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Towards a more comprehensive understanding of adults' responses to infant cues adopting a multi-method and non-heteronormative approach

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Abstract

Understanding what constitutes typical adult processing of infant cues and the potential individual variations associated with it is an important early step in comprehending how caregiving practices arise. By adopting a multi-method approach, the present work aimed to enrich the knowledge on adults' cognitive and electrophysiological responses to infant cues, by focusing on the role of the adults' sex, the perceived quality of early care from caregivers, and the actual involvement in childcare. Four studies were presented to cover different perspectives on adults' responses to infant cues, from cognition to electrophysiology and parental behaviors. Methodologies encompassed cognitive experimental tasks, EEG, standardized observations, and self-reported measures. Samples included non-parents, different-sex parents, and same-sex parents. Overall, the present work responded to the recent interest in understanding adults' responses to infant cues going beyond a heteronormative perspective. Our findings reinforced the argument that differences between males and females, if present in the response to infant stimuli, might not always be biologically determined, but reinforced by societal norms. In addition, we supported the relevance of accounting for both past and current experiences of care when investigating the adults' cognitive and electrophysiological responses to infant cues. Eventually, we started to gain some knowledge on the neurophysiological correlates of sensitive caregiving in different family contexts. On the whole, considering the complexity of plural family models, we hopefully contributed to socializing the idea that there are different ways of conceiving and understanding parenting nowadays.

Keywords: parenting; infant cues; same-sex parent family; attention; event-related potentials; sex differences; acceptance-rejection theory; parental involvement.

Theoretical background and state of art

The salience of infant cues

The early relationship between a parent and an infant is widely recognized as pivotal in shaping many aspects of the child's development (Sroufe, 2005). Of note, the quality of this bond is heavily dependent on the adult's ability to sensitively detect and respond to the infant's cues (Ainsworth et al., 1978). Therefore, an appropriate perception and interpretation of infants' signals is an integral part of sensitive caregiving, which in turn supports the development of a secure infant–caregiver attachment relationship (Ainsworth et al.,1978). In the preverbal stage of child development, for instance, adults must rely on detecting and understanding facial emotions of infants, in order to meet the infant's needs according to their physiological needs and affective states. In this regard, evolutionary theorists (Lorenz, 1943; 1971) have argued that infant facial characteristics serve as important cues for adaptive behavior in adults. Infant face morphology (i.e., large, bulbous forehead, large eyes, small chin, and narrow nose) has been described as the so called "*Baby schema*" (Lorenz, 1943; 1971), which also includes infants' sounds and smell. The caretaking mechanism triggered by the baby schema and other infants' behavioral features has been referred to as "*Kindchenschema*" (Lorenz,1943; 1971), which is an innate releasing mechanism eliciting caregiving behaviors in adults.

Generally, infant cues have been demonstrated to elicit a coordinated set of affective, cognitive and neurophysiological responses in adults, which ultimately guide and motivate them to provide protection and nurturance for a child (George & Solomon, 2008). Research on the correlates of adults' responses to infant cues have provided different descriptions depending on the methodologies used across studies (e.g., cognitive paradigms, EEG) and on the modality of the infant cues (e.g., visual, infant face; auditory, infant cry). Moreover, the factors associated with individuals' variations in the responses to infant cues have been demonstrated to span from adult and child characteristics to contextual and experience-related factors (Dudek & Haley, 2020). Given its potential implications on caregiving practices, enhancing the understanding of what constitutes typical adult processing of infant cues and the potential individuals' variations associated with it is compelling.

Cognitive response to infant cues

Cognitive conflict tasks (e.g., Stroop, Go/no-Go, visual search tasks) have been used to measure adults' cognitive responses to infant faces; therefore, these tasks inform about the adults' ability to provide appropriate responses to infant stimuli against competing stimuli and demands in the surrounding environment, as it might occur in real life (Fleming et al., 2008). Therefore, cognitive conflict tasks usually display infant faces as distractors, while the behavioral performance of adults is directed toward other target stimuli (e.g., Hodsoll et al., 2011). In Go/no-Go tasks, an index of attentional bias has been generally measured to refer to the difference in attention, in terms of response times (RTs), captured by infant versus other stimuli (e.g., adult cues). In particular, a greater cognitive engagement of adults towards infant versus adult faces (i.e., RTs infant - RTs adult) has been referred to as *attentional bias to infant faces* (Lucion et al., 2017), which is one of the mechanisms elicited in response to baby schema (Jia et al., 2021). So far, the attentional bias to infant faces has been measured comparatively between infant and non–infant faces, different valences of infant faces, or among different groups (e.g., parents versus non–parents).

A recent review by Lucion and colleagues (2017) outlined that a greater attentional bias toward infant versus adult faces can be consistently detected in all adults; that is, adults' attention seems to be universally drawn towards infants. Given the importance of emotional facial expressions in conveying information about the infant's physical and mental states (Sullivan, 2014), some research has focused on the role of emotional valence of faces in modulating adults' attentional bias to infant cues. Whilst an effect of infant facial expressions has been detected in some studies (Pearson et al., 2009; 2010a; 2010b; 2013), other research did not find such a modulation of the emotional valence (Thompson-Booth et al., 2014a; Oliveira et al., 2017; Dudek & Haley, 2020; Long et al., 2021). Overall, it has been suggested that infant faces capture adults' attention, irrespective of the emotional content displayed (Dudek & Haley, 2020); once the automatic attention is captured, the subsequent processing of these salient stimuli takes place and direct adults' behaviors.

Electrophysiological response to infant cues

Behavioral measures such as RTs reflect a considerable number of cognitive processes that take place and get consolidated by the time individuals makes a response; however, they cannot provide any information about the separated stages of attention deployment toward a specific stimulus. On the other hand, Event-related potentials (ERPs) might tease apart at what stage of the processing individual differences in the adults' responses emerge. Exploring the timing of infant cue processing is important when considering the dynamic and temporally sensitive nature of adult–child interactions (Purhonen et al., 2008). Given their optimal temporal resolution, ERPs have been therefore used to investigate differences among individuals' responses to infant cues, which might occur at different stages of processing (Vuoriainen et al., 2022). ERPs have been generally defined by their polarity (positive= "P" or negative= "N") and the time window they occur (milliseconds; ms). The amplitude in microvolts (mv) might vary depending on experimental manipulations, providing an index of the variability in strength and cognitive resources required for a stimulus detection. In previous research on parenting, ERPs have been computed to describe adults' responses to target infant stimuli (i.e., images, sounds or videos of infants) during passive or active viewing or listening paradigms, comparatively between infant and non–infant stimuli, or between different valences of infant cues.

Among different infant cues, infant faces have been demonstrated to elicit a negative deflection called the N170, peaking around 170 ms after stimulus onset at temporal occipital electrode sites. This component has been described to reflect the perceptual processing and structural encoding of facial features (Eimer, 2011). Later ERPs elicited by infant faces, reflecting a more elaborate processing and sustained attention, include the Late Positive Potential (LPP) and the P300, which are positive deflections beginning around 300 ms after stimulus onset, mainly at parietal/centroparietal regions (Hajcak et al., 2009; Hajcak & Foti, 2020). These components have been argued to reflect the output of neural processes related to attentional processes for motivationally salient stimuli and top-down cognitive processes (Hajcak & Foti, 2020). Given that the nomenclature used in different studies have not uniformly conformed to separate definitions of the two waves (Cuthbert et al., 2000; Olofsson et al., 2008), results relating to the P300 and LPP components have been interpreted together (i.e., as a P300/LPP complex) in a recent meta-analysis on parental responses to infant cues (Vuoriainen et al., 2022). ERP studies on adults' responses to infant faces have demonstrated that infant compared to adult faces elicit a larger amplitude of the components at both early (N170) and later (P300/LPP) stages of face processing (Kuzava et al., 2020; Vuoriainen et al., 2022). Together, the strength of the N170 and P300/LPP responses might reflect the structural encoding, attention allocation, and sustained elaboration of infant cues in adults[1].

With respect to the role of the emotional valence of faces, distressed infant faces have been found to elicit a larger N170 response in some studies (Proverbio et al., 2006; Rodrigo et al.,

[1] It should be noted that, whilst the N170 specifically reflects the structural encoding of faces, an P300/LPP activation has been described also in response to other types of infant cues (e.g., infant cry; Maupin et al., 2019; Lowell et al., 2023; Peoples et al., 2022).

2011; Doi & Shinohara, 2012; Peltola et al., 2014; Dudek & Haley, 2020); however, other research failed to find such a significant effect (Malak et al., 2015; Maupin et al., 2019; Rutherford et al., 2017a; Rutherford et al., 2017b). In addition, no effects on the N170 amplitude were found in parents when viewing their own child's face as opposed to another child's face (Bornstein et al., 2013; Grasso et al., 2009; Waller et al., 2015; Weisman et al., 2012). Differently, a larger P300/LPP amplitude was related to adults' responses to personally significant faces, such as own child's faces (Grasso et al., 2009; Weisman et al., 2012; Bick et al., 2013), own child's crying faces (Doi & Shinohara, 2012), and romantic partners' faces (Guerra et al., 2012). In a consistent way, the P300/LPP amplitudes were found affected by the emotional valence of stimuli, being larger, for instance, in response to emotional versus neutral faces (Schupp et al., 2004; Olofsson et al., 2008; Rodrigo et al., 2011; Malak et al., 2015).

Factors associated with adults' cognitive and electrophysiological responses to infant cues

Parental status

Even though infant cues have been demonstrated to universally draw the attention of adults (Brosch et al., 2007; Proverbio et al., 2011; Cárdenas et al., 2013; Pearson et al., 2010; 2011a; 2011b; 2013; Thompson-Booth et al., 2014a; Thompson-Booth et al., 2014b; Oliveira et al., 2017), parents have showed a higher attentional bias to infant faces than non-parents (for a review, see Lucion et al., 2017). For instance, Thomson-Booth and colleagues (2014a) demonstrated that first-time mothers displayed longer RTs to infant compared to adult faces than did non-mothers. In a following study (Thompson-Booth et al., 2014b), it was consistently demonstrated that infant faces elicited a greater attention compared to pre-adolescent, adolescent, or adult faces in mothers versus non-mothers. Oliveira and colleagues (2017) highlighted that parents (both mothers and fathers) showed a higher attentional bias to infant versus adult faces than did non-parents. Accordingly, hormones, social learning, together with caregiving experiences, may heighten responses to infants in parents compared to non-parents (Parsons et al., 2017). As an important implication, an enhanced motivated attention might facilitate a preferential orientation toward infants in parents, consequently guiding appropriate parental behaviors (Ferrey et al., 2016).

Consistent with behavioral evidence, previous studies adopting an EEG methodology have found that parents showed a larger N170 amplitude in response to infant faces as compared to non-parents (Proverbio et al., 2006; Weisman et al., 2012, Vuoriainen et al., 2022). Kuzava and colleagues (2020) highlighted that, only for parents, the N170 amplitude in response to crying infant faces was larger than the one in response to neutral stimuli. Regarding the P300/LPP component, whilst one study (Proverbio et al., 2006) reported a larger a P300/LPP response to infant faces in parents compared to non-parents, other studies found either no significant effects of parental status (Peltola et al., 2014) or even a smaller P300/LPP amplitude to unfamiliar infant faces in parents (Weisman et al., 2012). In a recent meta-analysis, Vuoriainen and colleagues (2022) did not find any robust differences in the P300/LPP complex amplitude between parents and non-parents. Therefore, an increased encoding of infantile facial features in parents might be more clearly detected at the early visual processing stage (Vuoriainen et al., 2022).

Sex

In previous research, women were found more motivated towards infants compared to men (for a review, see Hahn et al., 2013). In particular, sex differences have been observed in the sensitivity to infant cuteness (Lobmaier et al., 2010) and sometimes explained in terms of the differential hormonal status between women and men (Sprengelmeyer et al., 2009). Overall, a female advantage in detecting infant cues has been interpreted as subserving women's traditional role as primary caregivers, with this ability helping develop and maintain the mother–infant bond. However, Young and colleagues (2017) outlined that whether sex differences emerged in behavioral studies, small effect sizes have been generally reported in relation to statistically significant effects (Parsons et al., 2017). Consistently, a complex picture has emerged in the studies addressing sex differences in the adults' attentional bias to infant faces. Whilst some studies did not find any differences between mothers and fathers (e.g., Oliveira et al., 2017), nor between nulliparous females and males (e.g., Brosch et al., 2007), other studies found a more consistent attention allocation toward infant stimuli in women than in men (Cárdenas et al., 2013; Proverbio et al., 2006). On the one hand, Brosch and colleagues (2007), using a dot-probe task, demonstrated that infant compared to adult faces captured more attention in nulliparous individuals independently of their sex. Differently, Cárdenas and colleagues (2013), who examined nulliparous adults' overt attentional bias toward infant faces using an eye-tracker methodology, reported that a more consistent attention allocation to infant faces in females versus males.

With respect to EEG research, few studies have included men in the investigation of the electrophysiological responses to infant faces (Proverbio et al., 2006; 2011; Hahn et al., 2016; Colasante et al., 2017; Jia et al., 2021). Because of the scarcity of ERP studies on men, in a recent meta-analysis, Kuzava and colleagues (2020) were not able to examine sex as a potential moderator of the N170 amplitude in the adults' response to infant faces. According to the behavioral findings, EEG studies have so far provided mixed findings regarding sex differences in adults' response to infant cues. For instance, Proverbio and colleagues (2006) demonstrated that the P100 component in response to infant faces was larger in women (both mothers and non-parent women) than in men; in addition, mothers, compared to fathers, had an advantage in the perceptual processing of infant faces at the N170 stage of processing. Smaller P300 amplitudes were elicited in mothers versus fathers, especially with infant expressions of distress (Proverbio et al., 2006) Differently, Hahn and colleagues (2016) found that the amplitude of both early (N170, P200) and late (LPP) components were not modulated by the participants' sex; women tended to show an overall increased left hemisphere activity compared to men during the early processing of faces, but this effect was not specific for infant faces. Colasante and colleagues (2017) found that the P100 and LPP amplitudes were larger in response to infant than adult faces in non-parent women compared to men; based on these findings, a unique advantage for women in the early processing and sustained attention to infant faces was suggested. Jia and colleagues (2021) demonstrated that the N170 amplitude to infant sad expressions was larger, in the left hemisphere, in women than in men.

All in all, considering relevant methodological differences among the studies and the different levels of processing accessed, findings regarding sex differences should be still debated. In this regard, it should be noted that past research rarely defined what was meant by sex or gender and how it was measured (e.g., if gender and sex were appropriately distinguished; Lindqvist et al., 2021). In addition, the variability explained by sex might have overlapped with the contribution of other socio-cultural variables (e.g., characteristics related to individuals' social gender, stereotypical parental behaviors in women and men), which have not been considered in previous research.

Parental involvement in childcare

Early theoretical accounts based on human and animal studies have suggested that the caregiving responses to infant cues might be experience-sensitive (Featherstone et al., 2000; Kim et al., 2010; Stolzenberg & Champagne, 2016). Of note, several factors have been linked to caregiving experiences, such as the number of children that parents have (i.e., parity), the duration of parenthood (i.e., child age), and the parental involvement in childcare (i.e., quality and quantity of activities accomplished). As with any skill, adults' responsiveness to infant cues might be therefore linked to any of these caregiving experiences (Parsons et al., 2021). Accordingly, at the cognitive level, Pearson and colleagues (2010) demonstrated that the attentional bias towards distressed infant faces was greater in multiparous compared to primiparous women. Whilst the effect of parity has been further studied using other explicit behavioral measures (Parsons et al., 2021), other nuances of caregiving experiences, such as the parental involvement in childcare, have been neglected in previous behavioral research addressing the cognitive responses of adults to infant cues.

Consistently, studies examining the contribution of parental involvement in childcare in the adults' electrophysiological responses to infant cues are lacking. When it comes to the role of varying levels of caregiving experiences, Maupin and colleagues (2019) highlighted that maternal parity may play an important role at later stages of maternal infant cue perception, modulating the P300 response to infant faces. In relation to the duration of parenthood, Kuzava and colleagues (2020) found that the LPP amplitude to infant cries were larger than the one related to neutral stimuli for parents of children of 2 years of age and older, but not parents of younger children. The evidence that the preferential elaboration of infant faces may not be uniquely associated with biological processes but also related to nurturing experiences has been corroborated by studies including non-biological mothers (Grasso et al., 2009; Bick et al., 2013; for a review see Maupin et al., 2015). Moreover, a systematic review (Giannotti et al., 2022b) has recently highlighted the importance of parental involvement in childcare in the adults' response to infant cues, suggesting that this factor might modulate fathers' neurobiological (detected using neuroimaging techniques, e.g., fMRI, fNIRS) and behavioral responses to infants. Nonetheless, to the best of our knowledge, only one study controlled for the quantity of time that fathers spent with their child when investigating fathers' electrophysiological response to infants (Waller et al., 2015); in this study, this variable was considered only marginally. Therefore, the role of parental involvement in childcare in the adults' EEG response to infant cues needs further investigation.

Perceived quality of past care experiences from caregivers

Early experiences with one's own caregivers guide the development of a relationship model in children, which in turn regulates the interactions with significant others (Bowlby, 1969/1982). In the context of Attachment Theory (Bowlby, 1969/1982), representations of past experiences of care in terms of attachment quality have been found to modulate adults' cognitive response to infant faces (Jia et al., 2017; Long et al., 2021). For instance, Jia and collaborators (2017) demonstrated that the participants' patterns of attachment, measured with the Experiences in Close Relationships (Brennan et al., 1998), was associated with their attentional bias to infant stimuli measured though eye movements; in particular, women with higher attachment avoidance had a lower attentional bias to infant compared to adult faces (Jia et al., 2017). Long and collaborators (2021) have consistently found that an attachment tendency to avoidance, measured though the State Adult Attachment Measure (Gillath, 2009), negatively predicted adults' attentional bias to infant faces at 500 ms.

Consistently, the quality of the adults' attachment representations was related to the N170 and P300/LPP amplitudes in response to infant faces (Fraedrich et al., 2010; Leyh et al., 2016; Groh & Haydon, 2018; Lowell et al., 2023). Fraedrich and colleagues (2010) found that insecure versus secure mothers showed a more pronounced N170 amplitude in response to infant faces, independently of the emotional valence of faces (Fraedrich et al., 2010). Moreover, secure mothers showed a stronger P300 amplitude response to infant faces compared to insecure mothers (Fraedrich et al., 2010). Similarly, Leyh and colleagues (2016) demonstrated that insecure mothers exhibited a more negative N170 amplitude in response to infant negative facial expressions than secure mothers. An increased P300 amplitude to infant emotional faces was also found in secure versus insecure mothers (Leyh et al., 2016). Groh and Haydon (2018) differently demonstrated that a history of insensitive care during childhood heightened mothers' significance attributed to distressed infant cues; insecure mothers showed an enhanced P300 amplitude in response to their own distressed infant faces as compared to secure mothers. Ma and colleagues (2017) highlighted that anxiously compared to avoidantly attached women exhibited a larger N170 amplitude in response to infant faces. In addition, securely attached women showed a larger P300 amplitude to infant faces than avoidantly attached women (Ma et al., 2017). Consistent with an efficiency model of interpretation of ERPs (e.g., Lowell et al., 2023), it might be more demanding for insecure women to process structural features of infant faces; this argument might be complemented by behavioral evidence of a lower accuracy and longer response times in their responses to infant stimuli. However, the studies so far were mostly focused on women samples, and mainly confined to the Attachment theory perspective.

Interpersonal Parental Acceptance Rejection Theory (IPARTheory)

Building from another theoretical account, the Interpersonal Parental Acceptance Rejection Theory (IPARTheory; Rohner, 2021), formerly known as Parental Acceptance–Rejection Theory (PARTheory; Rohner, et al., 2012), posits that the individuals' interpersonal relationships with significant others are characterized by an affectional bond falling along a continuum from acceptance to rejection. Despite the change in the name and emphasis to include a greater variety of interpersonal relationships throughout the life span, the IPARTheory has continued to feature the consequences, causes, and other correlates of adults' recollections of parental experiences of acceptance–rejection during childhood (Rohner & Lansford, 2017). In particular, parental acceptance refers to expressions of love, affection, nurturance, and support that individuals perceived from their own parents during childhood. Conversely, parental rejection refers to the absence of these positive feelings, and to the display of a variety of physically and psychologically hurtful behaviors and affects (Rohner, 2012). Importantly, robust empirical evidence has demonstrated that the levels of parental acceptance and rejection during childhood might be related to later child outcomes (Khaleque &Rohner, 2002). On the one hand, children who perceived more acceptance by their own parents showed more positive psychological, social, behavioral, emotional developmental outcomes, such as, for instance, high rates of self-esteem and social competence, and low rates of depression and behavioral problems. On the other hand, higher parental rejection was demonstrated to negatively impact on individuals' mental health, sense of well-being, physical health, and interpersonal relationships (Rohner & Britner, 2002; Khaleque & Rohner, 2002; Rohner & Khaleque, 2010; Rohner, 2021). Moreover, the quality of perceived care from one's own caregivers during childhood has been described to have an influence on the development of stable social, emotional and cognitive dispositions of individuals (Rohner et al., 2012); these mental representation, which have been compared to the concepts of Internal Working Models in the Attachment theory (Bowlby, 1969/1982), tend to extend from childhood into adulthood in the absence of counter experiences (Rohner et al., 2012; Seyedmousavi et al., 2022). For instance, individuals who were more rejected by their own caregivers during childhood might develop some long-lasting cognitive distortions relative to personal relationships as being unpredictable, untrustworthy, and perhaps hurtful (Rohner et al., 2012).Therefore, differences in the early experiences of care can lead to distinct emotional and cognitive organizations in adults, which may guide their responding when confronted with attachment-relevant stimuli, such as infant cues.

Even though some similarities have been observed between the Attachment theory and the IPARTheory perspectives (Ripoll-Núñez & Carrillo, 2016), some divergences have been also highlighted; these considerations have pointed to the need of enriching the empirical evidence in the two specific theoretical contexts separately. However, very little research has been carried out regarding adults' responses to infant cues in the theoretical framework of IPARTheory. Using a Single-Category Implicit Association Test (SC-IAT; Karpinski & Steinman, 2006; Senese et al., 2013) and a semantic differential scale (Osgood, et al., 1957), Senese and colleagues (2018) demonstrated that higher levels of remembered maternal rejection were negatively associated with both implicit and explicit maternal responses at the sixth month of pregnancy, and with only implicit responses to infant cues at the third month after childbirth. However, no research to date has investigated the role of recollected experiences of care, in the context of IPARTheory, on adults' attentional bias to infant cues. Similarly, whether an history of parental acceptance/rejection is linked to adults' N170 and P300/LPP amplitude responses to infant cues has not been investigated yet.

The present work

The value of studying adults' response to infant cues is substantiated by the evidence that individuals' variations in the processing of infant cues might provide an early indication of the quality of caregiving behaviors (Lucion et al., 2017; Vuoriainen et al., 2022). At the cognitive level, the attentional bias toward infant faces has been linked to the quality of the parent-child interaction and maternal bonding (Pearson et al., 2011a; Dudek & Haley, 2020). For instance, Pearson and colleagues (2011a) demonstrated that the attentional bias to distressed versus non-distressed infant faces was greater in pregnant mothers who reported a more successful postpartum bonding with the child (Pearson et al., 2011a). Dudek and Haley (2020) found that an enhanced attentional bias to infant compared to adult faces before infant birth predicted the quality of observed maternal sensitivity thereafter. With respect to EEG studies, accumulating evidence has indicated that variations in caregiving qualities were related to different neurophysiological responses to infant cues (Vuoriainen et al., 2022). Rodrigo and collaborators (2011) found that, compared to control mothers, neglecting mothers had an attenuated LPP response to infant emotional expressions. Bernard and colleagues (2015) found that Child Protective Services (CPS)–referred mothers did not differentiate between emotional expressions (i.e., crying and laughing versus neutral faces) at the LPP stage of processing. In a following study on CPS-referred mothers, a greater LPP amplitude to own versus other children was associated with higher levels of sensitivity in mothers (Bernard et al., 2018). Kuzava and colleagues (2019) found that maternal profiles characterized by undifferentiated LPP responses to infant emotional expressions were associated with a lower level of sensitivity in mother-child interactions. Overall, these findings validate the importance of examining adults' cognitive and electrophysiological responses to infant cues, as well as potential individuals' variations associated with them, to ultimately predict sensitive caregiving behaviors in adults. Noteworthy, understanding individual differences in the responses to infant cues might ultimately help to identify potential mechanisms that could be targeted by intervention and treatment efforts (Rutherford & Mayes, 2011).

In light of its potential value, the present work aimed to provide a more comprehensive understanding of the adults' cognitive and electrophysiological responses to infant cues in the light of a non-heteronormative perspective. Bringing together different methodologies, we focused on the role of sex, perceived quality of care experiences during childhood, as well as parental involvement in childcare, in the adults' cognitive and electrophysiological responses to infant cues. Therefore, whilst the first two studies (Study 1 and Study 2) focused on the adults' cognitive response to infant faces computed as an attentional bias to infant faces, Study 3 and Study 4 investigated the ERP responses to infant and child related cues. Including same-sex mothers, Study 2 and Study 4 provided first empirical evidence on the automatic mechanisms underlying caregiving responses in these families.

Specifically, in Study 1 we investigated the contribution of the perceived quality of care from caregivers, as well as of adults' sex, on the attentional bias to infant faces in parents and non-parents. Sex differences in the subsample of parents were clarified in the light of their parental involvement in childcare; of note, this helped to disentangle the variability explained by sex and parental involvement in parents' response to infant cues.

Focusing on an understudied population, Study 2 investigated the role of past and current experiences of care (i.e., the experiences of caring for an infant and being cared for as a child) in the attentional bias to infant faces in a sample of same-sex mothers. Since previous research on this field has been confined to heteronormative samples of mothers, the inclusion of same-sex mother families provided both theoretical and methodological advances for the topic.

Employing an EEG methodology, Study 3 examined whether temporal patterns of structural (N170) and higher-level (LPP) face processing, in a sample of non-parents, might vary based on the perceived quality of care experiences from caregivers. Building on the IPARTheory arguments (Rohner, 2021), multi-level indicators (i.e., attention, ERPs) were examined to shed further light on the complex role of the perceived quality of care in the adults' responses to infant cues. Exploratory analyses were additionally employed to examine potential sex differences in the light of adults' gender roles; key to this exploratory investigation was the argument that differences between males and females in the response to infant stimuli might not be only biologically determined, but instead reinforced by societal norms.

Adopting a multi-method research strategy, Study 4 was the first one to investigate ERP responses to child-related stimuli in the understudied population of same-sex mothers. By implementing a novel and ecological experimental paradigm, we further explored the associations between the ERP responses to child-related stimuli and maternal characteristics as well as the quality of caregiving behaviors. Importantly, we started to enrich the understanding of the phenomenology of sensitive caregiving by including different family contexts.

Study 1: Attentional bias to infant faces in parents and non-parents: the role of parental status, sex and the perceptions of past experiences of care from caregivers[2]

Introduction

A face of an infant constitutes a highly salient cue that captures the attention of adults, eliciting nurturing behaviors which in turn promote the parent-child attachment bonding (Ainsworth & Bell, 1970; Ainsworth et al., 1978). On this note, infant faces are characterized by specific physical features, including large, rounded foreheads and small chins, large low-set eyes, short and narrow noses and bulging cheeks. The configuration of perceptual infantile features (i.e., *Baby Schema*, Lorenz, 1943) acts as an innate releasing mechanism for adults' caretaking behaviors and affective orientation towards infants, with the evolutionary function of enhancing offspring survival. In previous research, a preferential attention towards infant faces, in adults, has been measured using cognitive conflict tasks (e.g., Stroop, Go/no-Go, visual

[2] This chapter is based on the following works:

- "*The perceived quality of maternal care during childhood shapes attentional bias to infant faces in parents and nonparents*" which has been published in *Journal of Family Psychology (doi: 10.1037/fam0001198)*. The study has been conducted in collaboration with Prof. Simona de Falco (Department of Psychology and Cognitive Sciences, University of Trento) and Dr. Michele Giannotti (Department of Psychology and Cognitive Sciences, University of Trento).

- "*Attentional Prioritization of Infant Faces in Parents: The Influence of Parents' Experiences of Care*" which has been recently published in the *International Journal of Environmental Research and Public Health (doi: 10.3390/ijerph20010527)*. The study has been conducted in collaboration with Prof. Simona de Falco (Department of Psychology and Cognitive Sciences, University of Trento), Prof. Paola Rigo (Department of Developmental Psychology and Socialisation, University of Padua), Dr. Xenia Schmalz (Department of Child and Adolescent Psychiatry, Psychosomatics and Psychotherapy, University Hospital, LMU Munich) and Dr. Michele Giannotti (Department of Psychology and Cognitive Sciences, University of Trento).

search tasks). In these studies, an attentional bias index has been computed as the difference in attention, in terms of Reaction Times (RTs) captured by infant versus other stimuli, such as adult faces; the larger was the difference, the greater was the cognitive engagement that adults deployed towards infant faces (for a review, see Lucion et al., 2017).

Parental status and sex

Previous studies have consistently evidenced a greater attentional bias to infants versus adult faces in all adults (Lucion et al., 2017). Therefore, infant faces have been demonstrated to be prioritized over other social stimuli, in terms of attention, by both non-parents (Brosch et al., 2007; Proverbio et al., 2011; Cárdenas et al., 2013) and parents (Pearson et al., 2010; Pearson et al., 2011b; Thompson-Booth et al., 2014a; Thompson-Booth et al., 2014b; Oliveira et al., 2017). However, when accounting for the role of parental status, a stronger attentional bias has been detected in parents compared to non-parents (Thomson-Booth et al., 2014a; Oliveira et al., 2017; for a review see Lucion et al., 2017).

Differently, a more complex and unclear picture has emerged regarding potential sex differences in the adults' attentional bias to infant faces. Using a modified Go/no-Go task (Bindemann et al., 2005), Oliveira and colleagues (2017) showed that parents (mothers and fathers) had a higher attentional bias to infant versus adult faces relative to non-parents; however, sex differences were not found, neither between mothers and fathers, nor between nulliparous females and males (Oliveira et al., 2017). Consistently, Brosch and colleagues (2007) demonstrated that infant compared to adult faces captured more attention in nulliparous adults, independently of their sex. On the other hand, some studies have found a more consistent attention allocation toward infant stimuli by women as compared to men (Cárdenas et al., 2013; Proverbio et al., 2006).

Given the mixed findings, recent works have suggested that sex differences in caregiving responses might be clarified by examining the role of potential confounding factors (Carone &

Lingiardi, 2022; Giannotti et al., 2022a). For instance, cultural norms and social expectations related to parenthood, as the often gendered and unbalanced division of childcare in different-sex families, might frequently overlap with parent sex. Therefore, in different-sex parent families, mothers usually devote much time in caring for a child compared to fathers (Patterson et al., 2004). These socio-cultural variables potentially overlapping with parent sex have not been generally considered in previous research; so, we cannot exclude that differences previously related to parents' sex might be better explained in the light of other variables, such as the amount of parental involvement in childcare (see Rajhans et al., 2019 for a similar consideration). For this reason, it has been recently suggested to consider sex and parental involvement as two independent variables in research on parents, in order to disentangle the specific contribution of the two predictors on the outcome variables (Carone & Lingiardi, 2022; Giannotti et al., 2022a). Despite these recommendations, caregiving involvement has been seldom considered in research on mothers and fathers' responses to infants (Giannotti et al., 2022b).

Perceived quality of care experiences from caregivers

Beyond these factors, the perceived quality of care during childhood has been demonstrated to modulate adults' responses to infant cues (Senese et al., 2018). The IPARTheory (Rohner et al., 2021) postulates that individuals' interpersonal relationships with significant others are characterized by an affectional bond falling along a continuum from acceptance to rejection. Of note, an individual's perception of acceptance from their own caregivers during childhood has been consistently demonstrated to underlie a healthy development and later psychological adjustment (Rohner et al., 2021). Similar to Internal Working Models (IWM) (Bowlby, 1969/1982), the perceived quality of care from caregivers has been also associated with the development of stable social, emotional and cognitive dispositions in adults, which can be used in different contexts and personal relationships

(Rohner et al., 2012). Crucially, individuals who perceived more rejection from their own caregivers might develop some cognitive distortions relative to personal relationships as being unpredictable, untrustworthy, and perhaps hurtful (Rohner et al., 2012). In line with the IPARTheory, Senese and colleagues (2018) demonstrated parental experiences during childhood played a critical role in regulating mothers' implicit responses to infant cues. In particular, adopting a SC-IAT paradigm (e.g., Senese et al., 2013), they found that mothers reporting higher levels of maternal rejection had a neutral to negative implicit response to infant cues (Senese et al., 2018). However, in the context of the IPARTheory, no research has investigated the role of recollected experiences of care on the attentional bias to infant faces. In addition, it is still unknown whether the potential associations between the perceived quality of parental care and attentional bias to infants might be modulated by other concomitant factors in adults, such as individuals' sex and the actual experience of being a parent.

Study aims and hypotheses

In a mixed sample of parents and non-parents, we first aimed to confirm a greater attentional bias (i.e. slower RTs) to infant relative to adult faces. Then, we investigated whether infant faces retained more attention than adult faces, in parents compared to non-parents and in women compared to men. As the third objective of the study, we examined whether the attentional bias to infant faces varied based on the perceived experiences of care with one's own father and mother. In doing so, we also considered the potential modulating effect of adults' sex and parental status. Exploratorily, we eventually investigated, in the sub-sample of parents, the role of parental involvement in childcare as a potential confounding factor when accounting for sex differences in the adults' attentional bias to infant faces.

In relation to the study aims, we expected that infant faces would interfere with the task performance more than adult faces, slowing RTs to peripheral stimuli in Go conditions, especially in parents compared to non-parents. Given that mixed findings have been outlined with respect to sex differences, we refrained from deriving a priori hypothesis. In addition, we expected that more accepting experiences of care from one's own caregivers would be associated with a greater attentional bias to infant versus adult faces. Given that the modulating role of sex and parental status in such association has never been studied before, this investigation should be intended as exploratory. Similarly, the preliminary exploration of the role of parental involvement with childcare did not allow for a derivation of a priori hypotheses.

Methods

Participants

A mixed group of 116 parents being in a couple (*n*=58 mothers; *n*=58 fathers) and 112 non-parents (*n*=56 women; *n*=56 men) was recruited for this study (*N*=228). As inclusion criteria, i) non-parents should not have any daily experience with childcare; ii) parents should cohabit with their partners at the time of the experiment; iii) the age of parents' only or youngest child should range between 2 and 60 months. Only participants with complete data (*n*=105 parents; *n*=111 non-parents) were included in the final analyses. Given that 4 non-parents reported to have some daily experience with childcare, they were excluded from the final sample. Due to a low accuracy level in the behavioral paradigm (i.e., lower than 50% in at least one block of the experiment), 6 participants were excluded from the sample of parents and 5 participants were excluded from the sample of non-parents. As a result, the final sample was composed of *N*=201 participants (*N*=102 non-parents, *n*=53 women and *n*=49 men; *N*=99 parents, *n*=52 mothers and *n*=47 fathers). An overview of the characteristics of the study participants is reported in Table 1. The study was approved by the ethical committee of the University of Trento and complied with the Helsinki declaration. All participants gave informed consent before participating.

Table 1

Characteristics of the study participants grouped by parental status and sex; N=number; M= mean; %= percentage; SD=standard deviation.

	Non-parents (*N*=102)			Parents (*N*=99)		
Group or variable	**N**	**M or %**	**SD**	**N**	**M or %**	**SD**
Females	53	52%		52	53%	
Nationality	53			52		
Italian	53	100%		51	98%	
Non-Italian	0	0%		1	2%	
Education	53			52		
Middle School	0	0%		2	4%	
High School	42	79%		19	37%	
Bachelor's Degree	5	9%		11	21%	
Master's Degree	6	4%		16	31%	
Postgraduate/Doctorate	0	11%		4	8%	
Age	53	21.9	2.3	52	33.5	5.6
PARQmother	53	37.6	12.6	52	36.9	13.1
PARQfather	52	42.1	15.2	52	38.6	12.8
Males	49	48%		47	47%	
Nationality	49			47		
Italian	49	100%		47	100%	
Education	49			47		
Middle School	3	6%		9	19%	
High School	20	41%		17	36%	
Bachelor's Degree	13	27%		6	13%	
Master's Degree	8	16%		10	21%	
Postgraduate/Doctorate	5	10%		5	11%	
Age	49	24.4	3.5	47	37.2	7.2
PARQmother	49	34	6	46	34.5	9.8
PARQfather	49	41.3	10.5	46	38.7	10.4

Self-reports

Self-reports were administered through Qualtrics (Qualtrics, Provo, UT). A socio-demographic questionnaire was administered to collect individuals' basic information as displayed in Table 1. Questions related to the child's age, number of children, and early involvement with childcare were asked to parents only. Parents were asked to answer all the questions by referring to the youngest child in case of multiple children. With respect to their involvement with childcare, parents were asked- *how many hours a week do you spend alone with your child*- and the response was provided on a quantitative continuous scale. This item has been extracted, translated and adapted from the Parental Primary Caregiving Role semi-structured interview (Abraham et al., 2014). We made sure that parents referred to a period within 3 years of age of their child to account for the early involvement in childcare, which is usually associated with stronger differences in the division of care between mothers and fathers.

Parental Acceptance-Rejection scale (PARQ)

All participants completed the Italian validated short-form version (Senese et al., 2016) of the Parental Acceptance-Rejection scale (PARQ) (Rohner, 2005b), which consists of two scales measuring past experiences of maternal and paternal care. Each scale, which has 24 items, originates a total maternal (PARQmother) and paternal score (PARQfather), consisting of four different dimensions: (1) warmth/affection; (2) hostility/aggression; (3) indifference/neglect; and (4) undifferentiated rejection. Warm and affectionate parental behaviors can be either verbal (e.g., praising, complementing) or physical (e.g., cuddling). Hostile and aggressive parental behaviors can be verbal (e.g., insulting), physical (e.g., hitting), or symbolic (e.g., aggressive gestures). Indifferent and neglecting parental behaviors are characterized by being physically or psychologically unavailable for the child. Undifferentiated rejection reflects the perception that the parent does not care about them, regardless of whether they behave in an aggressive, neglectful, or unaffectionate way (Rohner & Lansford, 2017).

Whilst higher PARQ scores reflect the experience of being more rejected, lower scores reflect more acceptance. Participants indicated how well each statement described their experience of care using a four-point Likert scale (from 4=*almost always true* to 1=*almost never true*). In this study, PARQmother and PARQfather scales had adequate reliability (PARQmother α=0.93; PARQfather α=0.94).

Experimental task

The experimental task was run on JATOS (Lange et al., 2015). Participants were given a modified Go/no-Go task derived from an established paradigm (Bindemann et al., 2005) to measure attentional bias to emotional and unemotional infant and adult faces (Figure 1; Pearson et al., 2010; 2011a; 2011b; 2013; Dudek et al., 2020; Gemignani et al., 2022; 2024a; 2024b). A central black fixation point was presented for 745 ms. Then, the fixation point turned into green or red, signaling the Go or no-Go condition respectively. Simultaneously, two lines, one horizontal and one vertical, appeared at the periphery of the screen. Standardized images of adult and infant faces appeared behind the Go/no-Go cross during the stimulus display (245 ms). Only for Go trials, participants were asked to indicate on which side of the screen the vertical line appeared by pressing “n” (for right) or “v” (for left) on the keyboard. The screen response was presented until participant response; it was aborted if no responses occurred within 2000 ms. No responses were required in no-Go trials. Thirty-six images (6 males; 6 females) of unfamiliar infant faces aged 4-12 months were extracted from the Tromso Infant Faces Database (TIF; Maack et al., 2017); thirty-six images of unfamiliar adult faces (6 males; 6 females) were extracted from the Karolinska Directed Emotional Faces (KDEF; Lundqvist et al., 1998). For each identity, 3 facial expressions displaying happy, neutral and sad emotional expressions were chosen. Whilst distressed infant faces displayed an infant crying, happy faces displayed a smiling expression and neutral faces displayed no emotional content. Faces were cropped in an oval shape, converted into grayscale, and presented against a uniform white background. Images were matched for size using GNU Image Manipulation Program v. 2.8.22 and averaged approximately 170 x 198 pixels. Images were equalized for luminance and saturation using MATLAB. An illustrative representation of the experimental stimuli is displayed in Figure 2. Participants completed a practice block of 12 trials with no faces, then a practice block of 12 trials displaying adult or infant faces in the background. After practice, experimental trials consisted of 6 blocks of 36 trials (24 Go and 10 no-Go trials). The order of trials was randomized within blocks, but Go trials occurred twice as frequently as no-Go trials. To decrease the potential risk of popout (Palermo & Rhodes, 2003), conditions were fixed in each block. Block order was randomized across subjects. The target line location was balanced within each block (50% on the right; 50% on the left). Due to COVID-19 restrictions, the task was administered online during a Zoom meeting to check the quality of data collected. Participants were send a link to perform the task and were instructed to i) be sitting in a quiet environment; ii) keep their left index finger on the "v" and their right index finger on the "n" of the keyboard during the task; iii) ignore the face stimuli appearing in the background; iv) be as accurate as possible in the localization judgment. Potential doubts were solved by the experimenters. The experimenters shut down their microphone and camera during the task but monitored participants' engagement for the entire duration of it.

Figure 1

Schematic representation of a trial in the Go/no-Go experimental task.

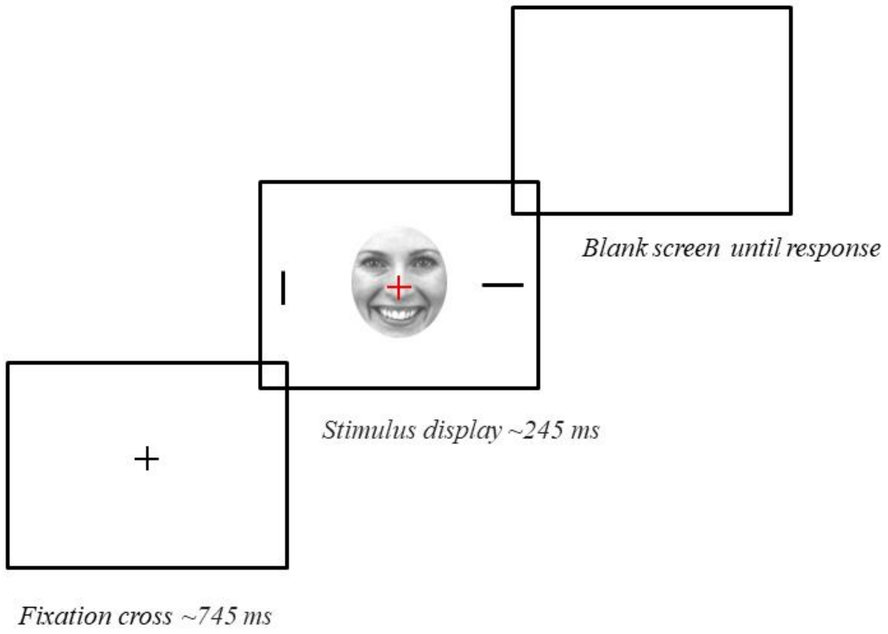


Figure 2

Illustrative example of experimental stimuli (adult and infant faces) displaying three different expressions (happy, neutral, sad).

Data analysis

Preliminary differences between parents and non-parents and men and women were tested via Two Sample t-tests for numeric variables. Two-sample Wilcoxon rank-sum test was used to compare the level of education between the groups. Alpha level was set at <.05. Preliminary analyses were conducted for evaluating the number of correct trials for different blocks. The overall accuracy for Go trials was 96.2%, which confirmed the ability of participants to complete the task as instructed. The percentage of false alarms (incorrect no-Go trials) was 3.5%. The measure focusing on response accuracy was analyzed using generalized mixed-effects models (GLMM) to accommodate the binomial nature of the variable. RTs were computed on the time elapsing from stimulus display onset until the response in Go trials. Only correct trials were considered for the RTs analyses. RTs were analyzed via linear mixed-effects models (LMM; Bates et al., 2015) performed using the lme4 (Version 1.1-28) library (Bates et al., 2015) in Rstudio (Version 4.1.1; RStudio Team, 2021). Responses below 100 ms or above 1400 ms (0.6% of correct trials) were considered outliers and removed. To approximate a normal distribution, RTs were transformed into logarithms, and the distributions were checked visually on the trial-, participant- and item- levels. As the distributions were approximately normal, we did not exclude any further items, participants, or trials. Independent variables such as face age, emotional valence, parental status, and sex were contrast-coded, so that the intercepts reflected the grand mean of conditions. Continuous independent variables (PARQmother, PARQfather, involvement, age, child age) were centered subtracting the overall mean across participants. Considering demographic differences between the groups of parents and non-parents, age was considered as a covariate in the models. Missing data in self-reports was not replaced. The absence of significantly influential outliers was preliminarily checked for all the variables; regarding the early involvement in childcare, we excluded outlying scores among participants (>50; *n*=6) to approximate a normal distribution. However, we performed sensitivity analyses by reintroducing the outlying scores of parental involvement. Table 2 summarizes the characteristics of the main models implemented. The effects were checked using the Type III Analysis of Variance with Satterthwaite's method (Appendix 1).

Table 2

An overview of the aims, independent variables, random effect structures, and statistically significant effects of the main models. Results confirmed across multiple models are reported only once. For the Aim 3, we reported only the model including PARQmother, since no effects of PARQfather were found.

Aims	Independent variables	Random effect structures	Significant effects
Aim 1: Confirm that infant faces retain more attention relative to adult faces.	Face age, emotional valence, and their interaction.	Subject, image	**Main effect of face age**: infant faces retain more attention compared to adult faces.
Aim 2: Investigate whether attentional bias to infant versus adult faces is associated with adults' sex, parental status, and their interaction.	Face age, sex, parental status and their interactions; age is added as a covariate.	Subject, image	**Main effect of sex**: women are slower in task performance compared to men. **Main effect of parental status**: parents, compared to non-parents, allocate more attention to all types of faces. **Two-way interaction effect between face age and sex**: women, compared to men, allocate more attention to infant versus adult faces.
Aim 3: Examine whether attentional bias to infant faces is associated with individuals' differences in care experiences during childhood. The modulating effect of parental status and sex is also considered.	Face age, PARQmother, parental status, sex, and their interactions; age is added as a covariate.	Subject, image	**Two-way interaction effect between face age and parental status**: mothers, compared to fathers, allocate more attention to infant versus adult faces. **Two-way interaction between face age and PARQmother**: individuals who perceived a more accepting maternal care allocate more attention to infant versus adult faces. **Three-way interaction between face age, PARQmother, sex**: maternal rejection weakens the attentional bias to infant versus adult faces more in males as compared to females.
Aim 4 (only in parents): Explore if attentional bias to infant faces is related to parents' sex when considering the parental involvement in childcare.	Face age, parent sex, early involvement with childcare, and their interactions; child age is added as covariates.	Subject, image	**Two-way interaction between face type and early parental involvement**: those parents more involved with early childcare allocate more attention to infant relative to adult faces. The interaction effect between face age and sex is no longer found.

Results

Preliminary results

In our sample, parents were significantly older as compared to non-parents ($t(199) = -16.6$, $p < .001$). No differences in PARQmother and PARQfather emerged between parents and non-parents. Relative to women, men were significantly older ($t(199) = -2.7$, $p < .01$). No sex differences emerged in relation to PARQfather. Regarding PARQmother, women reported a higher perception of maternal rejection compared to men ($t(198) = 2.0$, $p < .05$). The groups (i.e., parents vs. non-parents and males vs. females) did not differ for their levels of education. Compared to fathers, mothers were more involved with early childcare ($t(91) = 5.1$, $p < .001$; Figure 3). This effect persisted after reintroducing the outlying scores of early parental involvement ($t(97) = 4.4$, $p < .001$). RTs as a function of the different face age conditions in mothers, fathers, non-parent women and men are reported in Table 3.

Figure 3

Division of early childcare in terms of hours in a week (y axis) between the mothers and fathers in each couple (x axis). For each dyad, the different involvement of the two members is marked by different colors.

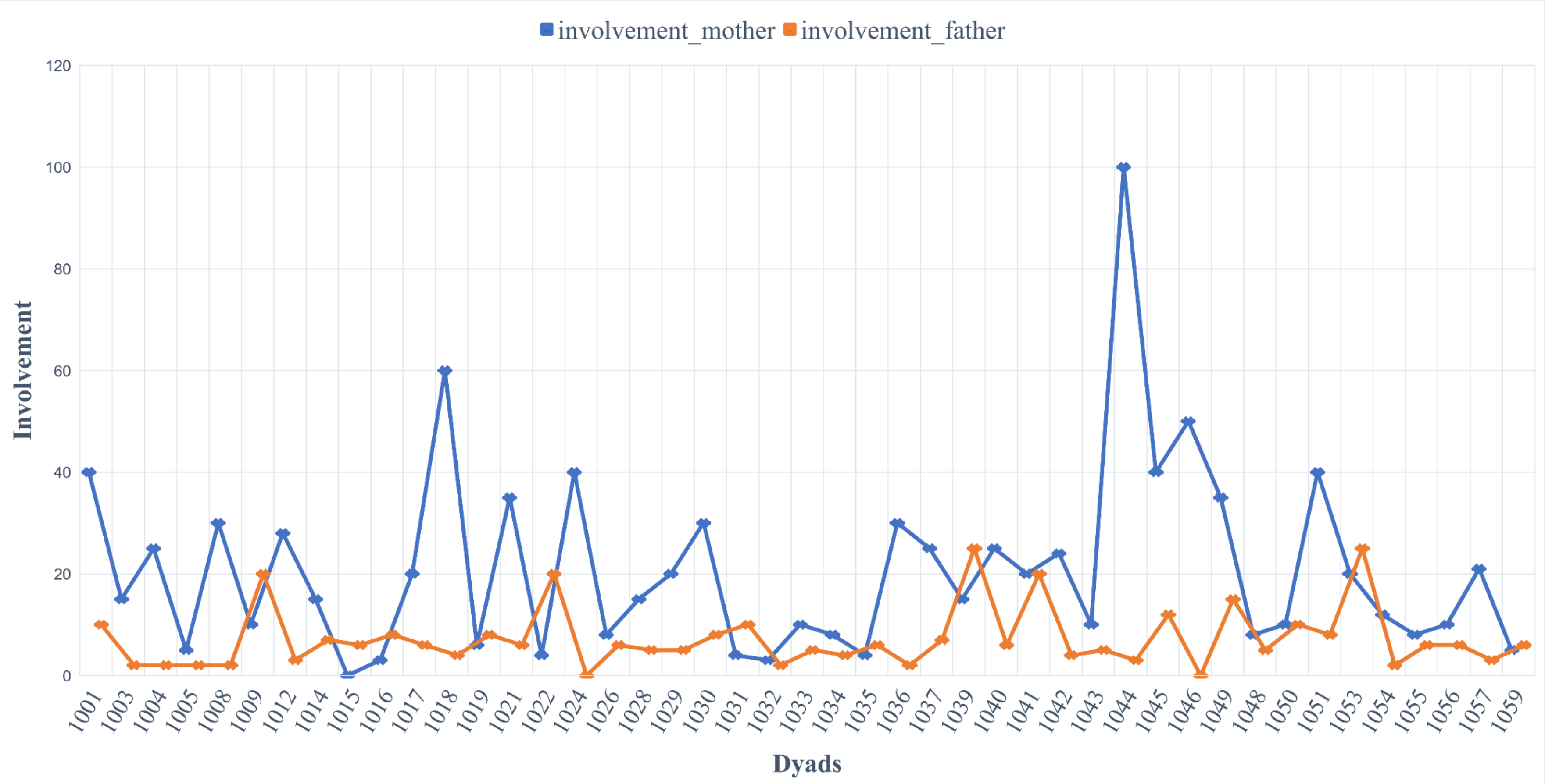


Table 3

Mean non-log transformed RTs (SD) as a function of different face age conditions in mothers (n=52), fathers (n=47), non-parent women (n=53) and men (n=48).

	Mean RTs (SD)			
Face age	**Mothers**	**Fathers**	**Non-parent women**	**Non-parent men**
Infant	702.5(159.2)	633.0(126.9)	620.7(141.9)	604.0(143.1)
Adult	682.8(145.0)	621.7(125.0)	607.7(132.3)	596.5(141.0)

Main analysis

At first pass, we fitted a GLMM with face age (adult, infant) and emotional valence (happy, neutral, sad) predicting trial-level accuracy; two additional models were fitted by adding parental status and sex as fixed factors. Due to the overall high level of accuracy, these analyses did not yield any significant results; all subsequent models used RTs as dependent variable. To investigate Aim 1, we implemented a LMM in which face age and emotional valence were used as fixed terms, and their interaction was considered. The model included random intercepts for subjects and images. The model confirmed a main effect of face age (β = -0.009, *SE* = 0.001, t = -7.94, $p < .001$), as infant faces captured more attention, slowing RTs, compared to adult faces. The effect remained robust after varying all the slopes (β = -0.009, *SE* = 0.002, t = -4.19, $p < .001$) and the slope of the main effects (β = -0.009, *SE* = 0.002, t = -4.17, $p <.001$). Neither the main effect of the emotional valence nor the interaction effect between face age and emotional valence were significant.

To investigate Aim 2 (Table 2), we implemented a LMM including sex, face age, and parental status as fixed terms; their interactions between the terms were considered. Age was added as a covariate. Given that no statistically significant effects of emotional valence were detected in the basic models, we collapsed across the expressions to reduce the model complexity (Bates et al., 2015). This model confirmed a main effect of face age, with greater attention retained by infant versus adult faces (β = -0.009, *SE* = 0.001, *t* = -7.85, $p < .001$), and a main effect of parental status (β = 0.03, *SE* = 0.02, *t* = 2.04, p =.04), as parents allocated more attention to all the types of faces as compared to non-parents. A main effect of sex also emerged (*β* = 0.03, *SE* = 0.01, *t* = 2.80, *p* =.006); women were overall slower in the task performance compared to men. A two-way interaction effect emerged between face age and sex (*β* = -0.002, *SE* = 0.0009, *t* = -2.130, *p* =.03); women, as compared to men, allocated more attention toward infant versus adult faces. In addition, a two-way interaction effect between face age and parental status approached significance (*β* = -0.002, *SE* = 0.0009, *t* = -2.13, *p* = .06); compared to non-parents, parents had the tendency to allocate more attention to infant versus adult faces. A three-way interaction between face age, sex and parental status was not significant.

To explore Aim 3 (Table 2), we first implemented a model including face age, PARQmother, and PARQfather as fixed effects; the interactions between the terms were considered. This model highlighted effects worthy to follow up on PARQmother (Appendix 1). Conversely, we did not find significant effects related to PARQfather. Therefore, we implemented a more complex model with face age, PARQmother, sex, and parental status as fixed factors; their interactions were considered. Age was added as a covariate. With the only exception of the main effect of parental status, this model, which was the most complex among the ones implemented, confirmed and extended all the effects found so far (Appendix 1). In particular, the model confirmed the main effect of face age (*β* = -0.009, *SE* = 0.001, *t* = -7.33, *p* < .001) and the main effect of sex (*β* = 0.03, *SE* = 0.01, *t* = 2.89, *p* = .004) in the same direction as before. It highlighted a two-way interaction between face age and the perceived experience of care with one's own mothers (*β* = 0.0006, *SE* = 0.0001, *t* = 5.68, *p* < .001). That is, those individuals who perceived more maternal acceptance (i.e., lower scores of PARQmother), allocated more attention to infant versus adult faces. This effect is displayed in Figure 4. A three-way interaction between face age, parental status and care experiences with one's own mother was not detected. Differently, a three-way interaction effect between face age, sex and care experiences with one's own mother was found (*β* = -0.0004, *SE* = 0.0001, *t* = -3.91, *p* < .001); males who felt mostly rejected by their mothers, compared to females, decreased their attentional bias to infant faces to a greater extent (i.e., Figure 5 versus Figure 6; by increasing the levels of maternal rejection the same inversion in the attentional bias cannot be evidenced in females when compared to males). The two-way interaction effects between face age and sex (β = -0.002, *SE* = 0.0009, t = -2.920, p =.004) and face age and parental status (β = -0.002, *SE* = 0.001, t = -2.13, p =.03) emerged in the same directions as described before.

In relation to Aim 4 (Table 2), we exploratorily built a LMM in which the early involvement with childcare was added as a fixed term, in addition to face age and parent sex. The interactions between the terms were considered. Both parent age and child age were added as covariates. A significant main effect of face age (β = -0.01, *SE* = 0.002, t = -6.55, p < .001) and sex (β = 0.04, *SE* = 0.02, t = 2.19, p = .03) emerged as before. A two-way interaction effect between face age and parental early involvement in childcare was detected (β = -0.0007, *SE* = 0.0002, t = -3.71, p < .001); more involved parents with early childcare allocated more attention toward infant relative to adult faces (Figure 7). This effect was robust after reintroducing the outlying scores for parental involvement (β = -0.0004, *SE* = 0.0002, t = -2.57, p = .01). In addition, to check for the potential dependency of data within each couple of parents, we accounted for the dyad in the random structure of the model; of note, the interaction effect between face age and involvement stayed stable (β = -0.0006, *SE* = 0.0001, t = -3.71, p < .001). An interaction effect between sex and face age was no more detected in this model. The numerical values related to the effects of the models are reported in Appendix 1.

Figure 4

Interaction between face age and PARQmother (higher scores mean more rejection).

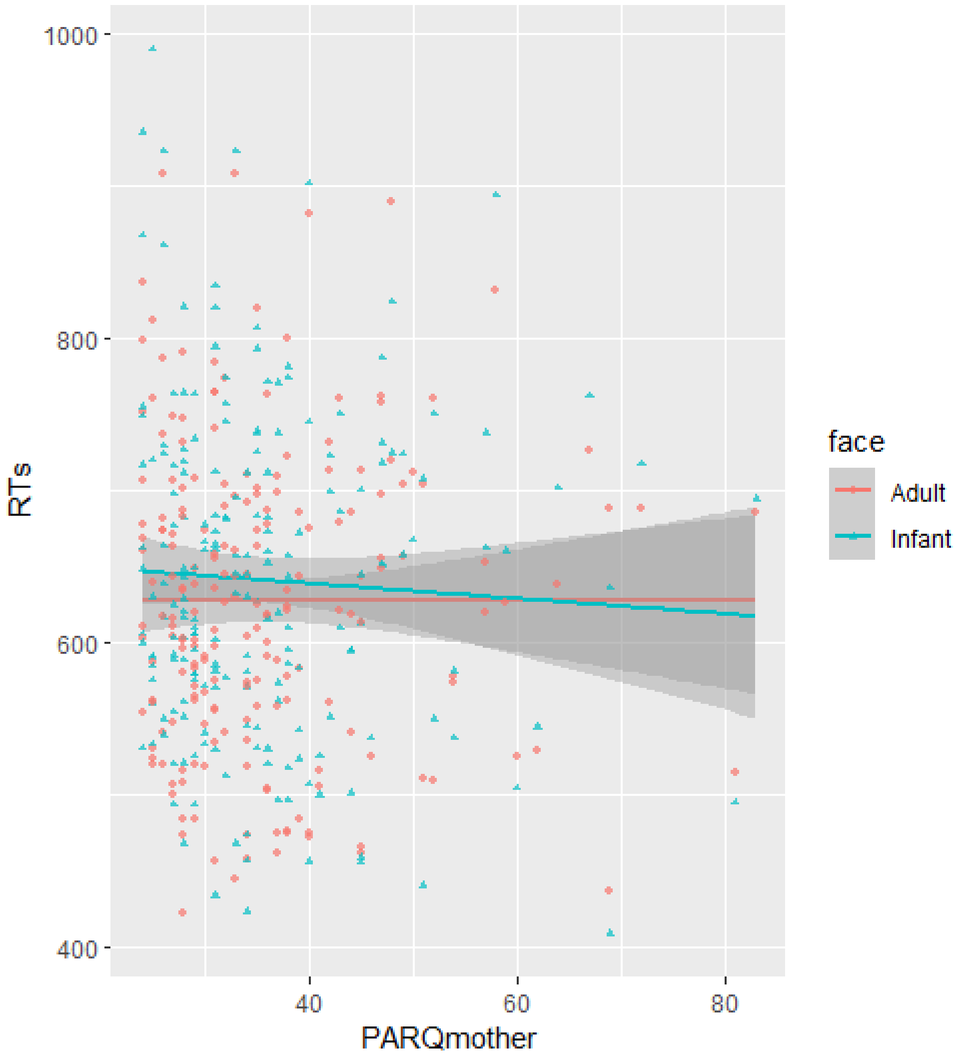


Figure 5

Interaction effect between face age, PARQmother, and adults' sex. This pattern has been displayed by males.

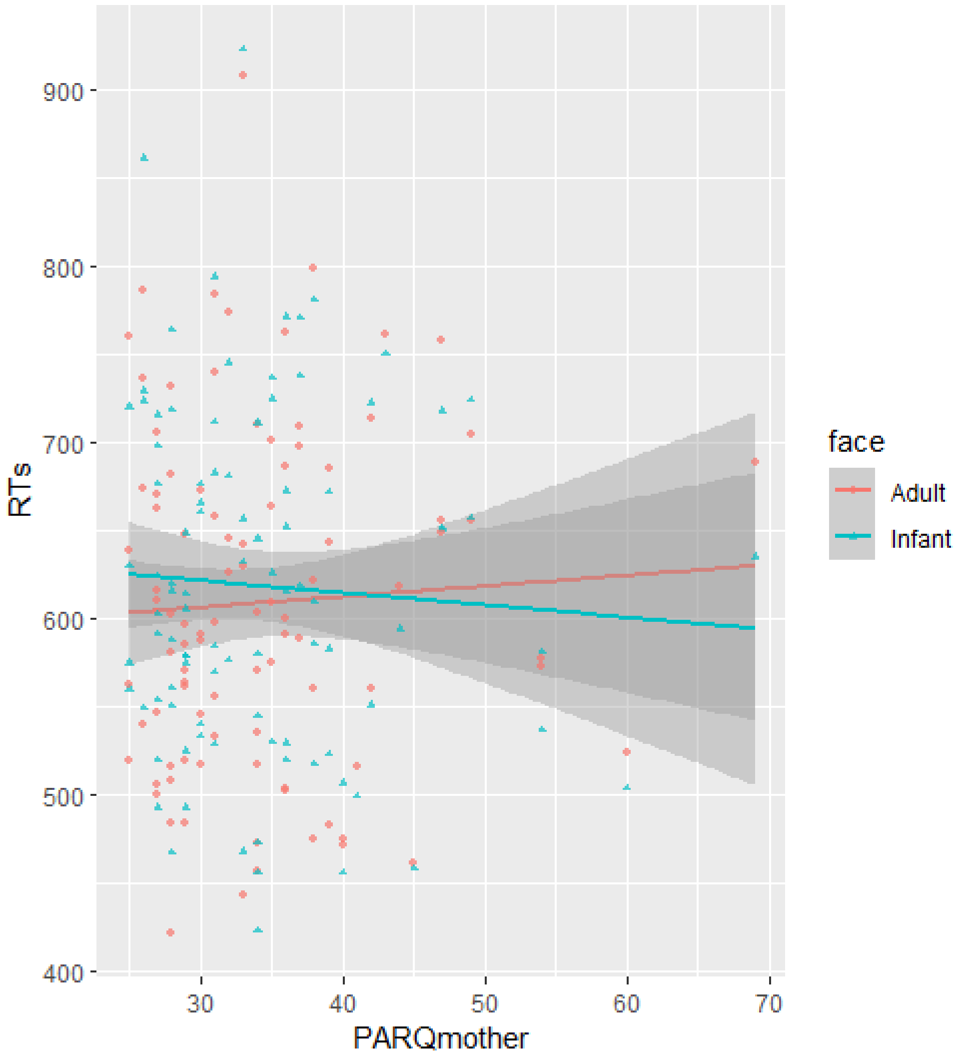


Figure 6

Interaction effect between face age, PARQmother, and adults' sex. This pattern has been displayed by females.

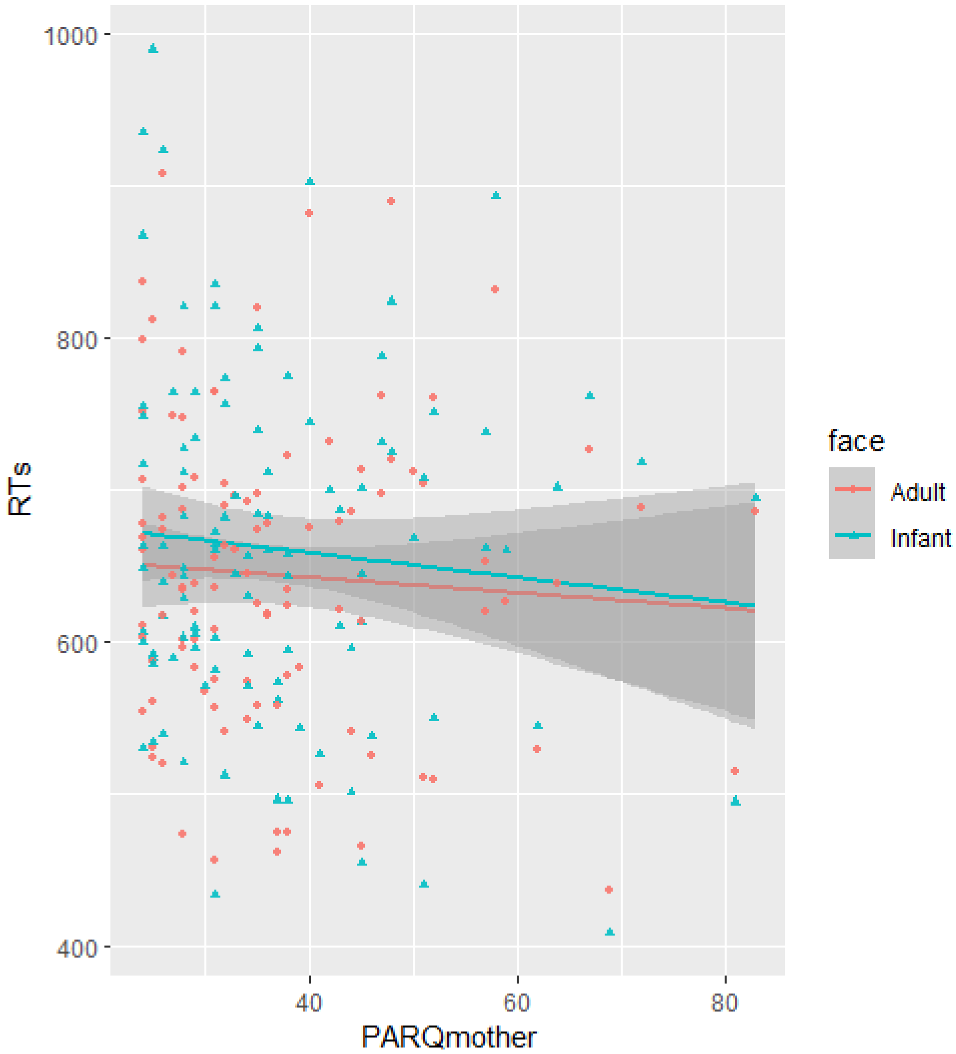
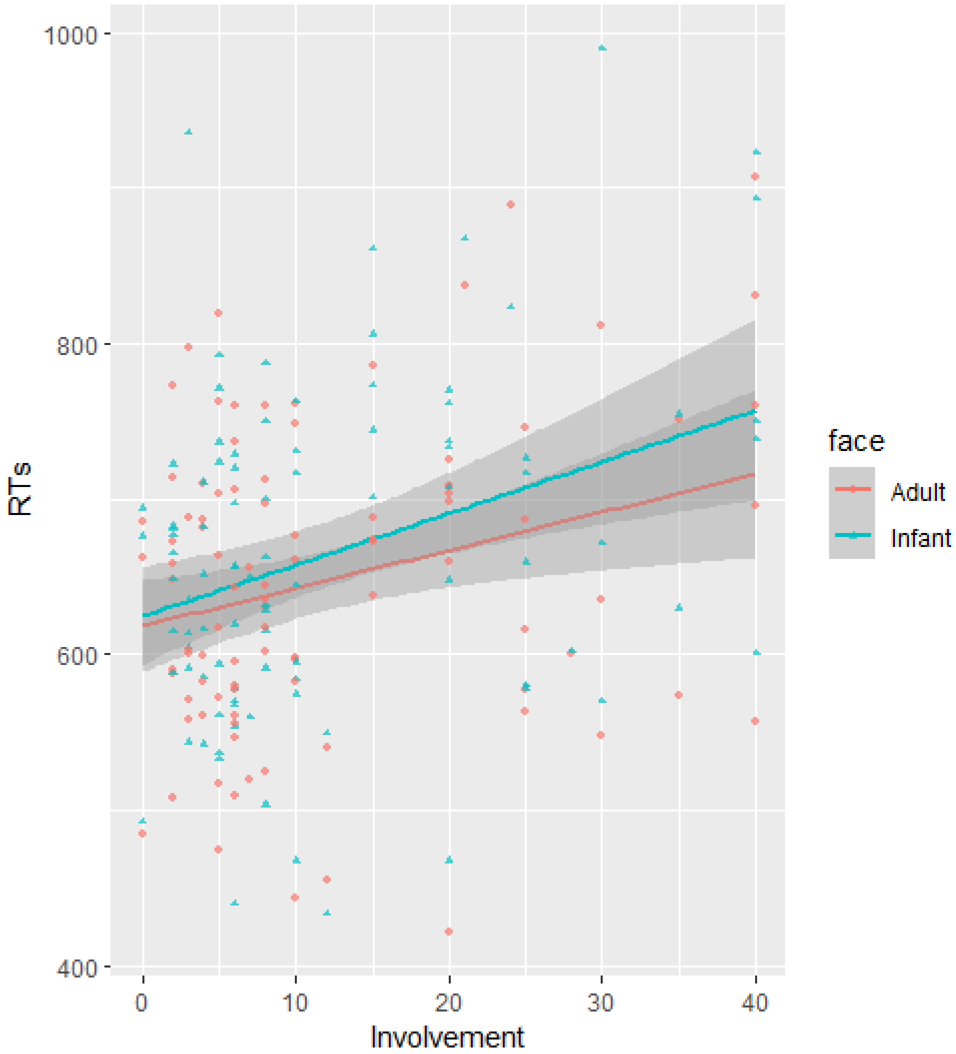


Figure 7

Interaction between face age and parental involvement with early childcare.



Discussion

In this study, we sought to investigate whether an enhanced attention to infant versus adult faces varied in relation to parental status, sex, the perceived quality of past experiences of care and the interactions between these factors in parents and non-parents. Grounded in the IPARTheory (Rohner, 2021), this work was the first one examining the contribution of the perceived care experiences with one's own mother and father on the attentional bias to infant faces. Moreover, we added meaningfully to the literature by considering adults' sex and parental status in modulating this relationship. Preliminarily, we put some bases on the exploration of sex differences in parents' responses to infant cues in the light of other potential confounding socio-cultural factors, which have been mostly neglected in previous parenting research.

As a methodological check of the task validity, we confirmed that infant faces retained more attention relative to adult faces in parents and non-parents. On this note, infant facial cues provide the adults with a wealth of information about the infant's states and guide them through the selection of appropriate caretaking behaviors. Of note, the emotional valence of infant faces did not mediate the behavioral performance in the task, as it was detected in previous studies (i.e., greater attentional bias for distressed infant faces compared to other conditions; Pearson et al., 2010; 2011a; 2011b; 2013). Even though the emotions displayed by infant faces are important to elicit an appropriate caregiving behavior in adults, here we found that infant faces captured adults' attention irrespective of the emotional content displayed. Consistently, Long and colleagues (2021) did not find a moderating effect of facial expressions on attentional bias toward infant faces in a sample of non-parents. In parents, Oliveira and colleagues (2017) found that attentional bias to infant faces was independent of the emotional valence of infant facial expressions. Accordingly, Dudek and Haley (2020) speculated that different responses based on the type of emotional expression might not be detected at behavioral levels, but captured using finer methodologies (e.g., EEG). However, given well-established evidence that affective stimuli attract more attention than neutral stimuli (Vuilleumier, 2002), it might be that our task was not sensitive enough to detect such effect of emotional valence. In addition, in blocked conditions, as we used here, there may be some adaptation or habituation to the expressions, reducing the attentional saliency of the emotions expressed in adults.

Regarding the role of parental status, parents tended to allocate more attention to infant faces relative to non-parents. On this note, it might be important, especially for parents, to rapidly attend to infant cues in an environment where other information competes for attention. However, as it has been claimed in previous research (e.g., Parsons et al., 2017), parenthood might be related to subtle perceptual changes. In line with this consideration, the significant interaction effect between face age and parental status was not robust across the different models implemented in this study (i.e., the interaction effect was significant in the third model, but it only approached statistical in the second model).

Regarding sex differences, we first found that infant faces retained more attention compared to adult faces in women relative to men. In the subsample of parents, however, we further explored sex differences by accounting for parental early involvement in childcare. Interestingly, the interaction effect between sex and face age was no longer detected. On the other hand, a statistically significant interaction between face age and parental early involvement in childcare emerged; that is, parents who were more involved in early childcare allocated more attention to infant than adult faces. As we considered the variable of parental involvement only marginally and we measured it using a single item, our results should be considered with caution. However, this evidence might represent a starting point for future research, which should be encouraged to evaluate the role of parental experiences when investigating sex differences in parents' responses to infant cues. In this regard, Endendijk and colleagues (2017; 2018a) found that gendered stereotypical behaviors can even increase after the transition into parenthood; so, the conflation between sex and other potential confounding variables should be importantly considered in future research on parenting. Further investigation on the role of parental involvement would additionally benefit by including couples of same-sex parents, who are less susceptible to the gendered division of care which might occur in different-sex parents (Carone

& Lingiardi, 2022). As we also included also non-parents here, the consideration of other potential confounding variables (i.e., gender-related norms; Lindqvist et al., 2021; Ding et al., 2020) might have shed further light on the actual variability explained by sex in the adults' cognitive response to infants. All in all, in light of these considerations and previous evidence on the topic (Rollè et al., 2019; Giannotti et al., 2022b), these preliminary results additionally encouraged fathers, as well as mothers, to be involved with early childcare, as their engagement might be positively linked to their responses towards the child and ultimately improve the quality of parent-child relationships (Lamb, 2010).

In line with our third hypothesis, we found that the attentional prioritization of infant versus adult faces varied in relation to the perceived quality of care experiences during childhood; in particular, those individuals who perceived more accepting and warm maternal care were more engaged, in terms of attention, to infant versus adult faces. According to the IPARTheory (Rohner, 2021), mental representations constructed from warm care experiences might positively shape the way in which individuals perceive, construe, and react to external stimuli, especially when it comes to attachment-related stimuli. On the other hand, being neglected during childhood may trigger perceptual biases which tend to extend from childhood into adulthood in absence of any counter experiences (Rohner et al., 2012). Accordingly, we found that individuals with less optimal perception of early maternal care displayed a weakened attentional bias to infant compared to adult faces. However, we were not able to find any effects related to the perceived quality of paternal care. Nonetheless, the lack of significant results in our study does not imply that there is no merit in exploring the impact of early paternal experiences of care, which has been detected using other methodologies (Truzzi et al., 2018). It is also possible that our findings have been driven by the circumstance that mothers have been more involved with childcare, in the past decades, as compared to fathers. So, the impact of early experiences with one's own mother or father may not be intrinsically different per se, but the experience of care with the primary caregiver, may they be a mother or a father, might better predict later cognitive variations related to attention bias to infant cues. Future research should better clarify what mostly predicts child development, whether it is parent sex, or the parental roles related to socio-cultural norms.

Moreover, a modulating effect of parental status was not found in this association. Therefore, the experience of receiving care from one's own mother regulated adults' attention to infant faces independently of the actual experience of parenthood. In other words, the experience of being a parent might not exert enough influence to override the association between the perceived quality of maternal care and the attentional bias to infant faces. Differently, a three-way interaction effect between face age, sex and early experiences with one's own mother indicated that the contribution of early maternal rejection on the attentional bias to infant faces was more pronounced in males as compared to females. In particular, when males felt more rejected by their mothers, their attentional bias to infant versus adult faces tended to decrease to a greater extent compared to the pattern displayed by women (i.e., this can be seen by comparing Figure 5 and Figure 6). A recent meta-analysis has shown that, although the magnitude of the difference was not great, memories of maternal acceptance in childhood had significantly stronger relations with adult sons' psychological adjustment than that of adult daughters (Ali et al., 2015). Consistent with this evidence, it may be that males have a greater developmental sensitivity to poor environmental experiences with their own mothers when compared to females. Given that caution is needed in interpreting a three-way interaction effect, a task for future research and theory construction would be to corroborate these potential effects (Ali et al., 2015).

Limitations and future directions

Our results should be considered in the light of some limitations and point towards future directions. First, participants were given the experimental task in a poorly controlled environment; however, the online version of the task allowed researchers to overcome the restrictions related to COVID-19 pandemic in the Italian context. In addition, despite not being as precise as the lab-based equivalents, the precision of the web-based tasks has been found appropriate, especially if they have included the presentation of visual stimuli (Bridges et al., 2020). In our study, we made sure that the online version of the task was reliable by comparing the response times collected in the online version and in the lab version of the task. Multiple checks displayed a constant lag of around 4 milliseconds. Anyway, the replication of our results in a more standardized environment would increase the validity of the procedure.

Secondly, our study was cross-sectional and relied on self-report measures. Future studies could follow individuals longitudinally to explore the causal relationships among the variables and adopt more ecological observational measures. In addition to this, the experiment-wise alpha may be inflated given the multiple models tested here. Relatedly, we were not able to calculate the effect sizes of our findings; on this note, despite LMM have the advantage to capture multiple sources of random variations in the data (Westfall et al., 2014), there is no agreement on how to calculate effect sizes (Nakagawa & Schielzeth, 2012).

Moreover, the heterogeneity of the sample of parents in terms of child age could have reduced the generalizability of our findings. It should be said that we adopted less stringent requirements in terms of child age to also include fathers in our study, considering that they have been usually underrepresented in parenting research. On this note, in spite of the difficulties in recruiting fathers, we think that including them in future works might help to overcome the general devaluation that has been placed on fatherhood, when compared to motherhood, in the last decades of parenting research.

Regarding the PARQ measure, we suggest doing further research distinguishing between early experiences of care with primary/secondary caregivers, rather than asking about past experiences with one's own mother/father. This methodological advance could also result in a more inclusive practice in research, for instance, when it comes to children of same-sex parent families. Moreover, since a substantial amount of variance in the adults' response to infant cues might be explained by the influence of cultural, behavioral, genetic, and neurobiological aspects, a multi-method approach can be adopted in future studies investigating the role of the quality of early care in the adults' responses to infant cues. On this note, two studies in non-parent adults found that different genetic polymorphisms sensitized the impact of early care experiences on adults' implicit responses to infant faces (Senese et al., 2017) and cries (Senese et al., 2019). Therefore, studying the interaction between different individual aspects could help to capture the complexity of the relationships between the different variables. With respect to the early involvement with childcare, we acknowledged that a single item was a poor index of the wide parental care experiences in our sample. Moreover, the question was a bit ambiguous for participants, who might have referred to the current week or a previous time whenever the age of their children was greater than 3 years. In addition, especially for fathers, measuring indirect involvement in childcare might have better captured their specific contribution to childcare (Hawkins & Palkovitz, 1999; Pleck, 2012). Generally, to obtain a richer and more accurate understanding of this topic, we encourage future research to consider both quantitative and qualitative aspects of parental involvement (Rollè et al., 2019; Giannotti et al., 2022b).

Conclusion

Measures of attentional bias toward infant faces might provide objective data on the automatic processes underlying adults' responses to infants (Lucion et al., 2017). Our results confirmed that infant faces induced greater attention compared to adult faces. Women, compared to men, were preliminarily found to allocate more attention to infant versus adult faces. However, this effect was no more significant after accounting for parental involvement in childcare in the sub-sample of parents. Those individuals who remembered a more accepting maternal care allocated more attention to infant versus adult faces. Importantly, parental status did not modulate this effect, but the sex of participants did. Overall, our findings build upon the existing IPARTheory research and provide new empirical evidence on the underlying processes that potentially regulate global adult caregiving.

Study 2: Attentional bias to infant faces might be associated with previous care experiences and involvement in childcare in same-sex mothers[3]

Introduction

Mother-infant interactions rely on the ability to express signals through facial expressions (Ainsworth et al., 1978). Importantly, infants' non-verbal signals capture the attention of mothers and are used to communicate needs, with the evolutionary goal to get care and protection from the caregiver (Lorenz, 1943, 1971). An appropriate perception and interpretation of infants' signals is an integral part of sensitive caregiving, which supports the development of a secure attachment relationship (Ainsworth et al., 1978). Since it has been described as one of the antecedents of maternal sensitivity, a specific line of research has examined mothers' preferential attention to infant cues.

Attentional bias to infant faces

Behavioral tasks assessing the preferential attention towards infants in mothers have typically presented infant cues as distractors during cognitive conflict tasks (e.g., Stroop, Go/No Go, visual search tasks). An attentional bias index has been computed as the difference in attention captured by distinct stimuli, such as infant versus adult faces; empirical evidence has consistently suggested a greater attention allocation of mothers to infant cues (for a review, see Lucion et al., 2017). Using an attentional Go/no-Go task, Pearson and colleagues (2010) demonstrated that pregnant women took

[3] This chapter is based on the following work:

"*Attentional bias to infant faces might be associated with previous care experiences and involvement in childcare in same-sex mothers*" which has been published in *International journal of clinical and health psychology (doi: 10.1016/j.ijchp.2023.100419)*. The study has been conducted in collaboration with Prof. Simona de Falco (Department of Psychology and Cognitive Sciences, University of Trento), Prof. Paola Rigo (Department of Developmental Psychology and Socialisation, University of Padua) and Dr. Michele Giannotti (Department of Psychology and Cognitive Sciences, University of Trento).

longer to respond to the peripheral stimuli when infant faces (in particular those displaying distress) appeared on the screen as distractors. In a following study (Pearson et al., 2011a), a greater attentional bias to infant distressed faces was associated with more successful mother-infant bonding at 3-6 months postpartum. Using a modified Irrelevant Feature Visual Search paradigm (Theeuwes, 1991) Thomson-Booth and colleagues (2014a) demonstrated that women, mothers in particular, showed slower Reaction Times (RTs) in search arrays containing infant versus adult faces. The highly salient nature of infant faces consistently elicited greater attention compared to pre-adolescent, adolescent, or adult faces in mothers versus non-mothers in a following study (Thompson-Booth et al., 2014b).

The role of maternal experiences in caring for their children

Different characteristics of mothers have been found to modulate their attentional bias to infant faces (Lucion et al., 2017). Pearson and colleagues (2010) demonstrated that whilst non-depressed pregnant women took longer to disengage attention from distressed infant faces, this evidence was not detected in women experiencing depressive symptoms. In a following study, a higher engagement of attention to infant distressed faces was found in breastfeeding compared to formula-feeding mothers (Pearson et al., 2011b) Thompson-Booth and colleagues (2014a) found that a greater attentional bias to infant faces was associated with less parental distress reported by mothers. In addition, a greater attentional bias to infant versus adult faces was found in high- versus low-sensitive mothers (Dudek & Haley, 2020).

However, little attention has been put on how mothers' differences in the attentional bias to infant faces might be related to maternal caregiving experiences. Of note, several factors can be linked to caregiving experiences, such as the number of children that a mother have (i.e., parity), the duration of motherhood (i.e., child age), and the maternal involvement in childcare (i.e., quality and quantity of activities accomplished). Pearson and colleagues (2010) demonstrated that attentional bias towards distressed infants was greater in multiparous compared to primiparous women. Whilst the effect of parity in modulating maternal responses to infant faces has been corroborated using other methodologies (e.g., ERPs; Maupin et al, 2019; Rutherford et al., 2019), the other nuances of caregiving experiences have been mainly neglected. In addition, research including adoptive parents or surrogate parents, which could help understanding the role of experience-related determinants in the attentional bias to infant cues, is currently lacking.

The role of maternal experiences in being cared for as a child

Besides the actual experiences of care, mothers' attentional bias to infant faces might be linked to the perceived quality of care received from caregivers during childhood. According to Bowlby's theoretical work (1969/1982), repeated interactions with attachment figures are schematized in the form of Internal Working Models (IWM) that synthesize the main self-other interactive dynamics and are automatically activated by individuals when processing new situations. Similarly, it has been assumed that the perceived interpersonal rejection during childhood may hinder the development of stable mental representations in later adult life, influencing the individuals' view of self, others and interpersonal contexts (IPARTheory; Rohner, 2021). At the empirical level, retrospective remembrances of maternal care experiences during childhood have been found associated with mothers' implicit and explicit responses to infant faces (Senese et al., 2018). Though evidence is still scarce, it might suggest that early care experiences with one's own mother during childhood might shape implicit attentional responses to infant cues. Differently, very scarce evidence has been provided regarding the role of the quality of paternal care (Khaleque & Rohner, 2002).

Same-sex parenting

Despite having important implications on the quality of mother-child bonding, research on attentional bias toward infant faces have been mainly confined to heteronormative samples of mothers. Up to date, there is no evidence about the attentional bias to infant faces and its potential correlates in same-sex parent families. Besides extending empirical knowledge on parenting beyond the heteronormative perspective, it should be noted that investigating the correlates of attentional bias in same-sex parent families could be advantageous both methodologically and theoretically. About the role of maternal involvement in childcare, it has been consistently evidenced that same-sex mother families share parenting more equally than do mothers and fathers within different-sex parent families (Patterson et al., 2004; 2013). This might result in individual differences in maternal involvement that are not largely defined according to the traditional parent sex roles as in different-sex couples of parents, in which mothers usually devote much time in childcare as compared to fathers.

When it comes to the contribution of the perceived quality of care during childhood, the experience of parental rejection itself might somewhat differ among sexual minorities, and they might experience more hostile behaviors from significant others possibly related to stigmatization. This topic should require greater attention, since the link between parental rejection, psychological adjustment, and personality development has proved even stronger among sexual minorities than in the general population (Ryan et al., 2009; 2010). That being said, potential variations in the attentional bias to infant faces might reflect a greater developmental exposure to poor environmental experiences in same-sex parent families. Moreover, it has been suggested that the empirical knowledge related to IPARTheory needs to be developed further to encompass LGBTQIA+ people experiences (Fuller, 2017). Despite these considerations, no research to date has investigated the role of recollected experiences of care from caregivers on the attentional bias to infant faces in same-sex mother families.

The current study

The main goal of our study is to clarify how different care experiences throughout mothers' lives (i.e., the experiences of caring for an infant, as well as the experiences of being cared for as a child) might be related to the attentional bias to infant cues in same-sex mothers. We primarily aim to i) confirm that infant faces retain more attention compared to adult faces; ii) investigate whether the attentional bias to infant versus adult faces is associated with mothers' involvement with childcare; iii) investigate whether mothers' individual variations in past experiences of care with one's own caregivers are associated with the attentional bias to infant faces. First (i), we expect that infant faces interfere with the task performance more than adult faces, slowing RTs to peripheral stimuli in Go conditions. Given that a specific attentional bias to infant distressed faces have been found in some previous research on mothers (Pearson et al., 2010; 2011a; 2011b; 2013), we might also expect to find such an effect. Secondly (ii), we expect that the attentional bias to infant versus adult faces could be related to maternal commitment in childcare. Thirdly (iii), we expect that the experience of receiving care from one's own mother during childhood would be associated with the attentional bias to infant faces in mothers. Due to the lack of previous evidence on the contribution of paternal care in this area of research, we cannot advance a priori hypotheses.

Methods

Participants

A group of N=76 mothers being in a same-sex couple participated in the study. Contact with most mothers was made through the Italian Association "*Famiglie Arcobaleno*" (i.e., an association that brings together same-sex parents in Italy), which sent an invitation to participate in the study to all its members through the mailing list. A snowball sampling was also used, such that mothers who participated in the study were asked to forward the study invitation to other same-sex mother families who might have been interested in joining the study. To be included in the study sample, i) the age of mothers' only or youngest child should range between 2 and 36 months; ii) mothers should have raised their child since birth[4]. Both members of each same-sex couple were first invited to participate in the study together. However, whilst 70 mothers (92%) participated in the experiment with their partner, 6 mothers (8%) participated alone. Only participants with complete data (*n*=73 mothers) were included in the final analyses; whilst two mothers did not complete the task, one mother was excluded from the final sample for technical issues while performing the task. The majority of participants were Italian (95.8%), but 3 of them (4.2%) were of a different nationality (i.e., German, American,

[4] Mothers who had a child from a previous heterosexual relationship were not included in the study. This criterion was substantiated by the evidence that, until recent years, Italian non-heterosexual individuals often became parents in the context of previous heterosexual relationships (e.g., Baiocco et al. 2014).

Ecuadorian). The Socio-Economic Status (SES) of mothers was calculated according to Hollingshead's (1975) criteria (Rossi, 1994). An overview of participants' characteristics is reported in Table 4. The study was approved by the ethical committee of the University of Trento and complied with the Helsinki declaration.

Table 4

Descriptive statistics of the participants' characteristics. N=number; M=mean; SD=standard deviation; %= percentage.

Variable	**N**	**M(SD) or %**
Socio-Economic Situation (SES)	73	
medium-low	4	5.5%
medium	16	22%
medium-high	31	42.5%
high	22	30%
Parent age	73	39.1 (5.7)
Nationality	73	
Italian	70	95.8%
Non-Italian	3	4.2%
Relationship with partner	73	
<5 years	10	13.6%
6-10 years	36	49.4%
11-15 years	21	28.8%
>15 years	6	8.2%
Number of children	73	
Primiparous (1 child)	63	86.3%
Multiparous (2 children)	10	13.6%
Child age (in months)	73	17.4 (11.8)
Involvement in childcare	71	43.7 (5.1)
PARQmother	73	38.8 (12.8)
PARQfather	72	46 (15.2)

Self-reports

Sociodemographic data was first collected. Mothers were asked to answer all the questions by referring to the youngest child in case of multiple children.

Parental involvement in childcare

To assess parental involvement in childcare, mothers completed 10 items (Appendix 2) adapted from the Parental primary caregiving role Structured Interview (Abraham et al., 2014). The original set of questions covered multiple caregiving domains, including parental responsibilities (e.g., take the child to the doctor), nurturing (e.g., change the diaper, prepare the bottle) and playful behaviors (e.g., tickle the child, blow on his/her belly). For this study, we considered only the questions related to parental nurturing behaviors, such as those behaviors that parents usually exhibit in daily contact with the child. Items were translated into Italian and back-translated in English by a native English speaker. To compute a total score, responses to items (1=*not at all;* 2=*rarely;* 3=*a few times a week;* 4=*About once a day*; 5=*more than once a day*) were summed, with a higher score reflecting a higher degree of maternal involvement in childcare. Cronbach's alpha was satisfactory for the scale (α = 0.81). McDonald's ω total was 0.87.

Recollected experiences of care

Mothers completed the Italian validated short-form version (Senese et al., 2016) of the Parental Acceptance-Rejection scale (PARQ) (Rohner, 2005b). According to the IPARTheory (Rohner, 2021), all interpersonal relationships with significant others are characterized by an affectional bond that falls somewhere along a continuum from acceptance to rejection. The Italian validated short-form version of PARQ consists of two scales measuring past experiences of care with one's own mother and father. Each scale, which has 24 items, originates a total maternal/paternal score (i.e., PARQmother and PARQfather) consisting of four different dimensions: (1) warmth/affection, (2) hostility/aggression, (3) indifference/neglect, and (4) undifferentiated rejection. Computing the total score (high score = more rejection), the warmth scale is reverted. Participants indicated how well each statement described their experience of perceived care using a four-point

Likert scale (from 4 = *almost always true* to 1 = *almost never true).* In this study, the two total scores had a good reliability (PARQmother α = 0.94; PARQfather α = 0.95).

Experimental task

Mothers completed a modified Go/no-Go task derived from an established paradigm (Bindemann et al., 2005) to measure attentional bias to infant and adult emotional and unemotional faces (Figure 1 in Study 1; Pearson et al., 2010; 2011a; 2011b; Dudek & Haley, 2020). A central black fixation point was presented for 745 ms. Then, the fixation point turned into green or red, signaling the Go or no-Go condition respectively. Simultaneously, two lines, one horizontal and one vertical, appeared at the periphery of the screen. Standardized images of adult and infant faces appeared behind the Go/no-Go cross during the stimulus display (245 ms). Only for Go trials, participants were asked to indicate on which side of the screen the vertical line appeared by pressing "n" (for right) or "v" (for left) on the keyboard. The screen response was aborted if no response was registered within 2000 ms. Thirty-six images (6 males; 6 females) of unfamiliar infant faces aged 4-12 months were extracted from the Tromso Infant Faces Database (TIF; Maack et al., 2017); 36 images of unfamiliar adult faces (6 males; 6 females) were taken from the Karolinska Directed Emotional Faces (KDEF; Lundqvist et al., 1998). For each identity, 3 facial expressions (happy, sad, neutral) were chosen. Whilst distressed infant faces displayed an infant actively crying, happy faces displayed a smiling expression, and neutral faces displayed no expression. An illustrative representation of the experimental stimuli can be seen in Figure 2 in Study 1. Images were cropped in an oval shape, converted into grayscale, and presented against a uniform white background. Images were matched for size using GNU Image Manipulation Program v. 2.8.22 (GIMP Development Team, 2017). Faces averaged approximately 4x5 cm and were equalized for luminance and saturation using MATLAB (The MathWorks, Natick, MA). Mothers completed a practice block of 12 trials with no images, then a block of 12 trials displaying faces in the background. Experimental trials consisted of 6 blocks of 36 trials (24 Go and 10 no-Go). The order of trials was randomized within blocks, but Go trials occurred twice as frequently as no-Go trials. The experimental conditions were fixed for each block (Palermo & Rhodes, 2003), but the block order was randomized across participants. The target line location was balanced within each block (50% on the right; 50% on the left). RTs in ms were computed from the onset of the stimulus display to the participant's response to identify the location of the target vertical line during Go trials.

Procedure

To overcome geographical barriers in recruiting the sample (i.e., same-sex mothers were from different regions of Italy), all the experimental procedures were conducted online. Self-reports were administered through Qualtrics (Qualtrics, Provo, UT). The experimental task was run on JATOS server (Lange et al., 2015). The experimental task was conducted by an experimenter during a Zoom meeting. Mothers within each couple completed the task separately during a single session, but they did in separate sessions whenever the first option was not applicable. Mothers were asked to keep their left index finger on the "v" and their right index finger on the "n" of the keyboard during the task. After explaining the instructions and solving doubts, experimenters shut down their microphone and camera but monitored participants' engagement with the task for its whole duration.

Data analysis

Paired t-tests were preliminarily run to check for potential differences within the sample. Correlation analyses were also preliminarily implemented. Missing data in self-reports was not replaced. Analyses were conducted for evaluating the number of correct answers for different blocks. The overall accuracy for Go trials was 96.6%, which confirmed the ability of participants to complete the task as instructed. The percentage of false alarms (i.e., incorrect No-Go trials) was 3.9%. Response accuracy was analyzed using a Generalized Linear Mixed-Effects Model (GLMM). RTs were analyzed via linear mixed-effects models (LMM; Bates et al., 2015); only correct trials were considered for RTs analyses. The models were performed using the lme4 (Version 1.1-28) library (Bates et al., 2015) in Rstudio (Version 4.1.1; RStudio Team, 2021). Participants' responses being too fast (below 100 ms) or longer than 1400 ms from the stimulus onset were considered outliers (0.2%) and removed. To approximate a normal distribution, RTs were transformed into logarithms, and the distribution was checked visually on the trial-, participant- and item- levels. As the distributions were approximately normal, we did not exclude any further items, participants, or trials. Face age and the emotional valence were contrast-coded, such that the intercepts reflected the grand mean of all conditions. The scores of parental involvement and PARQ were centered by subtracting the overall mean across participants. In order to disentangle the role of maternal involvement in childcare from the concomitant contribution of other experiences of care, we added the child age and parity as potential covariates in Model 2 (Table 5). However, we checked for the possible effect of those covariates also in the Model 3 and Model 4 (Appendix 2). To control for the potential co-dependences of data of mothers belonging to the same couple, we checked the results by adding the dyad (i.e., parents being in the same couple) in the models' random structures (Appendix 2). Table 5 summarizes the aims, independent variables, random effect structures, and significant results of the main models implemented.

Table 5

Overview of the main aims, independent variables, random effect structures, and significant results of the study. Effects replicated across multiple studies are reported only once.

Aims	Independent variables	Random effect structure	Results
Model 1: confirm that infant faces engage more attention (slower RTs) compared to adult faces.	Face age, emotional valence, and their interaction.	Participant, stimuli.	**Main effect of face age**: infant faces, compared to adult faces, retain more attention.
Model 2: investigate whether the attentional bias to infant faces is associated with maternal involvement in childcare.	Face age, maternal involvement, and their interaction. Child age and parity are added as covariates.	Participant, stimuli.	**Main effect of face age**: infant faces engage more attention compared to adult faces. **Two-way interaction between face age and maternal involvement in childcare**: more involved mothers are more biased, in terms of attention, toward infant versus adult faces.
Model 3: investigate whether differences in past care experiences with one's own mother (PARQmother) are associated with the attentional bias to infant faces.	Face age, PARQmother, and their interaction.	Participant, stimuli.	**Main effect of face age**: infant faces engage more attention compared to adult faces.
Model 4: investigate whether differences in past care experiences with one's own father (PARQfather) are associated with the attentional bias to infant faces.	Face age, PARQfather, and their interaction.	Participant, stimuli.	**Main effect of face** age: infant faces engage more attention compared to adult faces. **Two-way interaction between face age and PARQfather**: those mothers who felt more rejected by their own father during childhood are more biased to infant versus adult faces. No effects of PARQmother were found.

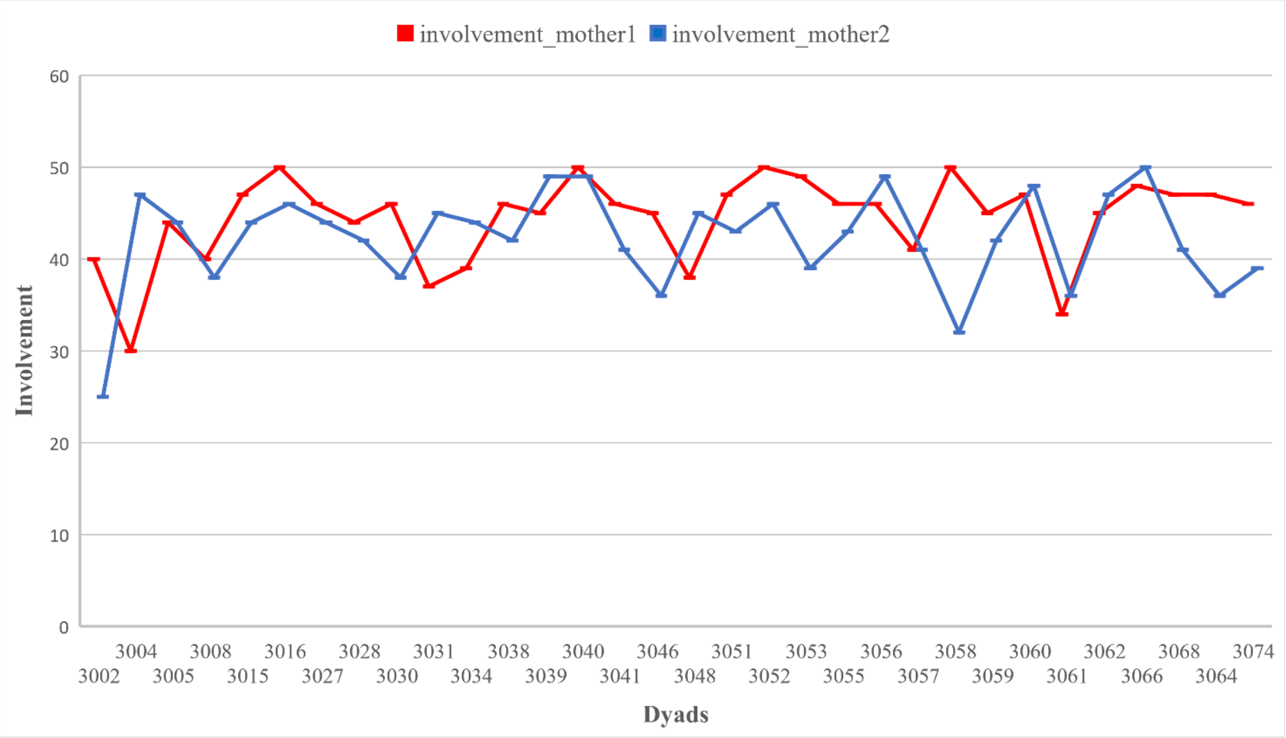
Results

Preliminary results

Mothers reported to be statistically significantly more rejected by their own fathers than by their own mothers during childhood ($t(71) = 3.49$, $p < .01$). Pearson correlation analyses did not show any statistically significant associations between parental involvement and PARQmother, nor between parental involvement and PARQfather. PARQmother and PARQfather showed a positive correlation ($r = 0.26$, $p = .03$). Figure 8 displays the division of childcare activities between the mothers in each same-sex couple; from a visual inspection of data, it seems mothers within each couple shared the childcare activities in a fairly egalitarian manner.

Figure 8

Division of childcare between the mothers in each couple. Each dyad is reported in the x axis; the amount of involvement is reported in the y axis. For each dyad, the different involvement of the two members of the couple is marked by different colors.



Main analysis

We fitted a GLMM with face age and emotional valence predicting trial-level accuracy. Due to a high level of accuracy, analyses did not yield any significant result; thus, all subsequent models used RTs as dependent variable. To investigate the first aim of this study, we implemented a LMM (Model 1; Table 5) in which face age (adult, infant) and emotional valence (happy, neutral, sad) were used as fixed terms, and their interaction was considered. The model included random intercepts for participants and experimental stimuli. Model 1 showed a main effect of face age (β = -0.015, *SE* = 0.002, t = -9.070, $p < .001$), as infants slowed RTs to a greater extent compared to adult faces. This effect remained statistically significant after increasing the complexity of the random structure by varying all the slopes (β = -0.015, *SE* = 0.004, *t* = -3.540, $p < .01$) and only the slope of the main effects (β = -0.015, *SE* = 0.004, *t* = -3.566, $p < .01$). Model 1 also evidenced a main effect of the emotional valence of expressions (β = -0.006, *SE* = 0.002, t = -3.068, p= .003), as mothers allocated greater attention to sad faces compared to happy and neutral faces. However, this effect was robust by increasing the complexity of the model structure in the subsequent models. The interaction between face age and the emotional valence was not significant. In Model 2 (Table 5), involvement with childcare was added as fixed effects in addition to face age. The interaction between the two terms were also considered. To reduce the complexity of the model, we collapsed across the expressions. Model 2 confirmed the main effect of face age, with greater attention retained by infant versus adult faces (β = -0.015, *SE* = 0.002, *t* = -8.011, $p < .001$). It highlighted a two-way interaction effect between face age and the involvement with childcare (β = -0.001, *SE* = 0.0003, t = -3.331, $p < .001$). Interestingly, more involved mothers were more biased, in terms of attention, toward infant versus adult faces (Figure 9). Child age and parity did not test significantly. In Model 3 and Model 4 (Table 5), PARQmother and PARQfather were added as fixed effects, respectively, in addition to face age. The interaction between the terms were considered. Model 3 confirmed the main effect of face age, with greater attention retained by infant versus adult faces (β = -0.015, *SE* = 0.002, *t* = -8.536, $p < .001$). The interaction effect between face age and PARQmother was not significant. Model

4 confirmed the main effect of face age (*β* = -0.015, *SE* = 0.002, *t* = -8.875, *p* < .001) and highlighted a two-way interaction between face age and PARQfather (*β* = -0.0003, *SE* = 0.0001, *t* = -2.788, *p*= .005). That is, those mothers who were more rejected by their own father were more biased, in terms of attention, by infant versus adult faces (Figure 10). Numerical values related to the effects of main models are reported in Appendix 2. The effects of the Model 3 and Model 4 stayed robust accounting for the child age and parity as covariates (Appendix 2). In addition, all the effects reported here remained stable after accounting for the dyad in the random structure of the models (Appendix 2).

Figure 9

Interaction effect between face age and maternal involvement with childcare.

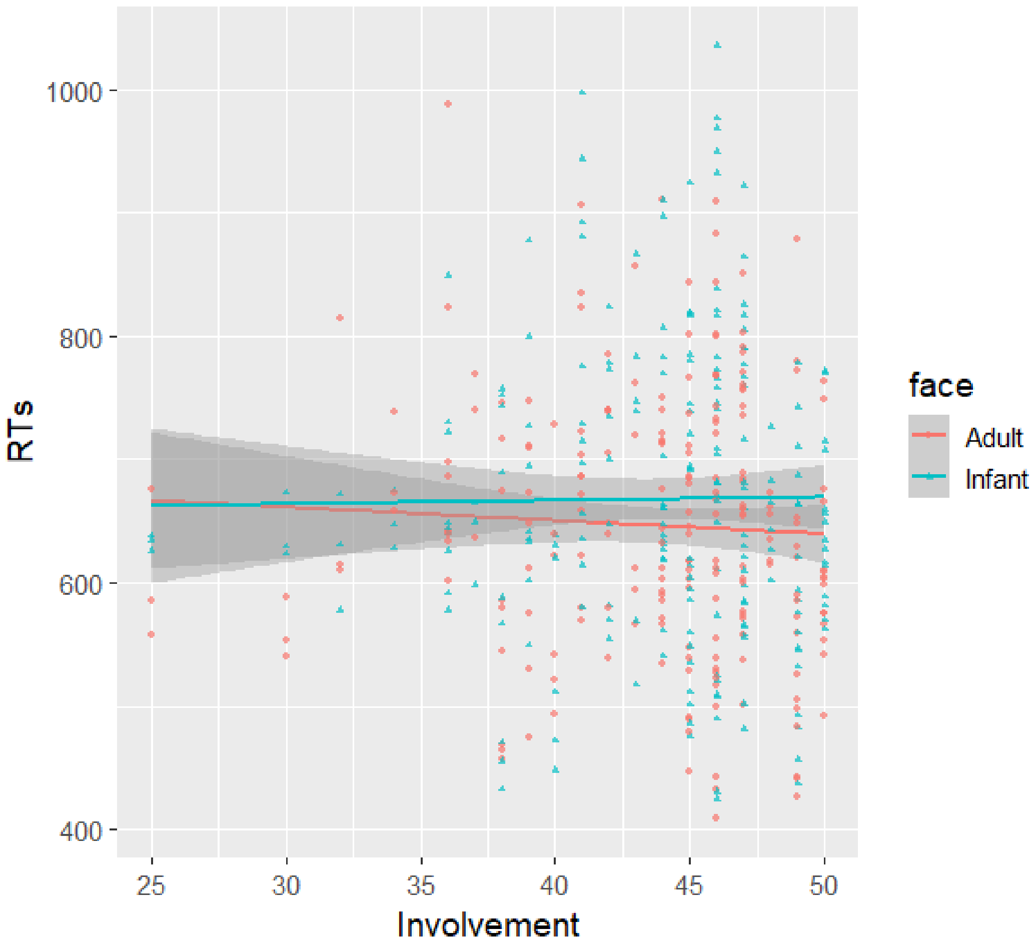
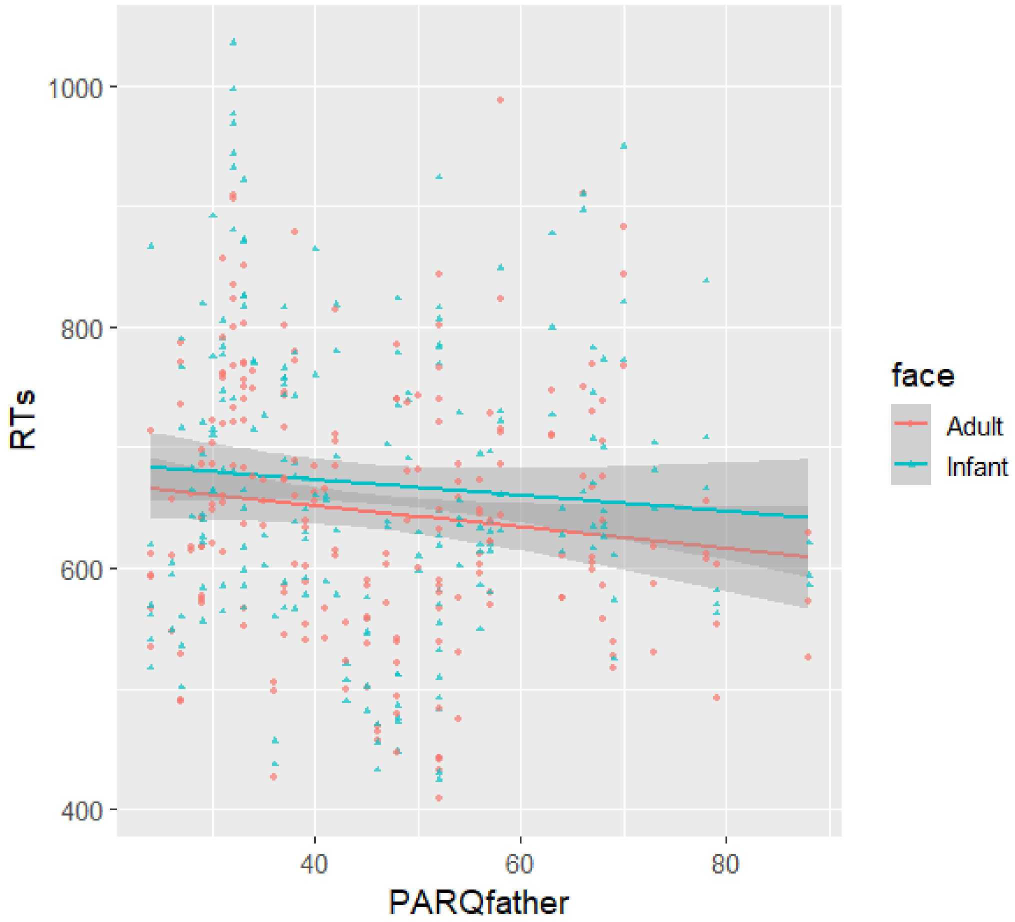


Figure 10

Interaction effect between face age and PARQfather.



Discussion

This study has sought to investigate whether an enhanced attention to infant over adult faces is associated with the past care experiences with one's own caregivers during childhood and current commitment in childcare in same sex mothers. By extending previous findings entirely based on heteronormative samples of parents, our evidence is the first one to support that the attentional prioritization of infant faces is related to the engagement with childcare in a population of mothers that is less susceptible to the traditional division of childcare (Carone & Lingiardi, 2022; Giannotti et al., 2022a). Given that the attentional bias to infant faces has been associated with the quality of mother-infant bonding in previous research (Pearson et al., 2011a; Dudek & Haley, 2020), our results might clarify potential underlying mechanisms contributing to maternal sensitivity in diverse family contexts.

Consistent with well-established evidence from previous research (e.g., Pearson et al., 2010; 2011a; 2011b; Thomson-Booth et al., 2014a; 2014b), we demonstrated that infant faces elicited more attention compared to adult faces. It has been assumed that there is an intrinsic quality of infant faces (*Baby Schema*; Lorenz, 1943) which facilitates parents' allocation of attention toward them (Oliveira et al., 2017). In an ecological perspective, an increased recruitment of attentional resources to infant cues may benefit human caregiving in parents, helping them to respond to infants' needs (Ainsworth et al., 1978). On this note, we did not expect to find any differences in the attentional bias to infant faces in same-sex mothers compared to previous evidence in heteronormative samples of mothers; however, extending previous knowledge on this field including same-sex parent families was compelling.

An interaction effect between face age and emotional valence, as it was detected in previous studies (i.e., a greater attentional bias for distressed infant faces; Pearson et al., 2010; 2011a; 2011b), was not found here. However, given that this effect was not consistently evidenced across the studies (e.g., Dudek & Haley., 2020; Oliveira et al., 2017), our results might align with the strong motivational salience attributed to all infant stimuli regardless of their facial expressions. As previously suggested (Dudek & Haley., 2020), whilst the attentional bias to infant faces might be modulated by a general preferential processing of infant faces, a neural preference reflecting face–sensitive encoding might be more specific for infant distress cues. In addition, a main effect of the emotional valence of expressions emerged in the first model, such that sad faces were associated with the longest RTs compared to other conditions; however, this effect was not confirmed in subsequent models. Overall, since infants' facial expressions might convey important information for understanding their physical and mental needs, further research should explore more in depth the role of the emotional valence of facial expressions.

We demonstrated that the attentional bias to infant versus adult faces varied in relation to maternal involvement with childcare; more involved mothers were more biased, in terms of attention, to infant versus adult faces. From a visual inspection of the data (Figure 9), it should be noted that whilst infant faces engaged mothers' attention no matter their level of involvement, maternal attention to adult faces dropped dramatically by increasing their commitment in childcare. This resulted in a greater bias to infant versus adult faces for those mothers who were more involved in childcare. The fact that we included a sample of same-sex mothers gave strength to our findings, as we ruled out socio-culturally driven differences in the division of childcare as it might occur different-sex couples (Carone & Lingiardi, 2022; Giannotti et al., 2022a). Even though previous evidence has suggested that maternal attentional bias to infant cues might established prenatally and thus partially independent of caregiving experience (Pearson et al., 2010; Dudek & Haley, 2020), here we found that maternal involvement may come into play in modulating attentional bias to infant cues postnatally, with greater involvement in childcare reflecting a greater prioritization of attention to infant over other social stimuli. As already demonstrated in those studies including samples of non-biological mothers (Grasso et al., 2009; Bick et al., 2013), a preferential elaboration of infant faces might not be limited, therefore, to biological processes; instead, it might be partially related to nurturing experiences of caregivers. It should be noted that seminal studies on this topic (Grasso et al., 2009; Bick et al., 2013; Abraham et al., 2014) adopted images or video-clips of parents' own infants as experimental stimuli. Although research on parity has demonstrated that nurturing experiences might be linked to maternal responses to unfamiliar infant cues (Maupin et al., 2019; Rutherford et al., 2019), it might be that a higher level of commitment in childcare would have even increased maternal attentional response, in terms of response times, to own infant faces. Future research should therefore adopt own-infant stimuli to see whether this argument can be corroborated empirically. Overall, our results empathized the importance of same-sex mother's involvement in childcare, which might be related to underlying cognitive mechanisms underlying maternal response to infants and ultimately linked to a positive mother–child relationship (Golombok et al., 2023).

As the measure from Abraham and colleagues' work (2014) has been considered an optimum point of reference for assessing caregiving involvement (for a review, see Giannotti et al., 2022b), we decided to extract a pool of those questions. However, we considered only the items assessing nurturing maternal behaviors on a daily basis which could be accomplished by both recognized and unrecognized parents in the Italian context[5] (Appendix 2). The same nurturing behaviors are frequently addressed in parental involvement measures (Giannotti et al., 2022b). For instance, Laflamme and colleagues (2002) investigated parents' responsibility in caregiving activities related to feeding, bathing, and dressing the child, reading to the child, and going for a walk with the child. Gettler and colleagues (2011) examined the quantity of time fathers engaged in caregiving behaviors, including feeding and bathing the child, playing with the child, and reading to the child. Despite these considerations, selected questions might have provided a circumscribed assessment of parental committed behaviors, not capturing the overall dynamics of mother-child relationships across time.

[5] In Italy, civil unions between same-sex partners were regulated, for the first time, in February 2016. However, serious gaps regarding same-sex parent families' protection and recognition still remain (Baiocco et al., 2020). For instance, the 2016 law does not recognize and protect the relationship between the child and the non-biological parent; in fact, non-biological parents are frequently not recognized as legal guardians of their child. As a result, some childcare activities can not be automatically accomplished by non-biological parents (e.g., taking the child to the doctor, taking the child to or from the daycare center). In this study, we were careful to consider only those items covering parental behaviors which could be accomplished by both recognized and unrecognized mothers.

In addition, the contribution of other components of parental involvement, such as emotional engagement with one's own child (e.g., soothing the child when they are upset), has been neglected in our study.

From the attachment theory perspective (Bowlby, 1969/1982), the intrapsychic organization of attachment influences the ways in which people process emotional information. With respect to the underlying adults' cognitive processes, this may be noticeable on the differential allocation of attention toward different types of affective and social stimuli (Edelstein & Gillath, 2008). In the present study, we unexpectedly found a statistically significant interaction between early care experiences with one's own father and the attentional bias to infant faces; those mothers who were more rejected by their own father were more biased, in terms of attention, to infant compared to adult faces. We must clarify that whilst the level of attention to faces generally decreased by increasing the level of paternal rejection, attention to adult faces dropped significantly (Figure 10). In contrast with previous evidence (Gemignani et al., 2022), this resulted in a greater bias to infant versus adult faces in those mothers who were more rejected by their own fathers. Of note, the descriptive mean of paternal rejection in our sample (*M*= 46) was greater than the ones previously reported in other studies (e.g., *M*= 38.695; Gemignani et al., 2022; *M(wave1)* = 35.81, *M(wave2)* = 34.00 and *M(wave3)* = 33.52; Putnick et al., 2015). Given that a milder level of paternal rejection was previously reported, a failure in finding such a result before might have been due, previously, to a low variance in the model estimation. On a different perspective, it should be also noted that, beyond the consideration of attentional bias as a differential measure, mothers' RTs decreased in response to all the types of faces as the level of paternal rejection increased. Thus, in line with previous evidence showing a perceptual bias toward social information in secure versus insecure mothers (Fraedrich et al., 2010; Leyh et al., 2016), our result might importantly suggest that attention to faces generally decreased in more rejected mothers.

Contrary to our hypothesis, we did not find that individual differences in the attentional prioritization of infant over adult faces were related to early care experiences with one's own mother in same-sex mothers. Compared to previous studies (Gemignani et al., 2022), it should be noted that our sample was smaller and included only women. In this study, mothers may also have had different attachment styles related to adverse care experiences. In fact, whilst anxiously attached individuals become highly sensitive and vigilant to potential threat information and devote more cognitive resources to attachment-related stimuli, avoidantly attached individuals tend to elaborate less on the emotional cues they encode (Edelstein & Gillath, 2008). So, differences in attachment styles might explain a differential deployment of attention toward social and infant cues in our sample. In addition, considering that previous evidence was based on heteronormative samples, the experience of parental rejection itself might somewhat differ among sexual minorities; so, acknowledging the fact that LGBTQIA+ people might have been underrepresented in previous research, future studies should consider the specific circumstances of their experiences (D'Amico & Julien, 2012; Fuller, 2017).

Limitations and future directions

Limitations of our study should be considered and ultimately point toward future directions. Future research might clarify the role of individual mental health as a potential covariate in relation to our findings (e.g., Pearson et al., 2010). In non-heterosexual identities, the role of perceived stigma should also require greater attention (Crouch et al., 2014; Baiocco et al., 2015). Moreover, different routes to parenthood for same-sex mothers have not been analyzed in this study; indeed, this might expose a great variability to our conclusion. On this note, we collected the information regarding the type of relation that mother had which the child, such that mothers could pick one of the following options (i.e., biological parent, adoptive parent, step-parent, foster parent, non-biological parent recognized at birth, prefer not to say, other) or self-define themselves in the text entry. We refrained from asking further information about the conception of the child, as this may have added vulnerability to our sample (Wells, & Lang, 2016), and it was not one of the main objectives of our study. Overall, given the wide variability of the information we obtained[6], we decided that it would not be appropriate to dichotomize the variable into distinctive categories (e.g., biological versus non-biological parents). However, future research could focus on this topic embracing the complexity of different types of mother-child relationships, paying much attention to the new reproductive options (Golombok et al., 2023). Importantly, investigating the role of biological relatedness with the child might strengthen the idea that biological processes might explain only partially maternal responsiveness to infant cues, and that maternal involvement is important for the mother-infant bonding, besides the experience of pregnancy and birth (Golombok et al., 2023). Another difficulty in this field is that same-sex parent samples mainly involve Caucasian individuals with a high or medium-high socio-economic status, as they need to afford the often-expensive medical treatments to become parents. On this note, the possibility to achieve parenthood can be considered a privilege only for those who can afford that. Further research should consider less visible parents (e.g., transgender parents) and parents with different characteristics in terms of ethnic groups and social classes.

By adopting longitudinal designs, further research is also needed to establish the direction of the associations found in this study. With respect to the parental involvement measure, researchers should be warned that answers about the childcare activities provided by same-sex mothers may be biased by structural barriers (i.e., laws and policies) which might be present in the different countries for same-sex parents. In addition, further studies with a larger number of study participants should investigate the expected unifactorial structure of the items selected in our study, in order to ascertain whether the measure adopted might be reliable for assessing the construct of parental involvement. On this note, a larger sample size would also allow researchers to explore the possible dependencies

[6] In Italy, same-sex couples of women cannot access any forms of assisted reproduction or adoption. Most children in same-sex mother families are conceived through medically assisted procreation (*Procreazione Medicalmente Assistita,* PMA) techniques, which can be accomplished abroad (e.g., Netherlands, Denmark, Spain). Across different countries, multiple types of conception are accessible for same-sex intended mothers. In line with this heterogeneity, in this study, a considerable number of mothers defined themselves with labels not uniquely related to one of the options given. For instance, some mothers reported to be the birthing (gestational) but not the genetic mothers, or the other way around (i.e., see the ROPA; Reception of Oocytes from Partner treatment). For some mothers, whether this situation occurred or not was not clear by the answer given.

of data from mothers being in a couple by implementing more complex statistical models, such as the Actor–Partner Interdependence Model (APIM; Cook & Kenny, 2005). In addition to this, as different experiences of care might be related to different attachment styles in adults, further studies might benefit from a combination of measures relating to both IPARTheory (Rohner, 2021) and Attachment Theory (Bowlby, 1969/1982).

Eventually, we are aware that parenthood is a complex phenomenon, and multiple factors might contribute to caregiving differences above and beyond cognitive variations related to attention; therefore, it is essential to examine whether the attentional bias to infant cues might constitute an early determinant of maternal sensitivity in different family forms, in order to ultimately promote sensitive maternal behaviors and the child development across the families.

Conclusion

In a considerable sample of same-sex mothers, we examined, for the first time, the contribution of past and current experiences of care on the attentional bias toward infant faces. Taken together, mental representations of care built during childhood and direct commitment in childcare were associated with same-sex mothers' attentional bias toward infant faces. Apart from having a value on its own, inclusive research of different family contexts is needed conceptually and methodologically; this might allow researchers to consider different parental roles and arrangements as compared to the traditional ones (Carone & Lingiardi, 2022). Overall, psychological research needs to embrace the complexity of nowadays plural family models, socializing the idea that there are different ways of conceiving and understanding parenting (Monaco & Nothdurfter, 2023). On this note, this work represents an opportunity to extend previous knowledge confined to different-sex parents. Importantly, when it comes to child development, a quantitative synthesis consistently indicated positive outcomes for children raised by same-sex families (Fedewa et al., 2015); however, perceived social stigma has been found to negatively interfere with child adjustment (Bos & van Balen, 2008;

Golombok et al., 2018). Therefore, we crucially point to the need of framing research on same-sex parent families on accurate and robust empirical findings to inform social policy aimed at reducing social stigma and promoting the families’ well-being.

Study 3: The role of early experiences of care from caregivers in adults' responses to infant faces: an EEG study grounded in the Interpersonal Parental Acceptance–Rejection Theory[7]

Introduction

The Interpersonal Acceptance-Rejection Theory (IPARTheory; Rohner, 2021) posits that the feeling of being cared for by significant others is a fundamental human need associated with many positive developmental outcomes regarding individuals' mental and physical health. In this framework, the perceived quality of care during childhood has been linked to the development of mental representations, similar to Internal Working Models (IWM) (Bowlby, 1969/1982), which guide adults' behaviors in different contexts and relationships (Rohner et al., 2012). Crucially, the feeling of being rejected from one's own caregivers has been associated with the development of cognitive distortions about themselves and the relationships with the others, which tend to extend from childhood into adulthood in absence of any counter experiences (Ripoll-Núñez & Carrillo, 2016). Generally, an appropriate perception and interpretation of infant cues has been consistently related to a secure attachment history of individuals (e.g., see van IJzendoorn, 1995). However, in the theoretical framework of the IPARTheory (Rohner et al., 2012), whether the perceived quality of care

[7] This chapter is based on the following works:

- "*Response to infant faces in young adults with adverse caregiving experiences: an EEG study grounded in the interpersonal parental acceptance–rejection theory*", which is currently Under Review. The study has been conducted in collaboration with Prof. Simona de Falco (Department of Psychology and Cognitive Sciences, University of Trento).

- "*Moving beyond adults' sex as a predictor: an investigation of gender roles on the EEG responses to infant faces in young adults*", which is currently in preparation. The study has been conducted in collaboration with Prof. Simona de Falco (Department of Psychology and Cognitive Sciences, University of Trento).

from one's own caregivers during childhood might modulate adults' responses to infant cues has been poorly investigated.

ERP responses to faces

Emotion Recognition tasks have been used to investigate individuals' differences in the Evoked Response Potentials (ERPs) in response to infant faces (Vuoriainen et al., 2022). ERP studies on this topic have focused on the N170, P300 and Late Positive Potential (LPP) waveforms (Vuoriainen et al., 2022). The N170, peaking at around 170 milliseconds (ms) after the stimulus onset at temporal-occipital electrode sites, has been described as reflecting the perceptual processing and structural encoding of facial features (Eimer, 2011). The LPP and P300 components, which are positive deflections beginning at around 300 ms after the stimulus onset, mainly at parietal/centroparietal regions, have been strictly related to individuals' attentional processes for motivationally salient stimuli (Hajcak & Foti, 2020). The amplitude in microvolts (mv) of these components might vary depending on the experimental manipulation, providing an index of variability in strength and cognitive resources required for a stimulus detection. It has been demonstrated that infant compared to adult faces elicit larger components, in terms of amplitude, at both early (N170) and later (P300/LPP[8]) stages of face processing (Kuzava et al., 2020; Vuoriainen et al., 2022). Distressed infant faces have been found to elicit the strongest N170 response in some studies (Proverbio et al., 2006; Rodrigo et al., 2011; Doi & Shinohara, 2012; Peltola et al., 2014; Dudek & Haley, 2020); however, other research failed to find a modulation of the emotional valence of faces (Malak et al., 2015; Maupin et al., 2019; Rutherford et al., 2017a; Rutherford et al., 2017b). A larger P300/LPP amplitude have been found in response to personally significant faces, such as own child's faces (Grasso et al., 2009; Weisman et al., 2012; Bick et al., 2013), own child's crying faces (Doi & Shinohara, 2012), and romantic partners' faces (Guerra et al., 2012). In addition, the P300/LPP amplitudes have been

[8] Given that the nomenclature used in different studies did not uniformly conform to separate definitions of the P300 and LPP waves, these components have been discussed interchangeably (i.e., in terms of a P300/LPP complex) in a recent meta-analysis on the topic (Vuoriainen et al., 2022).

consistently found to be modulated by the emotional valence of the stimuli, being generally larger in response to emotional versus neutral faces (Schupp et al., 2004; Olofsson et al., 2008).

The contribution of early experiences of care

In the framework of the Attachment Theory (Bowlby, 1969/1982), attachment representations of adults have been related to the N170 and P300/LPP amplitudes in response to infant faces (Fraedrich et al., 2010; Leyh et al., 2016; Groh & Haydon, 2018; Lowell et al., 2023). Fraedrich and colleagues (2010) found that insecure compared to the secure mothers showed a more negative N170 amplitude in response to infant faces, independently of the emotional valence of faces (Fraedrich et al., 2010). Differently, secure mothers showed a larger P300 response to infant faces (Fraedrich et al., 2010). Similarly, Leyh and colleagues (2016) demonstrated that insecure mothers exhibited a more negative N170 amplitude in response to infant negative facial expressions than secure mothers. An increased P300 amplitude to infant emotional faces was found in secure versus insecure mothers (Leyh et al., 2016); in addition, secure mothers detected more clearly, at the behavioral level, infants' emotional expressions (Leyh et al., 2016). Groh and Haydon (2018) differently demonstrated that secure mothers showed an attenuated P300 amplitude in response to their own distressed infant faces; however, in line with previous evidence, they were more accurate in identifying infants' distress cues at the behavioral level (Groh & Haydon, 2018). Lowell and colleagues (2023) did not find any effects of the attachment classification on the P300 amplitude in response to infant faces in mothers. To the best of our knowledge, only one study (Ma et al., 2017) has been conducted in a sample of non-parents. Ma and colleagues (2017) found that anxiously attached women, compared to avoidantly attached women, exhibited a larger N170 amplitude in response to infant faces. Securely attached women showed a larger P300 amplitude, than avoidantly attached women, to infant faces. They also exhibited shorter RTs, compared to anxiously and avoidantly attached women, in recognizing infants' expressions (Ma et al., 2017). Consistent with an efficiency model of the interpretation of ERPs (e.g., Lowell et al., 2023), it might be overall more demanding for insecure individuals to process structural features of infant faces, as they showed a larger N170 amplitude response to infant faces. This evidence might be complemented, at the behavioral level, by lower accuracies and longer response times in recognizing facial expressions. Differently, results on the later stages of processing (i.e., P300/LPP amplitude) have been mixed. However, all the studies so far (Fraedrich et al., 2010; Leyh et al., 2016; Ma et al., 2017; Groh & Haydon, 2018; Lowell et al., 2023) included only women. Moreover, in the theoretical context of IPARTheory, no research to date has examined the relationship between the perceived quality of parental care during childhood and the N170 and P300/LPP amplitudes in response to infant faces.

Sex differences

Beyond the contribution of past experiences of care, ERP research has highlighted sex differences in the adults' ERP response of infant cues (Kuzava et al., 2020). Whilst findings have been generally equivocal (e.g., see Hahn et al., 2016), some evidence has suggested that women showed a stronger differential response to infant faces than men do, especially at the early stages of infant face processing (Proverbio et al., 2006; Colasante et al., 2017; Jia et al., 2021). For instance, Proverbio and colleagues (2006) demonstrated that mothers, compared to fathers, had an advantage in the perceptual processing of infant faces at the N170 stage of processing (Proverbio et al., 2006). Jia and colleagues (2021) demonstrated that the N170 amplitude in response to infant sad expressions was larger, in the left hemisphere, in women than in men. However, because of scarcity of ERP studies on this topic including men, a recent meta-analysis (Kuzava et al., 2020) was not able to not ascertain whether sex was a significant moderator of the adults' N170 response to infant faces. All in all, sex has been described as a salient feature in infant face recognition, but the results are still unclear.

In this regard, it should be noted that sex have been mostly assessed as a binary variable in previous research (i.e., with the only possible responses: woman/man or female/male), although it is not (Ansara & Hegarty, 2014; Hyde et al., 2019). Additionally, in the study methods, it has been rarely defined what was meant by sex or gender and how they were measured (Lindqvist et al., 2021). To move beyond the biological essentialism of studies considering only individuals' sex as predictor, as well as to overcome the sex/gender dichotomy (Bem, 1995), recent research has suggested operationalizing more clearly the variables measured and considering different layers of individual sexual identities. In particular, it has been recently suggested to consider important aspects of individuals' social gender, such as gender roles and norms[9], since they might have erroneously neglected and thus conflated with sex in previous research (Lindqvist et al., 2021). On this note, the variability explained by sex and gender roles in the adults' ERP responses to infant cues needs to be still disentangled. Key to this exploratory investigation would be the argument that differences between males and females in the response to infant stimuli might not be only biologically determined, but instead reinforced by societal norms.

The present study

In a mixed sample of non-parent adults, we primarily aimed to investigate whether the perceived quality of maternal and paternal care was associated with the N170 and LPP[10] amplitudes to emotional and unemotional infant and adult faces. In addition, we explored whether sex differences occurred in modulating these relationships. Since we implemented an active EEG task paradigm for this study, both behavioral and neurophysiological data were considered. At the behavioral level, we expected that adults who felt more rejected during childhood showed longer RTs and lower levels of accuracy in recognizing emotional faces. At the neurophysiological level, we expected that i) infant compared to adult faces elicited a larger N170 amplitude; ii) LPP amplitude was larger in response to emotional

[9] Gender norms (Eagly, 1987) have been described to provide the scripts for performing individuals' own gender. In particular, Bem (1974; 1995) operationalized gender roles related to femininity and masculinity as two independent dimensions, stemming from internalized sex-typed social standards of desirability (e.g., femininity is associated with warm and gentle behaviors, whereas masculinity is linked to strong and ambitious personalities).

[10]Since the P300 was mostly evidenced in oddball task paradigms (e.g., Fraedrich et al., 2010; Leyh et al., 2016), we referred to our target component as LPP, given that our task consisted in an equal frequency of presentation of different stimuli.

versus neutral faces; iii) adults who felt more rejected during childhood showed a larger N170 amplitude to infant faces.

Beyond the main objectives of this study, based on the previous literature on the topic suggesting a female advantage at the N170 stage of infant face processing (Proverbio et al, 2006; Jia et al., 2021), we aimed to investigate sex difference in the adults' N170 response to infant faces in light of the contribution of individuals' gender roles. This step was performed as an additional and exploratory analysis.

Methods

Participants

We recruited *N*=64 (*n*=31 males; *n*=33 females) non-parent adults to participate in this study. Participants were mainly undergraduate students from the University of Trento, recruited through posting on social media (i.e., Facebook, Instagram, Telegram). The sample size was consistent with previous research on the topic (i.e., *N*=65 Weisman et al., 2012; *N*=63 Rutherford et al., 2017c; *N*=59 Lowell et al., 2023; *N*=63 Rutherford et al., 2021; *N*=68 Peoples et al., 2022). To be included in the final sample, participants should report i) to have no prior history of neurological or psychiatric disorders and to be free from any psychotropic medication; ii) to have a normal or correct-to-normal vision; iii) to be over 18 years of age and Italian native speakers; iv) to have no children or any daily contact with children. In total, *n*=3 participants were excluded from the final sample based on these criteria. One additional participant was excluded for their age. The final sample was composed by *n*=60 non-parents (*n*=30 males; *n*=30 females). Six out of 60 participants (10%) were left-handed. Whilst 27 participants (45%) reported to have a normal vision, 33 of them (55%) reported to have a corrected-to-normal vision. A broader overview of study participants is reported in Table 6. The study was conducted in accordance with the Declaration of Helsinki. The ethics committee of the University of Trento approved this study. All participants signed the informed consent before participating

Table 6

Characteristics of study participants grouped by sex; N=number; M=mean; %= Percentage; SD=standard deviations.

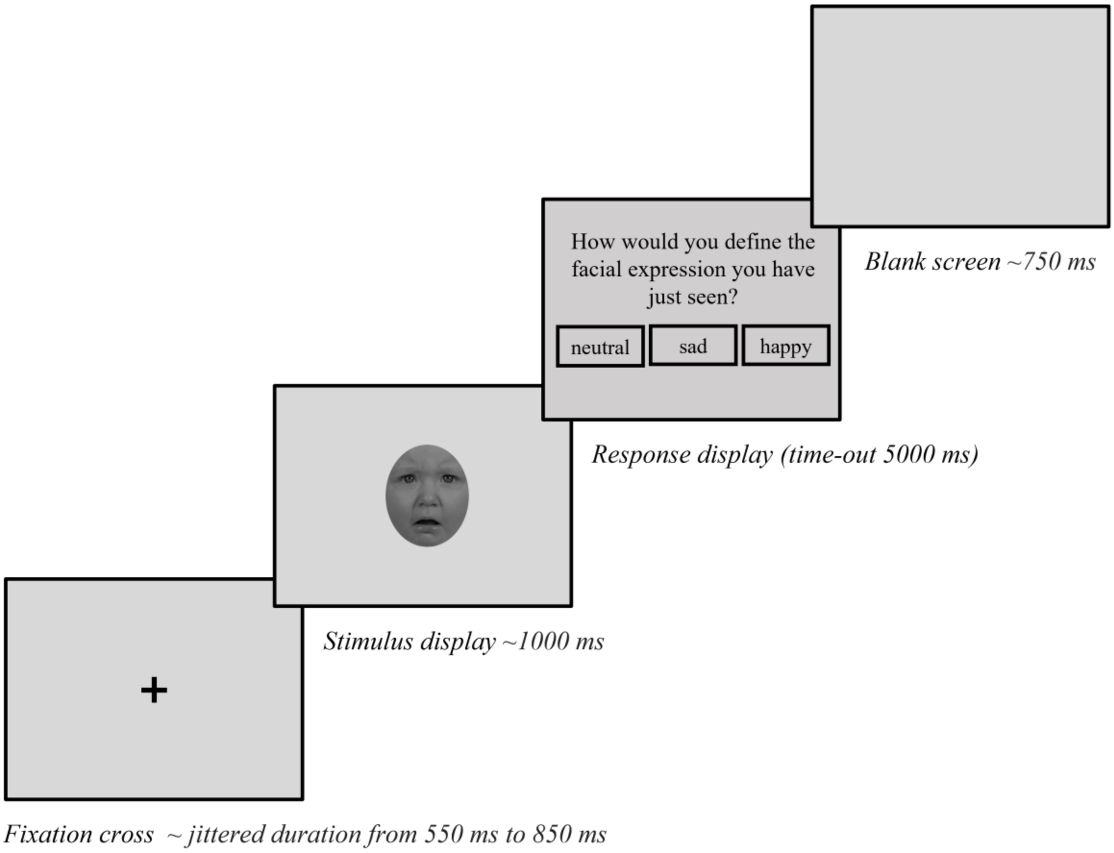
	Females (N=30; 50%)		Males (N=30; 50%)	
Group or variable	**N**	**M (SD) or %**	**N**	**M (SD) or %**
Nationality	30		30	50%
Italian	28	93%	30	
Non-Italian	2	7%	30	100%
Education	30		30	
Middle School	0	0%	1	3.5%
High School	18	60%	13	43.5%
Bachelor's Degree	8	27%	10	33%
Master's Degree	3	10%	3	10%
Postgraduate/Doctorate	1	3%	3	10%
Age	30	22 (3.0)	30	23.2 (3.2)
PARQmother	30	40.4 (12.4)	30	36.3 (7.5)
PARQfather	30	44.6 (16.1)	30	43.9 (10.5)
Femininity	30	54.1 (7.1)	30	45.5 (10.7)
Masculinity	30	46.0 (6.8)	30	45.1 (7.6)

Experimental task and stimuli

In the EEG laboratory, participants were first asked to complete a brief questionnaire collecting some demographic information and handedness. They were sited in a dimly lit room and performed an Emotion Recognition Task (Figure 11) in which they were asked to evaluate infant and adult faces displaying three different facial expressions (happy, neutral, sad). The task was developed using OpenSesame Software (Mathôt et al., 2012). Each trial started with the presentation of a fixation cross at the center of the screen with a jittered duration of 550-850 ms. A stimulus display was then presented for 1000 ms, followed by a response display until participants' response (time-out 5000 ms), and a blank screen for 750 ms. Participants were asked to i) be as accurate as possible; ii) minimize eye or body movements during the recording; iii) put their index, middle and ring fingers of the preferred hand on the "c" or "v" or "b" keys on the keyboard. In addition, participants were instructed to look at each face and, only after its offset, to indicate whether the face expressed a happy, neutral, or sad expression. The match between responses ("happy" or "neutral" or "sad") and the keys in the keyboard ("c" or "v" or "b") were randomly assigned for each participant. Standardized experimental stimuli included 36 images (6 male infant; 6 female infant) of unfamiliar infant faces aged 4-12 months extracted from the Tromso Infant Faces Database (TIF; Maack et al., 2017) and 36 images of unfamiliar adult faces (6 males; 6 females) taken from the Karolinska Directed Emotional Faces (KDEF; Lundqvist et al., 1998). An example of the experimental stimuli used can be seen in Figure 2 (Study 1). The stimuli were cropped into an oval shape, converted into gray scale and matched for size and luminance using Photoshop. They were presented against a uniform gray background. Participants completed a practice block of 8 trials, then 4 test blocks of 72 trials. A self-paced break followed each block. Trial order was randomized within each block. Type of faces was balanced within the block. The completion of the task took around 16 minutes.

Figure 11

An example of a trial structure in the Emotion Recognition task.



EEG acquisition and pre-processing

A continuous EEG activity was recorded using an eego sports system (ANTNeuro) at a sampling frequency of 1000 Hz, from 64 Ag/AgCl shielded electrodes referenced to CPz and placed in the standard 10-10 locations on an elastic cap (Brain Products). An additional electrode (Electrooculogram, EOG) was placed under the left eye. Impedance was kept under 20 kΩ. Data pre-processing was performed with the MATLAB toolboxes EEGLAB v2022.0 (Delorme & Makeig, 2004) and ERPLAB (Lopez-Calderon & Luck, 2014). EEG data was re-referenced offline to the average of electrodes; mastoids and EOG were excluded. EEG data was band-pass filtered, with cutoffs of 0.1 and 30 Hz. Epochs were segmented for each trial, starting from -1000 ms to 2000 ms from the stimulus onset. Baseline correction from -1000 ms was performed. For one participant, one channel was classified as bad (F8) and interpolated. Artifacts were rejected by eye inspection.

Independent Component Analysis (ICA; RUNICA algorithm) was performed to remove noise components from the signal (e.g., eye-blinks); ICA components were visually inspected and selected for deletion only when their topography clearly indicated a source of noise. The IClabel tool (Pion-Tonachini et al., 2019) was also used for this purpose. After excluding incorrect trials, accepted epochs were averaged for each condition (*N*=44.5 trials for adult happy condition; *N*=44.8 for adult neutral condition; *N*=44.2 for adult negative condition; *N*=45.1 for infant happy condition; *N*=44.8 for infant neutral condition; *N*=44.9 for infant sad condition). ERPs were then computed for each condition, only for correct trials, in discrete time windows and electrode groups. The N170 component was defined as the average activity in a 170- to 230-ms time window following stimulus onset and it was averaged across the parieto-occipital electrodes P7, P8, P07, P08. The LPP component was defined as the mean activity in a 300- to 700-ms time window over the parietal electrodes PZ, P1, P2, POZ, PO3, PO4, which showed the most prominent waveform (e.g., Peltola et al., 2014; 2018). The LPP activity over a different group of centro-parietal electrodes was computed and checked (e.g., see Kuzava et al., 2019); however, the overall activity resulted to be less prominent compared to the other (see Appendix 3).The N170 and LPP amplitudes entered statistical models after being averaged across groups of channels and time windows.

Self-reports

Self-reports were completed through Qualtrics (Qualtrics, Provo, UT). A socio-demographic questionnaire built ad-hoc was used to collect basic information of participants, i.e., sex, gender, age, education level, and occupation.

Parental Acceptance-Rejection scale

Participants completed the Italian validated short-form version (Senese et al., 2016) of the Parental Acceptance-Rejection scale (PARQ; Rohner, 2005b), which consists of two scales measuring the perceived past experiences of care with one's own mother and father. Each scale, which has 24 items, originates a total maternal/paternal score consisting of four dimensions: (1)

warmth/affection (e.g., *My [mother/father] makes me feel wanted and needed*); (2) hostility/aggression (e.g., *My [mother/father] treated me harshly*); (3) indifference/neglect (e.g., *My [mother/father] paid no attention to me as long as I did nothing to bother them*); and (4) undifferentiated rejection (e.g., *My [mother/father] saw me as a big nuisance*). Participants indicated how well each statement described their past experience using a four-point Likert scale (from 4 = *almost always true* to 1 = *almost never true*). Higher scores of the scale reflect more maternal or paternal rejection. In this study, the two total scores had good reliability: PARQmother α=0.91; PARQfather α=0.93.

Bem Sex-Role Inventory

The Bem Sex-Role Inventory (BSRI; Bem, 1974) was translated into Italian and used to measure gender roles related to femininity (e.g., "*tender*", "*emotional*") and masculinity (e.g., "*competitive*"). The items assess gender roles in terms of personality traits and stereotypical behaviors associated to femininity and masculinity, scored in a continuous but not mutually exclusive manner. Another scale including gender-neutral adjectives is assessed. Participants were required to rate how well each adjective described their own personality on a scale from 1 to 7. Despite administering the entire scale, to compute the scoring of the scales, we used the same items as the ones adopted in Salvati and colleagues (2016). The gender-neutral scale was not used here. In total, 10 adjectives for femininity and 10 adjectives for masculinity were summed. For the femininity scale, one item (i.e., "gentle"[11]) negatively correlated with the others; therefore, it was removed from the final scoring. After that, the two total scores had satisfactory reliability: Masculinity α=0.76; Femininity α=0.89.

Data Analysis

All statistical analyses were performed with R studio 2022.12.0. Preliminary comparisons between males and females were tested through two-tailed independent-sample t-tests. Inaccurate

[11] We translated the word "gentle" using the Italian adjective "mite". Since this characteristic might be either a feminine or a masculine trait in our social context, it might not fit well with the other adjectives related to feminine traits.

trials and outlying RTs (>3 *SD*) were removed. Linear mixed-effects models (LMM; Bates et al., 2015) were implemented to account for the distinctive contribution of face age (infant, adult), emotional valence (happy, neutral, sad), sex (male, female), PARQmother and PARQfather on the behavioral (RTs, accuracy) and neurophysiological (N170, LPP) measures. The models included random intercepts for participants. The interactions between fixed terms were considered. Of note, sex was considered as a factor with only two levels, i.e., "*males*"; "*females*", since no other responses were given by participants in this study[12]. PARQmother and PARQfather were centered by subtracting the mean value across participants and tested in distinctive models. Therefore, we adopted a more differentiated approach, to investigate the effects of the perceived care from one's own caregivers separately; in addition, we tried to avoid the possible collinearity between the two scales. Effects were checked using the Type III Analysis of Variance with Satterthwaite's method. The interactions between fixed terms were considered up to three ways. A summary of the models and main results is reported in Table 10, displayed at the end of the results' section. The numerical values related to all the models are reported in Appendix 3. In addition to the main analysis, we added a further step to exploratorily investigate the contribution of sex and gender norms on the N170 amplitude in the adults' response to infant cues. For this aim, a full model was specified accounting for both sex and gender roles related to femininity and masculinity (Appendix 3). The interactions between the terms were retained in the model only in the cases in which their exclusion would determine a significant decrease in goodness-of-fit. For this purpose, the function used in R studio was drop1 (https://bbolker.github.io/mixedmodels-misc/glmmFAQ.html). The specification of the model can be inspected in Appendix 3

[12] Of note, sex assigned at birth was asked to participants using a multiple-choice question with the possible response options: *male*; *female*; *intersex*. Differently, participants' gender was asked using a multiple-choice question with the possible response options: *woman*; *man*; *transgender*; *genderqueer*; *other (with possible specification)*. Accordingly, given that many scholars have already raised the importance of updating socio-demographic questions on sex and gender to go beyond the binary conceptualization of those constructs (Ansara & Hegarty, 2014; Broussard et al., 2018; Fraser, 2018; Hughes et al., 2016; Hyde et al., 2019; Magliozzi et al., 2016; Lindqvist et al., 2021), we strived to align with that line of research by including different options.

Results

Preliminary results

No statistically significant differences emerged in terms of age, PARQmother, PARQfather, or masculinity scores between males and females. Females displayed higher scores in femininity as compared to males ($t(58) = 4.1$, $p < .001$). PARQmother and PARQfather showed a positive correlation ($r(58) = 0.55$, $p < .001$).

Behavioral Data

From the final sample of participants (*N*=60), *N*=55 non-parents were included in the behavioral analyses; *n*=5 participants were excluded due to a considerably low level of accuracy (i.e. less than 50% of correct trials in at least one experimental block). Overall, the accuracy level among participants was high (90%), suggesting that the task was completed as instructed. Descriptive values of RTs and Accuracy in the different experimental conditions are reported in Table 7.

Table 7

Mean RTs (SD) and Accuracy (SD) as a function of the different experimental conditions.

Conditions	RTs (SD)	Accuracy (SD)
Infant happy	464.0 (172.5)	0.9 (0.1)
Infant neutral	529.0 (202.3)	0.8 (0.1)
Infant sad	4.63.7 (165.1)	0.9 (0.1)
Adult happy	442.9 (165.0)	1.0 (0.1)
Adult neutral	468.2 (169.6)	0.9 (0.1)
Adult sad	475.1 (170.2)	0.9 (0.1)

Reaction Times (RTs)

A LMM with face age, emotional valence, sex, and PARQmother as independent variables was first performed. The model evidenced a main effect of face age ($F(1,255) = 12.1$, $p < .001$) and emotional valence ($F(2,255) = 15.8$, $p < .001$). A significant interaction between face age and emotional valence also emerged (*F*(2,255) = 10.7, *p* < .001). Post-hoc comparisons revealed that participants had slower RTs in categorizing infant compared to adult faces (adult vs. infant; *t*(54) =-6.0, *p* < .001), and neutral compared to happy (neutral vs. happy; *t*(54) = 4.6, *p* < .001) and sad faces (sad vs. neutral; *t*(108) = -2.9, *p* = .01). Neutral infant faces were associated with slower RTs as compared to all the other conditions (*ps* <. 001). In addition, a significant effect of PARQmother emerged (*F*(1,51) = 8.1, *p* < .01); participants who felt more rejected by their own mother during childhood were overall slower in performing the task. A significant interaction between PARQmother and sex was detected (*F*(1,51) = 4.2, *p* = .04); males who felt more rejected by their own mothers, compared to females, displayed a greater increase of RTs in response to all faces. Another LMM with the face age, emotional valence, sex, and PARQfather as independent variables was performed. The model confirmed the same effects found before. The main effect of PARQfather only approached statistical significance (*F*(1,51) = 3.2, *p* = .08).

Accuracy

A LMM with face age, emotional valence, sex, and PARQmother as independent variables was first performed. The model evidenced the main effects of face age (*F*(1,255) = 86.5, *p* < .001), emotional valence (*F*(2,255) = 24.3, *p* < .001), as well as an interaction between face age and emotional valence (*F*(2,255) = 34.1, *p* < .001). In particular, participants were more accurate in categorizing facial expressions of adult than infant faces (adult vs. infant; *t*(54) = 13.0, *p* < .001), and in detecting happy (sad vs. neutral; *t*(108) = 5.1, *p* < .001) and sad (neutral vs. positive; *t*(108) = -5.3, *p* < .001) versus neutral facial expressions. The worst performance, in terms of accuracy, was related to the categorization of infant neutral faces (all contrasts with the other conditions were significant; *ps* < .001). Statistically significant differences also emerged between the level of accuracy in recognizing sad versus happy infant faces (*t*(197) = 3.3, *p* = .02), sad versus happy adult faces (*t*(197) = -3.7, *p* < .01), and neutral adult versus happy infant faces (*t*(184) = 3.5, *p* < .01). Significant main effects of PARQmother (*F*(1,51) = 5.3, *p* = .03) and sex (*F*(1,51) = 7.0, *p* = .01) also emerged.

That is, non-parents who felt more rejected by their own mother were less accurate in performing the task; in addition, females were more accurate than males. Statistically significant interactions between PARQmother and emotional valence ($F(2,255) = 14.6$, $p < .001$) and between emotional valence and sex ($F(2,255) = 4.7$, $p < .01$) were found. A three-way statistically significant interaction between PARQmother, emotional valence and sex ($F(2,255) = 8.3$, $p < .001$) emerged; males who were more rejected by their own mother, compared to females, had a greater decrease in terms of accuracy in categorizing sad and happy versus neutral facial expressions. Another LMM with the type of face, expression, sex, and PARQfather as independent variables was performed. The model confirmed the effects found before. The main effect of PARQfather was not statistically significant.

Event-Related Potentials (ERPs)

From the final sample (*N*=60), *N*=56 non-parents were included in the ERP analyses; *n*=4 participants were excluded due to excessive artifacts in the EEG data (>30% of trials; *n*=2) or technical problems in the signal acquisition (*n*=2). The mean amplitude values of the N170 and LPP components (Table 8, Table 9) and the Grand Average waveforms (Figure 12, Figure 13) are below.

Table 8

Mean N170 amplitude (SD) as a function of the different experimental conditions.

Conditions	N170 amplitude (SD)
Infant happy	-1.6 (4.2)
Infant neutral	-1.6 (4.3)
Infant sad	-1.6 (4.3)
Adult happy	-1.1 (4.0)
Adult neutral	-0.8 (4.0)
Adult sad	-1.1 (4.1)

Table 9

Mean LPP amplitude (SD) as a function of the different experimental conditions.

Conditions	LPP amplitude (SD)
Infant happy	4.0 (2.5)
Infant neutral	3.8 (2.6)
Infant sad	4.4 (2.7)
Adult happy	3.8 (2.3)
Adult neutral	4.3 (2.5)
Adult sad	4.3 (2.4)

Figure 12

Grand-averaged N170 component in response to all conditions. Amplitude (mv) is reported in the y axis. Latency (ms) is reported in the x axis.

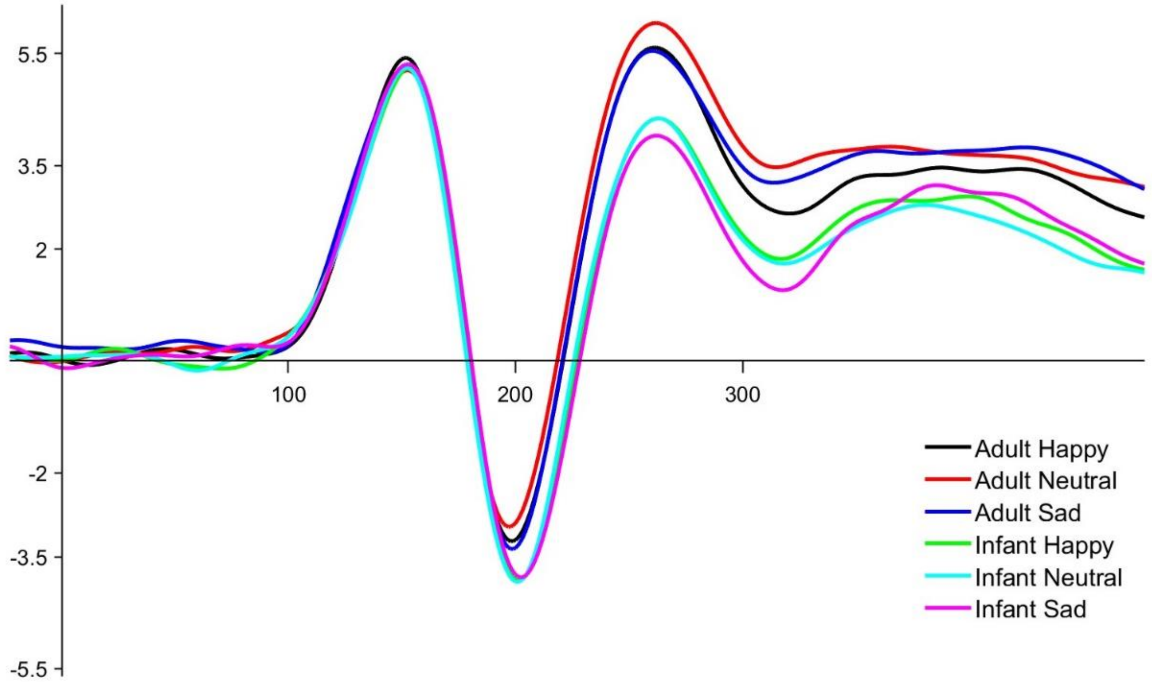
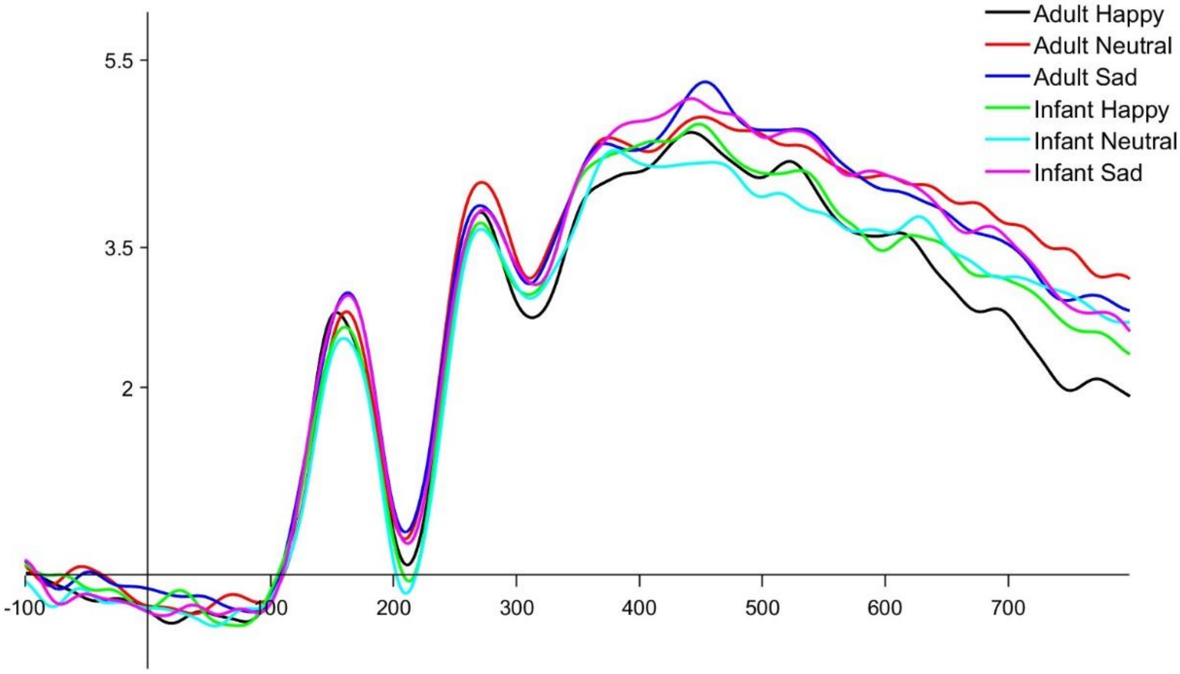


Figure 13

Grand-averaged LPP component in response to all conditions. Amplitude (mv) is reported in the y axis. Latency (ms) is reported in the x axis.



N170 amplitude

A preliminary analysis was implemented to consider the effect of lateralization (i.e., right, left) on the N170 amplitude (Appendix 3); given that we found a non-significant effect of the lateralization, we collapsed the N170 across hemispheres in the subsequent models. A LMM with the face age, emotional valence, sex, and PARQmother as independent variables was first performed. The model evidenced the main effect of face age ($F(2,260) = 66.3$, $p < .001$). The interaction effect between face age and sex was statistically significant ($F(1,260) = 5.7$, $p = .02$); females, compared to males, had a larger N170 amplitude in response to infant versus adult faces. The main effect of PARQmother was not significant. Another LMM with face age, emotional valence, sex, and PARQfather as independent variables were performed. The model confirmed the effects found before. A main effect of PARQfather ($F(1,52) = 5.1$, $p = .03$) and an interaction effect between PARQfather and face age ($F(1,260) = 4.8$, $p = .03$) additionally emerged; those individuals who felt more rejected by their own father during childhood displayed a greater N170 amplitude in response to all faces. In particular, a greater level of paternal rejection was associated with an increased the N170 amplitude to infant versus adult faces. A three-way interaction effect between the type of expression, PARQfather and sex emerged ($F(1,260) = 3.2$, $p = .04$); females who felt more rejected by their own father, compared to males, had a stronger increase in the N170 negative amplitude in recognizing emotional faces.

LPP amplitude

A LMM with face age, emotional valence, sex, and PARQmother as independent variables was first performed[13]. The model highlighted the main effect of emotional valence ($F(2,260) = 9.1$, $p < .001$; Figure 14), and the interaction between face age and emotional valence ($F(2,260) = 3.9$, $p = .02$; Figure 14). Post-hoc analyses revealed that sad faces elicited a larger LPP amplitude compared

[13] Given previous literature on the topic (e.g., Rutherford et al., 2019; Maupin et al., 2019; Peoples et al., 2022), the scalp topography (i.e., right vs. left lateralization) was not preliminarily tested for this component.

to happy faces (*t*(110) = 4.2; *p* > .001); the difference between sad and neutral faces approached statistical significance (sad faces > neutral faces; *t*(110) = 2.3; *p* = .06). Adult sad faces elicited larger LPP amplitudes compared to infant neutral (*t*(207) = 3.2; *p* = .03) and adult happy faces (*t*(218) = 3.6; *p* < .01). Infant sad faces elicited stronger LPP amplitudes compared to infant neutral (*t*(218) = 3.44; *p* = .01) and adult happy faces (*t*(207) = 3.6; *p* < .01). Adult neutral faces elicited stronger LPP amplitudes than infant neutral (*t*(162) = 3.3; *p* = .02) and adult happy faces (*t*(218) = 3.6; *p* > .01). Another LMM with face age, emotional valence, sex, and PARQfather as independent variables was performed. The model confirmed the effects found before. A three-way statically significant interaction emerged between emotional valence, sex, and PARQfather (*F*(2,260) = 5.9, *p* < .01); females who felt more rejected by their own father during childhood, compared to males, had a stronger decrease of the LPP amplitude in response to happy and sad faces. An overview of the models and the main results is reported in Table 10.

Figure 14

Effects of the emotional valence of faces on the LPP amplitude.

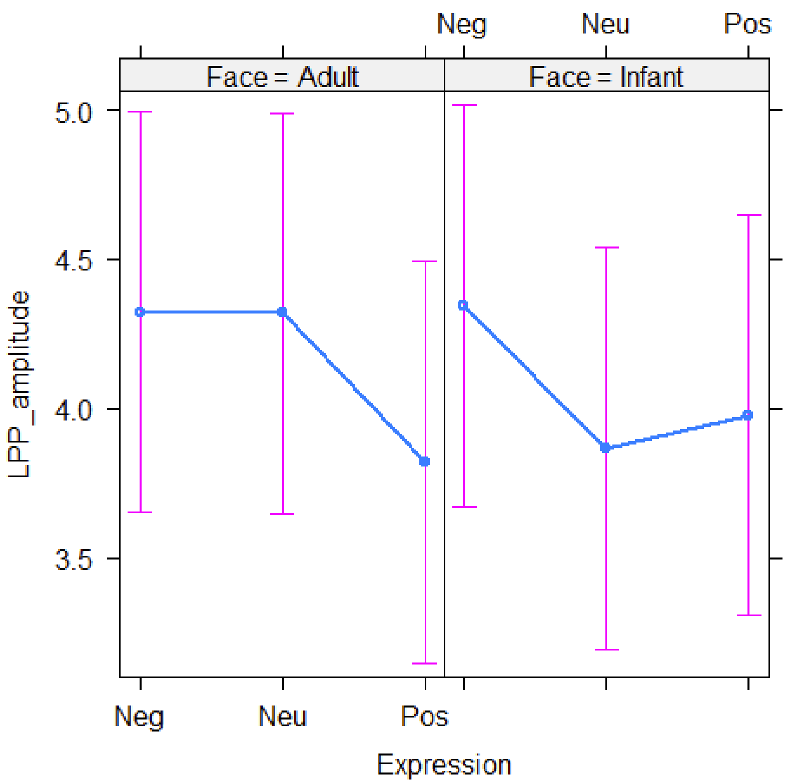


Table 10

LMMs grouped by dependent variables: RTs, Accuracy, N170, and LPP. The main results of the models are reported.

Models	Main Results
RTs	
• LMM with the face age, emotional valence, sex, and **PARQmother**; interactions were considered. • LMM with face age, emotional valence, sex, and **PARQfather**; interactions were considered.	• Neutral infant faces were associated with longer RTs compared to the other conditions. • Slower RTs in performing the task were displayed by those individuals who felt more rejected by their own mother during childhood. • Males who felt more rejected by their own mothers, compared to females, displayed a greater increase of RTs in performing the task. • No effects were found for PARQfather.
Accuracy	
• LMM with face age, emotional valence, sex, and **PARQmother**; interactions were considered. • LMM with the face age, emotional valence, sex, and **PARQfather**; interactions were considered.	• The worst accuracy was related to the categorization of infant neutral faces. • Lower levels of accuracy were displayed by those individuals who felt more rejected by their own mother during childhood. • Males who were more rejected by their own mother, compared to females, had a greater decrease of accuracy in categorizing sad and happy faces. • No effects were found for PARQfather.

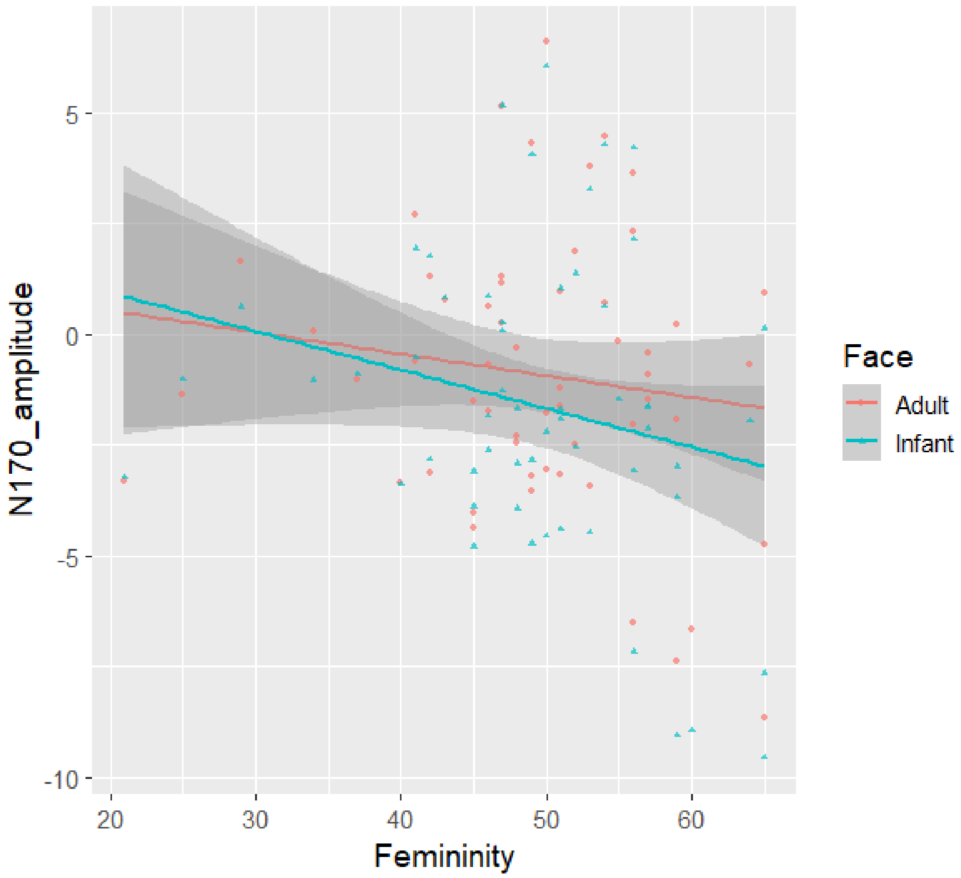
Models	Main Results
N170	
• LMM with face age, emotional valence, sex, and **PARQmother**; their interactions were considered. • LMM with the face age, emotional valence, sex, and **PARQfather**; their interactions were considered.	• Infant faces elicited a larger N170 amplitude than adult faces. • No statistically significant effects were related to PARQmother. • A greater N170 amplitude to infant versus adult faces were displayed by those individuals who felt more rejected by their own father. • Females who felt more rejected by their own father, compared to males, had a stronger increase in N170 amplitude to sad and happy faces.
LPP	
• LMM with face age, emotional valence, sex, and **PARQmother**; their interactions were considered. • LMM with the face age, emotional valence, sex, and **PARQfather** as independent variables; their interactions were considered.	• Sad faces elicited the largest LPP amplitude. • No statistically significant effects were related to PARQmother. • Females who felt more rejected by their own father, compared to males, had a stronger decrease of LPP amplitude to emotional faces.

Exploratory analysis

The full model was specified as follows: *N170_amplitude ~ Face_age * Emotional_valence + Face_age:Femininity + Face_age:Masculinity + Face_age:Sex + (1|Subject)*. From the full model, only the interaction between face age and femininity scores was significant ($F(2,86.4) = 5.0$, $p = .008$). Therefore, the reduced model was specified as follows: $N170 \sim Face\_age * Femininity + (1|Subject)$. This model outlined a main effect of face age ($F(1,278) = 3.9$, $p < .05$), and a statistically significant interaction between face age and femininity ($F(1,278) = 15.4$, $p < .001$). Infant faces were associated with a heightened N170 amplitude compared to adult faces. In addition, individuals with higher levels of femininity displayed a greater N170 amplitude to infant versus adult faces (Figure 15).

Figure 15

Interaction effect between face age and femininity on the N170 amplitude.



Discussion

The present work contributed to enhance IPARTheory's arguments by focusing on the neurophysiological correlates of parental acceptance-rejection (Rohner & Khaleque, 2010). In particular, we found rich patterns of associations between neurophysiological and behavioral responses of adults to infant cues and the quality of early experiences of care with their caregivers. Adopting an exploratory approach, we also provided some preliminary evidence that sex differences in the adults' response to infant cues might be explained by socio-cultural factors, which should be importantly considered.

Behavioral evidence

At the behavioral level, participants showed the worst performance, in terms of RTs and accuracy, in recognizing neutral infant faces. Therefore, these stimuli might be more difficult to categorize as compared to other expressions characterized by more distinctive facial features (i.e., infant smile and cry; Lewinski, 2015). Importantly, as the level of perceived maternal rejection increased, participants' RTs in categorizing faces increased and their level of accuracy decreased. In line with previous findings (Leyh et al., 2016; Liu et al., 2017, Ma et al., 2017), we found that experiences of adverse maternal care hindered adults' ability to recognize facial expressions. In addition, males who felt more rejected by their own mother during childhood, as compared to females, displayed longer RTs in response to all faces and a lower level of accuracy in categorizing emotional faces. A recent meta-analysis has shown that, although the magnitude of the difference was not great, memories of maternal warm care during childhood had significantly stronger relations with adult sons' psychological adjustment than that of adult daughters (Ali et al., 2015). Accordingly, , males, compared to females, might have displayed, in our study, a greater developmental sensitivity to poorer environmental experiences with their own mothers during childhood.

Neurophysiological evidence

At the neurophysiological level, we confirmed that infant faces elicited a larger N170 amplitude compared to adult faces, independently of the emotional valence displayed (Proverbio et al., 2011; Colasante et al., 2017). Thus, at very early stages of face processing, infant faces garnered heightened attentional resources in adults, independently of the valence of the emotional expression. In terms of the LPP amplitude, we did not find a larger response to infant faces. Since non-parents might attribute less relevance to infant faces compared to parents (e.g., Proverbio et al., 2006), this may explain a lack of a significant finding in this study. According to the established evidence of a negativity bias in adults (e.g., Ito et al., 1998), we found that sad faces elicited an overall larger LPP amplitude compared to other conditions. From the LPP mean amplitude values, crying infant expressions, in particular, seemed to prompt the greatest LPP positivity. This aligns with the special importance and focal attention elicited by infants' distress (Doi & Shinohara, 2012). However, in line with Jia and colleagues (2022), we found that the difference between the LPP amplitudes to infant versus adult sad expressions was very small. In fact, not all the post-hoc comparisons were statistically significant.

Moreover, we found that participants who felt more rejected by their own fathers during childhood showed an enhanced N170 amplitude to infant faces. In line with previous evidence (Fraedrich et al., 2010), this effect was independent of the emotional valence of facial expressions. Overall, this might reflect a greater need for discrimination resources, at very early stages of infant face processing, for those individuals who felt rejected by their own parents. Differently, such an effect of the quality of early maternal care was not detected. The importance of a warm paternal care on adults' sensitivity to social stimuli has been evidenced before (Truzzi et al., 2018). Using the Parental Bonding Instrument (Parker, 1989), for instance, Truzzi and colleagues (2018) suggested that a history of appropriate paternal care in non-parents accentuated the heightened sensitivity to human cry, partially determined by the individuals' genetic predisposition. Overall, our result might strengthen the empirical evidence on the importance of the paternal role in the offsprings' development and social cue processing (Grossmann et al., 2002; Leidy et al., 2013; Rodrigues et al., 2021).

Regarding the modulating role of sex, we found that females who felt more rejected by their own father during childhood, compared to males, had a stronger increase in the N170 amplitude, as well as a decrease in the LPP amplitude, in response to emotional faces. Therefore, females who perceived more paternal rejection during childhood might struggle more in decoding structural characteristics of emotional faces and in allocating a sustained attention toward them. Consistent with previous research (Leyh et al., 2016; Ma et al., 2017), it has been widely assumed that experiences of a secure base support might promote later individuals' emotional processing (Spangler et al., 2010; Groh & Haydon, 2018). In our study, as this evidence was found only in females in relation to early experiences of paternal rejection, it might complement those cross-sex effects found at the behavioral level. Accordingly, Sultana and Khaleque (2016) demonstrated that only the recollections of paternal acceptance made a significant and independent contribution to the adult daughters' adjustment. Taken as a whole, our results potentially suggest that males and females might develop different developmental pathways relating to emotional face processing whether they felt rejected by their own mothers or fathers.

Exploratory evidence

In addition to the main results of the study, to move beyond the use of sex as the only and often binary predictor in previous parenting research, we exploratorily investigated the effect of gender roles on the N170 amplitude response to infant faces. Based on previous literature, sex differences emerged in the adults' N170 amplitude to infant faces (Proverbio et al., 2006; Colasante et al., 2017; Jia et al., 2021); of note, the same result was also evidenced in our first analyses. However, gender roles related to femininity, rather than sex, demonstrated to be a better predictor of the N170 amplitude response to infant faces. Therefore, sex-typed stereotypical behaviors and traits related to femininity might be deeply rooted in the human brain, being associated with a very early (N170) effect in face processing beyond the individual's sex. Given that the variability explained by gender roles might have conflated with the one of sex in previous research (i.e., females are traditionally more imbued with ideals of femininity as compared to males), we argue that not accounting for different aspects related to individuals' sexual identities might lead to inaccurate or misinterpreted findings relating to sex differences. As it has been generally suggested (Hyde et al., 2019), although sex differences have been found in parenting research (e.g., Hahn et al., 2013), these should not be always intended as context- or culturally independent (Joel & McCarthy, 2017).

Strengths and limitations

Some limitations of the study should be pointed out. First, our study was cross-sectional and relied on self-report measures. Future studies could follow individuals longitudinally to explore the causal relationships among variables and adopt a multi-method approach. In addition, as different experiences of care might be related to different attachment styles in adults, further studies might benefit from a combination of measures relating to both IPARTheory (Rohner, 2021) and Attachment Theory (Bowlby, 1969/1982). This would also improve the comparability with previous studies on this topic (Fraedrich et al., 2010; Leyh et al., 2016; Groh & Haydon, 2018; Lowell et al., 2023).

Importantly, the experiment-wise alpha may be inflated in our study, given the many models tested. The statistical analyses implemented have been rather articulated, and they provided complex results in terms of interaction effects. Relatedly, we were not able to calculate the effect sizes of our findings; on this note, despite LMMs have the advantage to capture multiple sources of random variations in the data (Westfall et al., 2014), there is no agreement on how to calculate effect sizes of the effects (Nakagawa & Schielzeth, 2012). Beyond the ERP amplitudes, future studies may focus on the ERP latencies; thus, integrating data regarding both strength (amplitude) and speed (latency) of ERP responses may provide new insight regarding the efficiency of neural processing.

With respect to the PARQ, we acknowledged that this measure might have not captured the experiences of the individuals grown up in one-parent families or same-sex parent families; in fact, this measure specifically asks about the experiences of care with one's own mother and father. To overcome this issue, participants of this study had the possibility to leave comments at the end of the survey, whether they had something more to say regarding their possibly different lived experiences. However, a future advancement of the measure could provide a more inclusive assessment of early experiences of care of individuals, embracing the complexity of different family forms nowadays. Moreover, in this study we gave empirical support to the idea that mothers and fathers can play a distinctive role in their child's later outcomes in terms of responses to social cues. A task for future research would be to replicate these effects; in particular, the specific contribution of a mother or a father on the adult's later responses to infant cues might be read, in future, in the light of the parents' roles in child rearing, rather than their sex.

Moreover, since the BSRI has been validated a long time ago, it might not reflect current gender roles in our society (Hoffman & Borders, 2001). Accordingly, we did not find any differences in the masculinity traits between females and males in our study. So, a new version of the measure should be developed to meet new societal changes in terms of gender roles and norms (Lindqvist et al., 2021). In addition to this, in this study we considered only the categories related to feminine and masculine traits. However, some individuals might not conform to either of these categories, which do not capture, per se, the complex mosaics of nowadays gender norms and behaviors. Building from our preliminary findings, future research should continue exploring the role of different aspects related to individual social gender in the adults' response to infant cues. For this purpose, even though write-in responses regarding sex and gender present challenges for data cleaning and management in research, they might also allow researchers to capture a greater diversity in future (Krueger et al., 2020). Eventually, although the preliminary investigation of gender roles put good premises for future research, this evidence does not imply that there is no merit in investigating sex differences in parenting research. Since individuals are embodied in ways that reflect both evolution and social contexts, studying the interactive effect between sex and social characteristics might help approach a more comprehensive perspective.

Conclusion

Adults' adjustment relies to a great extent on the nature of intimate relationships with caregivers during childhood (Bowlby, 1977). Building on the IPARTheory (Rohner, 2021), coherence across multi-level indicators (i.e., attention, ERPs) in our study documented the complex role of the perceived quality of care in the adults' responses to infant cues. Unprecedentedly, we found that perceived paternal rejection during childhood was associated with adults' electrophysiological responses to infant faces. On the other hand, memories of adverse maternal care were found to hinder adults' behavioral responses in recognizing facial expressions. Overall, we gave empirical support to the idea that both mothers and fathers can play a central role in the development of their child's processing of emotional and social cues. Interestingly, cross-sex effects were also found; at the behavioral level, males displayed a greater developmental sensitivity to poor environmental experiences with their own mothers, whereas, at the neurophysiological level, females displayed a greater sensitivity to the quality of early paternal care. These effects could be further explored in future. Eventually, we gave preliminary strength to the argument that sex differences in the response to infant cues might not be always biologically determined but reinforced by societal norms. In line with this, individuals' sex should no longer be considered the only core of individuals' sexual identity, but many other aspects should be accounted for in research (Nowatzki & Grant, 2011).

Study 4: Maternal response to interactions with their own child: a preliminary EEG study in a sample of same-sex mothers[14]

Introduction

The mother-child bond plays an ethologically important role in promoting the child's survival and healthy development. In this regard, attending and appropriately understanding the signals from their own child is necessary, for mothers, to provide adequate nurturance and care (Ainsworth & Bell, 1970; Ainsworth et al.,1978). Empirically, the intuitive nature and temporal dynamics of mother-child interactions can be reflected in the millisecond temporal resolution of the Event-Related Potentials (ERPs; Vuoriainen et al., 2022). In particular, the LPP (Late Positive Potentials) component, which is a prolonged positivity occurring approximately from 300 milliseconds (ms) after a stimulus presentation (Luck, 2014), has been proved of relevance to the investigation of maternal responding (e.g., see Kuzava et al., 2020; Vuoriainen et al., 2022). The LPP amplitude, in fact, reflects the elaborate appraisal in the prolonged attention stage; in addition, it is sensitive to biological and motivational relevance of the stimuli (Hajcak et al., 2016). Consistently, previous studies on mothers have demonstrated an overall larger LPP amplitude in response to one's own child versus other children's faces (Grasso et al., 2009; Weisman et al., 2012; Doi & Shinohara, 2012; Bornstein et al., 2013; Bernard et al., 2018). This evidence has suggested that one's own child is a universally salient

[14] This study is part of a larger multi-center project PRIN 2017 - Research Project of National Relevance - Ministry of Education, University and Research – "*Same-sex and different-sex parent families through assisted reproduction: Parenting, attachment, child adjustment and neural correlates*" unit of Trento (local P:I. Prof. Simona de Falco; Department of Psychology and Cognitive Sciences, University of Trento). This study has been coordinated by Prof. Paola Rigo (unit of Padova; Department of Developmental Psychology and Socialisation) and it has been conducted in collaboration with Prof. Paola Venuti (Department of Psychology and Cognitive Sciences, University of Trento), Prof. Alessandra Simonelli (Department of Developmental Psychology and Socialisation, University of Padua), and Dr. Michele Giannotti (Department of Psychology and Cognitive Sciences, University of Trento).

stimulus, which captures and sustains attention of mothers (Bernard et al., 2018). However, to the best of our knowledge, past research on this topic has been confined to heteronormative samples of mothers; no evidence has been provided so far regarding same-sex mothers.

In particular, previous research has primarily focused on biological parents; however, some research has also included non-biological mothers (Grasso et al., 2009; Bick et al., 2013; for a review, see Maupin et al., 2015). For instance, Grasso and colleagues (2009) explored differences in the ERP responses in biological, foster and adoptive mothers who were presented with photographs of their own child, unfamiliar children, familiar and unfamiliar adults. Both biological and non-biological mothers showed a larger LPP amplitude in response to the pictures of their own child compared to all other stimuli. In line with this, Bick and colleagues (2013) confirmed that foster mothers' P300 response was significantly larger when viewing photographs of their own child as compared to other children. In addition, mothers' oxytocin production became associated with the ERP activity in response to their own child only over the course of the mother-infant bond (Bick et al., 2013). This body of evidence including non-biological parents has overall suggested that a heightened processing of child cues is not limited to biological processes, but also related to parenting experiences (Maupin et al., 2015). On this note, several factors have been described to contribute to maternal caregiving experiences, such as the maternal involvement in childcare (i.e., quality and quantity of activities accomplished), duration of motherhood (i.e., child age), and number of children that the mother has (i.e., parity). Previous ERP research investigating the role of maternal parity (Maupin et al., 2019) and the duration of motherhood (Kazuka et al., 2020) has suggested that these factors might play a role in modulating the LPP amplitude responses to infant cues in mothers. However, no research to date has investigated the possible contribution of maternal involvement in childcare on the ERP response.

In addition, research has suggested that experiences prior to having children, such as experiences of early care from caregivers, may be related to maternal electrophysiological responses to infants; in particular, individuals' attachment quality was found to modulate the P300/LPP amplitudes to infant faces in mothers (Fraedrich et al., 2010; Leyh et al., 2016; Groh & Haydon, 2018; Lowell et al., 2023). Nonetheless, the results provided have been inconclusive; whilst some studies highlighted that secure versus insecure mothers displayed an increased P300 amplitude in response to infant cues (Fraedrich et al., 2010; Leyh et al., 2016), others did not find any effects of the attachment quality (Lowell et al., 2023), or even an oppositive effect on the P300 amplitude (Groh & Haydon, 2018). In addition, all the studies were framed, both theoretically and methodologically, in the context of the Attachment Theory (Bowlby, 1969/1982). To the best of our knowledge, no studies have investigated the relationship between early care experiences and maternal ERP responses to infant cues in the context of the Interpersonal Acceptance Rejection theory (IPARTheory; Rohner, 2021)[15].

Accumulating evidence has indicated that variations in maternal affective qualities were related to different neurophysiological responses to child's cues; on this note, a larger P300/LPP amplitude in response to child's faces has been associated with more appropriate caregiving behaviors in mothers (for a meta-analysis, see Vuoriainen et al., 2022). Conversely, a decreased LPP amplitude to infant cues was related to less optimal maternal caregiving behaviors (Rodrigo et al., 2011; Bernard et al., 2015; 2018; Kuzava et al., 2019). Accordingly, Rodrigo and collaborators (2011) found that, compared with control mothers, neglecting mothers had an attenuated LPP response to infant emotional expressions. Bernard and colleagues (2015) found that Child Protective Services (CPS)–referred mothers did not differentiate between emotional expressions at the LPP stage of processing. Consistently, Kuzava and colleagues (2019) found that maternal profiles characterized by undifferentiated LPP responses to emotional expressions of infants were associated with lower levels of maternal sensitivity. In another study on CPS-referred mothers, Bernard and colleagues (2018) found that a greater LPP amplitude to own versus other children was associated with higher levels of maternal sensitivity. Therefore, at the LPP stage of processing, mothers might need to attend to the child's cues in order to provide appropriate care. However, a more comprehensive understanding of

[15] A detailed explanation of the theory can be found in the previous chapters.

the phenomenology of maternal sensitive caregiving is still needed. For instance, much knowledge on this topic could be importantly gained by including samples of mothers from different family contexts.

Overall, current perspectives on parenting have emphasized that multiple indicators of maternal responses (e.g., brain responses, self-reports, observed behaviors) are best studied simultaneously (Teti & Cole, 2011; Groh et al., 2015). Therefore, by adopting a multi-method research strategy, the present study aimed to investigate, for the first time, the LPP response to own versus other- parent-child interactions in a sample of same-sex mothers. Of note, we did not expect to find any differences compared to previous evidence on heteronormative samples of mothers; however, extending previous knowledge by including different family forms was compelling for the topic. In addition, we explored the relationships between the LPP amplitude and i) maternal involvement in childcare, ii) the perceived quality of early experiences of care from caregivers, and iii) the quality of maternal behaviors. Based on the previous literature on the topic, we expected that stimuli of own parent-child interactions elicited a larger LPP amplitude, as compared to the other stimuli, in same-sex mothers. In addition, in line with previous evidence, we expected that a i) greater involvement in childcare, ii) more accepting past experiences of past care from caregiver and iii) more appropriate maternal behaviors were associated with a larger LPP amplitude to child-related stimuli. However, given the lack of previous research on same-sex mothers' families and the fact that we adopted a novel experimental design, we generally favored an exploratory approach.

Methods

Participants

A group of N=32 mothers being in a same-sex couple participated in the study. The recruitment of most of the mothers was made through the Italian Association *Famiglie Arcobaleno* (i.e., an association that brings together same-sex parents in Italy), which sent an invitation to all the members through a mailing list. A snowball sampling was also used, such that mothers who participated in the study were asked to forward the study invitation to other same-sex mother families. To be included in the sample, mothers should 1) have raised their child since birth; 2) speak Italian fluently; 3) not be pregnant at the time of the experiment. The age of the mothers' children ranged between 3 and 11 years. Our sample included both biological and non-biological mothers[16]. Both members of each couple of same-sex mothers were first invited to participate in the study. However, whilst 30 mothers (94%) participated in the experiment with their partners (*N*=15 couples), 2 mothers (6%) participated alone, as their partner was not available or not willing to participate. All participants reported a normal vision, or a vision corrected to normal. The majority of participants were Italian (94%), but two of them (6%) reported having a dual (i.e., American and Italian; Polish and British) nationality. Mothers were compensated for their participation. The study was approved by the Ethics Committee of the University of Trento and adhered to the principles of the Declaration of Helsinki as well as its subsequent revisions.

Procedure

The current study was divided into three phases. Phase I concerned mothers being involved in a playful interaction with their child recorded during a Zoom meeting. Each interaction was videotaped to create the experimental stimuli for the mothers' EEG recording, and later coded using the Emotional Availability Scales (EAS; Biringen & Easterbrooks, 2012). Phase II involved the mothers' laboratory visit, preferably within a few weeks from the collection of the experimental stimuli, to participate in the EEG recording protocol. Mothers were invited to take part in the EEG procedure only if they did not report any neurological problems and their health conditions were suitable for the EEG recording. Phase III involved the mothers' completion of online self-reports

[16] As explained for Study 2, we could not be sure about the exact composition of the sample in terms of biological and non-biological mothers.

through Qualtrics (Qualtrics, Provo, UT). Standard procedures for acquiring informed consents were used, and tasks were briefly described to mothers prior to the start of each phase.

Phase I: Mother-infant interactions

In Phase I, mothers were sent a puzzle suitable for their child's age and invited to join in a Zoom meeting in due time. During the Zoom meeting, each mother was asked to play with the puzzle with their child for about 10 minutes; after that, the mother was told to stop playing and ignore their child for about 1 minute. Eventually, the mother was told to start playing again with their child. Mothers were asked to adjust the camera in a location that captured both the mother and the child, who needed to remain in proximity to one another for the whole videorecording.

Creation of experimental stimuli

Video-clips (i.e., 3-second segments) of mothers' interactions with their own child were extracted from the video-recordings of the playful interactions (Phase I). The video-clips extracted displayed both successful (i.e., the parent interacted with the child) and unsuccessful (the parent did not interact with the child) mother-child interactions. The final stimuli were selected after being evaluated by four raters according to the type of interaction (successful vs. unsuccessful) displayed. Raters were asked whether the interaction displayed was clearly successful or unsuccessful and they could answer by choosing among the following options: "*yes*" or "*no*", or "*I don't know*". Video-clips were excluded from the final stimuli whether two or more raters responded with "*I don't know*" or "*no*". Control stimuli consisted of n=20 video-clips (3-second segments; n=10 successful and n=10 unsuccessful video-clips) displaying unfamiliar parents interacting with their own child. The control stimuli were previously collected by the experimenters by video-recording other parent-child interactions and were then evaluated following the same procedure as the one described before. The control stimuli reflected different characteristics in terms of child age and sex, potentially matching a wide range of conditions (i.e., the details of the control stimuli are reported in Appendix 4). All video-clips were cut, converted into gray scale and matched for size and luminance using Videopad

Editor Video. The stimuli were presented against a uniform gray background. The sound was removed from the video-clips.

Emotional Availability (EA) coding

The fourth version of the Emotional Availability Scales (EAS; Biringen & Easterbrooks, 2012) was used to assess maternal Emotional Availability (EA) during mother-child interactions. Emotional availability (EA; Emde & Easterbrooks, 1985) describes the quality of emotional exchanges between the child and the parent. In particular, EA is a relationship construct that captures the ability of each partner to read and respond to the other's emotional communications (Bornstein et al., 2006). The EAS measure consists of four scales for adults including 1) sensitivity, 2) structuring, 3) non-intrusiveness and 4) non-hostility, as well as two scales for children including 1) responsiveness and 2) involvement. Adult sensitivity includes appropriate and positive affective exchanges within the dyad; it also refers to clear and accurate perceptions of emotions, responsiveness to emotions, the ability to handle conflictual situations and the awareness of timing. Adult structuring refers to the ability to promote and organize the child's activities by providing appropriate prompts and suggestions during the interaction, without limiting the child's autonomy. Non-intrusiveness refers to the adult's qualities such as the absence of over-direction, over-stimulation, interference, or over-protection, and hence refers to the parental capacity of encouraging appropriate autonomy while maintaining connection with the child. Non-hostility refers to the ability of the adult to interact with the child without showing any signs of hostility, neither openly nor covertly. Responsiveness refers to the child's eagerness to respond to the bids of the relational partner, and to the child's manifestation of clear signs of pleasure during the interaction. Involvement refers to the child's ability to actively engage with and involve the parent in the interaction through different modalities. Each of these scales is rated on a global score, ranging from 1 to 7; higher scores refer to more functional behaviors. Specifically, scores between 5.5 and 7 are considered functional, scores around 4 indicate inconsistency, and scores of 3 or below refer to more difficult/problematic behaviors. The instrument has shown good psychometric properties in both normative and clinical populations, demonstrating to be a valid measure for assessing the relational dyadic affective quality (Biringen et al., 2014). In our study, videos of mother-child interactions were coded by one independent rater reliable to the system. Another rater codified the interactions after receiving a specific training and having reached a significant level of reliability. Disagreements between the raters were discussed until consensus was achieved. The inter-rater reliability was calculated using the Intraclass Correlation Coefficient (ICC) on a set of 10 out of 31 videos (32% double-coded videos; ICC=0.74; 95%-Confidence Interval for ICC=0.602<ICC<0.836).

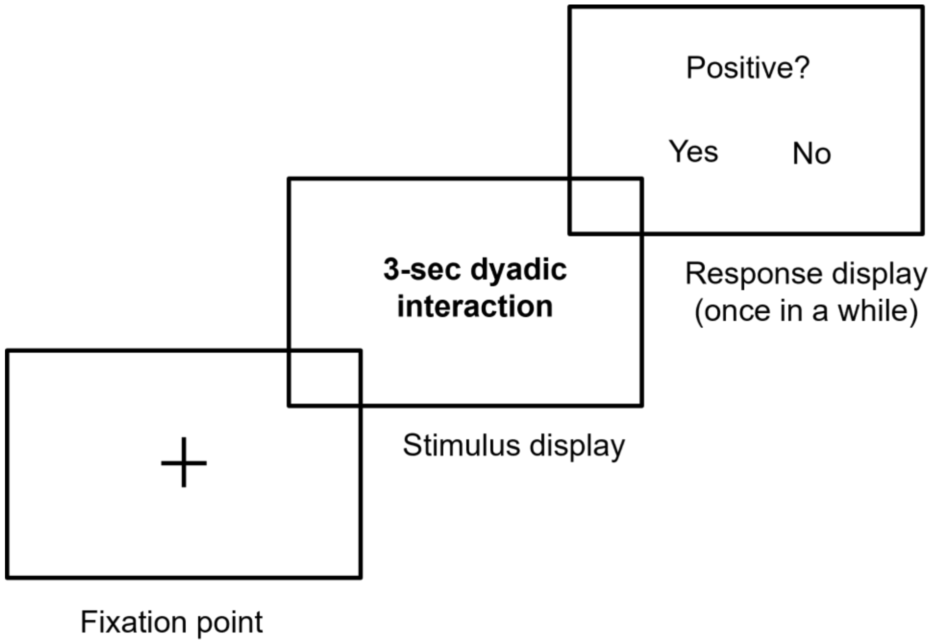
Phase II: EEG acquisition and pre-processing

In the EEG laboratory (Phase II), mothers were sited in a dimly lit room and performed a passive task during an EEG recording. Upon entering the laboratory, we briefly explained the procedure, positioned the electrode cap on the mother's head, and prepared electrode sites using conductive paste to minimize impedance. A continuous EEG activity was recorded using an eego sports system (ANTNeuro) at a sampling frequency of 1000 Hz, from 64 Ag/AgCl shielded electrodes referenced to CPz and placed in the standard 10-10 locations on an elastic cap (Brain Products). An additional electrode (Electrooculogram, EOG) was placed under the left eye. Impedance was kept under 20 kΩ. The passive task was developed using Psychopy Software (Peirce et al., 2019). An example of a trial structure of the task is displayed in Figure 16. The session began with a short set of practice stimuli, which were not used during the test phase, to acclimate the mother to the task. In total, mothers performed 2 practice blocks made of 8 trials respectively; in the practice phase, each experimental condition (i.e., own-interaction-successful, own-interaction-unsuccessful, other-interaction-successful, other-interaction-unsuccessful) was randomly repeated 4 times. In the test phase, each trial started with the presentation of a fixation cross at the center of the screen with a jittered duration from 1 to 3 seconds (s). A stimulus display was then passively presented for 3 s. Once every six trials, a catch trial was presented to check for the mother's attention by asking to evaluate the type of interaction displayed. Mothers were previously instructed to choose the option "*positive*" when they were presented with a successful interaction, such as an interaction in which the parent and child cooperated together; on the other hand, they were instructed to choose "*negative*" whether they saw an unsuccessful interaction (i.e., when the parent and the child did not cooperate together). Mothers could provide a response on a dichotomous scale (yes/no). During the test phase, mothers completed 6 test blocks of 40 trials each (i.e., 240 trials in total; each of the four conditions was repeated 60 times in a random order). A self-paced break followed each block. Mothers were asked to minimize eye or body movements during the recording. The whole task lasted around 20 minutes.

EEG data preprocessing was performed with the MATLAB toolboxes EEGLAB v2022.0 (Delorme & Makeig, 2004) and ERPLAB (Lopez-Calderon & Luck, 2014). EEG data was re-referenced offline to the average of electrodes; mastoids and EOG were excluded. EEG data was band-pass filtered using the Butterworth filter, with cutoffs of 0.1 and 30 Hz. Epochs were segmented for each trial, starting from -400 ms to 3000 ms from the stimulus onset (i.e., long epochs were extracted considering the experiment timing). Baseline correction from -400 ms was performed. Artifacts were first rejected by eye inspection. Independent Component Analysis (ICA; RUNICA algorithm) was used to remove noise components from the signal related to eye-blinks. ICA components were visually inspected and selected for deletion only when their topography clearly indicated a source of noise. The IClabel tool (Pion-Tonachini et al., 2019) was also used for this purpose. The signal was epoched based on different bins corresponding to different experimental conditions. A more automated artifact rejection was additionally performed, as suggested by the software developers (https://eeglab.org/): EEG data with peak-to-peak amplitudes exceeding $\pm$ 70 µV was rejected. For each participant, only in the cases in which at least 80% of the initial epochs remained, ERPs were computed on accepted epochs. ERPs were averaged for each condition in a discrete time window and electrode groups. The LPP component was defined as the mean activity in a 300 to 700 ms time window (e.g., see Endendijk et al., 2018b) averaged over the centro-parietal electrodes (Cz, CP1, CP2, Pz; e.g., Kuzava et al., 2019).

Figure 16

Example of a trial structure of the passive task. Here is represented the catch trial.



Phase III: Self-reported measures

Mothers completed the self-reports in Phase III. In addition to the measures reported below, mothers completed a socio-demographic questionnaire built ad hoc to collect basic information (e.g., age, child age, educational level, occupation).

Parental involvement in childcare

Mothers completed an Italian translated version of the Child Caregiving Involvement Scale (see Appendix 4) adapted from Wood and Repetti's work (2004) to assess parental involvement in childcare. The 10-item scale measured maternal perceptions of their own, their partner, and others' responsibility for childcare activities. Items were designed to assess both indirect involvement (e.g., making child-care arrangements, coordinating or planning child-related activities) and direct involvement in childcare (e.g., playing or reading to a child, staying home with a sick child). Each item was rated on a 5-point response scale, ranging from 1=*none or very little responsibility* (less than 10%), 2=*some responsibility* (10%–40%), 3=*about half of the responsibility* (40%–60%), 4=*much responsibility* (60%–90%), to 5=*almost complete or complete responsibility* (90%–100%).

For each item, mothers rated separately (a) their own responsibility, (b) their partner's responsibility, and (c) other childcare providers' responsibility (e.g., baby-sitter). A proportion score was calculated to provide a measure of a mother's self-reported responsibility for childcare tasks relative to their perceptions of the partners' and other providers' responsibilities. The proportion scores were created using the following formula: *mother's own caregiving score / sum of mother's ratings of his own, their partner's, and other providers' caregiving responsibility scores* (Wood & Repetti, 2004). Considering the objectives of our study, we used only the proportion score relating to mothers' own reports of involvement in childcare in the main analyses. Cronbach's alpha for this scale was satisfactory ($\alpha = 0.86$) [17].

Parental Acceptance-Rejection scale

The Parental Acceptance–Rejection Questionnaire (PARQ) is a self-report measure, used in the IPARTheory framework, to assess the individuals' perception of acceptance and rejection from their own parents during childhood (Rohner, 2005b). In this study, mothers completed the Italian validated short-form version of PARQ (Senese et al., 2016). This measure consists of 2 scales (24 items in each scale) originating a total maternal/paternal score (i.e., PARQmother and PARQfather). Each of these scales assesses four different dimensions: (1) warmth/affection, (2) hostility/aggression, (3) indifference/neglect, and (4) undifferentiated rejection. Mothers indicated how well each statement described their experiences of remembered early care using a four-point Likert scale (from 4 = *almost always true* to 1 = *almost never true).* In this study, the two total scores had a good reliability (PARQmother $\alpha = 0.93$; PARQfather $\alpha = 0.96$).

Statistical analyses

Descriptive statistics were first run on the data to examine mean scores, frequencies, percentages and distributions. Missing data was not replaced. Accuracy in catch trials was 78%, which indicated

[17] Even though we did not use the other scales in the main analyses, the Cronbach's alphas were satisfactory: partner's responsibility: $\alpha = 0.91$; other providers' responsibility: $\alpha = 0.88$.

a good level of mothers' attention while performing the task. To remove the within-subject noise from the signal, a differential score (ΔLPP) reflecting the specific magnitude of activity elicited by each experimental condition was computed. For instance, the ΔLPP relating to the first condition was computed as follows: *meanLPPamplitude[cond1] - meanLPPamplitudes[cond2,3,4] = ΔLPPamplitudecond1*. The same logic was used to compute the ΔLPP relating to the other conditions: e.g., :*meanLPPamplitude[cond2] - meanLPPamplitudes[cond1,3,4] = ΔLPPamplitudecond2*. The ΔLPP was checked for normality assumptions by using the Shapiro-Wilk test (Appendix 4). Then, a 2×2 Repeated-Measure ANOVA with familiarity (own vs. other) and interaction type (successful vs. unsuccessful) as within-subjects factors was implemented on the ΔLPP amplitude. Parent age and child age were checked as covariates in the model (for a meta-analysis, see Kuzava et al., 2020). Effect sizes for ANOVAs were presented as generalized eta squared (*ges*). Pairwise comparisons were Bonferroni corrected. Then, Spearman correlation analyses were computed, since not all data was normally distributed (see Appendix 4). Correlation analyses consisted of relating the ΔLPP amplitudes in different conditions to self-reports (Caregiving involvement, PARQ) and maternal EA qualities. A check of the associations found was computed considering another differential score, computed only between the two own-interaction conditions. This further check was performed to exclude potential confounding effects related to the context familiarity[18] (see Appendix 4). Therefore, the second differential score was computed as follows: *meanLPPamplitude[cond2]-meanLPPamplitudes[cond1]*.

[18] Video-clips of own successful and unsuccessful interactions were recorded in the same settings (e.g., mothers' own house), so they usually displayed the same surroundings. The variability shared by these two conditions was therefore cancelled out by computing the differential score.

Results

Preliminary analysis

From the total sample of mothers (*N*=32), all the mothers completed the self-reports, 31 mothers were considered for the EAS coding (i.e., one mother was excluded since she spoke in a non-Italian language during the interaction), and 22 mothers were considered for the ERP analyses. Regarding these, 10 mothers were excluded due to several reasons: i) excessive artifacts in the EEG data (>20% of noisy epochs; *n*=2 mothers excluded), ii) technical problems in the signal acquisition (*n*=5 mothers excluded), iii) individuals' health conditions not feasible for the EEG registration (*n*=1 mother excluded) or for the study criteria (*n*=1 mother was excluded since she got pregnant in the time elapsing between Phase I and II). In addition, one mother (*n*=1) was not available to visit our laboratory for the EEG recording. Characteristics of the study participants are reported in Table 11, which also shows the number of incomplete cases for each variable. Mean values of the ΔLPP amplitude and of the raw LPP amplitude as a function of different experimental conditions are reported in Table 12. For each mother, the perception of self versus their partner's involvement in childcare is displayed in Figure 17; of note, mothers seemed to perceive the division of care as fairly egalitarian within their couples. The representative Grand Average LPP waveform is displayed in Figure 18.

Table 11

Characteristics of the study participants; N=number; M=mean; %= percentage; SD=standard deviations.

Variable	N	M (SD) or %
Parent age	32	43.4 (6.4)
Child age	32	4.9 (2.2)
Number child	32	
Primiparous	22	69%
Multiparous	10	31%
Educational level	32	
Middle-school diploma	1	3%
High-school diploma	11	34%
Bachelor's degree	4	13%
Master's degree	8	25%
Postgraduate level	8	25%
Nationality	32	
Italian	30	94%
Non-Italian	2	6%
Relationship with partner	32	
6-10 years	8	25%
11-15 years	13	41%
>15 years	11	34%
Involvement in childcare (me)	32	0.4 (0.1)
Involvement in childcare (partner)	32	0.4 (0.1)
Involvement in childcare (other)	32	0.2 (0.04)
PARQmother	32	36.9 (12.4)
PARQfather	31	44.4 (15.2)
Sensitivity	31	5.7 (0.8)
Structuring	31	5.7 (1.0)
Non_Intrusiveness	31	6.5 (0.8)
Non_Hostility	31	6.8 (0.5)
(child) Responsiveness	31	5.6 (0.8)
(child) Involvement	31	5.5 (1.0)

Table 12

Mean values of the ΔLPP amplitude and of the raw LPP amplitude as a function of different conditions.

Conditions	ΔLPP amplitude (SD)	Raw LPP amplitude (SD)
Own-interaction-successful	0.4 (0.5)	1.8(1.7)
Own-interaction-unsuccessful	0.4 (0.6)	1.8(1.8)
Other-interaction-successful	-0.3 (0.5)	1.2(1.4)
Other-interaction-unsuccessful	-0.5 (0.6)	1.1(1.3)

Figure 17

Perception of self versus the partner's involvement in childcare for each mother.

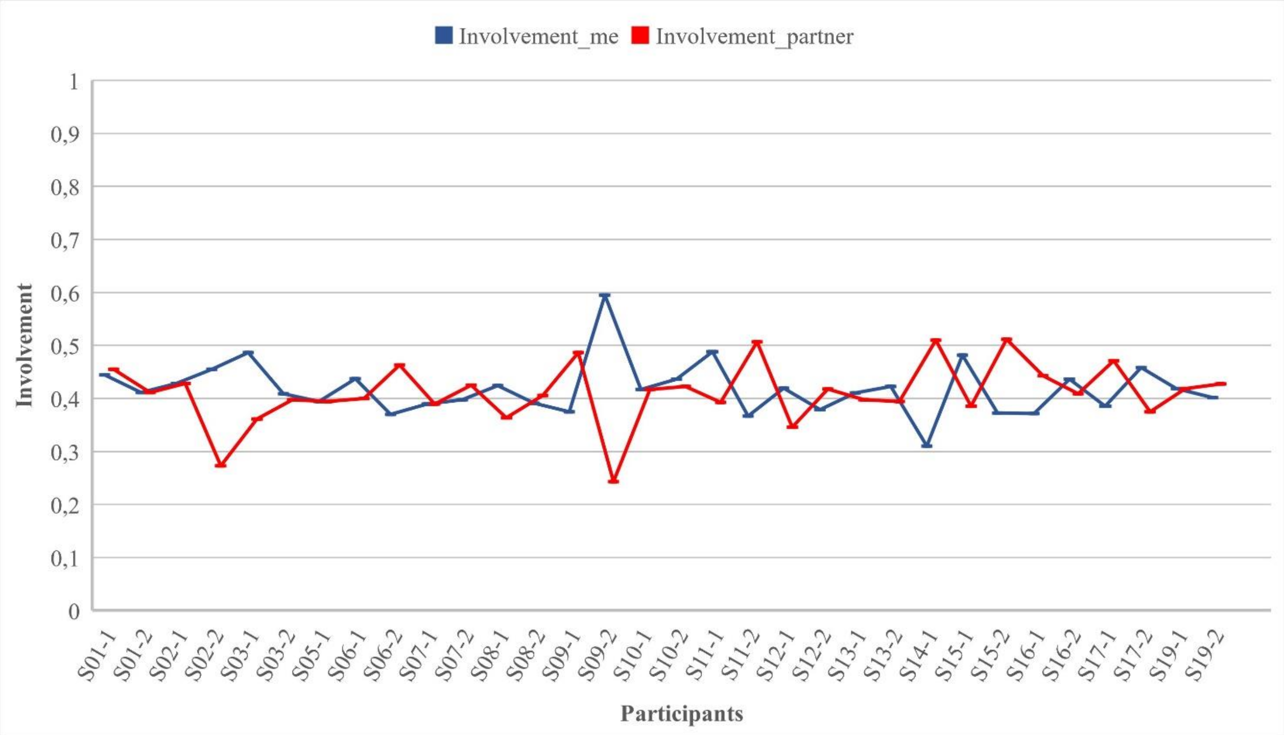
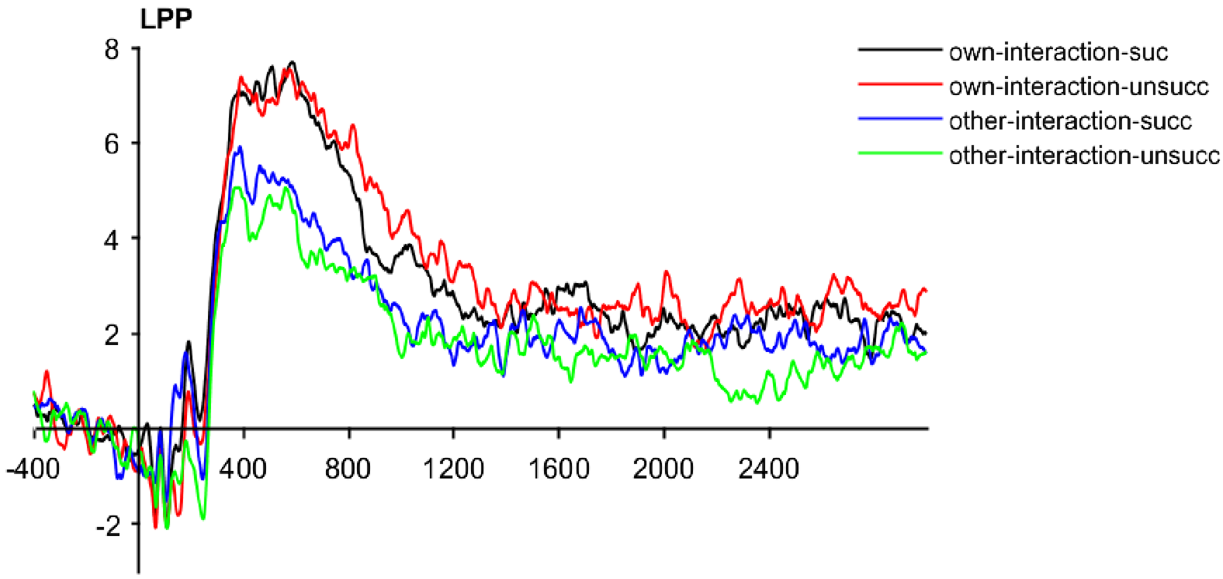


Figure 18

Grand-averaged LPP component in response to the different experimental conditions. Amplitude (mv) is reported in the y axis. Latency (ms) is reported in the x axis.



Main analysis

A 2×2 Repeated-Measure ANOVA on the ΔLPP yielded a statistically significant effect of familiarity ($F(1,21) = 15.6$; $p = .0007$; *ges* = 0.3). Post-hoc analyses revealed that mothers' interactions with their own child elicited a larger ΔLPP amplitude compared to viewing other parent-child interactions ($t(21) = -3.9$; $p = .0007$). The effect was stable after controlling for parent age and child age ($F(1,21) = 15.6$; $p = .0007$; *ges* = 0.3). Neither a main effect of the interaction type nor an interaction effect between familiarity and interaction type was found. Numerical values related to the effects of the ANOVA are reported in Table 13.

With respect to the Spearman correlational analyses, no statistically significant relationships emerged between the ΔLPP amplitudes in different conditions and maternal perception of self-involvement in childcare. Similarly, no statistically significant correlations emerged between the ΔLPP amplitudes and the perceptions of early experiences of maternal and paternal care. Regarding the EA qualities, a statistically significant correlation emerged between the ΔLPP amplitude in response to own unsuccessful mothers-child interactions and non-intrusiveness ($r = 0.5$, $p = .04$). That is, mothers with higher levels of non-intrusiveness showed an enhanced LPP amplitude in response to the unsuccessful interactions with their own child. A statistical tendency toward a positive correlation emerged also between the ΔLPP amplitude in response to own unsuccessful mothers-child interactions and sensitivity (r = 0.4, p = .06). R values of the correlations among the investigated variables are reported in Table 14. A Scatterplot of the statistically significant correlation detected is displayed in Figure 19. The results of the correlation analysis were checked using the secondly computed differential score (as explained in the *Statistical analyses*), which confirmed and extended the results found (see Appendix 4).

Table 13

Results of the Repeated- Measure Anova on the ΔLPP amplitude.

Effects	**Degree of freedom**	**F-value**	***p*-value**	***ges***
Familiarity	(1,21)	15.6	0.0007***	0.3
Interaction type	(1,21)	1.9	0.2	0.008
Familiarity*Interaction type	(1,21)	0.7	0.4	0.007

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Table 14

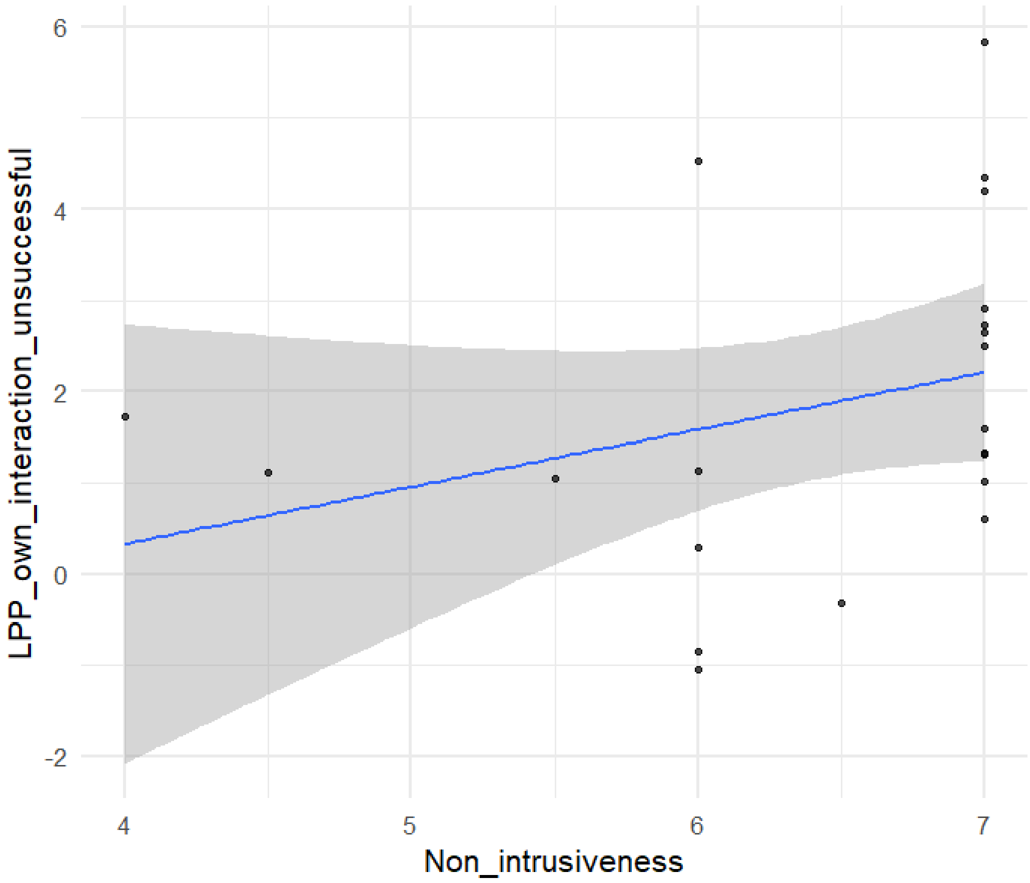
Correlations among the investigated variables; r values are reported.

	ΔLPP (own_successful)	**ΔLPP (own_unsuccessful)**	**ΔLPP (other_successful)**	**ΔLPP (other_unsuccessful)**
Sensitivity	-0.03	0.4	-0.01	-0.3
Structuring	0.02	0.4	-0.02	-0.3
Non-Intrusiveness	-0.2	0.5*	0.08	-0.4
Non-Hostility	0.0	0.3	-0.2	-0.1
(Child) Responsiveness	-0.1	0.1	0.2	-0.05
(Child) Involvement	-0.2	0.1	0.2	-0.02
PARQmother	0.1	0.1	-0.3	0.01
PARQfather	-0.1	-0.05	0.03	0.1
Involvement (me)	0.1	0.1	0.05	-0.2

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Figure 19

Correlation between the ΔLPP in response to own unsuccessful interactions and maternal non-intrusiveness.



Discussion

Adopting a multi-method research strategy, the present study was the first one to investigate the ERP responses to child-related stimuli in the understudied population of same-sex mothers. Our focus on same-sex mothers was therefore motivated by the fact that no research so far focused on these types of family. Taken as a whole, our findings informed the field of the neural correlates of parenting beyond a heteronormative perspective. Moreover, employing a novel and ecological experimental task, we started to enrich the understanding of the phenomenology of sensitive caregiving in different family contexts.

ERP response

Studies investigating articulated maternal behaviors consistently highlighted positive parenting qualities in same-mother families, such as the high level of warmth and sensitivity with their children (for a detailed dissemination of the topic, see Carone, 2021). However, the automatic and unconscious processes underlying maternal responses have been left uninvestigated in these families. For the first time in a sample of same-sex mothers, we found that the LPP amplitude was larger in response to mothers' interactions with their own child compared to other parent-child interactions. In line with previous research (Weisman et al., 2012; Bornstein et al., 2013; Bernard et al., 2018), we therefore supported the "own-child specific" sustained attentional response in same-sex mothers. In general, differences in mothers' responses when viewing their own versus another child may be related to the unique emotional bond between the mother and the child, as well as the intensely personal relevance of it. Accordingly, images of a mother's own child might confer associations, memories, and meanings that extend far beyond the physical features of the baby schema (Kuzava, 2021). Consistent with this argument, the familiarity effect remained robust, in our study, after controlling for the child age. However, differently from previous evidence, it should be noted that our goal was to detect the electrophysiological underpinnings of the mother ‘‘being with their infant'' rather than viewing their own infants in particular conditions (e.g., smiling, crying; Grasso et al., 2009; Bick et al., 2013). Therefore, using a novel experimental task, we aimed to capture the mechanisms underlying maternal responses to more naturalistic stimuli, as we asked mothers to respond to dynamic videos, and not just to photos of their own or other children. This represented a considerable strength of our study compared to previous research (see Wan et al., 2015 for a similar consideration). In fact, due to the use of static stimuli so far, we could not tell whether the neurobiological responding to infant stimuli was explained by the artificial nature of the stimuli (e.g., focus on one component of facial expressions or vocalizations; use of stimuli from unfamiliar infants). This issue has raised questions about the generalizability of findings to parents' neurobiological responses when interacting with their own infant; differently, we enriched previous literature in the context of the ecological and dynamic parent-infant exchanges (Xu & Groh, 2023). Nonetheless, much EEG research on this topic using dynamic infant stimuli might contribute to a broader discussion of our results, which is now limited due to no literature available using the same methodology. In addition to this, we did not find any effects of the type of interaction (successful vs. unsuccessful) on the LPP amplitude. This was consistent with previous evidence demonstrating a modulation of LPP amplitude based on the relationship and social context, which might be more influential than the emotional valence of the experimental stimuli (Schiano Lomoriello et al., 2022).

ERP response and self-reports

Another objective of our study was to explore the associations between the LPP amplitude in different conditions and the maternal involvement in childcare, as well as the mother's perceived quality of early care from their own caregivers. First, it was interesting to notice that, in our study, same-sex mothers perceived the division of childcare as fairly egalitarian within their couples (see Figure 17). In line with previous research on the topic (Patterson et al., 2004; 2013; Goldberg et al., 2012), this could be regarded as one of the strengths of same-sex parent families, which are characterized by a considerable flexibility in the dyadic division of childcare (Carone & Lingiardi, 2022). However, in terms of correlations, we did not find any associations between the LPP amplitudes and the maternal involvement in childcare. In line with this evidence, Grasso and colleagues (2009) did not find any associations between the Commitment scale scores (This Is My Baby interview; Bates & Dozier, 1998) and the P300 amplitude responses in biological and non-biological mothers. Perhaps, exploring the quality of activities accomplished, rather than only the quantity of involvement in childcare, might result in a more promising methodological choice for future research. Therefore, parenting involves many types of behaviors, such as, for instance, feeding and comforting, taking care of appointments, and playing with the child. Engaging in certain types of parental behaviors might contribute to tuning maternal responses to infants in different ways than others. Moreover, we adopted a relative instead of an absolute measure of parental involvement. Since same-sex parents usually share childcare tasks in a more egalitarian way than heterosexual couples (Farr & Patterson, 2013), perhaps all caregivers in the present sample spent a considerable amount of time with their infants. This might have not allowed us to detect significant variations in the degree of involvement in childcare within each couple, which might have been associated, in turn, with significant variations in maternal brain activity (see Ellis-Davies et al., 2022 for a similar explanation). Similarly, we did not find any associations between the LPP amplitude and the perceived quality of past care from caregivers. Of note, a considerable number of same-sex mothers accessed assisted reproduction through clinics, which typically require intended parents to undergo psychological counselling. This might stand to reason that parents who completed the conception process might have elaborated more deeply their early experiences of care with caregivers, smoothing potential differences even in those cases in which early parental rejection occurred (see Carone et al., 2023 for a similar explanation). However, since early adverse experiences have been demonstrated to worsen parenting outcomes (e.g., Lang et al., 2010; Juul et al., 2016; Kluczniok et al., 2016) future studies should further explore this topic. In particular, a deeper phenotyping of early care experiences with caregivers, using narrative or qualitative techniques (e.g., Halverson, 1988), might better correlate with maternal EEG responses to child cues. In addition, the specific circumstances of

LGBQIA+ parents' experiences should be considered in future (D'Amico & Julien, 2012; Fuller, 2017. In general, we cannot rule out that a lack of statistically significant results in relation to both the self-reported measures might have been due to our study being underpowered.

EEG and observed maternal behavior

Of particular interest for this work was the ways in which differences in the LPP amplitude were potentially associated with differences in the quality of maternal caregiving behaviors. Generally, mother-child dyads displayed good levels of EA in this study, with their scores resembling the ones presented in another pilot study on same-sex mothers (Barone et al., 2020). This gave support to the well-established evidence indicating positive mother-child relationships in same-sex mother families (e.g., Bos et al., 2007; Fedewa et al., 2015; Golombok et al., 2023). In addition to this important premise, we found that mothers with higher levels of non-intrusiveness showed an enhanced LPP amplitude in response to unsuccessful interactions with their own child (i.e., the condition in which the mother and the child did not interact together). A tendency toward statistical significance was also detected in relation to mothers' LPP amplitude in response to unsuccessful interactions with their own child and maternal sensitivity. Our findings supported some previous evidence that the elaboration of distressed child signals might be crucially related to optimal maternal qualities (e.g., Rodrigo et al., 2011; Bernard et al., 2015; Kuzava et al., 2019). In line with this, mothers must be able to deal with their own emotional responses to infant distress in order to provide high-quality care to their child (Groh et al., 2015). However, in our study, the video-clips displaying unsuccessful mother-child interactions did not always show a child being distressed. Thus, our findings may reflect a pattern of neural activity in response to subtle variations in child signals, which might be correlated to optimal EA qualities. In a realistic environment, in fact, mothers need to respond appropriately to subtle child cues as well as to more emotionally evocative stimuli, like crying or smiling.

Partially at odds with our findings, Endendijk and colleagues (2018b) highlighted that an increased LPP activity in response to infant faces was associated with higher levels of intrusiveness in mothers. The authors suggested mothers might have paid excessive attention to the child cues, as reflected by a greater LPP amplitude; this might have been associated with their greater levels of intrusive behaviors (Endendijk et al., 2018b). All in all, the association between the LPP amplitude and maternal intrusiveness might be not linear, but, for instance, u-shaped, with very low or high LPP amplitudes being associated with suboptimal maternal behaviors. Most importantly, whether a larger or smaller LPP amplitude to child cues is adaptive for caregiving might be dependent on the kinds of caregiving demands elicited by each child (Kuzava, 2021). In addition, numerous methodological differences between the studies, including the fact that they used static images of unfamiliar infant faces, might explain the different results.

Of note, no other correlations with maternal EA qualities emerged. We might assume that our teaching task performed at home, which was well-structured for the mother and the child, particularly elicited the maternal quality of non-intrusiveness (i.e., mothers must keep from completing the puzzle for their child). Perhaps, variations in maternal sensitivity are best captured in those situations in which the infant shows more distress (Endendijk et al., 2018b). Another possible explanation is related to the average age of children in our sample, who were mostly preschoolers or primary schoolers. On this note, maternal non-intrusiveness is particularly adaptive in those developmental stages, in which mothers help the child progress to the zone of proximal development by encouraging their autonomy. However, considering that some other significant associations emerged using the secondly computed differential score (i.e., between LPP and maternal hostility; see Appendix 4), future research with a larger sample size might clarify our results in relation to the different EA dimensions.

Limitations and future directions

The results of the present study should be read in the light of some limitations, with some of them reflecting common difficulties of research with sexual minority populations (Krueger et al., 2020).

First, the associations we found did not imply a causal relationship; it is therefore possible that positive parenting might influence parental neurobiology just as parental neurobiology may contribute to positive parenting. In addition, the study was not sufficiently powered, and the small sample size kept from drawing firm conclusions regarding the associations found. In this regard, the difficulty in recruiting a sample of same-sex mothers who could travel to our laboratory from different areas in Italy should be acknowledged. In addition to the geographical barriers, COVID-19 pandemic precluded lab visits for a considerable number of mothers who were willing to participate. Relatedly, the wide child age in our study reflected the fact that our inclusion criteria were not as stringent as the ones previously adopted in studies addressing the neurobiological aspects of parenting, which usually focused on a narrower period of child development. Moreover, the fact that our sample included both biological and non-biological mothers might have added some variability to our conclusions. In addition to this, since same-sex mothers frequently have a twin pregnancy due to the assisted reproduction techniques, this variable should be also taken into account in future research, as it has been demonstrated to modulate maternal responsiveness (Ellis-Davies et al., 2022).

Methodologically, EEG activations related to dynamic stimuli might not be best captured by ERP analyses; therefore, future research could perform more complex analyses, as the spectral or time-frequency analyses (e.g., Killeen & Teti, 2012), to describe the brain activity elicited by dynamic stimuli. Moreover, even though we tried to standardize the experimental stimuli, the own- versus other- stimuli might have differed in many ways beyond familiarity, and the degree of this difference might have varied between participants. Regarding control stimuli of parent-child interactions, we were not able to control for any possible combinations of conditions (see Appendix 4).

Since mothers included here were mainly highly educated and with a high socio-economic status, much effort should be put in including families from different social backgrounds in future. This would allow researchers to disentangle the variability explained by the level of education and income of parents from the one related to family dynamics and processes. Eventually, it is possible that the associations between neural activity and maternal optimal behaviors would differ depending on the developmental stage of the child. A task for future research might be, therefore, to test different patterns of associations in different developmental stages, using analytic approaches which can model changes over time. Since EA does not cover all the parental abilities that are important for child development, different nuances of caregiving behaviors might be importantly explored.

Conclusion

Delineating the neurobiological mechanisms underlying maternal behaviors may result in a better understanding of the nature of mother-child bonding under different circumstances. For this purpose, this study responded to the need to detail the ways in which brain responses to child-related cues may be associated with maternal characteristics and caregiving behaviors in diverse family contexts. Using a novel and ecological experimental paradigm, we found that the LPP amplitude was enhanced in same-sex mothers when they viewed videos of interactions with their own child. Moreover, a less intrusive maternal behavior was related to a higher LPP activation in response to own unsuccessful mother-child interactions. Taken together, our findings provided evidence to the non-existent literature regarding the neural correlates of maternal response in same-sex mothers. Furthermore, we gave strength to previous evidence that the elaboration of distressed child signals might be crucially related to optimal parental qualities. Since LGBTQIA+ parents have been frequently excluded from family research and policies (Costa 2021; ILGA, 2023) especially in the Italian context, much scientific effort is needed to provide empirical evidence on these families deconstructing negative attitudes and stereotypes towards the (Rollè et al., 2020; 2022; Baiocco et al., 2020).

Final Discussion

Infant cues are considered to be *innate releasers* or *motivational entities* eliciting a coordinated set of neurobiological, cognitive and behavioral responses in adults (Barrett & Fleming, 2011; Swain et al., 2007; 2011). The appropriate perception and interpretation of infants' signals is an integral part of sensitive caregiving, which supports the development of a child and fosters a secure attachment relationship (Ainsworth et al., 1978). The present work aimed to enrich the knowledge on adults' cognitive and electrophysiological responses to infant cues, focusing on the role of adults' sex, the perceived quality of early care from caregivers, as well as the actual involvement in childcare.

In the following sections, general important results and considerations on the adults' cognitive and electrophysiological responses to infant cues will be first outlined; then, the main findings related to the factors associated with adults' responses to infant cues will be addressed in detail. Possible limitations and future developments of this work, as well as the conclusive arguments of this thesis, will be eventually presented.

Cognitive response to infant cues

At the cognitive level, our findings confirmed that adults' attention prioritized infant rather than adult faces (e.g., see Lucion et al., 2017). In Study 1 and Study 2, we found that infant faces elicited a greater attentional bias compared to adult faces in non-parents, different-sex parents and same-sex mothers. In line with previous evidence on the topic (Thompson-Booth et al., 2014a; Oliveira et al., 2017; Dudek & Haley, 2020; Long et al., 2021), a significant effect of the type of facial expression was not found across the studies.

Specifically, in Study 1 we found that parents, both mothers and fathers, tended to allocate more attention to infant versus adult faces relative to non-parents. Accordingly, it might be important, especially for parents, to rapidly attend to infant cues in an environment where other information competes for attention. In Study 2, we extended, for the first time, empirical evidence which were confined to heteronormative samples of parents to same-sex mothers. Consistent with our findings, including a mixed sample of same-sex and different-sex parent families (i.e., *n*=22 mothers and *n*=22 fathers from same-sex parent families; *n*=22 mothers; *n*=22 fathers from different-sex parent families), recent data (Gemignani et al., *Under Review*) has suggested that the attentional bias to infant faces might be an automatic cognitive process underlying adults' responses to infant cues, independently on parents' sex and the type of family structure (i.e., different- versus same-sex parent family).

Electrophysiological response to infant cues

At the neurophysiological level, in Study 3 we confirmed that infant compared to adult faces elicited a larger N170 amplitude in adults, independently of the emotional valence displayed. On the other hand, the LPP amplitude was found consistently larger in response to emotional versus unemotional faces; in particular, crying infant expressions seemed to prompt the greatest LPP positivity in adults. Therefore, whilst structural characteristics of faces corresponding to baby schema were prioritized by adults in the early stages of processing (Proverbio et al., 2011; Colasante et al., 2017), a preferential attention toward infant distress emerged at later stages (Doi & Shinohara, 2012).

In Study 4, we found that the LPP amplitude was larger in response to mothers' interactions with their own child compared to other parent-child interactions; therefore, we supported the established "own-child specific" sustained attentional response in same-sex mothers (Weisman et al., 2012; Bornstein et al., 2013; Bernard et al., 2018). These findings importantly provided first evidence to the non-existent literature regarding the neural correlates of maternal responses in same-sex mothers. With respect to previous evidence adopting static images of infant faces (Grasso et al., 2009; Weisman et al., 2012; Doi & Shinohara, 2012; Bornstein et al., 2013; Bernard et al., 2018), the use of highly ecological dynamic stimuli yielded more validity to our findings. In fact, due to the use of static stimuli so far, the generalizability of findings to parents' neurobiological responding when interacting with their own infant was called into question (see Wan et al., 2015 for a similar consideration). Differently, we enriched previous literature in the context of the ecological and dynamic parent-infant exchanges (Xu & Groh, 2023). Moreover, we found that a less intrusive maternal behavior was related to a higher LPP amplitude in response to own unsuccessful mother-child interactions. Therefore, we gave strength to the argument that the elaboration of distressed child signals might be crucially related to optimal parental qualities (Rodrigo et al., 2011; Bernard et al., 2015; Kuzava et al., 2019). Noteworthy, this is, so far, the first evidence enriching the understanding of the neurophysiological correlates of sensitive caregiving including different family contexts.

Sex

Sex differences in the adults' response to infant faces were previously explained in terms of the differential hormonal status and pregnancy-related changes between women and men (Hahn et al., 2013), and interpreted as subserving the women's traditional role of primary caregivers (Lobmaier et al., 2010; Sprengelmeyer et al., 2009).

In Study 1, we preliminarily suggested that females compared to males had a greater attentional bias towards infant faces; nonetheless, this effect was no longer detected, in the subsample of parents, after accounting for their early parental involvement in childcare. In line with this, whilst evidence on sex differences has received little empirical support in parenting research so far (Young et al., 2017), cultural norms related to parenthood, as the often gendered division of childcare between mothers and fathers in different-sex parent families (Patterson et al., 2004; 2013; Farr & Patterson, 2013), might help to explain the potential sex differences found in the adults' response to infant cues (Gemignani et al., 2022). Accordingly, it might be that whether differences favored mothers over fathers in previous research (e.g., Proverbio et al, 2006; Cárdenas et al., 2013), they might have reflected differences in the ways mothers and fathers are socialized to parents, but not real differences in parents' sex (Ellis-Davies et al., 2022). Thus, social-cultural variables related to family dynamics might have conflated with sex in previous research (Biblarz & Stacey, 2010). As a result of biological essentialism, a greater importance has been traditionally placed on motherhood, whereas paternal role has been disregarded (Kringelbach et al., 2016).

As we also included non-parents in Study 1, the consideration of other socio-cultural factors potentially related to sex could have shed further light on our results. For instance, Ding and colleagues (2020) demonstrated that behavioral responses to infant stimuli were susceptible to social expectations related to the individuals' gender in non-parents. Therefore, in Study 3 we investigated the role of sex and gender norms in the non-parents' N170 response to infant faces. At first glance, females compared to males seemed to display a larger N170 amplitude in response to infant faces; however, a higher score in femininity, independently of non-parents' sex, was actually associated with a heightened N170 amplitude in response to infant faces. As in the case of parental involvement in childcare for parents, the effect of gender roles has been possibly confused with the one explained by sex in previous research on adults' response to infant cues. Therefore, considering that females are traditionally more imbued with ideals of femininity as compared to males (Lindqvist et al., 2021), the two variables might have been partially overlapping.

All in all, our findings suggested that, although sex differences might be detected in the adults' responses to infant cues (Hahn et al., 2013), they are not always biologically determined, but they might be better explained or reinforced by societal norms. In light of these arguments, considering only individuals' sex in parenting research might produce inaccurate, or at least incomplete, findings. That is particularly true if sex is operationalized as a binary variable; in that case, diversity in sexual identities might not be captured with binary response options; so, empirical research might fail to recognize the individuals falling outside the traditional categories (i.e., intersex individuals). In spite of these arguments, this evidence does not imply that there is no merit in investigating sex differences in parenting research. Since individuals are embodied in ways that reflect both evolution and social contexts, studying the effect of sex and social characteristics might help approach a more comprehensive perspective. Therefore, by considering multiple layers of individual identities, we think that both theoretical knowledge and methodological practices would be enriched in future research on the topic.

Parental Involvement in childcare

Parental engagement with childcare has proved to be of considerable importance for parent-child relationships and for the child's optimal development (Bono et al., 2016; Cano et al., 2019; Rollè et al., 2019). However, very little attention, to date, has been drawn on how parental involvement in childcare might be associated with adults' cognitive and electrophysiological responses to child cues. As a general remark, we confirmed the well-established evidence (Patterson et al., 2004; 2013; Goldberg et al., 2012; Farr & Patterson, 2013) that same-sex mothers tend to divide the childcare activities within the couple in a more egalitarian was as compared to different-sex couples; this pattern can be inspected across the different studies (i.e., comparing Figure 3, Figure 8 and Figure 17).

When it comes to the main analyses, in Study 1 we preliminarily outlined that those parents, both mothers and fathers, who were more involved in early childcare displayed a greater attentional bias to infant versus adult faces. Covering multiple aspects of parental involvement, in Study 2 we confirmed that more involved same-sex mothers displayed a stronger attentional bias to infant versus adult faces. The fact that we included a sample of same-sex mothers gave strength to our findings, as we ruled out socio-culturally driven differences in the division of childcare as it might occur different-sex couples (Carone & Lingiardi, 2022; Giannotti et al., 2022a). Overall, even though previous evidence has suggested that attentional bias to infant cues is established prenatally and thus partially independent of caregiving experience (Dudek & Haley, 2020; Pearson et al., 2010), our results have consistently highlighted that parental involvement may come into play in modulating attentional bias to infant cues postnatally, with greater involvement in childcare reflecting a greater prioritization of attention to infant over adult faces. This evidence, in line with previous evidence on non-biological parents (Bick et al., 2013; Grasso et al., 2009), gave support to the idea that a preferential elaboration of infant faces might not be only related to biological processes, but also associated with nurturing experiences in parents.

On the other hand, parental involvement in childcare was not found to be associated with the LPP amplitude in response to parent-child interactions in same-sex mothers in Study 4. Overall, this might suggest that the quantity of time that parents spend with their child might not fully explain the different nuances of parental responses to infant cues, as detected at different levels of investigation by implementing different methodologies. Indeed, rather than focusing only on the quantity of time that parents spend with their child, much effort should be put on addressing qualitative aspects of parental involvement in childcare (Rollè et al., 2019; Palkovitz, 2019). Therefore, parenting involves many types of behaviors, such as, for instance, feeding and comforting, taking care of appointments, and playing with the child. Engaging in certain types of parental behaviors might contribute to tuning parents' responses to infants in different ways than others. In addition to this, the quantitative commitment of parents might not fully explain their caregiving roles; in fact, important aspects of caregiving, such as the ability of emotionally regulating the child when they are upset (e.g., see Bowlby, 1977), might be accomplished also by those parents who dedicate a limited amount of time to child rearing.

Another reason for the inconsistency of our findings might be related to the insufficient reliability of the measure used for assessing parental involvement in childcare. As suggested by two recent systematic reviews (Rollè et al., 2019; Giannotti et al., 2022b), the multidimensional construct of parental involvement in childcare has not been integrated into a comprehensive conceptual framework yet. Therefore, different conceptualizations of the concept have led to a great heterogeneity in terms of measures. Nonetheless, given its critical role in fostering parent–child relationships and child health and psychological outcomes (e.g., Feldman, 2000; Grossman et al., 2002; Fuertes et al., 2016), enhancing the theoretical understanding and methodological assessment of parental involvement in childcare might be of significant relevance for future research.

Perceived quality of past care experiences from caregivers

Among the different experiences that individuals might have throughout their life, early experiences of care from caregivers have been demonstrated to be essential for later adults' adjustment (Khaleque & Rohner, 2012). To investigate the contribution of early experiences of care from caregivers, the present work was grounded in the theoretical perspective of the IPARTheory (Rohner, 2021).

In Study 1, we found that experiences of warm care from one's own mothers during childhood were positively associated with a greater attentional bias to infant versus adult faces in parents and non-parents. On the other hand, those individuals who remembered being more rejected by their own mothers displayed a weakened attentional bias to infant versus adult faces. In Study 3, behavioral findings aligned with those displayed in Study 1. According to previous research (Senese et al., 2018), we overall suggested that an appropriate perception and interpretation of infant cues might be related to mental representations of warm care perceived from one's own caregivers during childhood. In particular, the perception of early maternal care may have an important role in the adults' cognitive responses to infant cues.

However, different results emerged in Study 2. Contrary to what expected, we found that higher levels of paternal rejection were associated with a greater attentional bias to infant versus adult faces in same-sex mothers. That is, those mothers who felt more rejected by their own fathers during childhood were more biased, in terms of attention, to infant versus adult faces. However, it should be noted that the level of mothers' attention to faces, in terms of RTs, generally decreased by increasing the level of paternal rejection. Beyond the consideration of the attentional bias as a differential measure, our result might have therefore suggested that the attention to faces generally decreased in more rejected mothers. This argument would be in line with previous studies showing a hindered perceptual bias toward social stimuli in those mothers who encountered adverse care experiences during childhood (Fraedrich et al., 2010; Leyh et al., 2016). In addition, it should be noted that the experience of acceptance/rejection in same-sex mothers might be different as compared to the one reported in heteronormative samples, due to potential adverse events that they might have experienced (e.g., coming out with parents, stigmatization; Fuller, 2017). Since LGBTQ+ individuals have been generally understudied in psychological research (Suen et al., 2020), future studies on this topic should importantly take into consideration the specific circumstances of their experiences of care (Fuller, 2017).

At the neurophysiological level, in Study 3, we demonstrated that non-parent adults who felt more rejected by their own fathers during childhood showed an increased N170 amplitude to infant versus adult faces. In other words, it might be more demanding, for those adults who felt more rejected by their own fathers, to elaborate infant faces, especially at the very early stage of face processing. On the other hand, no associations between past experiences of care and the LPP amplitudes to infant and child cues were observed, neither in Study 3 nor in Study 4. By adopting a task design involving the presentation of faces, however, it would be interesting to see whether the relationship between the N170 amplitude and early quality of care might be corroborated also in a sample of same-sex mothers. In Study 4, we could not test this association as we did not use faces as experimental stimuli.

Taken as a whole, our empirical evidence supported the IPARTheory's postulates that differences in the early experiences of care can lead to distinct emotional and cognitive organizations in adults, which guide their responding when confronted with attachment-relevant stimuli as infant cues. Coherence across the studies evidenced that whilst maternal care might affect adults' responses to infant cues at a cognitive level, the quality of paternal care might be related to the adults' early electrophysiological responses to infant faces. So, early experiences of care from mothers and fathers seemed to be distinctively important for the development of the child’s ability to process social cues. However, these patterns of relationships might be different for same-sex mothers, for whom other intervening variables, potential resilience factors, or subjective perceptions should be further explored. Importantly, in the context of the IPARTheory, another question should be raised, in future, about the unique variance in the LGBTQ+ individuals’ outcomes predicted by parental acceptance and rejection during childhood (D'Amico & Julien, 2012).

Cross-sex effects

Although exploratorily, we consistently found that adults’ sex modulated the associations between the perceived quality of care experiences from caregivers and adults’ cognitive and neurophysiological responses to infant cues. In particular, in Study 1 we highlighted that the influence of maternal rejection on the attentional bias to infant faces was more pronounced in males versus females. That is, when males felt more rejected by their mothers during childhood, their attentional bias to infant versus adult faces tended to decrease to a greater extent as compared to the pattern displayed by females. Consistently, at behavioral level, Study 3 outlined that males who felt more rejected by their own mother during childhood displayed longer RTs in response to faces and a lower level of accuracy in categorizing emotional faces as compared to females. At the neurophysiological level, the opposite pattern was evidenced; therefore, in Study 3 we found that females who felt more rejected by their own father during childhood had a stronger increase in the N170 and a decrease in the LPP amplitude in response to happy and sad faces compared to males. Overall, it might be that males and females develop different developmental pathways when it comes to social cue processing, whether they had perceived adverse early care experiences from their own mothers or fathers. At the behavioral level, males might display a greater developmental sensitivity to poor environmental experiences with their own mothers, whereas, at the neurophysiological level, females might have a greater sensitivity to the quality of early paternal care. Accordingly, a recent meta-analysis has shown that, although the magnitude of the differences was not great, cross-sex effects like these could be detected across studies (Ali et al., 2015).

However, future research should corroborate these results. For instance, it might be the case that care experiences with one's own mother or father may not be intrinsically different per se, but paternal or maternal roles, may they be taken on by a mother or a father, could better relate with different characteristics of early parenting styles in caring for children. Differences in caregiving roles, reflecting the different ways in which women and men have been socialized as parents, might better explain the outcomes for females and males' later response to infant cues as compared to parent's sex. This evidence would be supported, theoretically, by the gender-neutral model of parental constructs (Fagan et al., 2014; Biblarz & Stacey, 2010). Considering the modern societal changes, an increasing mismatch between parents' sex and their roles, even in the cases of different-sex parent families, requires a clear distinction of these aspects in future.

Limitations and future directions

Acknowledging the considerable strengths of this work, our findings should be considered in the light of some limitations, which can point towards future directions. First, the cross-sectional nature of the studies did not allow us to draw firm conclusions regarding the directionality of the effects found. Understanding the directions of the relationships by implementing longitudinal experimental designs can be the next step elucidating factors contributing to parental responses to infant cues. Secondly, we were not able to calculate the effect sizes of our findings; besides some solutions adopted in some specific experimental conditions (Westfall et al., 2014), there is therefore no agreement on how to calculate effect sizes of the effect sizes for LMMs.

To provide more inclusive and representative samples in our research, we were less stringent regarding the inclusion criteria (e.g., in terms of child age, type of conception of the child); this might have added some variability to our conclusions. In future research, it would be worthwhile to investigate the contribution of those factors which were left behind in this work. For instance, the consideration of the type of relationship that parents have with their child (e.g., biological versus non-biological) should be addressed by adopting a combination of quantitative and qualitative methodologies, informing about parents' reproductive experiences with a particular attention to the new reproductive options. Importantly, since many of the findings have been presented here for the first time, a thorough replication of them should be needed to provide their stability.

As we only considered the amount of parental involvement in childcare, future research varying types of caregiving involvement is encouraged. The use of qualitative and observational methods can help researchers to deepen the knowledge in this field; these methodologies, in fact, might be more suitable to grasp the dynamic nature of parental involvement in childcare, which is a complex phenomenon involving several dimensions (Rollè et al., 2019).

Regarding the PARQ measure, a task for future research would be to corroborate the effects found in this work; in particular, the specific contribution of a mother or a father on the adult's responses to infant cues might be interestingly read in function of their roles in child rearing, rather than their sex. As an additional consideration, asking about participants' experiences with their own primary or secondary caregiver, and not just with their own father or mother, can make the PARQ a more inclusive measure. If we consider, for instance, children living in same-sex parent families, future developments of the measure should be needed in this regard. As a considerable alternative, a question could be posed to participants before starting the questionnaire, asking to define which type of family they grew up with. By doing so, this information would not be taken for granted, resulting in individuals raised in different types of families feeling acknowledged.

Importantly, this work did not include any findings on same-sex father families. Men in same-sex parent families need to frequently negotiate a multi-minority status (Armesto, 2002); in addition, the legal barriers they need to face to access to parenthood are even more conspicuous compared to the ones faced by same-sex mother families (D'Amore et al., 2023). Besides the fact that they are not able to adopt, surrogacy is prohibited in many countries across Europe, namely Austria, Finland, France, Germany, Italy, Norway, Sweden, and Switzerland, and unregulated in Belgium, the Czech Republic, Ireland, Luxembourg, and Romania (D'amore et al., 2023). So, intended two-men families must frequently travel far away abroad, to specific states of the United States and Canada. In Italy, these aspects have contributed to the unbalanced composition of the "*Famiglie Arcobaleno*" members: of the total members, only around one third are fathers (Baiocco et al., 2015). In spite of the difficulties in recruitment, we encourage future studies collecting much evidence on same-sex father families, who might uniquely contribute to enrich the knowledge on parental responses to infant cues (Giannotti et al., 2022a). In addition, as same-sex parents who participated in our studies were mainly Caucasian highly educated individuals, with a high or medium-high socio-economic status, same-sex parents from different social, educational and economic backgrounds should be included in future research. As a general consideration, future studies on parenting are needed to expand the research samples, including more ethnic groups and different geographical contexts, as well as low-income and minority families. According to an intersectional perspective (Crenshaw, 2013; Cole, 2009), different narratives regarding parenthood are therefore worthy to be represented in future.

Eventually, relevant progress in the parenting field mostly occurs when research designs build a bridge between laboratory measures and the actual parenting behaviors (Feldman, 2015). Given that we measured the quality of parental behaviors only in Study 4, future research should elucidate the ecological validity of the measure for assessing attentional bias to infant faces, adopted in Study 1 and Study 2. Despite the value of this approach in teasing apart how infant faces are processed by adults, possible correlations with the quality of parent-child relationships should be explored. In such a way, the practical applications of this paradigm will be understood and optimized.

Conclusions

Importantly, adults' responses to infant signals are thought to organize caregiving behaviors. By bringing together different methodologies, this work aimed to provide a more comprehensive understanding of the adults' cognitive and electrophysiological responses to infant cues, focusing on the role of adults' sex, the perceived quality of early care from caregivers, as well as the actual involvement in childcare. On the whole, the present work gave a cohesive idea of how the investigation of brain activity, cognitive aspects and behaviors provides relevant findings that can integrate each other in caregiving research. In doing so, it responded to the recent interest in understanding the correlates of caregiving responses going beyond a heteronormative perspective on parenting. The findings reinforced the argument that differences between males and females, if present in the response to infant stimuli, might not be always biologically determined, but better explained or reinforced by societal norms. In addition, we supported the relevance of accounting for both past and current experiences of care when investigating adults' cognitive and electrophysiological responses to infant cues. On this note, future research might benefit from considering the qualitative aspects of the nuanced caregiving experiences. Eventually, we importantly acquired some knowledge on the neurophysiological correlates of sensitive caregiving in different family structures, which had not been investigated before. Overall, embracing the complexity of multiple family models, we attempted to value the importance of considering different narratives and perspectives in parenting research. Hopefully, accurate representations and inclusive data involving LGBTQ+ parents would help to improve the family outcomes and reduce disparities.

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Appendix 1

Numerical values of the effects found in Study 1

Type III Analysis of Variance Table with Satterthwaite's method for Aim 1.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 67.9)	63.0	<0.001***
Emotional valence	(1, 68.0)	0.7	0.4
Face*Emotion	(1, 68.0)	1.7	0.2

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Type III Analysis of Variance Table with Satterthwaite's method for Aim 2.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 70.2)	61.7	<0.001***
Parental status	(1, 196.0)	4.1	0.04*
Sex	(1, 195.9)	7.9	0.006**
Age	(1, 196.1)	0.3	0.6
Face age*Parental status	(1, 27406.1)	3.5	0.06
Face age*Sex	(1, 27405.3)	4.5	0.03*
Parental status*Sex	(1, 195.9)	2.9	0.09
Face age*Parental status*Sex	(1, 27405.7)	0.05	0.8

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Type III Analysis of Variance Table with Satterthwaite's method for Aim 3.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 69.9)	68.5	<0.001***
PARQmother	(1, 194.0)	0.03	0.9
PARQfather	(1, 193.9)	0.3	0.5
Face age*PARQmother	(1, 26862.7)	20.8	<0.001***
Face age*PARQfather	(1, 26862.9)	3.1	0.08

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Type III Analysis of Variance Table with Satterthwaite's method for Aim 3.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 73.0)	53.7	<0.001***
PARQmother	(1, 190.9)	0.8	0.3
Parental status	(1, 191.0)	0.1	0.7
Sex	(1, 190.9)	8.3	0.004**
Age	(1, 191.0)	0.4	0.5
Face age*PARQmother	(1, 27262.2)	32.3	<0.001***
PARQmother*Sex	(1,190.9)	0.006	0.9
PARQmother*Parental Status	(1,190.9)	1.29	0.3
Face age*Sex	(1, 27262.3)	8.5	0.004**
Face age*Parental Status	(1, 27263.0)	4.5	0.03*
Sex*Parental Status	(1,190.9)	2.0	0.2
Face age*PARQmother*Sex	(1, 27262.4)	15.3	<0.001***
Face age*PARQmother*Parental Status	(1, 27262.0)	0.6	0.4
PARQmother*Sex*Parental Status	(1, 190.9)	0.002	0.97
Face age*Sex*Parental Status	(1, 27262.7)	0.05	0.8
PARQmother*Sex*Face age*PARQfather	(1, 26862.0)	0.08	0.8

Note. *** = $p < .001$; ** = $p < .01$; * = $p < .05$

Type III Analysis of Variance Table with Satterthwaite's method for Aim 4.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 112.4)	42.9	<0.001***
Sex	(1, 85.0)	4.8	0.03*
Involvement	(1, 84.9)	0.3	0.5
Parent age	(1, 85.0)	0.6	0.4
Child age	(1, 85.0)	0.5	0.5
Face age*Sex	(1, 12334.4)	0.3	0.6
Face age*Involvement	(1, 12333.4)	13.7	<0.001***
Sex*Involvement	(1, 84.9)	2.1	0.1
Face*Sex*Involvement	(1,12333.8)	0.3	0.6

Note. *** = $p < .001$; ** = $p < .01$; * = $p < .05$

Appendix 2

Items on parental nurturing behaviors in Study 2

1) How often did you change your child's diaper?

2) How often did you prepare meals or bottles for your child?

3) How often did you feed your child or give your child a bottle?

4) How often did you play peek-a-boo with your child?

5) How often did you hold them?

6) How often did you do things like tickle your child, blow on their belly, or move their arms and legs around in a playful way?

7) How often did you put your child to sleep?

8) How often did you wash or bath your child?

9) How often did you take your child outside for a walk or to play in the yard, a park or a playground?

10) How often did you dress your child?

(5-More than once a day/ 4-About once a day/ 3-a few times a week/ 2-Rarely/ 1-Not at all)

Overview of the results of the main models implemented in Study 2

Results of Model 1

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.015	0.002	-9.070	<.001***
Emotional valence	-0.006	0.002	-3.068	.003**
Face*Emotion	0.003	0.002	1.297	.2

Note. *** = *p* < *.001;* ** = *p* < *.01;* * = *p* < *.05*

Model 1 (varying all the slopes in the random structure)

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.015	0.004	-3.540	<.001***
Emotional valence	-0.006	0.004	-1.279	.2
Face*Emotion	0.002	0.004	0.539	.6

Note. *** = *p* < *.001;* ** = *p* < *.01;* * = *p* < *.05*

Model 1 (varying only the slopes of the main effects in the random structure)

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.015	0.004	-3.566	<.001***
Emotional valence	-0.006	0.004	-1.280	.2
Face*Emotion	0.003	0.002	1.316	.2

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Note. The main effect of emotional valence did not remain stable by increasing the complexity of the random structure; therefore, this variable was dropped by the subsequent models to reduce their complexity (Bates et al., 2015).

Results of Model 2

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.015	0.002	-8.011	<.001***
Involvement	-0.001	0.004	-0.268	.8
Face*Involvement	-0.001	0.0003	-3.331	<.001***
Child age	-0.00003	0.002	-0.015	.99
Parity	-0.02	0.06	-0.411	.7

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Results of Model 3

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.015	0.002	-8.536	<.001***
PARQmother	0.0001	0.001	0.035	.97
Face*PARQmother	-0.00001	0.0001	-0.098	.9

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Results of Model 4

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.016	0.002	-8.875	<.001***
PARQfather	-0.001	0.002	-0.912	.4
Face*PARQfather	-0.0003	0.0001	-2.788	.005**

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Results of Model 3 and Model 4 after accounting for child age and parity as covariates

Results of Model 3

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.02	0.002	-8.536	<.001***
PARQmother	0.00003	0.001	0.02	.984
Face*PARQmother	-0.00001	0.001	-0.1	.922
Child age	-0.00006	0.002	-0.04	.969
Parity	-0.02	0.05	-0.423	.922

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Results of Model 4

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.02	0.002	-8.875	<.001***
PARQfather	-0.001	0.001	-0.871	.4
Face*PARQfather	-0.0003	0.0001	-2.788	.005**
Child age	-0.002	0.002	-0.129	.9
Parity	-0.02	0.06	-0.340	.7

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Results of all the models after accounting for the dyad in the random structure

Results of Model 1

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.015	0.001	-9.070	<.001***
Emotional valence	-0.006	0.002	-3.067	.003**
Face*Emotion	0.003	0.002	1.297	.199

Note. *** = *p* < .001; ** = *p* < .01; * = *p* < .05

Results of Model 2

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.015	0.002	-8.012	<.001***
Involvement	-0.002	0.004	-0.471	.6
Face*Involvement	-0.001	0.0003	-3.329	<.001***
Child age	-0.0003	0.002	-0.140	.9
Parity	-0.02	0.07	-0.377	.7

Note. *** = *p* < .001; ** = *p* < .01; * = *p* < .05

Results of Model 3

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.015	0.002	-8.537	<.001***
PARQmother	-0.0006	0.001	-0.5	.6
Face*PARQmother	-0.00002	0.0001	-0.099	.9

Note. *** = *p* < .001; ** = *p* < .01; * = *p* < .05

Results of Model 4

Fixed effect	**β**	**SE**	**t**	**p**
Face age	-0.016	0.002	-8.877	<.001***
PARQfather	-0.001	0.001	-1.207	.4
Face*PARQfather	-0.0003	0.0001	-2.788	.005**

Note. *** = *p* < .001; ** = *p* < .01; * = *p* < .05

Appendix 3

The LPP averaged amplitude over a group of centro-parietal electrodes (CZ, PZ, CP1, CP2)

Experimental Conditions	LPP amplitude (SD)
Infant happy	2.07(1.31)
Infant neutral	2.19(1.45)
Infant sad	2.54(1.32)
Adult happy	1.60(1.26)
Adult neutral	1.71(1.45)
Adult sad	1.76(1.25)

Numerical values of the results of the models implemented in Study 3

LMM for RTs and PARQmother: Type III Analysis of Variance Table with Satterthwaite's method.

Effects	Degree of freedom (numerator, denominator)	F-value	*p*-value
Face age	(1, 255)	12.1	<0.001***
Emotional valence	(2, 255)	15.8	<0.001***
PARQmother	(1, 51)	8.1	<0.01**
Sex	(1,51)	0.6	0.4
Face age* Emotional valence	(2,255)	10.7	<0.001***
Face age*PARQmother	(1,255)	0.0	0.99
Emotional valence*PARQmother	(2,255)	2.5	0.08
Face age*Sex	(1,255)	0.7	0.4
Emotional valence*Sex	(2,255)	0.2	0.8
PARQmother*Sex	(1,51)	4.2	0.04*
Face age* Emotional valence*PARQmother	(2,255)	0.06	0.9
Face age* Emotional valence*Sex	(2,255)	1.7	0.2
Face age* PARQmother*Sex	(1,255)	0.05	0.8
Emotional valence*PARQmother*Sex	(2,255)	0.9	0.4
Face age* Emotional valence*PARQmother*Sex	(2,255)	0.9	0.4

Note. *** = $p < .001$; ** = $p < .01$; * = $p < .05$

LMM for RTs and PARQfather: Type III Analysis of Variance Table with Satterthwaite's method.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 255)	12.3	<0.001***
Emotional valence	(2, 255)	15.3	<0.001***
PARQfather	(1, 51)	3.2	0.08
Sex	(1,51)	0.05	0.8
Face age* Emotional valence	(2,255)	9.6	<0.001***
Face age*PARQfather	(1,255)	0.05	0.8
Emotional valence*PARQfather	(2,255)	0.7	0.5
Face age*Sex	(1,255)	0.7	0.4
Emotional valence*Sex	(2,255)	0.4	0.7
PARQfather*Sex	(1,51)	0.2	0.7
Face age* Emotional valence*PARQfather	(2,255)	0.3	0.7
Face age* Emotional valence*Sex	(2,255)	1.7	0.2
Face age* PARQfather*Sex	(1,255)	0.1	0.7
Emotional valence*PARQfather*Sex	(2,255)	1.7	0.2
Face age* Emotional valence*PARQfather*Sex	(2,255)	0.5	0.6

Note. *** = $p < .001$; ** = $p < .01$; * = $p < .05$

LMM for Accuracy and PARQmother: Type III Analysis of Variance Table with Satterthwaite's method.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 255)	86.5	<0.001***
Emotional valence	(2, 255)	24.3	<0.001***
PARQmother	(1, 51)	5.3	0.03*
Sex	(1,51)	7.0	0.01*
Face age* Emotional valence	(2,255)	34.1	<0.001***
Face age*PARQmother	(1,255)	0.7	0.4
Emotional valence*PARQmother	(2,255)	14.6	<0.001***
Face age*Sex	(1,255)	0.5	0.5
Emotional valence*Sex	(2,255)	4.7	<0.01**
PARQmother*Sex	(1,51)	1.9	0.2
Face age* Emotional valence*PARQmother	(2,255)	2.7	0.07
Face age* Emotional valence*Sex	(2,255)	0.8	0.4
Face age* PARQmother*Sex	(1,255)	0.3	0.6
Emotional valence*PARQmother*Sex	(2,255)	8.3	<0.001***
Face age* Emotional valence*PARQmother*Sex	(2,255)	0.3	0.8

Note. *** = $p < .001$; ** = $p < .01$; * = $p < .05$

LMM for Accuracy and PARQfather: Type III Analysis of Variance Table with Satterthwaite's method.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 255)	75.8	<0.001***
Emotional valence	(2, 255)	26.3	<0.001***
PARQfather	(1, 51)	0.01	0.9
Sex	(1,51)	4.9	0.03*
Face age* Emotional valence	(2,255)	32.0	<0.001***
Face age*PARQfather	(1,255)	0.1	0.8
Emotional valence*PARQfather	(2,255)	0.3	0.7
Face age*Sex	(1,255)	0.6	0.4
Emotional valence*Sex	(2,255)	2.1	0.1
PARQfather*Sex	(1,51)	1.0	0.3
Face age* Emotional valence*PARQfather	(2,255)	0.2	0.8
Face age* Emotional valence*Sex	(2,255)	0.6	0.5
Face age* PARQfather*Sex	(1,255)	0.1	0.7
Emotional valence*PARQfather*Sex	(2,255)	0.6	0.6
Face age* Emotional valence*PARQfather*Sex	(2,255)	1.2	0.3

Note. *** = $p < .001$; ** = $p < .01$; * = $p < .05$

Preliminary analysis (Repeated Measure Anova) to test the effect of lateralization on the N170.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**	***ges***
Face age	(1, 55)	42.4	<0.001***	0.2
Emotional Valence	(2, 110)	1.4	>0.05	0.01
Lateralization	(1, 55)	2.4	>0.05	0.00
Face age*Emotional Valence	(2, 110)	2.2	>0.05	0.01
Face age*Lateralization	(1,55)	2.7	>0.05	0.00
Emotional Valence*Lateralization	(2, 110)	2.5	>0.05	0.00
Face age*Emotional Valence*Lateralization	(2, 110)	2.7	>0.05	0.00

*Note. *** = p < .001; ** = p < .01; * = p < .05*

LMM for N170 and PARQmother: Type III Analysis of Variance Table with Satterthwaite's method.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 260)	66.3	<0.001***
Emotional valence	(2, 260)	0.7	0.5
PARQmother	(1, 52)	1.4	0.2
Sex	(1,52)	0.003	0.95
Face age* Emotional valence	(2,260)	1.7	0.2
Face age*PARQmother	(1,260)	0.5	0.5
Emotional valence*PARQmother	(2,260)	0.1	0.9
Face age*Sex	(1,260)	5.7	0.02*
Emotional valence*Sex	(2,260)	0.03	0.97
PARQmother*Sex	(1,52)	0.7	0.4
Face age* Emotional valence*PARQmother	(2,260)	0.05	0.95
Face age* Emotional valence*Sex	(2,260)	0.6	0.5
Face age* PARQmother*Sex	(1,260)	0.2	0.6
Emotional valence*PARQmother*Sex	(2,260)	0.6	0.5
Face age* Emotional valence*PARQmother*Sex	(2,260)	0.3	0.7

*Note. *** = p < .001; ** = p < .01; * = p < .05*

LMM for N170 and PARQfather: Type III Analysis of Variance Table with Satterthwaite's method.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 260)	76.0	<0.001***
Emotional valence	(2, 260)	1.0	0.4
PARQfather	(1, 52)	5.1	0.03*
Sex	(1,52)	0.03	0.9
Face age* Emotional valence	(2,260)	2.1	0.1
Face age*PARQfather	(1,260)	4.8	0.03*
Emotional valence*PARQfather	(2,260)	0.6	0.5
Face age*Sex	(1,260)	6.9	<0.01**
Emotional valence*Sex	(2,260)	0.06	0.9
PARQfather*Sex	(1,52)	2.0	1.2
Face age* Emotional valence*PARQfather	(2,260)	0.9	0.4
Face age* Emotional valence*Sex	(2,260)	0.7	0.5
Face age* PARQfather*Sex	(1,260)	0.96	0.3
Emotional valence*PARQfather*Sex	(2,260)	3.2	0.04*
Face age* Emotional valence*PARQfather*Sex	(2,260)	0.02	0.98

Note. *** = $p < .001$; ** = $p < .01$; * = $p < .05$

LMM for LPP and PARQmother: Type III Analysis of Variance Table with Satterthwaite's method.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 260)	1.1	0.3
Emotional valence	(2, 260)	9.1	<0.001***
PARQmother	(1, 52)	0.1	0.8
Sex	(1,52)	0.5	0.5
Face age* Emotional valence	(2,260)	3.9	0.02*
Face age*PARQmother	(1,260)	0.3	0.6
Emotional valence*PARQmother	(2,260)	0.8	0.5
Face age*Sex	(1,260)	1.4	0.2
Emotional valence*Sex	(2,260)	2.4	0.1
PARQmother*Sex	(1,52)	0.2	0.7
Face age* Emotional valence*PARQmother	(2,260)	0.1	0.9
Face age* Emotional valence*Sex	(2,260)	0.9	0.4
Face age* PARQmother*Sex	(1,260)	0.02	0.9
Emotional valence*PARQmother*Sex	(2,260)	1.2	0.3
Face age* Emotional valence*PARQmother*Sex	(2,260)	4.7	0.01*

Note. *** = $p < .001$; ** = $p < .01$; * = $p < .05$

LMM for LPP and PARQfather: Type III Analysis of Variance Table with Satterthwaite's method.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1, 260)	1.3	0.3
Emotional valence	(2, 260)	9.6	<0.001***
PARQfather	(1, 52)	0.1	0.8
Sex	(1,52)	0.5	0.5
Face age* Emotional valence	(2,260)	5.4	0.005**
Face age*PARQfather	(1,260)	2.4	0.1
Emotional valence*PARQfather	(2,260)	0.6	0.6
Face age*Sex	(1,260)	1.3	0.3
Emotional valence*Sex	(2,260)	2.7	0.07
PARQfather*Sex	(1,52)	2.4	0.1
Face age* Emotional valence*PARQfather	(2,260)	0.8	0.5
Face age* Emotional valence*Sex	(2,260)	0.8	0.4
Face age* PARQfather*Sex	(1,260)	0.4	0.5
Emotional valence*PARQfather*Sex	(2,260)	5.9	0.003**
Face age* Emotional valence*PARQfather*Sex	(2,260)	0.4	0.7

Note. *** = $p < .001$; ** = $p < .01$; * = $p < .05$

Exploratory analysis on the contribution of sex and gender roles on the adults' N170

Outcome of the Drop1 function applied to the full model: *N170_amplitude ~ Face_age * Emotional_valence + Face_age:Femininity + Face_age:Masculinity + Face_age:Sex + (1 | SUBJ)*

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age*Emotional valence	(2, 272.0)	2.1	0.1
Face age*Femininity	(2,86.4)	5.0	0.008**
Face age*Masculinity	(2,86.4)	1.0	0.4
Face age*Sex	(2,86.4)	0.7	0.5

*Note. *** = p < .001; ** = p < .01; * = p < .05*

LMM for exploratory analysis (i.e., results of the reduced model): Type III Analysis of Variance Table with Satterthwaite's method.

Effects	**Degree of freedom (numerator, denominator)**	**F-value**	***p*-value**
Face age	(1,278)	3.9	<0.05*
Femininity	(1,54)	2.6	0.1
Face age* Femininity	(1,278)	15.4	<0.001***

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Appendix 4

Characteristics of control stimuli (n=20 video-clips in total)

	Preschool Age		School Age	
	Mother	**Father**	**Mother**	**Father**
Female child (successful)	3	None	None	2
Female child (unsuccessful)	2	None	None	3
Male child (successful)	None	3	2	None
Male child (unsuccessful)	None	2	3	None

Note. Preschool Age (3-6 years); School Age (6-11 years).

Child Caregiving Involvement Scale

1. Playing or talking or reading with child(ren)

2. Getting child(ren) ready for bed, school or other activities

3. Reviewing/helping with child(ren)'s school work

4. Teaching a child skills and things about the world (outside of school)

5. Getting up during the night with a child

6. Staying home with a sick child

7. Making child-care arrangements

8. Chauffeuring children

9. Out-of-home child-related activities or functions (with or without children; e.g., doctor visits, PTA, drop-offs, scheduling, making reservations)

10. Coordinating and planning child or family activities (e.g., planning pick-ups, drop-offs, scheduling, making reservations)

Likert scale: 1=none or very little responsibility (less than 10%); 2=some responsibility (10%–40%), 3=about half of the responsibility (40%–60%), 4=much responsibility (60%–90%), to 5=almost complete or complete responsibility (90%–100%)

Shapiro-Wilk test for normality

Variables	p-value
Sensitivity	.05
Structuring	.02*
Non-Intrusiveness	<.001***
Non-Hostility	<.001***
(Child) Responsiveness	.02*
(Child) Involvement	.008**
PARQmother	<.001***
PARQfather	.06
Involvement (me)	.01*
ΔLPP	.8

*Note. *** = p < .001; ** = p < .01; * = p < .05*

Correlations among the investigated study variables considering the secondly computed differential score *(i.e., meanLPPamplitude[cond2]-meanLPPamplitudes[cond1])).*

Variables	ΔLPP(2)
Sensitivity	0.5*
Structuring	0.4
Non-Intrusiveness	0.6**
Non-Hostility	0.5*
(Child) Responsiveness	0.3
(Child) Involvement	0.3
PARQmother	0.0
PARQfather	0.0
Involvement (me)	-0.1

*Note. *** = p < .001; ** = p < .01; * = p < .05*