersonal (within the individual) and interpersonal (between the individual and others) levels of influence (Cicchetti, 2006). Thus, investigating the non-clinical variation in parents' expressions of negative emotions, depression and anxiety as a predictor of infants' behavioral and physiological reactions in SR contexts are highly informative in understanding the effects of exposure to parental expressions in clinical samples.

SR requires infants to attend to the adults' emotional signals during person-infant-object interactions, to link the emotional signals to the stimulus (emotion-object associations), and to regulate their behavior accordingly (Feinman et al., 1992). Among these three essential components of social referencing skills, previous SR studies have predominantly relied on naturalistic observations of infants' regulation of behavioral and emotional reactions (i.e., the third component of social referencing). This research has greatly advanced our understanding of infants' emotion and behavior regulations.
Infants’ attention to emotion and referential cues

in everyday SR situations. In line with a developmental psychopathology approach, scientific interest has recently grown on the investigation of neural and physiological correlates of infants’ ability to form associations between the emotional signal and the stimulus (i.e., the second component) in SR situations. To form the emotion-object associations, infants have to process the threat value of referents’ emotional expressions and the referential cues (i.e., head and gaze direction) that link referents’ expressions to the ambiguous stimulus (i.e., the second component; Feinman et al., 1992). A previous study by Moses, Baldwin, Rosicky, and Tidball (2001) has revealed that infants rely on adults’ head and gaze direction in SR situations to infer whether an emotional signal relates to the ambiguous stimulus. In the current study, we investigated how emotion-object associations alter infants’ attention to unfamiliar objects, using a physiological index of attention allocation. We tested the effects of emotion and gaze direction on infants’ pupil responses in triadic person-infant-object contexts. The aim was to explore whether negative temperamental dispositions of typically developing infants and parents’ negative affect, depression and anxiety explain individual differences in infants’ attention allocation (measured via pupillary responses) to objects paired with emotional versus neutral facial expressions gazing towards vs. away from the objects.

Infants do not need to be active participants in triadic person-infant-object interactions to form emotion-object associations. A study by Mumme and Fernald (2003) revealed that SR processes can be activated by computerized presentations of emotion-object associations in SR. In their study, 12-month-old infants were first presented with actresses expressing positive and negative (vs. neutral) towards unfamiliar objects. Following the presentation of emotion-object associations, infants were presented with the objects (previously presented on the screen) in real life for 30 s. In line with the findings from naturalistic interactions, infants were found to interact less with the objects, and to express more negative affect when they have previously seen the objects paired with the actress expressing negative (vs. neutral) emotions. Another ERP study revealed an increase in neural correlates of 12-month-old infants’ attention to novel objects after these have been paired with caregivers’ facial and vocal expressions of negative (but not positive, vs. neutral) expressions (Carver & Vaccaro, 2007). Moreover, this study revealed positive associations between ERP correlates of infants’ attention to novel objects and their behavioral reactions during the emotion-object pairings (i.e., Negative Central [Nc] component and observed interest and proximity to the toys). The use of computerized tasks to investigate SR processes enable the investigation of infants’ attention allocation as a potential mechanism that may explain the behavioral findings revealing high reactivity to novelty in SR situations.
A series of studies in 3- to 7-month-old infants revealed that infants allocate enhanced attention to negative expressions gazing towards objects in the physiological level before SR processes fully manifest at the behavioral level (e.g., Hoehl & Striano, 2010b). Using ERP correlates of infants’ attention in a SR paradigm (i.e., Nc), Hoehl and colleagues assessed younger infants’ attention in triadic (person-infant-object) contexts via fully computerized tasks of SR to investigate the role of emotion and gaze/head direction as antecedents of SR (e.g., Hoehl, Palumbo, Heinisch, & Striano, 2008a; Hoehl & Striano, 2010a; Hoehl & Striano 2010b). In this paradigm, infants’ attention was measured during the pairing of novel objects with emotional (vs. neutral) facial expressions gazing towards (vs. away) these objects (e.g., Hoehl et al., 2008a; Hoehl & Striano, 2010a) and during the presentation of objects alone following the face-object pairing (e.g., Hoehl & Striano, 2010b; Hoehl, Wiese, & Striano, 2008b). These studies have shown that 6 and 7-month-olds allocate more attention to fearful (vs. neutral) faces only when the gaze was directed towards (vs. away from) the objects during the emotion-object pairing (Hoehl et al., 2008a; Hoehl & Striano, 2010b). Furthermore, 3 and 6-month-old infants were found to allocate more attention to the objects following the pairing of these with fearful (vs. neutral) faces gazing towards the object (Hoehl & Striano, 2010b; Hoehl et al., 2008b). In contrast, when the gaze was directed away from the object, no difference was found in infants’ attention allocation to objects during and following the pairing of these objects with fearful vs. neutral faces. Thus, fearful faces seem to elicit enhanced attention only in contexts where gaze direction helps the infant to disambiguate/clarify the referent of the threat signals.

However, a different pattern of results was reported in this paradigm at 9 months (Hoehl & Striano, 2010b), where both SR skills and negativity biases are about to emerge in infants’ behavior (Vaish et al., 2008; Walden & Ogan, 1988). Nine-month-olds allocated more attention to fearful vs. neutral faces paired with objects independent of gaze direction, while they showed more attention to the objects that have been previously paired with neutral vs. fearful faces gazing towards objects. It remains unclear why infants’ would show this different pattern of responses at 9 months, right before the emergence of SR processes.

Physiological correlates of infants’ processing of emotion and referential cues during emotion-object associations have not been studied during the developmental period when all infants actively use SR (i.e., that is after 14 months; Walden & Ogan, 1988). Differently from previous evidence that predominantly focused in the first year, our focus in the current study was on infants’ attention allocation at the age following the emergence of SR skills (after 14 months; Walden & Ogan, 1988). Using an eye-tracking adaptation and extension of the experiments by Hoehl and colleagues (e.g., Hoehl & Striano, 2010b) we tested how 14-to-17-month-old (range= 14.39 to 16.69) infants’ attention to unfamiliar objects changes after these have been paired with
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emotional (vs. neutral) facial expressions gazing towards (vs. away) from the objects. Two additional issues in infants’ joint processing of gaze and emotion were explored in the current study.

First, because existing evidence on emotion and gaze processing is predominantly on the comparison of fearful and neutral emotions (Hoehl et al., 2008a; Hoehl & Striano, 2010b; Hoehl et al., 2008b), it remains largely unknown whether the attention enhancing effect of fearful facial expressions also holds for other positive or negative facial expressions. Given the survival value of SR skills and negativity bias in infancy, one would expect this effect to be especially salient for negative emotions with threat-relevance (i.e., fear and anger) as compared to positive emotions. In a previous comparison of happy (vs. neutral) faces on 3-month-olds’ processing of novel objects in the same SR paradigm, Hoehl and Striano (2010a) found that infants showed enhanced attention to the presentation of happy faces gazing towards the objects; however, this pairing did not alter infants’ attention allocation when these objects were later presented alone. These findings reveal that the attention enhancing effect of fearful faces in triadic contexts may not apply to positive emotions. However, it is still unclear whether the differences between these later findings with happy faces and earlier findings with fearful faces (Hoehl et al., 2008a; Hoehl & Striano, 2010b; Hoehl et al., 2008b) are due the differences in emotional valence (positive vs. negative) or in threat-relevance of these emotions. To address this, we investigated how infants’ pupil response to unfamiliar objects changes after the objects were paired with threat-relevant (i.e., fear) or not threat-relevant (i.e., sadness) negative emotional expressions, as compared to happy and to neutral facial expressions.

The second issue concerns the measurement of infants’ attention allocation. Existing physiological evidence on the effects of emotion and gaze direction on infants’ attention comes from face-sensitive components of ERP responses. In recent years, pupil dilation has provided a promising alternative to ERP as a physiological index of attention allocation in emotion research in infancy (Geangu, Hauf, Bhardwaj, & Bentz, 2011; Gredebäck, Eriksson, Schmitow, Laeng, & Stenberg, 2012). Pupillary responses are mediated through brain structures involved in quick processing of biologically relevant stimuli like faces (like the amygdala and the locus coeruleus; Aston-Jones & Cohen, 2005; Aston-Jones, Rajkowski, Kubiak, Valentino, & Shipley, 1996), and in stress responses to threat (Lipski, 2012). Pupil dilation in response to affectively loaded stimuli under uniform lighting conditions has been found to reflect sympathetic processing, and attention allocation in adults (Bradley, Miccoli, Escriq, & Lang, 2008). Findings from recent pupil studies in infants revealed increased pupil dilation to negative as compared to neutral emotions (Geangu et al., 2011; Gredebäck et al., 2012). To our knowledge, no studies so far measured the joint effects of emotion and referential cues on infants’ attention via pupil dilation in triadic (person-infant-object) contexts.
Moreover, individual differences in infants’ attention to gaze and emotional expressions have not yet been investigated in computerized SR experiments. In the current study, we tested whether infants’ temperament and parents’ negative affect, depression and anxiety explain individual differences in infants’ attention to faces, and to objects that were paired with these faces. Like mentioned above, behavioral evidence (Aktar et al., 2013; De Rosnay, Cooper, Tsigaras, & Murray, 2006) has consistently revealed a positive association between parents’ expressions of anxiety in SR situations and infants’ avoidance of novel stimuli for temperamentally fearful infants of parents with and without anxiety disorders. More recent investigations of the effects of temperament and indirect effects of exposure to parents’ negative emotions, depression and anxiety on infants’ attention in computerized emotion experiments illustrate the relevance of considering intrapersonal and interpersonal processes in infants’ attention allocation. For example, available neurophysiological evidence on infants’ attention allocation to facial expressions reveals significant associations between 3-to-13-month-old infants’ fearful temperament and the ERP indices of their attention allocation to fearful and happy faces (De Haan, Belsky, Reid, Volein, & Johnson, 2004; Martinos, Matheson, & De Haan, 2012). Moreover, a negative association between temperamentally positive infants’ attention to fearful faces and their exposure to parents’ positive (but not negative) affect was found in typically developing infants (De Haan et al., 2004). Likewise, studies focusing on emotion processing among infants of clinically depressed (vs. non-depressed) mothers have revealed a decrease in infants’ attention to sad facial expressions when the mother is clinically depressed (Field, Pickens, Fox, Gonzales, & Nawrocki, 1998). Taken together, these findings provide preliminary support for the idea that infants’ negative temperament and their exposure to parents’ negative expressions are important correlates of infants’ attention allocation to negative facial expressions and physiological reactivity to ambiguous stimuli at the end of first year, while the direction of the associations remains to be further investigated. Considering that information processing in the case of depression and anxiety disorders is characterized by enhanced attention/vigilance to negative emotion (Leppänen, 2006; Van Bockstaele et al., 2014), physiological indices of infants’ attention allocation may constitute an important outcome in infancy that may be useful in detecting early risk for psychopathology.

To summarize, this study investigated how infants’ pupil response to unfamiliar objects changes after these have been paired with fearful, happy and sad (vs. neutral) faces gazing towards (vs. away from) the objects in a sample of typically developing infants between 14 and 17 months of age. Infants’ pupil diameters were recorded during a task where unfamiliar objects were presented first alone, then paired with a facial expression with referential cues of head/gaze direction, and then alone again. The effects of emotion and head/gaze direction were investigated on infants’ pupillary
Infants’ attention to emotion and referential cues

responses to facial expressions and novel objects paired with these expressions. Furthermore, infants’ negative temperament as well as parents’ negative affect, depression and anxiety were explored as potential sources of individual differences in infants’ attention to emotion in triadic emotion learning contexts. These measures were obtained by questionnaires filled in by both the mother and father of each participating infant.

Based on previous evidence on infants’ pupil dilation to emotion (e.g., Geangu et al., 2011; Gredebäck et al., 2012), we predicted a significant effect of emotion on infants’ pupil dilation, such that infants should show increased attention (larger pupils) to emotional as compared to neutral facial expressions. Further, if the effect extends to objects paired with faces, then infants should have a more pronounced increase in pupil size for objects that were paired with emotional (vs. neutral) faces. Additionally, we explored differences in pupil responses to different emotional expressions. If the effect of emotion is specific to negative emotions, infants should respond with increased attention (larger pupils) to both sad and fearful faces but not to happy and neutral ones. Additionally this increased attention should also extend/generalize to the objects that were paired with these faces. In contrast, if the effect of emotion is specific to threat-relevant emotions, infants should allocate increased attention to fearful, but not to sad or happy faces (and to objects paired with these faces). The effect of referential cues (gaze direction), which was found to affect infants’ attention in previous ERP studies, was explored for the first time using infants’ pupil responses. If infants are sensitive to referential cues, there should be increased attention (larger pupils) to objects that were paired with faces gazing towards (vs. away from) the objects.

In the light of previous behavioral (Aktar et al., 2013; De Rosnay et al., 2006), and ERP evidence (De Haan et al., 2004), we expected that infants’ negative temperament, as well as parents’ negative affect, depression and anxiety explain individual differences in infants’ attention to emotion in triadic emotion learning contexts. In view of previous evidence revealing a moderating role of infants’ temperament on the physiological correlates of infants’ attention (De Haan et al., 2004), we explored for the first time how the associations of parents’ negative affect, depression and anxiety with infants’ pupil responses to emotion change as a function of infants’ temperament.

METHODS

Participants

The sample for the study consisted of 57 infants (31 girls, $M_{\text{Age}} = 15.25$ months, $SD = .48$, range = 14.23 to 16.69 months), of which 43 infants visited with their mother, 10 with their father, and 4 with both parents. An additional 13 participants were tested but removed from analysis (due to fussiness, equipment failure and missing
data, see Data Reduction). Of 57 infants who participated, the questionnaire data was partially or fully available from 54 mothers and 48 fathers. (see Results for more information about missing scores per questionnaire). Families were part of a larger sample recruited via invitation letters sent by the municipality to families who recently became parents. Sociodemographic characteristics are presented in Table 1. The study was approved by the ethics committee at the University of Amsterdam. Parents provided informed consent for participation.

Table 1. Sample characteristics

<table>
<thead>
<tr>
<th></th>
<th>Mother</th>
<th>Father</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parents’ age M(SD)</td>
<td>34.35 (4.19)</td>
<td>37.43 (5.16)</td>
</tr>
<tr>
<td>N</td>
<td>54</td>
<td>47</td>
</tr>
<tr>
<td>Range</td>
<td>27 - 46</td>
<td>30 - 52</td>
</tr>
<tr>
<td>Dutch origin %</td>
<td>79.63</td>
<td>95.75</td>
</tr>
<tr>
<td>N</td>
<td>54</td>
<td>47</td>
</tr>
<tr>
<td>Educational level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary education (high school) %</td>
<td>3.70</td>
<td>14.89</td>
</tr>
<tr>
<td>Professional education %</td>
<td>3.70</td>
<td>6.38</td>
</tr>
<tr>
<td>Higher professional education %</td>
<td>16.67</td>
<td>27.66</td>
</tr>
<tr>
<td>University %</td>
<td>70.37</td>
<td>51.06</td>
</tr>
<tr>
<td>Professional level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Unemployed %</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Employed %</td>
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<td>89.36</td>
</tr>
<tr>
<td>Self -employed %</td>
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<td>10.64</td>
</tr>
<tr>
<td>Professional status</td>
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<td></td>
</tr>
<tr>
<td>Housekeeper %</td>
<td>3.70</td>
<td>-</td>
</tr>
<tr>
<td>Part Time %</td>
<td>64.82</td>
<td>21.74</td>
</tr>
<tr>
<td>Full Time %</td>
<td>25.93</td>
<td>78.26</td>
</tr>
<tr>
<td>Monthly income a M(SD)</td>
<td>4.43 (1.76)</td>
<td>5.41 (1.44)</td>
</tr>
<tr>
<td>N</td>
<td>49</td>
<td>44</td>
</tr>
<tr>
<td>Range</td>
<td>1-7</td>
<td>3-7</td>
</tr>
<tr>
<td>Working hours ( per week) M(SD)</td>
<td>30.24 (9.32)</td>
<td>37.80 (8.15)</td>
</tr>
<tr>
<td>N</td>
<td>51</td>
<td>46</td>
</tr>
<tr>
<td>Range</td>
<td>0 - 52</td>
<td>15 - 60</td>
</tr>
</tbody>
</table>

Notes: a Parental income was assessed with a 7-point scale from 1 (< 500 euros/month) to 7 (> 5000 euros/month)
Materials and Procedure

Stimuli
Stimuli were colored photographs of 16 unfamiliar objects (from the Novel Object and Unusual Name Database; NOUN; Horst & Hout, 2014). Because infants are known to be sensitive to the incongruent emotion-object associations towards the end of first year (Hirshberg & Svejda, 1990), we used pictures of different objects in each trial, instead of using the same objects with both positive and negative faces. The stimulus set had widths varying from 3.19 to 7.64 cm, $M = 5.23, SD = 1.34$; and height varying from 4.77 to 8.72 cm, $M = 6.78, SD = 1.11$. All were presented on a black background, alone or together with portrait photographs of a female model exhibiting neutral, fearful, happy, and sad facial expressions (9 cm x 15 cm). Considering the task demands, we chose to use the facial expressions of a single model in the current study. The photographs were taken from the Radboud Faces Database (Langner et al., 2010). Head/gaze direction of the actor was directed either towards or away from the objects. One randomly determined combination of objects and emotional facial expressions was used for all infants in the experiment.

Procedure
Infants’ pupil diameters were measured during the task via a Tobii T120 eye-tracker in a dimly lit room. Infants were secured in a car seat that was situated 60 cm away from the screen. The parent sat on a chair behind the infant during the tasks and was instructed not to intervene unless the infant became fussy.

The experiment consisted of a total of 16 trials that included 4 facial expressions with 2 head/gaze directions (left vs. right), and 2 object positions (on the left vs. right of the screen; see Figure 1). There were 2 blocks of 8 trials. Each block started with the neutral face-object pair and continued in a randomly generated order of (non-neutral) emotions. Two trials from a given emotional expression with a given head/gaze direction (for example, fearful faces with the right head/gaze direction) appeared in two consecutive trials where two different objects randomly appeared either on the left or on the right side of the screen, forming a pair of trials. An example of a pair of trials is presented in Figure 1. Each emotional expression was clustered in one pair of trials in each block. The same expression appeared in the second block with the reverse head/gaze direction (for example, fearful faces with the left head/gaze direction) and with novel objects. The order of the objects’ position (left, or right) in each pair of trials per block, and the order of emotion following neutral trials were randomly determined in each block.

Each trial started with an attention getter displayed at the center for 500 ms, and consisted of the following events (see Figure 1): Colored object presented at the center of the screen (Object Alone I, 2000 ms), a face appearing at the center of the screen with head and gaze towards the left or right, first alone (Face Alone, 1000
ms), and then together with the object on the left or right side of the screen (Object + Face, 2000 ms). The trial ended with the second presentation of the object alone at the center (Object Alone II, 2000 ms). A 70 ms sound was presented together with a blank screen after the first presentation and before the second presentation of the object, and without a blank screen between the presentations of Face Alone and Object + Face to attract infants’ attention. Prior to the start of each trial, an experimenter monitored infants’ attention and repeated the presentation of the visual attention getters when necessary.

**Figure 1.** Time flow of trials
This figure illustrates the time flow of two consecutive trials with fearful expressions. The trials in each block were clustered in pairs, such that each emotional expression with one head/gaze direction (fearful faces with the right head/gaze direction in the figure) appeared in two consecutive trials with two different objects on the left and right side of the screen. The order of the objects’ position in each pair of trials (presented on the right and left side of the figure) was randomly determined. The same expression appeared with the reverse head/gaze (i.e., fearful faces with left head/gaze direction in this case) and with novel objects in the other block.

Each trial started with an attention getter displayed at the center for 500 ms, and consisted of object presented at the center of the screen (Object Alone I), a face appearing at the center of the screen with head and gaze towards the left or right, first alone (Face Alone), and then together with the object on the left or right side of the screen (Object + Face). The trial ended with the second presentation of the object alone at the center (Object Alone II). A 70 ms auditory sound was used as attention getter at time points indicated with a sound icon.
Infants’ attention to emotion and referential cues

Questionnaires

Infants’ temperament. To measure infants’ temperamental dispositions for negative emotions, the mother and father of each participating infant were asked to fill out the fear and sadness scales of the Infant Behavior Questionnaire Revised (IBQ-R; Gartstein & Rothbart, 2003) where parents rate the frequency of infants’ expressions of fear (such as crying, or showing distress) and sadness (e.g., becoming tearful and sad) in number of occasions (e.g., fear while visiting a new place or meeting a stranger, or sadness after separation from the caregiver) during the most recent two weeks on a 7-point scale. Out of 57 couples that participated with their infant, the data was available from 53 mothers and 43 fathers for infants’ fearful temperament and from 54 mothers and 46 fathers for infants’ sad temperament. The reliability (Cronbach’s $\alpha$) for mothers and fathers, respectively) was .92 and .92 for fear, and .76 and .84 for sadness. The correlations between mothers’ and fathers’ ratings of infant temperament was $r = .56$, $p < .001$ for fear and $r = .40$, $p = .006$ for sadness. Mother’s and the father’s ratings on each scale were averaged to calculate infants’ fear and sadness scores.

Parents’ negative affect. To measure parents’ negative affect, we asked both parents to fill in the Negative Affect Schedule of The Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988). The Negative Affect Schedule (NAS) consists of 10 negative emotions, and measures on a 5-point scale the extent to which parents experienced these emotions in the last two weeks. Out of 57 couples that participated with their infant, the data was available from 54 mothers and 47 fathers for the NAS. The reliability of the scale (Cronbach’s $\alpha$) was .79 for mothers and .87 for fathers, respectively. Mothers’ and fathers’ negative affect was not associated (see Table 2).

Parents’ depression and anxiety. To measure parents’ symptoms of depression and anxiety, we asked both parents to fill in the second edition of Beck Depression Inventory (BDI-II; Beck, Steer, & Brown, 1996), a 21-item questionnaire measuring depressive symptoms, as well as the adult version of Screening for Anxiety Related Emotional Disorders (SCARED-A; Bögels & Van Melick, 2004), a 71-item questionnaire assessing symptoms of anxiety disorders. Out of 57 couples that participated with their infant, the data was available from 54 mothers and 44 fathers for these questionnaires. In the current study, the reliability of BDI-II was (Cronbach’s $\alpha$) .86 for mothers and .78 for fathers, and of SCARED-A, .89 for mothers and .88 for fathers. The correlations between parents’ scores on depression and anxiety as well as negative affect are presented in Table 2.
Statistical Analyses

Data reduction
The following steps were carried out to obtain the outcome variables: First, outlying values (> |4| SD) in each infants’ pupil diameters were removed. Second, missing observations (< 500 ms) were replaced via linear interpolation (see Jackson & Sirois, 2009) to account for blinks and tracking errors following the exclusion of outlying cases in the first step. Third, the pupil data was reduced to observations where the infant looked at the object or face, and was aggregated to 50 ms time intervals.

Outcome variables
Two main outcome measures, obtained from the presentations of Face Alone and Object Alone were used in the analyses. The first outcome consisted of infants’ pupil diameters to the 1000 ms presentation of Face Alone (20 observations with 50 ms intervals), averaged across left and right eyes. This outcome was used to measure infants’ attention to facial expressions, when presented without an object. Trials in which children looked at the presentation of Face Alone for less than 500 ms were excluded from analyses of facial expressions the dataset (see Gredebäck et al., 2012). The second outcome concerned the change in infants’ pupil responses to objects alone after the pairing of these with faces in the Object + Face presentation. To analyze how infants’ processing of the objects changes after being paired with faces, we subtracted the pupil diameters during the first presentation of the object from the pupil diameters in the second presentation of the object (Object alone II – Object alone I) from the left and the right eye at each 50 ms step of the 2000 ms presentation. The difference scores obtained from the right and left pupils were then averaged at each of the 40 observation points (50 ms steps of the 2000ms presentation of Object Alone). Trials in which children looked at the presentation of Object + Face Presentation for less than 500 ms were excluded from analyses of object processing because it was unclear whether they had enough time to process emotion-object association. Due to limited attention span in infancy, we chose not to apply further restrictions concerning the minimum number of trials that each infant must complete to be included. We adjusted our analytic approach accordingly and used multilevel models that are known to accommodate missing data (Bagiella, Sloan, & Heitjan, 2000). Of 57 infants who generated the data for the analyses, the eye-tracking data was available from 41 infants for Face Alone, and 56 infants for Object Alone Trials. Infants contributed to the data in average with 8.73 trials for the analyses of Object Alone (SD = 4.63, range: 1 to 16) and with 6.90 trials for the analyses of Face-Alone (SD = 5.18, range: 1 to 16). The number of available trials was not significantly associated with infants’ temperament, and with parents’ negative affect, depression or anxiety scores.
Main Analyses

Both outcomes were analyzed with multilevel regression models with auto-regressive covariance structure for repeated observations of pupil responses. Repeated observations of pupil response within and across trials were nested within infants. The repeated observations within trial consisted of infants’ pupil dilation to the presentations of Face Alone or Object Alone in 50 ms intervals during 1000 ms time window of Face Alone presentation or 2000 ms time window of Object Alone presentation. The repeated observations of pupil dilation between trials consisted of 16 repetitions of Face Alone and Object Alone presentations. The intercept and picture time were random effects in both models. Emotion (i.e., type of facial expression) and gaze (i.e., gaze direction) effects were treated as fixed effects, along with other predictors. Neutral expression and gaze/head towards object were the reference for emotion and referential cues in the regressions. Infants’ temperament, and parents’ negative affect, anxiety and depression were entered as continuous predictors in the models. Inspection of distributions indicated sufficient normality; skewness and kurtosis of all variables were < |2|, except for maternal anxiety. Three mothers with outlying scores (>3 SD) of anxiety were replaced by the next most extreme value in the distribution. To control for order effects, order of trials was included as a continuous variable in both models. Mean luminance (M = 12.14, SD = 0.77, range: 11.08 to 13.15) of each face was additionally included in the analysis of infants’ pupil responses to faces as a control variable. Scores on outcome variables and on maternal negative affect, anxiety, and/or depression were standardized for the analyses. The raw correlations between predictor variables are presented in Table 2.

The initial multilevel model for infants’ processing of facial expressions (the face model) consisted of the main effects of emotion, picture time, order and luminance. The initial multilevel model for infants’ processing of objects (the object model) consisted of the main effects of emotion, picture time, gaze direction, and order. The interaction between emotion and gaze direction was tested in the object model in the next step. Although the main effect of infants’ gender and its two-way interactions with emotion were initially added as additional predictors of infants’ pupil responses to faces, and to objects paired with faces in the analyses, none of these effects were significant in the current models. Infants’ gender was therefore removed from the analyses.
Table 2. Pearson correlations between infant temperament, parental negative affect, depression and anxiety

<table>
<thead>
<tr>
<th></th>
<th>Infant fearful temperament</th>
<th>Infant sad temperament</th>
<th>Maternal negative affect</th>
<th>Maternal depression</th>
<th>Maternal anxiety</th>
<th>Paternal negative affect</th>
<th>Paternal depression</th>
</tr>
</thead>
<tbody>
<tr>
<td>Infant fearful</td>
<td>r</td>
<td>n</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>temperament</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Infant sad temperament</td>
<td>r .34*</td>
<td>n 53</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal negative</td>
<td>r .04</td>
<td>n 53</td>
<td>.08</td>
<td>.00</td>
<td>.50**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>affect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal depression</td>
<td>r .08</td>
<td>n 53</td>
<td>.00</td>
<td>.50**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maternal anxiety</td>
<td>r .27</td>
<td>n 53</td>
<td>.14</td>
<td>.42**</td>
<td>.73**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paternal negative</td>
<td>r -.05</td>
<td>n 47</td>
<td>.18</td>
<td>.04</td>
<td>.10</td>
<td>.09</td>
<td></td>
</tr>
<tr>
<td>affect</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paternal depression</td>
<td>r -.02</td>
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<td>-.18</td>
<td>.13</td>
<td>.20</td>
<td>.38*</td>
</tr>
<tr>
<td>Paternal anxiety</td>
<td>r -.08</td>
<td>n 44</td>
<td>.29</td>
<td>.01</td>
<td>-.06</td>
<td>.15</td>
<td>.45**</td>
</tr>
</tbody>
</table>

* Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.01 level (2-tailed).

To investigate individual differences in infants’ pupil responses, first the main effects of infants’ fearful and sad temperament and of mothers’ and fathers’ negative affect were included in both models. Second, two-way interactions of these predictor variables with emotion were included. In the next step, the two-way interactions between parents’ negative affect and infants’ temperament were tested.
Finally, we explored the associations of infants’ pupil responses with parental depression and anxiety symptoms by separately analyzing these predictors in additional models. We repeated the same multilevel analyses, and tested the same interactions as the individual difference models described above. We first tested a model for parental depression (including infant temperament, excluding parental negative affect), and then a model for parental anxiety symptoms. Interactions tested in each step were included in or removed from the models based on t-tests. All the effects were evaluated at $\alpha = .05$. To probe significant interactions, we used online tools by Preacher, Curran, and Bauer (2006, http://www.quantpsy.org/interact/hlm2.htm). We first inspected the 95% confidence bands representing continuously plotted confidence intervals for the outcome slope across levels of the moderator. When the confidence interval does not include $y = 0$ for a given level of the moderator, the effect is interpreted as being significant at that level (i.e., $p \leq .05$). Next, we plotted the association of the predictor with the outcome across low, moderate and high levels of the moderator. Moderate, low and high levels were the mean, 1 SD below and 1 SD above the mean, respectively. Because confidence intervals cannot be computed for two-way interactions in the case of dichotomous variables (e.g., emotion) we based our interpretations on the interaction plots only in these cases.

RESULTS

The Effect of Emotion on Infants’ Processing of Faces
The initial face model for infants’ processing of facial expressions is presented in Table 3.a ($N = 41$). The effect of emotion and of picture time was significant in this model. Infants’ pupils were more dilated for negative (fearful and sad) vs. neutral facial expressions, while there was no significant difference in infants’ pupil dilation to happy (vs. neutral) faces. Infants’ pupil reactivity decreased over (picture) time.

The Effect of Emotion and Referential Cues on the Change in Infants’ Processing of Objects
The initial object model for the change in infants’ processing of objects ($N = 56$) is presented in Table 3.b. The effect of emotion and of picture time was significant in this model, while the effect of head/gaze direction was not significant. The change in pupil dilation decreased over (picture) time. Infants showed smaller increases in their pupil dilation to objects paired with happy, fearful and sad faces, as compared to those paired with neutral faces. The interaction between head/gaze direction and emotion was not significant in this model.
Chapter 6

Table 3. The effect of emotion on infants’ pupil dilation to faces (3.a), to objects paired with faces (3.b)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>3.a</th>
<th>3.b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE</td>
</tr>
<tr>
<td>Intercept</td>
<td>-0.14</td>
<td>.42</td>
</tr>
<tr>
<td>Happy</td>
<td>0.15</td>
<td>.10</td>
</tr>
<tr>
<td>Fearful</td>
<td>0.33</td>
<td>.09</td>
</tr>
<tr>
<td>Sad</td>
<td>0.22</td>
<td>.09</td>
</tr>
<tr>
<td>Picture time</td>
<td>-0.04</td>
<td>.00</td>
</tr>
<tr>
<td>Order</td>
<td>-0.01</td>
<td>.02</td>
</tr>
<tr>
<td>Block</td>
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<td>.13</td>
</tr>
<tr>
<td>Luminance</td>
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<td>.03</td>
</tr>
</tbody>
</table>

Notes: The neutral face was the reference for emotion effects. $R^2 = .85$ in 3.a and .35 in 3.b.

Table 4. The associations of infants’ pupil dilation to faces with infants’ negative temperament and with parental negative affect

<table>
<thead>
<tr>
<th>Parameter</th>
<th>3.a</th>
<th>3.b</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE</td>
</tr>
<tr>
<td>Intercept</td>
<td>0.01</td>
<td>.45</td>
</tr>
<tr>
<td>Happy</td>
<td>0.13</td>
<td>.10</td>
</tr>
<tr>
<td>Fearful</td>
<td>0.31</td>
<td>.09</td>
</tr>
<tr>
<td>Sad</td>
<td>0.22</td>
<td>.09</td>
</tr>
<tr>
<td>Picture time</td>
<td>-0.05</td>
<td>.01</td>
</tr>
<tr>
<td>Infant fear</td>
<td>0.02</td>
<td>.22</td>
</tr>
<tr>
<td>Infant sadness</td>
<td>0.03</td>
<td>.23</td>
</tr>
<tr>
<td>Maternal negative affect</td>
<td>0.10</td>
<td>.18</td>
</tr>
<tr>
<td>Paternal negative affect</td>
<td>-0.10</td>
<td>.17</td>
</tr>
<tr>
<td>Happy * Infant sadness</td>
<td>0.16</td>
<td>.07</td>
</tr>
<tr>
<td>Fearful * Infant sadness</td>
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<td>.07</td>
</tr>
<tr>
<td>Sad * Infant sadness</td>
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<td>.06</td>
</tr>
<tr>
<td>Luminance</td>
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<td>.03</td>
</tr>
<tr>
<td>Order</td>
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<td>.02</td>
</tr>
<tr>
<td>Block</td>
<td>0.17</td>
<td>.13</td>
</tr>
</tbody>
</table>

Notes: The neutral face was the reference for emotion effects. $R^2 = .87$.

1 Due to complications arising from hierarchical structure of multilevel regression models (Snijders & Bosker, 1994), and to different sample sizes in the models, $R^2$ change cannot be interpreted as a relative goodness-of-fit measure across models.
Individual Differences in Infants’ Processing of Faces

To test individual differences in infants’ pupil responses, we first added the main effects of infants’ fearful and sad temperament, and of parents’ negative affect to the initial face model in Table 3.a. None of these effects were significant. Among tested interactions, only the interaction between infants’ sad temperament and emotion was significant and was kept in the final model, presented in Table 4 (n = 33²). Infants with higher scores on sadness allocated more attention to happy, fearful and sad faces (see Figure 2). Neither the main effects, nor two-way interactions of parental depression and anxiety with emotion and infants’ temperament did significantly predict infants’ attention to facial expressions.

Figure 2. The plot for the relationship between infants’ sad temperament (on the x-axis) and their pupil response (on y-axis) to emotional faces as a function of emotion. The association between infants’ pupil response and infants’ sad temperament was positive for fearful, happy and sad (vs. neutral) faces.

² Among 41 infants with eye-tracking data in the Face Alone trials (see Table 3.a), data from 8 infants were missing in the analyses of individual differences because the data on fathers’ negative affect was missing.
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Table 5. The associations of infants’ pupil dilation to objects with infants’ negative temperament and with parental negative affect

<table>
<thead>
<tr>
<th>Parameter</th>
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<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
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<td>.002</td>
</tr>
<tr>
<td>Happy</td>
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<td>.17</td>
<td>.076</td>
</tr>
<tr>
<td>Fearful</td>
<td>-0.29</td>
<td>.17</td>
<td>.090</td>
</tr>
<tr>
<td>Sad</td>
<td>-0.36</td>
<td>.17</td>
<td>.033</td>
</tr>
<tr>
<td>Head/gaze direction</td>
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<td>.09</td>
<td>.707</td>
</tr>
<tr>
<td>Picture time</td>
<td>-0.01</td>
<td>.00</td>
<td>.003</td>
</tr>
<tr>
<td>Infant fear</td>
<td>0.08</td>
<td>.10</td>
<td>.421</td>
</tr>
<tr>
<td>Infant sadness</td>
<td>0.09</td>
<td>.10</td>
<td>.374</td>
</tr>
<tr>
<td>Maternal negative affect</td>
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<td>.09</td>
<td>.037</td>
</tr>
<tr>
<td>Paternal negative affect</td>
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<td>.10</td>
<td>.315</td>
</tr>
<tr>
<td>Order</td>
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<td>.582</td>
</tr>
<tr>
<td>Block</td>
<td>-0.04</td>
<td>.26</td>
<td>.869</td>
</tr>
</tbody>
</table>

Notes: The neutral face was the reference for emotion effects. \( R^2 = .36 \)

Individual Differences in the Change in Infants’ Processing of Objects Following the Emotion-Object Pairing

To test individual differences in the change in infants’ processing of objects paired with facial expressions, we first added the main effects of infants’ temperament, and of parents’ negative affect to the object model in Table 3.b. This model is presented in Table 5 (\( N = 46 \)). Among main effects, the effect of maternal (but not paternal) negative affect was significant. Higher levels of maternal negative affect predicted a less pronounced difference in infants’ pupil responses to objects after the pairing with emotional (vs. neutral) facial expressions. None of the tested interactions were significant in this model.

Finally, to explore whether variation in depressive and anxiety symptoms of parents explains infants’ processing of unfamiliar objects, we repeated the same analyses of individual differences first with scores of parental depression, and next of parental anxiety in place of parental negative affect. Paternal and maternal depression (but

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3 Due to complications arising from hierarchical structure of multilevel regression models (Snijders & Bosker; 1994), and to different sample sizes in the models, \( R^2 \) change cannot be interpreted as a relative goodness-of-fit measure across models.

4 Among 56 infants with eye-tracking data in the Object Alone trials (see Table 3.b), data from 10 infants were missing in the analyses of individual differences because the data on fathers’ negative affect was missing.
Infants’ attention to emotion and referential cues

Figure 3. Regions of significance for the simple outcome slope across the distribution of the infant sadness scores (at the top) and the plot for the relationship between maternal depression (on the x-axis) and the change in infants’ pupil response to objects (on y-axis) at moderate, low and high levels of infants’ sad temperament (at the bottom). The moderate, low and high levels of infant sadness were set to mean, and 1 SD below and above the mean respectively. Inspection of regions of significance (i.e., continuously plotted confidence intervals) revealed that the slope of the association was significant for infants with low ($z < -1.37$), and high levels of sadness ($z > 0.34$), while it was not significant for infants moderate levels of sadness. The association between infants’ pupil response and mothers’ depression was positive for infants with low levels of infant sadness, while it was negative for infants with high levels of infant sadness.
not anxiety) predicted the difference in infants’ pupil responses to objects after the pairing with emotional expressions. None of the interactions between parental depression and infant temperament were significant, except for the interaction between maternal depression and infants’ sad temperament. The model is presented in Table 6 (N = 43). Higher levels of paternal depressive symptoms predicted a more pronounced increase in infants’ pupil responses to objects following the pairing with emotional (vs. neutral) facial expressions. To investigate how the association between maternal depression and infants’ pupil reactivity differed across low, moderate and high levels of infant sad temperament, we inspected the interaction plots and confidence bands (see Figure 3). The plot of the interaction revealed that the association between maternal depression and infants’ pupil responses was negative for infants high in sad temperament while it was positive for infants with low in sad temperament. The association was not significant for infants with moderate levels of sad temperament. Confidence bands revealed that there was a significant association between mothers’ depression and infants’ pupil responses was significant for z-values of infant sadness < -1.37, and > .34). Parental anxiety did not significantly predict infants’ pupil responses, neither alone, nor in interaction with emotion or infants’ temperament.

Table 6. The associations of infants’ pupil dilation to objects with infants’ negative temperament and with parental depression

<table>
<thead>
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<th>Parameter</th>
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<th>SE</th>
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</thead>
<tbody>
<tr>
<td>Intercept</td>
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<td>.010</td>
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<tr>
<td>Happy</td>
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<td>.211</td>
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<td>Fearful</td>
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<td>.17</td>
<td>.200</td>
</tr>
<tr>
<td>Sad</td>
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<td>.17</td>
<td>.154</td>
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<tr>
<td>Head/gaze direction</td>
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</tr>
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<td>.001</td>
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<td>.27</td>
<td>.815</td>
</tr>
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</table>

Notes. The neutral face was the reference for emotion effects. $R^2 = .36$

1 Among 56 infants with eye-tracking data in the Object Alone trials (see Table 3.b), data from 13 infants were missing in the analyses of individual differences because the data on fathers’ depression was missing.
DISCUSSION

The current study used an eye-tracking paradigm to investigate how 14-to-17-month-old infants’ attention to unfamiliar objects changed after seeing these paired with happy, fearful, and sad (vs. neutral) faces with referential cues indicating the emotion-object association (head and gaze direction towards vs. away). To account for individual differences in infants’ responses, the associations of parents’ and infants’ negative emotional dispositions with infants’ attention to emotion and referential cues were explored. Below, we first discuss the findings on infants’ attention to emotion and referential cues, and then we turn to findings concerning individual differences.

Infants showed more attention (larger pupils) to negative faces (fearful and sad) independent of the threat-relevance than neutral faces when presented alone, while they showed the largest increases in attention to objects that were paired with neutral (vs. emotional) faces. Despite several differences in methodology and age group, these results are remarkably similar to those of Hoehl and Striano (2010b) where 9-month-old infants showed increased attention allocation (measured via ERPs) to fearful (vs. neutral) faces independent of gaze direction, while they showed more attention to objects paired with neutral (vs. fearful) faces gazing towards objects. Although the associations between infants’ ERP and pupil dilation remains to be tested in future studies, increased attention allocation to objects paired with static neutral faces observed both in this previous study at 9 months and in the current study at 15 months can be explained by infants’ sensitivity to ambiguous information (Campos, Thein, & Owen, 2003) in this period. Because a neutral signal makes it difficult for the infant to disambiguate the threat-value of the novel object, neutral faces may have triggered increased attention due to ambiguity. This increase in infants’ attention allocation to neutral faces may mean that less attentional resources would be available for the processing of the objects during face-object pairing, and therefore objects previously paired with neutral (vs. emotional) expressions would be relatively more novel and trigger more attention when presented alone.

In contrast to the findings of Hoehl and Striano (2010b) that revealed more attention to the objects that have been previously paired with neutral (vs. fearful) faces gazing towards (and not away from) objects in 9-month-old infants, referential cues (head/gaze direction) did not affect infants’ pupil dilation to objects paired with emotional (vs. neutral) expressions in the current study. Thus, it seems that neutral faces triggered enhanced attention to objects, independent of whether they are gazing towards or away from the object. Note that in Hoehl and Striano (2010b), enhanced attention to fearful faces observed during the object-face pairings was also independent of gaze. Considering that infants themselves use looking away as an avoidance strategy in the face of ambiguous SR situations at the end of first year (Aktar et al., 2013; De Rosnay et al., 2006), they may also recognize this avoidant behavior in others.
This idea is supported by evidence revealing that later in development, children can form face-object associations in similar experiments even when objects are presented with facial expressions with frontal gaze, (that is, towards the child, and away from objects; Dunne & Askew, 2013). Thus, enhanced attention allocation to face-object associations may be less dependent on overt referential cues at the end of first year, and beyond.

While it is clear that fearful faces triggered more attention than neutral expressions, the pairing of a neutral face with novel objects did increase infants’ attention to these objects more than a fearful face. Thus, negativity biases in infants’ attention may be specific to faces (and not extend to objects paired with faces). Negativity biases in infants’ attention to negative (vs. neutral) facial expressions were independent of threat relevance (i.e., it holds for both fearful, and sad expressions in the current study). The findings revealing more attention to objects paired with neutral (vs. emotional) expressions differ from those of SR studies where infants are confronted with ambiguous stimuli like strangers or robot toys (Aktar et al., 2013; Carver & Vaccaro, 2007; De Rosnay et al., 2006). In the current study, infants’ attention to referential cues and emotion was measured in a fully computerized task that did not involve direct confrontations with ambiguous objects. Instead, static pictures of novel objects and faces appeared on a computer screen. This static presentation may have lowered the functional significance and the threat value of the emotion signals paired with novel objects in the experiment. This lowered significance may explain the lack of an enhanced attention allocation to objects paired with negative emotional expressions. It remains to be investigated whether infants would show a negativity bias in their attention allocation for objects paired with fearful (vs. neutral) facial expressions if their pupil responses were measured during confrontations with these objects in real life.

Concerning individual differences, the results revealed that infants’ temperamental dispositions for sadness, mothers’ negative affect and both parents’ depression are related to physiological correlates of infants’ attention allocation to emotional faces in SR contexts. Higher levels of sad temperamental disposition in infants were linked to larger pupils to emotional (happy, fearful, sad vs. neutral) facial expressions when presented alone. This effect did not extend to the processing of the objects paired with these faces. However, in contrast to previous ERP evidence in typically developing infants (De Haan et al., 2004), infants’ fearful temperament was not associated with changes in attention to emotional faces in this study. The decrease in threat value of emotional signals resulting from the lack of a direct consequence of emotion-object associations on infants’ experience may explain why negative faces, and pairing of negative faces with novel objects, did not trigger a different response among temperamentally fearful infants in this study.
Higher levels of maternal negative affect predicted a decrease in the difference in infants’ attention allocation to objects after the pairing with emotional (vs. neutral) facial expressions. Moreover, infants’ sad temperament moderated the associations of mothers’ depression and in infants’ pupil responses to novel objects that were paired with facial expressions. The association of maternal depression and infants’ pupil responses to objects was negative for infants with high levels of sad temperament, while it was positive for infants with low levels of sad temperament and not significant for infants with moderate levels of sad temperament. These findings are in line with the idea that infants’ negative temperamental dispositions may influence the effect of exposure to maternal depression in a non-clinical sample. The negative associations of maternal negative affect and depression with infants’ attention to emotional expressions in the current sample are consistent with previous ERP evidence from clinical samples and non-clinical populations revealing a negative association between infants’ exposure to positive and sad expressions from mothers and their attention to positive and sad expressions in others (De Haan et al., 2004; Field, Diego, & Hernandez-Reif, 2009). Note however, that the negative association reported in the current study was in infants’ attention allocation to objects previously paired with positive and negative emotional expressions, and not in their attention allocation to facial expressions. Furthermore, the association of mothers’ depression was found to be positive for infants with low temperamental dispositions for sadness in the current study.

A question that arises from these findings is why infants without sad temperament would show more attention to objects paired with positive and negative facial expressions when their mothers are depressed. In the absence of previous evidence on the interplay between parents’ depression of infants’ sad temperament on infants’ attention allocation and later child outcomes, we can only speculate about the causes and functions of this association. As suggested by Peláez et al., (2013), and by Gewirtz and Peláez-Nogueras (1992), increased flat affect and decreased availability of depressed parents may limit infants’ access to mothers’ emotional signals in SR situations, and reduce infants’ frequency of using parents’ emotional signals in SR situations. Enhanced attention to others’ emotional expressions in triadic contexts in case of higher maternal depressive symptoms may be an adaptive response that helps infants gather information from others’ emotional signals when the depressed mother is not available. Because these infants are not temperamentally likely to respond negatively to novel objects (i.e., low in sad temperament), increased attention to others’ signals may especially be helpful for self-protection against potentially dangerous stimuli in the environment in infants low in sad temperament in this period. Such an increase in attention to others’ facial expressions is also adaptive for infants’ socio-emotional development as it helps to reduce infants’ exposure to depressed mothers’ flat affect. We therefore conclude that enhanced attention to
emotional expressions of others may act as a buffer against potential dangers in the environment, and against the effects of exposure to parental depression in infants without sad temperament. The effect seems to be specifically related to mothers’ flat/neutral affect characterizing depression.

The question that arises next is what the function and effect of such a decrease in attention allocation of temperamentally sad infants to objects paired with positive and negative emotional expressions is when the mother has more depressive symptoms. On the one hand, an overall decrease in attention to objects paired with negative facial expressions could protect temperamentally sad infants (who were found to be more vigilant to emotional faces as compared to infants who are not temperamentally sad in this study) against others’ strong negative emotional expressions to ambiguous stimuli. On the other hand, the shutting down to positive emotions could as well be seen as the cost of this early mechanism, which may result in a more flat affect that is less affected by others’ positive emotions in triadic person-infant-object interactions. As high levels of sad temperament is a potential risk for childhood depression, this lowered sensitivity towards positive emotion-object associations is an important finding that needs further study as an early pathway to depressive symptoms in infants of parents with clinical and non-clinical levels of depression.

Higher levels of paternal depression predicted an increase in infants’ attention allocation to objects paired with positive and negative facial expressions. Different from mothers’ depression, the effect of fathers’ depression was independent of infant temperament. Despite significant correlations between paternal negative affect and depressive symptoms, only paternal depression but not negative affect predicted infants’ attention, suggesting that the effect may be specifically related to the flat affect that accompanies depressive symptoms.

The results reveal that depressed moods of mothers and fathers have distinct associations with temperamentally sad infants’ attention allocation to objects in SR contexts. Infants with high sad temperament showed increased attention to objects paired with facial expressions when their father reports higher levels of depression, while they showed decreased attention when their mother reports higher levels of depression. These findings seem to be in line with the idea of distinct roles of mothers and fathers in infants’ socio-emotional development (Bögels & Perotti, 2011; Bögels & Phares, 2008). Bögels and colleagues explain the differences between mothers’ and fathers’ role in child development based on the differentiation in mother and father domains of expertise throughout the course of evolution. While mothers specialized in care and comfort, fathers specialized in dealing with the external world. According to this theory, fathers may “know best” whether novel/ambiguous stimuli should be avoided or confronted, and infants know that fathers know best. However, depressed fathers are not able to fulfill this role of showing their infant how to interpret novel
Infants’ attention to emotion and referential cues

stimuli, which may explain why fathers’ but not mothers’ depression is related to increased attention for novel objects paired with others’ emotional faces in the current study. Current findings reveal that exposure to higher levels of paternal depression may increase infants’ attention towards others’ positive and negative emotions. As enhanced attention to negative stimuli characterizes depression and anxiety (Leppänen, 2006; Van Bockstaele et al., 2014), exposure to paternal depressed moods may add up to the risk for later psychopathology in infants with high levels of sad temperament.

In contrast to depressive symptoms, mothers’ or fathers’ anxiety symptoms did not predict infants’ pupil responses to novel objects. Considering that parents’ fearful/anxious expressions have an observable effect on infants’ reactions in triadic SR contexts (De Rosnay et al., 2006), it is difficult to explain why the variation in parents’ anxiety symptoms did not predict infants’ attention to objects paired with negative faces. Differently from depression that is related to an overall increase in parents’ flat and sad emotional expressions, parents’ anxious expressions only manifest in reaction to specific stimuli, and fade in the absence of these stimuli (except for generalized anxiety (American Psychiatric Association, 2013). Thus, infants’ exposure to negative affect may be more prolonged in the case of depression compared to anxiety, resulting in a more easily detected effect in non-clinical samples.

The findings of the current study should be interpreted considering the following limitations. First, although the current study tested the effect of emotion and referential cues on infants’ physiological reactivity in triadic person-infant-object contexts, it remains unknown how infants’ physiological reactivity in the task relates to their behavioral and physiological responses to novelty in real life SR situations. Previous ERP evidence has revealed that parents’ emotion and referential cues towards novel toys observed in real life SR situations influence infants’ subsequent attention allocation to the pictures of these toys presented on a computer screen (Carver & Vaccaro, 2007), while further evidence is needed to fully establish the associations between physiological and behavioral indices of infants’ attention to emotion and to referential cues in real-life SR situations and in computerized SR tasks. Second, the current study only included static visual information to test the effects of gaze direction and emotion, while evidence reveals a larger influence of auditory and multimodal cues on infants’ emotion processing (Grossmann, 2010), and on behavior in SR contexts in infancy (Mumme, Fernald, & Herrera, 1996). Future studies using computerized tasks should consider using dynamic facial expressions with dynamic object displays to explore infants’ emotion processing. Third, although the findings seem to be in line with the idea of distinct roles of mothers and fathers in infants’ socio-emotional development (Bögels & Perotti, 2011; Bögels & Phares, 2008), the differences in infants’ attention allocation were tested only with female faces in the current study. It remains to be investigated whether these individual differences also
hold when infants are tested with female and male faces, as well as with their mothers' and fathers' faces. Finally, the cross-sectional and non-experimental design of the current study precludes any prospective or causal inference on the effect of parental negative affect, depression, and anxiety, and of infants' temperament on infants' attention to facial expressions, and to novel objects paired with these expressions in triadic emotion learning contexts. Despite these limitations, the current study provides the first evidence on the processing of emotion and referential cues via pupillometry in triadic person-infant-object interactions, and reveals significant associations of infants' negative temperament and parents’ negative emotions with infants' pupil reactivity to emotional facial expressions, and to emotion-object associations.
GENERAL DISCUSSION
General discussion

This thesis aimed to examine the links between exposure to parents’ depression and anxiety in the early years of life, and infants’ socio-emotional development. The dissertation first examined the associations between infants’ and parents’ emotional expressions, and between their reactions to novel stimuli in everyday interactions (Chapter 1, 2, 3, & 4), and next the associations between parents’ depression and anxiety, and infants’ attention to emotional stimuli (Chapter 1, 5 & 6). Infants’ temperamental dispositions were included as a vulnerability/susceptibility factor in the effects of exposure to parental depression and/or anxiety on infant outcomes (see Figure 1). In the next two sections of this final chapter, we first put the main findings reported in dyadic and in triadic contexts together, first in daily interactions and next in infants’ attention. A summary of key research findings is presented in Figure 2. The chapter continues with the integration of findings, followed by limitations, future directions, and it ends with clinical implications.

Exposure to Parents’ Depressed/Anxious Moods, and Infants’ Emotional Expressions/Reactions to Novelty in Daily Interactions

Dyadic parent-infant interactions

The findings of the current dissertation reveal that lifetime depression (and not anxiety) diagnosis interferes with mothers’ (but not fathers’) ability to provide a positive interpersonal environment to their infant in face-to-face interactions (Chapter 2). Mothers with lifetime depression diagnoses were less positive, and more flat during their interactions with the infant. Interestingly, lifetime depression did not influence the duration of fathers’ positive or neutral affect in the interaction. Infants’ positive affect during face-to-face interactions did not differ as a function of their mothers’ or fathers’ lifetime depression status. However, more depression symptoms (a continuous measure rather than the presence/absence of depressive diagnosis) in parents were linked to less positive and less negative affect from the infants in the interactions. Thus, more flat affect was observed in infants’ expressions when parents have higher levels of depression symptoms. Infants’ temperament did not moderate the effect of parents’ lifetime diagnoses on infants’ affect expressions. These findings on the effect of depression on parents’ and infants’ expressions of emotion in parent-infant face-to-face interactions are consistent with previous literature that consistently report a decrease in positive affect expressions of mothers with depression and their infants (reviewed in Chapter 1). This dissertation additionally reveals that depression-related alterations may not be salient in fathers’ expressions of affect in early face-to-face interactions.

Depression-related alterations in mothers’ facial expressions of emotions in parent-infant face-to-face interactions held with depressed mothers with and without anxiety disorders. However, anxiety disorders alone did not alter the duration of mothers’ or fathers’ expressions of positive or neutral affect during the parent-infant face-to-face interactions. Neither did infants’ positive or negative affect differ during
face-to-face interactions as a function of their mothers’ or fathers’ lifetime anxiety status. The findings revealing no alterations in the positive and negative expressions of affect in parents with lifetime anxiety disorders without depression are consistent with the limited number of previous studies (Kaitz, Maytal, Devor, Bergman, & Mankuta, 2010; Murray, Cooper, Creswell, Schofield, and Sack, 2007; Weinberg, Beeghly, Olson, & Tronick, 2008; reviewed in Chapter 1) that addressed the effects of parental anxiety disorder without comorbid depression on parents’ and infants’ expressions of emotion.

However, higher levels of anxiety symptoms in parents (a continuous measure rather than the presence/absence of anxiety diagnosis) predicted more positive and more negative affect, thus less emotional stability/more emotional variability in infants. But as the duration of parents’ expressions of positive and neutral affect does not seem to change directly during the interaction as a function of parents’ anxiety diagnosis or symptoms (Chapter 2), the decrease in infants’ emotional stability may be related to earlier repeated exposure to parents’ depressed moods, or to inherited alterations in physiological reactions rather than direct environmental transmission of facial affect via exposure in the interaction. Alternatively, the increase in infants’ positive and negative affect can be a reaction to higher levels of exaggerated behavior in parents with (vs. without) anxiety disorders. Exaggerated behavior is defined by an irregularly high frequency or intensity in the occurrence of certain aspects of parents’ interactive behavior including acknowledgements, vocalizations and gaze in addition to positive affect expressions, and it was previously found to be higher in interactions of mothers with (vs. without) anxiety disorders (Kaitz et al., 2010).

![Figure 1. An overview of the scope of this thesis.](image-url)
General discussion

Key Findings

Dyadic parent-infant interactions
- Parental lifetime depression diagnosis interferes with mothers’ (but not fathers’ or infants’) positive affect expressions.
- Parental lifetime anxiety diagnoses alone do not influence mothers’, fathers’ or infants’ expressions of positive or neutral affect.

Triadic parent-infant-object interactions
- Mothers and fathers with lifetime social anxiety disorder express more anxiety than reference parents during confrontations with unfamiliar stimuli in infancy and toddlerhood.
- More expressed anxiety (rather than the presence of a lifetime anxiety disorder) in mothers and fathers is linked to more avoidance of the stimuli in temperamentally reactive children in infancy, whereas the presence of a lifetime anxiety disorder in parents (rather than expressed anxiety) is linked to more fear/avoidance of the stimuli in toddlerhood.
- More expressed anxiety in infancy from mothers and fathers with comorbid lifetime social and non-social anxiety disorders prospectively predicts more avoidance in toddlerhood.

Attention to Emotional Stimuli in Dyadic Person-Infant Contexts
- Mothers’ and fathers’ anxiety, but not depression is associated with infants’ attention to emotional facial expressions.
- More anxiety in mothers and fathers is linked to more attention to emotional facial expressions in infants with high levels of fearful temperament, but to less attention to emotional facial expressions in infants with low levels of fearful temperament.

Attention to Emotional Stimuli in Triadic Person-Infant-Object Contexts
- Depression, but not anxiety in mothers and fathers is associated with infants’ attention to novel objects paired with emotional facial expressions in the following ways:
  - More depression in fathers is linked to more attention to objects following emotion-object pairing.
  - More depression in mothers is linked to more attention to objects following the pairing in infants with low levels of sad temperament, but to less attention to objects following the pairing in infants with high levels of sad temperament.

Box 1. An overview of the key findings of this thesis.

Triadic parent-infant-object interactions
In contrast to the lack of alterations in anxious parents’ expressions of emotion in parent-infant face-to-face interactions, this dissertation found evidence that mothers and fathers with lifetime social anxiety diagnoses express more anxiety than parents without diagnosis in parent-child-object interactions where their children were confronted with unfamiliar stimuli (i.e., social referencing situations with female strangers and robot toys, Chapter 3 & 4). This was true for parents who have lifetime social anxiety diagnoses only, but also for those who have comorbid social and other types anxiety disorders, and the effect held across social versus nonsocial stimuli, and when children are 12 and 30 months. However, lifetime diagnoses of other -nonsocial-
anxiety disorders alone do not seem to alter parents’ expressions of anxiety in these social referencing situations. Thus, the increase in parents’ expressed anxiety was specifically related to the presence of lifetime social anxiety disorder. It seems that anxiety expressions were triggered by the experience of being videotaped with one’s infant in the lab, and were similar with strangers vs. robot toys as unfamiliar stimuli in social referencing situations.

As regards infants’ reactions to unfamiliar stimuli in social referencing situations at 12 months, infants’ fear and avoidance of unfamiliar stimuli did not differ as a function of their mothers’ or fathers’ lifetime anxiety status. On the other hand, higher levels of expressed anxiety by mothers and fathers predicted increased avoidance of stimuli, an effect that held for infants who had temperamental dispositions for anxiety (i.e., moderate and high levels of behavioral inhibition). Thus, when it comes to 12-month-old infants’ avoidance, how parents behaved in the presence of the stimuli in social referencing situations mattered more than their lifetime anxiety diagnoses. The findings showing a larger influence of parents’ anxiety expressions on temperamentally reactive infants’ avoidance in the social referencing situations are consistent with earlier findings by Murray and colleagues (2008), who reported a larger increase in stranger avoidance of temperamentally fearful infants of parents with social anxiety disorders from 10 to 14 months. Our findings show that higher vulnerability of temperamentally fearful infants of mothers with social anxiety disorder reported in this earlier study (Murray et al., 2008) may in fact be mediated by the temperamentally fearful infants’ exposure to parents’ expressions of anxiety. Findings of the current thesis revealing an effect of exposure to parents’ expressions of anxiety in the situation, rather than an effect of lifetime diagnoses are also consistent with earlier experimental findings on social referencing processes by De Rosnay and colleagues (De Rosnay, Cooper, Tsigaras, & Murray, 2006), that showed a stronger influence of maternal (trained) anxious reactions on stranger avoidance of temperamentally fearful than non-fearful infants of mothers without diagnosis.

A follow-up of the same sample in social referencing situations in toddlerhood (at 30 months of age, Chapter 4) revealed that neither children’s avoidance of unfamiliar stimuli in social referencing situations, nor the association between parents’ expressed anxiety and children’s avoidance of unfamiliar stimuli is stable from infancy to toddlerhood. In contrast to the findings at 12 months, toddlers’ avoidance of unfamiliar stimuli differed as a function of their mothers’ or fathers’ lifetime social anxiety status, but not of their parents’ expressed anxiety. Children of parents with lifetime social anxiety diagnoses were more avoidant of the unfamiliar stimuli at 30 months. On the other hand, despite a parallel increase in expressed anxiety in parents, and avoidant reactions in infants when the mother has a lifetime social anxiety diagnosis, there was no significant association between parents’ expressions of anxiety and toddlers’ avoidance of stimuli. Thus, when it comes to 30-month-old
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toddlers’ avoidance of unfamiliar stimuli, parents’ lifetime social anxiety diagnoses mattered more than how parents behaved in the presence of the stimuli in social referencing situations. Moreover, earlier temperamental dispositions (i.e., behavioral inhibition at 12 months) did no longer moderate the strength of the associations between parents’ expressed anxiety (or social anxiety status) and toddlers’ avoidance. Although heightened anxiety expressions of parents with social anxiety diagnoses characterized social referencing situations at both 12 and 30 months, it seems that the direct transmission of anxiety via exposure to parents’ anxiety expressions in social referencing situations is specific to the end of first year. Moreover, there were prospective associations of earlier exposure to parental expressions of anxiety in social referencing situations with later child avoidance. Children of parents with comorbid social and other anxiety disorders who had been exposed to more anxiety from their parents at 12 months were more avoidant of the stimuli in social referencing situations at 30 months. The fact that this prospective association only holds for infants of parents with comorbid social and nonsocial anxiety disorders may be explained by stronger deviations in earlier exposure, or other biological or genetic vulnerabilities in these children. These vulnerabilities may have strengthened the effects of earlier exposure on later child behavior, or may simply become more salient in child behavior at 30 months.

Contributions
In addition to including the first longitudinal investigation of social referencing processes from infancy to toddlerhood, this dissertation advanced our knowledge on the transmission of depressed and anxious/avoidant interactive styles from parents to children in the early years in several other respects. First, it addressed for the first time the effect of fathers’ depression and anxiety disorders in interactions, in addition to mothers’ depression and anxiety. In contrast to a differential influence of depression on mothers’ vs. fathers’ facial expressions of positive affect in parent-infant interactions, parallel associations were found in mothers’ and fathers’ anxiety with infants’ avoidance. Second, the thesis advanced our understanding on the effects of parental anxiety disorder without comorbid depression in dyadic parent-infant interactions. The decrease in positive affect was specific to mothers’ depression, while lifetime anxiety disorder(s) alone did not influence the duration of mothers’ or fathers’ expressions of affect. Third, the effect of infants’ temperamental dispositions on infants’ and parents’ expressions of emotion in dyadic parent-infant interactions were for the first time considered in the investigation of parental depression and anxiety. Infants’ temperament did not influence infants’ or parents’ expressions of emotion in face-to-face interactions. In contrast, it exacerbated the effects of exposure to parental anxiety expressions in social referencing situations on 12-month-olds’ avoidance. Fourth and finally, the thesis investigated the diagnosis and context specificity in early social referencing processes by including parents with
social and/or nonsocial of lifetime anxiety disorders, and social and nonsocial types of ambiguous stimuli (a stranger vs. a robot). The increases in mothers’ and toddlers’ reactions were specific to parents’ social anxiety disorder, while no context specificity was found in social referencing processes with social vs. nonsocial stimuli.

**Exposure to Parents’ Depressed/Anxious Moods, and Infants’ Attention to Others’ Emotional Expressions in Dyadic and Triadic Contexts**

To address how depression- and anxiety-related variations in infants’ exposure to emotion from non-clinical parents may affect infants’ emotion processing, this dissertation tested the links between infants’ attention to emotional (vs. neutral) stimuli and parents’ depression and anxiety. Infants’ attention to emotional stimuli was tested using facial expressions of emotion (in Chapter 5), and objects paired with emotional facial expressions (in Chapter 6). These were used to investigate infants’ attention in dyadic person-infant contexts and triadic person-infant contexts respectively.

**Dyadic person-infant contexts**

In the current dissertation no significant association was found between non-clinical depression in parents and infants’ attention to facial expressions (Chapter 4). In contrast, maternal and paternal anxiety predicted infants’ fixations to emotional (vs. neutral) expressions in interaction with infants’ fearful temperament (Chapter 5). More maternal and paternal anxiety was related to longer fixations to emotional (vs. neutral) facial expressions in infants with high levels of fearful temperament, whereas it was associated with shorter fixations to positive and negative (vs. neutral) emotional expressions in infants with low levels of fearful temperament. Thus, high levels of anxiety from mothers and fathers seem to be linked to decreased interest or an avoidant processing style in the processing of facial expression with infants low in temperamental dispositions for fear, whereas it is related to an increase in interest or hyper-vigilant processing style in infants high in temperamental dispositions for fear.

The findings reveal that exposure to parents’ expressions of anxiety may enhance temperamentally fearful infants’ interest to others’ emotional (vs. neutral) expressions of emotion. Considering that enhanced attention to negative stimuli is a defining feature of anxiety disorders in children and parents, infants’ fearful temperament needs to be further investigated as a vulnerability in the effects of exposure to parents’ anxiety on infants’ early attention to emotional facial expressions. In contrast to these findings, parents’ anxiety did not predict infants’ pupil responses. Thus, it seems that the effect of parental anxiety is specific to behavioral indices of attention (i.e., fixation durations), and may not be detectable in the pupil responses.

**Triadic person-infant-object contexts**

Mothers’ and fathers’ depression, but not anxiety predicted infants’ attention (Chapter 6) to novel objects, after these were paired with emotional vs. neutral expressions.
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More depression in fathers was linked to a larger increase in pupil responses (i.e., more attention) to objects following both positive and negative emotion-object pairing. More depression in mothers was also linked to a larger increase in pupil responses (i.e., more attention) to objects following both positive and negative emotion-object pairing, but only in infants with low levels of sad temperament. In contrast, maternal depression predicted a decrease in pupil responses (i.e., less attention) to objects after the pairing in infants with high levels of sad temperament. Thus, exposure to more depression from mothers and fathers was related to heightened physiological sensitivity to the objects paired with emotion when infants have low levels of sad temperament. However, for infants with high levels of sad temperament, exposure to maternal depression decreased infants' sensitivity to objects, whereas paternal depression increased it.

Considering that infants with a sad temperament already show enhanced attention/vigilance to negative emotional expressions (presented without objects, Chapter 6), infants' lower interest to positive and negative emotional stimuli when the mother is depressed, may be a protective mechanism that helps to reduce the effect of exposure to others' negative moods on temperamentally sad infants' interest to novel objects. However, a disadvantage coming from the decrease in attention to objects paired with both positive and negative expressions may be that temperamentally sad infants of depressed mothers have a smaller likelihood to attend to, and thus learn from others' emotional signaling when confronted with unfamiliar stimuli. In contrast, the link of fathers' depression to temperamentally sad infants' attention was in the reverse direction, that is, fathers' depression was linked to an increase in infants' attention to objects that were paired with others' positive and emotional expressions. This implies higher likelihood that infants make use of others' positive and negative emotional signals towards unfamiliar stimuli when their father is depressed. To understand whether these differential alterations in infants' attention constitute a risk or a buffer for later psychopathology, it is essential to establish the links of these with later functioning in future research.

Contributions

This dissertation advanced our knowledge on the links between exposure to depression and anxiety in parents and infants' attention allocation to facial expressions in several respects. First, to the best of our knowledge, this thesis was the first to test and to show links between non-clinical levels of parental depression and anxiety and infants' attention to emotional stimuli. The inclusion of both physiological and behavioral (Chapter 5) indices of attention was another innovative aspect of this dissertation. Second, this study included infants' sad and fearful temperament as moderators of the link between parental depression and/or anxiety and infants' attention. The findings (summarized above) illustrate the importance of considering infants' temperament in infants' emotion processing in the context of parental depression and anxiety. Third,
this thesis extended the study of attention to person-infant-object contexts to discover how infants’ exposure to parents’ depression and anxiety may alter infants’ attention to unfamiliar objects paired by emotional (vs. neutral) facial expressions (Chapter 6). As summarized above, depression (but not anxiety) in mothers and fathers explain individual differences in infants’ attention to objects paired with others’ emotional expressions. Finally, to our knowledge the current dissertation was the first one to consider the variation in depression and anxiety levels from both fathers and mothers in the study of exposure effects on infants’ attention. This dissertation found parallel links between mothers’ and fathers’ depression, and anxiety and infants’ attention, except for the link between depression and temperamentally sad infants’ attention to objects paired with positive and negative emotional expressions (i.e., more depression in mothers was related to less attention, whereas more depression in fathers was linked to more attention).

**Integration**

*Exposure to parental depression and anxiety, and infants’ socio-emotional development*

Concerning the effects of infants’ exposure to parental depression, the findings of current dissertation suggests that lifetime depression diagnoses alter mothers’ but not fathers’ facial expressions of emotion during dyadic parent-infant interactions with their infant in the first half-year of life, contributing to a more flat, and less positive socio-emotional environment (Chapter 2). The potential associations of these early alterations in face-to-face interactions with later development of depression in the offspring is straightforward as they indicate early transmission of a less positive and more flat affective style characterizing depression from mothers to infants (Field, 1984). However, infants’ attention in dyadic contexts (thus to positive and negative [vs. neutral] facial expressions) was not explained by parents’ depression. In contrast, this thesis reveals that depression in parents may be linked to infants’ attention to objects paired with emotional expressions in triadic parent-infant-object contexts (Chapter 6). In the absence of evidence for a prospective link between early emotion processing and later depression, it is difficult to understand whether the depression-related changes found in this thesis in infants’ attention to objects constitute a risk or a buffer for later development of depression, or other psychopathology in children of depressed mothers.

Concerning the effects of infants’ exposure to parental anxiety, this thesis demonstrates a change in the effect of mothers’ and fathers’ lifetime anxiety on parents’ and infants’ emotional expressions and reactions from dyadic parent-infant interactions in the first half-year to triadic parent-infant-object interactions in the second half-year. Lifetime anxiety disorder in mothers and fathers does not alter parents’ or infants’ expressions of emotion in early face-to-face interactions, whereas exposure to parental anxiety in triadic parent-infant-object interactions predict
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avoidant responses to unfamiliar stimuli from temperamentally fearful infants at 12 months. In other words, anxiety-related alterations in exposure only become detectable as parent-infant interactions extend to ambiguous/unfamiliar objects in the environment at the end of first year (i.e., social referencing contexts).

Moreover, there seems to be a change in the effect of mothers’ and fathers’ lifetime anxiety diagnoses on infants’ avoidance in social referencing situations from infancy to toddlerhood. Higher levels of parental anxiety expressions in social referencing situations seem to directly influence temperamentally reactive children’s avoidance of novel stimuli only at 12, but not at 30 months, suggesting that the end of infancy may be a sensitive period in the environmental transmission of anxious/avoidant reactions from parents to temperamentally reactive children in social referencing situations. In line with this, infants’ exposure to parents’ expressions of anxiety seem to have prolonged effects on children’s avoidance of novel stimuli in toddlerhood in cases where parents have more severe comorbid instances of lifetime parental anxiety. In other words, exposure to parental anxiety expressions in this sensitive period may convey risk for the environmental transmission of anxious/avoidant reactions from parents with more severe forms of anxiety dispositions.

In contrast, infants’ attention in dyadic rather than triadic contexts (thus, to positive and negative [vs. neutral] facial expressions rather than to objects paired with these expressions) was explained by parents’ anxiety. Infants of more anxious mothers and fathers showed enhanced attention to positive and negative facial expressions. These alterations may be early forms of anxious responses that are defined by an increase in the avoidance of anxiety-provoking situations and enhanced attention/hyper-vigilance to negative emotions in childhood depression and anxiety.

Mothers’ vs. fathers’ depressed/anxious moods

Concerning the effects of exposure to mothers’ vs. fathers’ depression and anxiety, the results of this thesis suggests that lifetime depression diagnosis makes mothers but not fathers less positive and more flat in their facial affect than reference mothers in dyadic parent-infant interactions. Overall differences between mothers’ and fathers’ interactive styles may explain why lifetime depression diagnoses in mothers, but not in fathers was related to less positive affect durations. Evidence from the current dissertation (Chapter 2), and from earlier studies (reviewed in Chapter 1) suggest that fathers are overall less positive than mothers in their interaction with their infant. It seems that fathers construct infants’ socio-emotional environment by creating intense states of positive arousal via physical play in early interactions, rather than face-to-face exchange of positive affective states (Feldman, 2003; Forbes, Cohn, Allen, & Lewinsohn, 2004). In this sense, our investigation that exclusively focused on the duration of positive affect, rather than on the intensity of positive arousal or the amount of physical play in the father-infant dyad may not have captured depression-
and anxiety-related alterations in father’s interaction. In contrast, high levels of expressed anxiety from both mothers and fathers seem to make temperamentally fearful infants more avoidant of ambiguous stimuli in triadic parent-infant-object interactions (i.e., social referencing situations). Likewise, the presence of a lifetime social anxiety disorder in both mothers and fathers increased parents’ anxiety and toddlers’ avoidance of unfamiliar stimuli. Thus, depression is more salient in mothers’ than fathers’ facial expressions in face-to-face interactions, whereas fathers are as influential as mothers in the early modeling of anxious behavior in SR situations.

Moreover, the results of this thesis reveal similar links between mothers’ and fathers’ depression and anxiety, and infants’ attention to emotional stimuli (i.e., emotional [vs. neutral] facial expressions or objects paired with emotional [vs. neutral] facial expressions). The only exception was in the association between depression and attention to novel objects in infants with high levels of sad temperament. More depression in mothers was linked to less attention to objects paired with positive and negative expressions in infants, whereas more depression in fathers was linked to more attention to objects. Thus, it seems that mothers’ depression desensitizes infants to emotional stimuli while fathers’ depression sensitizes them to emotional stimuli in triadic contexts.

To summarize, the findings of this thesis are line with the idea that exposure to clinical and non-clinical parental depression and anxiety from both mothers and fathers influence infants’ interactive behavior and/or emotion processing. The findings illustrate the importance of fathers’ in addition to mothers’ depression and/or anxiety in exposure effects.

**Temperament as a moderator of the exposure to mothers’ vs. fathers’ depressed/anxious moods**

Concerning the effect of infants’ temperamental dispositions as a potential moderator of the link between exposure to parents’ depression and anxiety and infant outcomes, this dissertation reveals that infants’ temperament do not moderate the effect of parents’ lifetime diagnoses on infants’ expressions of affect in parent-infant face-to-face interactions. However, in line with the diathesis-stress (Zuckerman, 1999), vulnerability-stress (Ingram & Luxton, 2005; Nigg, 2006) and the differential susceptibility to environmental influences hypothesis (Belsky, Bakermans-Kranenburg, & Van IJzendoorn, 2007; Belsky & Pluess, 2009), fearful temperament seems to create a vulnerability for the exposure to parents’ expressions of anxiety in social referencing situations at 12 months.

Furthermore, findings from this thesis also suggest the associations between exposure to parental depression and anxiety and infants’ attention to emotional stimuli are moderated by infants’ own temperamental predispositions for negative emotion across parent-infant and parent-infant-object contexts (except for the positive
association between paternal depression and infants’ attention to objects). Taken together, the findings support a joint influence of exposure to parents’ depressed/anxious moods and of infants’ temperament on infants’ interactive behavior and emotion processing.

Limitations
The findings of this dissertation should be interpreted in the light if the following limitations: First, the non-experimental and correlational design of the studies in the current thesis precludes causal inferences on the effects of exposure to parental anxiety and/or depression and of infant temperament on infants’ behavior in early interactions, or on infants’ attention to emotional stimuli. Second, the majority of the studies in the current dissertation examined cross-sectional associations between exposure and infants’ behavior in early interactions or attention to emotional stimuli (except for Chapter 4), thus the thesis precludes any conclusions on the prospective links of depression- and anxiety-related alterations in infants’ exposure to parental emotions early interactions, and emotion processing to later emotional functioning. Third, infants’ early emotional behaviors and attention constituted the main infant outcome in the investigation of exposure effects, as alterations in these early processes has the potential to tap on the dysfunctional processes in interactive styles and attention of depressed and anxious children. However, the direct links between these aspects of early development and dysfunctional aspects of childhood depression and anxiety wait to be investigated in future studies. Fourth, although the current thesis included infants’ temperament as a behavioral index of biological and/or genetic vulnerability, the current dissertation did not consider purely genetic and biological indices in infants of parents with depression and anxiety. Delineating the mediating or moderating role of these non-environmental vulnerabilities together with prenatal influences remain essential in the investigation of environmental transmission of depression and anxiety. Finally, although the current dissertation is unique in bringing together the investigation of infants’ interactive behavior in early interactions and infants’ attention to emotional stimuli, the studies did separately consider these components of early socio-emotional development. Thus, the links between anxiety- and depression-related alterations in infants’ interactive behavior and infants’ attention remain to be investigated in future studies.

Future Directions
In the light of the limitations addressed above, we suggest that the first priority for future research on the effect of early exposure to parental negative emotions is the investigation of longitudinal links between exposure-related alterations in early emotional environment and later child functioning and psychopathology. The longitudinal link may help to identify which aspects of these alterations in infants’ early interactive behavior and attention is adaptive, that is, longitudinally linked to better outcomes. For example an earlier study by Creswell and colleagues (2008)
showed that 10-week-old infants of mothers with social anxiety disorders show less interest to high (vs. low) intensity fearful faces, whereas infants of control mothers showed more interest to high intensity fearful faces. A follow-up of this sample at 2-years revealed that less interest to high (vs. low) intensity facial expressions at 10-weeks is linked to better anxiety outcomes in the offspring of socially anxious mothers (Creswell et al., 2011). In contrast, more interest to high (vs. low) intensity facial expressions at 10-weeks was linked to better anxiety outcomes in the offspring of control mothers. This longitudinal study suggests that infants who show more interest to high intensity fearful faces may be at risk for later anxiety in children of socially anxious mothers. As illustrated by this study, the investigation of longitudinal links may help for understanding early vulnerability or resilience factors relating to infants’ attention and interactive behavior.

The second priority is the consideration of non-environmental factors such as early neurophysiological or genetic influences that may mediate or moderate the associations of exposure to parental depression and anxiety with infants’ interactive behavior and attention in addition to subsequent functioning. For example, the s allele of the serotonin transporter (5-HTTLPR) gene, which is known to create vulnerability for depression and anxiety (Lesch et al., 1996) was found to be linked to 7-month-old infants’ temperament and emotion processing in an ERP study (Grossmann et al., 2011). Genetic vulnerabilities are an important addition to future studies as they may provide further insight in individual differences in infants’ early interactive behavior and emotion processing. Genetic and/or biological vulnerabilities may mediate or moderate (thus reduce or exacerbate) the links of early exposure to parental depression and anxiety to infants’ socio-emotional development, and to later psychopathology.

The third priority is the simultaneous investigation of exposure effects in different aspects of infants’ socio-emotional development across samples of infants of parents with clinical and non-clinical depression and anxiety. For a more complete picture of the early exposure effects on infants’ development, it remains essential to examine the link between exposure to depression and anxiety in parents and infants’ attention and reactions to others’ and parents’ facial expressions in early interactions or in computerized experiments.

General Conclusion
This dissertation shows that exposure to depression- and/or anxiety-related alterations in mothers’ and fathers’ emotional expressions in early life is linked to alterations in infants’ affect and behavior in early interactions with parents, as well as in infants’ emotion processing. The thesis additionally illustrates the importance of considering fathers’ depression and/or anxiety and infants’ temperamental dispositions in the study of early exposure effects.
General discussion

Clinical Implications
The findings of the current thesis reveal significant alterations in mothers' and fathers' emotional expressions in everyday interactions in the first postnatal year in case of lifetime anxiety and depression diagnoses. Moreover, these alterations were found to be linked to parallel alterations infants' interactive behavior and to explain infants' emotion processing. To identify which patterns of interactive behavior and of emotion processing convey risk for later problems, it remains essential to test the links between these early alterations and later adaptation and psychopathology in the offspring in future research. Still, the findings of this thesis demonstrate that exposure to parents' depressed and anxious moods may constitute an early risk in the intergenerational transmission of depression and anxiety, highlighting the potential importance of protecting the offspring from these alterations in exposure by improving the screening, the prevention and the treatment of depression and anxiety disorders in mothers and fathers in the postnatal year. In the light of the findings demonstrating a joint influence of infants' exposure to parents' depression and anxiety, and infants' temperamental dispositions, it is additionally important to detect early signs of negative temperament in infants, together with depression and anxiety symptoms in parents. Quick and easy-to-administer screening instruments addressing these dimensions in parents' and newborn infants' behavior would be extremely helpful in detecting which parents and infants require specific attention to minimize/eliminate early exposure effects.

Keeping in mind that the majority of parents who have depression and anxiety disorders in the first postnatal year also have it during pregnancy (Beck, 2001; Heron, O'Connor, Evans, Golding, & Glover, 2004) or earlier (Robertson, Grace, Wallington, & Stewart, 2004) it appears that an important risk group to target later depression/anxiety following the child's birth is mothers and fathers with earlier or prenatal diagnoses of depression and anxiety. Moreover, findings from this thesis imply stronger deviations in the distribution of infants' exposure to parental emotions in the case of comorbid forms of depression and anxiety disorders, and in cases where both the mother and the father have depression/anxiety. Considering that comorbid forms of depression and anxiety disorders in one parent, and the presence of depression/anxiety in both parents (vs. one parent only) at the same time contribute to a more pronounced genetic and biological risk for intergenerational transmission of depression and anxiety, these families should be prioritized in the interventions targeting parents' depression/anxiety and interactive behavior with their infants.

In this thesis, the alterations reported in the interactions of depressed/anxious parents in the postnatal year were observed in the case of lifetime depression and anxiety disorders, revealing that depression- and anxiety-related alterations may extend to the periods where the parents do no longer satisfy criteria for a current diagnosis. This raises the possibility that the interventions that solely target current depression/
anxiety symptoms in parents are not enough to improve parent-infant interactions. Additional interventions specifically targeting parents’ interactive behavior (i.e., attention, emotional expressions and emotional reactions) should therefore be considered to more directly target depression- and anxiety-related alterations in infants’ early emotional environment in this period. The interventions focusing on attachment theory to target parent-child interactions in maternal depression revealed promising results (Gelfand, Teti, Seiner, & Jameson, 1996). However, these interventions address infants’ attachment rather than directly targeting attention and affect expressions in everyday interactions. Computerized training of attentional biases (often referred to as cognitive bias modification and cognitive control training, see Wiers, Gladwin, Hofmann, Salemink, & Ridderinkhof, 2013) in parents and infants (towards positive affect/away from threat) would be an interesting alternative to be considered in the interventions for parent-infant interactions in the case of depression and anxiety. An advantage of cognitive bias is that some of the tasks can be adapted to preverbal infants, for example by replacing verbal labels by visual/auditory and bi-modal stimuli, or by replacing verbal instructions with gradual training of infants’ attention to the target response (Wass, Porayska-Pomsta & Johnson, 2011). These techniques would thereby offer the unique possibility to intervene the interaction by training attention towards positive affect and away from threat in parents and infants. Another alternative is mindful parenting training (Bögels & Restifo, 2014) that has recently been adapted to new parents and infants. During mindful parenting sessions where one or both parents participate with the infant, parents’ early interactive behavior with the infant is directly addressed as parents are encouraged to provide sustained and undivided attention to their infants, to attend to the infants’ emotional signals of their infants, and to adopt a non-reactive parenting style in the face of parenting stress.
SUMMARY
Summary

Exposure to parents’ negative emotions in early life as a developmental pathway in the intergenerational transmission of depression and anxiety

The main goal of this thesis was to investigate how exposure to clinical and non-clinical forms of parental depression and anxiety in early life affects infants' socio-emotional development. Three aspects of early socio-emotional development were the focus of the current dissertation: infants’ emotional expressions, reactions to novelty in everyday interactions, and attention to emotional stimuli.

Chapter 1 described a literature review on the effects of exposure to parental negative emotions, depression and anxiety in the first year of life on these three aspects of infants' socio-emotional development. Our review revealed positive links between infants’ and parents’ emotional expressions and between infants’ and parents’ reactions to novel stimuli. In other words, infants’ emotional expressions and reactions to novelty mirror their parents’ emotional expressions and reactions in the first year of life. In the light of the reviewed evidence, we concluded that repeated exposure to depression- and anxiety-related alterations in parents’ emotional expressions and reactions in everyday interactions may contribute to intergenerational transmission of depression and anxiety. Our review also showed that infants’ increased exposure to parental negative emotions is linked to less attention to negative emotions and increased attention to positive emotion. We suggested that this may be a protective mechanism that increases the chances of infants’ exposure to positive expressions. Taken together, evidence reviewed in this chapter is in line with the idea that infants’ exposure to depressed and/or anxious parents’ negative emotions is linked to alterations in infants’ emotional expressions, reactions to novelty, and emotion processing.

Chapter 2 examined how mothers’ and fathers’ lifetime depression and/or anxiety, and infants’ temperament alter the parents’ and infants’ expressions of emotion during face-to-face parent-infant interactions. Mothers, but not fathers with lifetime diagnoses of depression were less positive during their interactions with their 4-month-old infants than mothers without a diagnosis. The duration of parents’ positive and neutral expressions did not significantly differ across mothers and fathers with vs. without lifetime anxiety diagnoses. Neither did the duration of infants’ positive, negative and neutral expressions differ as a function of parents’ lifetime depression and/or anxiety diagnoses or infants’ temperamental predispositions. We concluded that maternal lifetime depression is linked to less positive affect from mothers during face-to-face interactions with the infant, while this link may not generalize to anxiety diagnoses, or to fathers’ or infants’ expressions.

Chapter 3 and 4 focused on parent-infant-object interactions to test the links between infants’ and parents’ reactions to novel stimuli at 12 and 30 months of age. The cross-sectional and longitudinal associations of parents’ anxiety (expressions of anxiety, and lifetime social and/or nonsocial anxiety diagnoses) with children’s fear and avoidance
were examined during encounters with social and nonsocial novel stimuli in a social referencing paradigm. Both at 12 and 30 months, parents with lifetime social anxiety disorders expressed more anxiety in social referencing situations. The association between parents’ expressed anxiety and infants’ avoidance did not differ across mothers and fathers. At 12 months, parents’ expressions of anxiety in the SR situations, rather than lifetime diagnoses predicted infants’ avoidance in interaction with infants’ temperament. Higher levels of expressed anxiety from parents were linked to more avoidance from infants with moderate-to-high levels of negative temperament. At 30 months, infants of parents with social lifetime anxiety diagnoses were more fearful/avoidant in SR situations, while parents’ expressions of anxiety did not significantly predict children’s fear/avoidance. Moreover, children of parents with comorbid social and nonsocial anxiety disorders, who expressed moderate-to-high levels of anxiety at 12 months were more fearful/avoidant at 30 months. We concluded that exposure to parents’ expression of anxiety in social referencing situations in infancy may contribute to intergenerational transmission of anxiety in children of parents with comorbid social and nonsocial anxiety disorders. The direct link between exposure to expressions of anxiety from parents in SR situations and child fear/avoidance may be specific to the end of infancy, and may not hold in toddlerhood.

Chapter 5 examined the associations of 13-to-16 month old infants’ attention to emotional (vs. neutral) facial expressions (measured via fixations and pupil dilation) and infants’ temperament, parents’ depression and anxiety. For infants with low levels of fearful temperament, more maternal and paternal anxiety was associated with shorter fixations to emotional (vs. neutral) expressions. In contrast, for infants with high levels of fearful temperament more maternal and paternal anxiety was associated with longer fixations to emotional (vs. neutral) expressions. In turn, infants’ sad temperament, or parents’ depression and anxiety symptoms did not significantly predict infants’ pupil responses to facial expressions. To our knowledge, this is the first eye-tracking study investigating the links between infants’ attention to emotional expressions and parents’ depression and anxiety. The findings are in line with the idea that infants’ exposure to mothers’ and fathers’ anxiety, and infants’ negative temperamental predispositions jointly influence infants’ attention to emotional stimuli.

Chapter 6 investigated the links between 14-to-17-month-old infants’ attention (measured via pupil dilation) to unfamiliar objects that were paired with emotional (vs. neutral) expressions, infants’ temperament and parents’ depression and anxiety. More depression in mothers predicted a larger increase in pupil responses (more attention) to objects following emotion-object pairing in infants with low levels of sad temperament, while it predicted a decrease in pupil responses (thus, less attention) in infants with high levels of sad temperament. More depression in fathers predicted larger pupil responses to objects after the emotion-object pairing independent
Summary

of infants’ temperament. To the best of our knowledge, this was the first study addressing individual differences explained by parents’ depression and anxiety in infants’ attention allocation to emotion-object associations using pupillometry. The findings support the idea that negative temperamental predispositions interact with infants’ exposure to mothers’ and fathers’ depression to predict infants’ attention to emotion-object associations.

To conclude, this thesis revealed significant alterations in mothers’ and fathers’ emotional expressions in everyday interactions with their infants in the case of lifetime anxiety and/or depression diagnoses. Moreover, these alterations were directly linked to parallel alterations in infants’ interactive behavior and explained individual differences infants’ emotion processing in interaction with infants’ temperament. The findings highlight the potential importance of protecting the offspring from these alterations by improving the screening, the prevention and the treatment of depression and anxiety disorders in mothers and fathers in the postnatal year.
SUMMARY IN DUTCH

Samenvatting
Summary in Dutch (Samenvatting)

Blootstelling aan negatieve emoties van ouders in de vroege jaren als een ontwikkelingspad in de intergenerationele overdracht van depressie en angst

Het hoofddoel van deze dissertatie was om te onderzoeken hoe blootstelling aan klinische en niet-klinische vormen van depressie en angst van ouders de sociaal-emotionele ontwikkeling van baby's beïnvloedt. In deze dissertatie lag de focus op drie aspecten van de vroege sociaal-emotionele ontwikkeling van baby's: emotionele uitdrukkingen, reacties op nieuwe stimuli in alledaagse interacties en aandacht voor emotionele stimuli.

In Hoofdstuk 1 is een literatuuronderzoek beschreven naar de effecten van blootstelling van baby's aan negatieve emoties, depressie en angst van ouders op deze drie aspecten van de sociaal-emotionele ontwikkeling in het eerste levensjaar van het kind. Dit literatuuronderzoek onthulde positieve verbanden tussen emotionele uitdrukkingen van baby's en hun ouders en tussen reacties op nieuwe stimuli van baby's en hun ouders. Met andere woorden: in het eerste levensjaar spiegelen baby's de emotionele uitdrukkingen en reacties op nieuwe stimuli van hun ouders. Naar aanleiding van deze eerdere bevindingen hebben we geconcludeerd dat een herhaalde blootstelling van baby's aan depressie- en angst-gerelateerde veranderingen in emotionele uitdrukkingen en reacties in alledaagse interacties van hun ouders bij zou kunnen dragen aan de intergenerationele overdracht van depressie en angst. Daarnaast onthulde het onderzoek dat toegenomen blootstelling van baby's aan negatieve emoties van ouders samenhangt met minder aandacht voor negatieve emoties en meer aandacht voor positieve emoties. Wij suggereerden dat dit een beschermingsmechanisme zou kunnen zijn, wat de kans kan vergroten dat baby's blootgesteld worden aan positieve uitdrukkingen. De onderzochte bevindingen in dit hoofdstuk zijn in lijn met het idee dat blootstelling van baby's aan de negatieve emoties van depressieve en/of angstige ouders is gerelateerd aan veranderingen in emotionele uitdrukkingen, reacties op nieuwe stimuli en emotieverwerking van baby's.

In Hoofdstuk 2 is onderzocht hoe levenslange chronische depressie en/of angst van moeders en vaders en het temperament van baby's de emotionele uitdrukkingen van ouders en baby's veranderen tijdens face-to-face-interacties tussen ouders en baby's. Moeders (in tegenstelling tot vaders) met een levenslange depressiediagnose waren minder positief tijdens hun interactie met hun 4 maanden oude baby dan moeders zonder diagnose. De duur van positieve en neutrale uitdrukkingen van ouders verschilde niet significant voor moeders en vaders met of zonder levenslange angstdiagnoses. Tevens verschilde de duur van positieve, negatieve en neutrale uitdrukkingen van baby's niet als functie van chronische depressie- en/of angstdiagnoses van hun ouders of als functie van het temperament van de baby. We concludeerden hieruit dat chronische depressie van moeders samenhangt met minder positieve emotie van moeders tijdens face-to-face-interacties met baby's,
Hoofdstuk 3 en 4 richtten zich op ouder-baby-objectinteracties om het verband tussen reacties op nieuwe stimuli van 12 en 30 maanden oude baby’s en hun ouders te onderzoeken. De cross-sectionele en longitudinale verbanden tussen angst van de ouders (uitdrukkingen van angst en levenslange sociale en/of niet-sociale angstdiagnoses) en angst en vermijding van hun kind werden onderzocht tijdens het in aanraking komen met nieuwe sociale en niet-sociale stimuli in een social referencing-paradigma. Zowel bij 12 als 30 maanden oude baby’s uitten ouders met chronische sociale angststoornissen meer angst in deze social referencing-situaties. Daarnaast verschilde het verband tussen de geuite angst van de ouders en vermijding van hun baby’s niet voor moeders en vaders. Bij 12 maanden oude baby’s voorspelden angstuitingen van ouders in social referencing-situaties, in tegenstelling tot levenslange diagnoses, vermijding van de baby’s in interactie met het temperament van baby’s. Een hogere mate van geuite angst van ouders was gekoppeld aan meer vermijding van baby’s met gematigde tot hoge negatieve temperamentniveaus. Baby’s van 30 maanden oud van ouders met levenslange sociale angstdiagnoses waren angstiger en meer vermijdend in social referencing-situaties, terwijl hun angst/vermijding niet significant kon worden voorspeld door de angstuitingen van hun ouders. Bovendien waren kinderen van ouders met comorbide sociale en niet-sociale angststoornissen, die bij 12 maanden gematigde tot hoge niveaus van angst lieten zien, angstiger/meer vermijdend op de leeftijd van 30 maanden. We concludeerden hieruit dat blootstelling aan angstuitingen van ouders in social referencing-situaties tijdens de babytijd bij zou kunnen dragen aan intergenerationele overdracht van angst bij kinderen van ouders met comorbide sociale en niet-sociale angststoornissen. De directe link tussen blootstelling aan angstuitingen van ouders en angst/vermijding van kinderen in social referencing-situaties zou echter specifiek aanwezig kunnen zijn in de late baby-fase en houdt wellicht geen stand in de peutertijd.

In Hoofdstuk 5 werden de verbanden onderzocht tussen de aandacht (gemeten door middel van fixatie en pupildilatatie) voor emotionele (versus neutrale) gezichtsuitdrukkingen van 13 tot 16 maanden oude baby’s, het temperament van de baby’s en de depressie en angst van hun moeders en vaders. Meer angst bij moeders en vaders was gerelateerd aan kortere fixaties op emotionele (versus neutrale) uitdrukkingen bij baby’s met lage niveaus van een angstig temperament, terwijl het was gekoppeld aan langere fixaties op emotionele uitdrukkingen bij baby’s met hoge niveaus van een angstig temperament. Een depressief temperament van baby’s, of depressie- en angstsymptomen van ouders waren echter geen significante voorspellers van de pupilreacties van baby’s op gezichtsuitdrukkingen. Voor zover bekend is dit de eerste eye-tracking-studie die de relatie onderzocht tussen aandacht van baby’s voor gezichtsuitdrukkingen en depressie en angst van ouders. Uit deze
bevindingen kunnen we concluderen dat een combinatie van blootstelling van baby’s aan angst van ouders en de aanleg van baby’s voor een negatief temperament de aandacht van baby’s voor emotionele stimuli kunnen beïnvloeden.

Hoofdstuk 6 onderzocht de verbanden tussen de aandacht (gemeten door middel van pupildilatatie) van 14 tot 17 maanden oude baby’s voor onbekende objecten die gepaard werden met emotionele (versus neutrale) gezichtsuitdrukkingen, hun temperament en depressie en angst van hun ouders. Een hogere mate van depressie van moeders voorspelde een grotere toename in pupilreacties (meer aandacht) op objecten na het combineren van emotie en object bij baby’s met een lage mate van een depressief temperament, terwijl het een afname in pupilreacties (minder aandacht) voorspeld bij baby’s met een hoge mate van een depressief temperament. Een hogere mate van depressie van vaders voorspelde grotere pupilreacties op objecten na het combineren van emotie en object onafhankelijk van het temperament van hun baby. Voor zover bekend was dit het eerste onderzoek dat, door middel van pupillometrie, individuele verschillen in aandachtallocatie naar emotie-objectassociaties van baby’s bestudeerde die konden worden verklaard door depressie en angst van de ouders. De bevindingen ondersteunen het idee dat er een interactie bestaat tussen aanleg voor negatief temperament en blootstelling aan depressie van moeders en vaders en dat deze interactie de aandacht van baby’s voor emotie-objectassociaties kan voorspellen.

Samengevat: Deze dissertatie toonde aan dat er significante veranderingen zijn in emotionele uitzetting van moeders en vaders in alledaagse interacties met hun baby’s in het geval van chronische angst- en/of depressiediagnoses bij de ouders. Bovendien waren deze veranderingen direct verbonden aan parallelle veranderingen in het interactiegedrag van hun baby’s en verklaarden deze veranderingen individuele verschillen in emotieverwerking van baby’s in interactie met hun temperament. De bevindingen benadrukken het potentiële belang van het beschermen van het nageslacht tegen deze veranderingen door verbetering van de screening, de preventie en behandeling van depressie en angststoornissen bij moeders en vaders in het postnatale jaar.
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PUBLICATIONS AND CONTRIBUTIONS OF CO-AUTHORS
Publications and Contributions of co-Authors

Chapter 1 will be submitted as:

**Contributions:**
Evin Aktar wrote the paper as the first author under supervision of Susan Bögels who was the project leader of the study. Susan Bögels contributed to the writing of the discussion section, and reviewed the paper.

Chapter 2 is submitted as:

**Contributions:**
Susan Bögels, Cristina Colonnesi, Mirjana Majdandžić and Wieke De Vente designed the study. Evin Aktar coded the observational data from parents. As the first author of this paper, she also conducted the statistical analyses and wrote the paper. Cristina Colonnesi coded the observational data from infants and supervised the coding of parent data. She also contributed to the statistical analyses, and reviewed the paper. Mirjana Majdandžić reviewed the paper and the statistical analyses. Wieke De Vente contributed to the statistical analyses, and reviewed the paper. Susan Bögels reviewed the paper and the statistical analyses. Susan Bögels was the project leader of the study.

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Susan Bögels, Mirjana Majdandžić and Wieke De Vente designed the study and collected the observational data. Evin Aktar coded the observational data on social referencing tasks, conducted the statistical analyses and wrote the article as the first author of this study. Mirjana Majdandžić coded the observational data on behavioral inhibition tasks, supervised the coding of social referencing tasks and reviewed the paper and the statistical analyses. Wieke De Vente contributed to the statistical analyses, and reviewed the paper. Susan Bögels contributed to the statistical analyses, and reviewed the paper. Susan Bögels was the project leader of this study.
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Chapter 5 is submitted as:

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Evin Aktar designed this study, conducted the statistical analyses and wrote the article as the first author. Dorothy Mandell contributed to the design of the experiment, and to the statistical analyses, and reviewed the paper. Wieke De Vente and Mirjana Majdandžić contributed to the design of the experiment, reviewed the paper and the statistical analyses. Frans Oort contributed to the statistical analyses. Daan Van Renswoude computed the fixation data, and reviewed the paper. Maartje Raijmakers and Susan Bögels were the project leaders of this study, they contributed to the design of the experiment, reviewed the paper and statistical analyses.

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Evin Aktar designed this study, conducted the statistical analyses and wrote the article as the first author. Dorothy Mandell contributed to the design of the experiment, reviewed the paper and statistical analyses. Wieke De Vente and Mirjana Majdandžić contributed to the design of the experiment, reviewed the paper and the statistical analyses. Maartje Raijmakers and Susan Bögels were the project leaders of this study, they contributed to the design of the experiments, reviewed the paper and statistical analyses.
UITNODIGING

voor het bijwonen van de
openbare verdediging
van het proefschrift

Exposure to Parents’
Negative Emotions in Early Life
as a Developmental Pathway
in the Intergenerational
Transmission of
Depression and Anxiety

op woensdag 3 februari
om 12:00
in de Agnietenkapel,
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