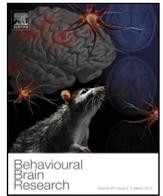




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### Research report

# Socioeconomic disadvantage, neural responses to infant emotions, and emotional availability among first-time new mothers

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### HIGHLIGHTS

- Low income was linked to neural processing of infants' emotions among mothers.
- Low income was associated with dampened amygdala response to positive infant faces.
- Low income was associated with elevated amygdala response to negative infant faces.
- The amygdala response was linked to more intrusive interactions with own infants.

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### ABSTRACT

During the early postpartum period, mothers exhibit increased amygdala responses to positive infant expressions, which are important for positive mother–infant relationships. Socioeconomic disadvantage is associated with altered amygdala response to emotional stimuli as well as more negative mother–infant relationships. However, little is known about the role of socioeconomic disadvantage in neural responses specifically to infants. Thus, we examined whether socioeconomic disadvantage (indexed by lower income-to-needs ratio) is associated with neural responses to infant emotions and parenting behaviors among new mothers. Using fMRI, neural responses to infants' emotional expressions (positive, negative, and neutral faces) were assessed among 39 low- and middle-income first-time mothers during 0–6 postpartum months. Lower income-to-needs ratio was associated with dampened amygdala responses to positive infant faces, but increased amygdala responses to negative infant faces. An indirect effect of socioeconomic disadvantage on emotional availability via amygdala activation suggests that socioeconomic disadvantage is associated with heightened neural sensitivity to infants' negative emotions, which is further associated with mothers' intrusiveness observed during interactions with their own infant. The findings suggest that low-income mothers may be more vulnerable to altered neural processing of infants' emotional expressions which may further influence mothers' emotional availability during interactions with their own infants.

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### 1. Introduction

During the early postpartum period, both structural and functional adaptation in the brain play an important role in parenting among new mothers [1–3]. Among neural changes associated with parenting, researchers have identified that heightened amygdala sensitivity to infant emotional expressions, particularly positive expressions, play an important role in secure mother–infant attachment and sensitive parenting [4–7]. However, little is known about

factors that may influence individual variations in neural responses to infant emotions among new mothers. Socioeconomic disadvantage increases exposure to unstable and stressful environments, which can hinder mothers' ability to provide optimal care for their own infants [8–11]. Thus, in the current study, we examined whether maternal socioeconomic disadvantage is associated with altered neural processing of infants' emotional expressions. We then examined whether the altered neural responses to infants' emotional expressions were associated with mothers' parenting behaviors during the early postpartum period.

The quality of maternal care during the early months of the first year has a significant long-term impact on infants' cognitive and emotional development [12]. The concept of mothers' emotional availability has been used to describe and assess the

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quality of maternal care [13–15]. Emotional availability is based on Ainsworth's maternal sensitivity scale with a more explicit emphasis on the dyadic nature of emotions (both positive and negative) during mother–infant interactions. High emotional availability is characterized by mothers' own emotional expressions that are attuned to the child's emotional expressions. Among aspects of emotional availability to young children, maternal sensitivity (appropriate emotional expression and response to the child's expressions) and nonintrusiveness (emotional presence without overriding the child's needs) are highly relevant to mothers' appropriate understanding of emotional cues from their infants [16]. Difficulties in understanding infant emotions can be associated with low emotional availability behaviors such as intrusive or insensitive parenting, which can lead to negative mother–infant relationships and insecure infant–mother attachment [17–20]).

Given the importance of sensitive mothering during the first year, the neurobiological mechanisms of parenting have been studied using both animal and human models. Among the many neural regions involved in responding to infant emotional cues, the amygdala has been highlighted for its significant role in understanding emotional expressions of others [21]). The role of the amygdala in processing other's emotional cues is critically involved in parenting. In rodents, lesions in the amygdala impair maternal sensitivity [22], and mother–pup interactions increase *c-fos* changes in the amygdala [23]. In human mothers, the amygdala is activated by infant faces, indicating the role of the amygdala in detecting the salience of infant cues for parenting [1,5,24].

However, postpartum factors that influence individual variations in amygdala responses to infant faces are still not well understood. A previous study suggests that lower levels of parental distress are associated with heightened amygdala responses to positive infant faces among new mothers [25]. In the current study, we focused on the potential role of socioeconomic disadvantage in maternal neural responses to infants. Socioeconomic disadvantage has been linked to mothers' more limited emotional availability for their own infants [26,27]). Socioeconomic disadvantage was also associated with increased maternal distress, which was then linked to reduced neural responses to infant cry in medial and middle prefrontal regions among first-time mothers [28]). However, this study did not examine the relations between neural activation and mothers' own parental behaviors nor include different types of infants' emotion cues. Therefore, the current study aims to examine whether neural processing of positive and negative infant cues, particularly in the amygdala, may be a pathway by which socioeconomic disadvantage influences observed parenting behaviors among new mothers.

Currently, there is converging evidence that socioeconomic disadvantage is associated with an individual's heightened amygdala reactivity to negative emotional cues such as negative adult faces [29–31]. Increased levels of stress have been suggested as one of the key pathways by which socioeconomic disadvantage is associated with elevated neural and behavioral reactivity to negative emotion [2,32,33]. Low-income mothers report higher levels of psychological distress during the postpartum period [34]). Thus, socioeconomic disadvantage and associated emotional distress among new mothers may be associated with altered neural processing of infant emotional expressions, such as elevated neural responses to infants' negative expressions rather than positive expressions.

The current cross-sectional study examined whether socioeconomic disadvantage (assessed by lower income-to-needs ratio) was associated with neural responses to positive and negative infant faces, and further with parenting behaviors among low- and middle-income first-time new mothers. In the amygdala, we hypothesized that the interaction effects of income-to-needs ratio and infant emotion would be significant, and that lower income-to-

needs ratio would be associated with altered amygdala activation, particularly reduced amygdala response to positive infant faces and increased amygdala response to negative infant faces. Increased levels of emotional distress among lower-income mothers may further be associated with variations in neural responses to infant faces. Moreover, we examined the indirect effect of socioeconomic disadvantage on parenting behaviors via the amygdala responses to infant emotions. We hypothesized that dampened amygdala response to positive infant faces and elevated amygdala response to negative infant faces would be associated with mothers' sub-optimal parenting behaviors, i.e. lower maternal sensitivity and higher maternal intrusiveness.

## 2. Materials and methods

### 2.1. Participants

First-time mothers with their biological infants at age 0–6 months were recruited through fliers and brochures in metro Denver areas, including midwifery clinics as well as the WIC (Women, Infant, and Children) and Colorado state Prenatal Plus programs to ensure socioeconomic diversity in the sample. Eligible mothers were English-speaking and free from the following: pregnancy-related or infant medical illnesses involving more than a one-night stay in the neonatal intensive-care unit (NICU), current or historical psychiatric/neurological illness other than depression or anxiety diagnoses (to keep a controlled but ecologically valid community sampling approach), psychoactive drug use (except antidepressants), and magnetic metal in the body. Lower-income women were oversampled to be nearly half of the sample (see Family Income of the Measures section for more details). Of the 47 participants who were recruited, 8 mothers were excluded from analyses because they did not have complete fMRI data. Five mothers completed only home visits, two mothers were claustrophobic, and one mother had excessive motion above criteria (see fMRI data preprocessing for details). Thus, a total of 39 mothers were included in the analyses presented here. Among them, 27 participants were overlapping with the sample of a previously published paper using a different fMRI task [28]. Their demographic characteristics are described in Table 1.

Four participants reported a history of depression or anxiety disorder diagnosis. Participants were largely psychoactive drug free except one participant who reported using an antidepressant. Participants were relatively diverse in terms of their ethnicity/race with 43.6% reporting Caucasian and 41% reporting Hispanic background (Table 1). No demographic variable (i.e. maternal age, race/ethnicity, handedness, mood disorder status, breastfeeding status, postpartum month at the time of scan, mothers' time spent away from infants, infant's sex, or interval between home and fMRI visits) was associated with income-to-needs ratio,  $rs(37) < 0.24$  or  $> -0.27$ ,  $ps > 0.10$ .

### 2.2. Procedures

Mothers were initially contacted by phone to assess their eligibility for the study. If eligible, a home visit was scheduled. During the home visit, mothers completed questionnaires and interviews on income and maternal mood. Mother–infant interactions were also video-recorded during the home visit. In a subsequent visit for the fMRI portion of the study, mothers visited the Intermountain Neuroimaging Center at the University of Colorado – Boulder. The average interval between home and fMRI visits was around 3 weeks (see Table 1). Participants received monetary compensation for their participation at the end of each visit, and child care

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