（博士論文表紙様式）

Maternal Postpartum Depressive Symptoms Predict Delay in Non-verbal Communication in 14-month-old Infants

（　母親の産後うつ症状は 14 か月児における非言語的コミュニケーションの遅延を予測する　）

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Maternal postpartum depressive symptoms predict delay in non-verbal communication in 14-month-old infants

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ABSTRACT

We investigated the potential relationship between maternal depressive symptoms during the postpartum period and non-verbal communication skills of infants at 14 months of age in a birth cohort study of 951 infants and assessed what factors may influence this association. Maternal depressive symptoms were measured using the Edinburgh Postnatal Depression Scale, and non-verbal communication skills were measured using the MacArthur-Bates Communicative Development Inventories, which include Early Gestures and Later Gestures domains. Infants whose mothers had a high level of depressive symptoms (13+ points) during both the first month postpartum and at 10 weeks were approximately 0.5 standard deviations below normal in Early Gestures scores and 0.5–0.7 standard deviations below normal in Later Gestures scores. These associations were independent of potential explanations, such as maternal depression/anxiety prior to birth, breastfeeding practices, and recent depressive symptoms among mothers. These findings indicate that infants whose mothers have postpartum depressive symptoms may be at increased risk of experiencing delay in non-verbal development.

1. Introduction

Human communication skills develop dramatically during infancy, with recent literature highlighting the importance of non-verbal communication skills (e.g. gestures), versus verbal communication skills (e.g. language), during the earliest stages of life. Specifically, emergence and development of non-verbal communication skills is predictive of and succeeded by development of verbal communication skills (Alexander Pan, Rowe, Spier, & Tamis-Lemonda, 2004; Bates & Dick, 2002; Bavin et al., 2008; Reilly et al., 2006; Reilly et al., 2010), implying that "gesture paves the way for language development" (Iverson & Goldin-Meadow, 2005). Accordingly, delayed development of non-verbal communication skills has been suggested

Abbreviations: CDI, the MacArthur-Bates Communicative Development Inventory; DSM-IV-TR, the Diagnostic and Statistical Manual of Mental Disorders, 4th edition, Text Revision; EPDS, Edinburgh Postnatal Depression Scale; HBC Study, the Hamamatsu Birth Cohort for Mothers and Children; SCID-I, the Structured Clinical Interview for DSM-IV Axis I Disorders.

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to be associated with poor language development in later life (Brignell et al., 2016) as well as a range of neuropsychiatric conditions (Chartrand & Lakin, 2013; Galeote, Sebastian, Checa, Rey, & Soto, 2011; Kjellmer, Hedvall, Fernell, Gillberg, & Norrelgen, 2012; Luyster, Seery, Talbott, & Tager-Flusberg, 2011; Stone, McMahon, Yoder, & Walden, 2007; Zwaigenbaum, Bryson, & Garon, 2013). These studies have thus implied the utility of non-verbal communication skills as a milestone for accurate prediction and better understanding of trajectories of a range of developmental domains. However, details regarding infant populations most at-risk for delayed development in non-verbal communication skills remain unclear. The primary aim of this study is to explore predictors of delayed development in non-verbal communication skills.

Potential sociodemographic predictors of these population, i.e. infants with delayed non-verbal communication skills have been reported in literature, including male gender (Reilly et al., 2006), non-Caucasian ethnicity (Tamis-LeMonda, Song, Leavell, Kahana-Kalman, & Yoshikawa, 2012), and low maternal education (Rowe & Goldin-Meadow, 2009). Beyond the aforementioned studies examining sociodemographic predictors, maternal predictors of a child's non-verbal communication skills has not been well understood. In early years of research, gestures and imitations have been discovered to start soon after birth and thought to be responses to maternal actions (Meltzoff & Moore, 1977, 1992), suggesting that maternal responsivity is a key to facilitate non-verbal communication of infants. Recent studies added to this and suggested that "baby sign program" or gesture training may influence on responsiveness of mothers (Kirk, Howlett, Pine, & Fletcher, 2013; Vallotton, 2009). Conversely, if maternal responsivity is decreased due to some reasons, this may hinder facilitation of non-verbal communication skill. Maternal depressive symptoms after childbirth, commonly referred to as postpartum depression, are therefore of interest in this regard, as such symptoms are likely to decrease responsivity to the child and thus to affect child development both psychologically and biologically (Apter-Levy, Feldman, Vakart, Ebstein, & Feldman, 2013; Conroy et al., 2012; Keim et al., 2011; Kingston, Tough, & Whitfield, 2012; Koutra et al., 2013; McManus & Poehlmann, 2012; Nasreen, Kabir, Forsell, & Edhborg, 2013). Of clinical note, maternal depressive symptoms after childbirth are known to be one of the most prevalent psychiatric manifestations among women, noted in some 10% to 20% of women after childbirth (Gavin et al., 2005; O'Hara & McCabe, 2013). Further, maternal depressive symptoms after childbirth have been reported to be predictive of infants' language delay (Brennan et al., 2000; Quevedo et al., 2012). In this regard, one can suspect if maternal depressive symptoms also confer risk for delayed development, possibly in 1 per 10 to 5 infants' non-verbal communication skills.

Here, we examined the association between maternal depressive symptoms, measured during the first month and 10 weeks after childbirth, and infants' development of non-verbal communication skills, measured at 14 months of age using the MacArthur-Bates Communicative Development Inventories (CDI; Fenson et al., 2007), translated and validated in Japanese (Ogura & Watanuki, 2004). Any association, if confirmed, would then be investigated to determine what factor underlies this association.

2. Methods

This study was conducted as part of the ongoing hospital-based birth cohort study, the Hamamatsu Birth Cohort for Mothers and Children (HBC Study), the details of which has been described elsewhere (Takagai et al., 2016; Tsuchiya et al., 2010). Briefly, participants were mothers and their newborn infants, with mothers enrolled during pregnancy and infants enrolled at birth, both to be followed-up until the child was approximately 10 years of age. On comparison with official national statistics, our subjects were shown to be representative of mothers and infants in Japan in terms of socioeconomic status, parity, birth weight, and gestational age at birth (Takagai et al., 2016; Tsuchiya et al., 2010).

2.1. Ethical considerations

The study was conducted in accordance with the guidelines proposed in the World Medical Association Declaration of Helsinki and has been approved by the Medical Ethical Committee of Hamamatsu University School of Medicine, Japan (No. 20–82, 21–114, 22–29, 24–67, 24–237, 25–143, 25–283, E14-062). Full written informed consent for the study was obtained from participating parturients for both parent and child data.

2.2. Participants

In the framework of HBC Study, we consecutively contacted all pregnant women who were expected to give birth at either of our two research sites—Hamamatsu University Hospital and Kato Maternity Clinic, both situated in Hamamatsu City—between December 1, 2007, and November 30, 2011. For the present study, the parturients were followed up from mid-pregnancy, when they were approached to enter the study (between the 14th and 26th week of gestation), to 14 months after childbirth. Infants to whom the parturients gave birth were also followed up from birth to 14 months of age in the present study. Of the 1064 infants followed-up until 14 months of age, 113 (11%) were excluded for missing their examination at the age of 14 months due to difficulties in visiting our research site, and so the remaining 951 were investigated in our study.

Comparison of the 113 excluded participants and 951 participants to be analysed showed no significant differences between the two groups in terms of annual household income, years of maternal education, or infants' gestational age at birth, gender, birth order, or twin births (no multiple births other than twins occurred). Only mean mother's age (but not mother's partner's age) was significantly younger among excluded participants than analysed participants (30.1, standard deviation [SD] 5.0 vs. 31.8, SD 5.1 years; $t = 3.21$, $df = 1062$, $p < 0.001$).

For 951 infants, there were 857 mothers involved. This indicates 764 mothers had 764 infants enrolled in this study; 92 mothers had 184 infants enrolled (2 infants per mother); 1 mother had 3 infants enrolled (3 infants per mother). In the following regression analyses, we adopted robust standard errors allowing for intra-sibling correlations (*vce cluster* option in Stata software). Without this option, the estimated confidence intervals become too narrow and are prone to overestimation of significance of the associations of interest, as intra-sibling correlation is substantial particularly in child data (Senterre, Leveque, Vanthournout, & Dramaix, 2015).

A study proposed that baby sign programs can enhance child's language production (Goodwyn, Acredolo, & Brown, 2000). Some participating children might have attended this program, although we have not collected data on this.

2.3. Measures

2.3.1. Maternal depressive symptoms

We assessed maternal depressive symptoms using the Japanese version (Okano et al., 1998) of the Edinburgh Postnatal Depression Scale (EPDS) (Cox, Holden, & Sagovsky, 1987), which is commonly used to roughly estimate the prevalence of postpartum depression (Halbreich & Karkun, 2006). Participants were asked to complete the EPDS questionnaire at approximately 2, 4, and 10 weeks after childbirth. Since major depressive disorder of postpartum onset is defined as a major depressive episode occurring during the first 4 weeks after childbirth in the Diagnostic and Statistical Manual of Mental Disorders, 4th edition, Text Revision (DSM-IV-TR; (American Psychiatric Association, 2000), we chose the higher of the two scores at the 2nd and 4th weeks after birth and presented the value as the score during the first month after childbirth. With regard to cutoff scores, a cutoff of 8/9 was validated in Japanese version of EPDS (Yoshida, Yamashita, Ueda, & Tashiro, 2001) and 12/13 in the original version (Matthey, 2008). We therefore defined scores of less than 9 points as indicating no depression or a low level of depressive symptoms, 9 to 12 points as a medium level, and 13 points or higher as a high level of depressive symptoms in the present study. The clinical validity of both the original and Japanese versions of the EPDS as a screening tool has been confirmed (Cox et al., 1987; Tamaki, Murata, & Okano, 1997; Yoshida et al., 2001), and both validation studies have reported satisfactory sensitivity and specificity for identifying a major depressive episode, as defined in DSM-IV-TR. At the time of measurement of depressive symptoms in the present study, the current version of the DSM system (DSM-5) had not been published.

2.3.2. Non-verbal communication skills

We evaluated non-verbal communication skills of participating infants at age 14 ± 1 months using the MacArthur-Bates Communicative Development Inventories (CDI:(Fenson et al., 1993, 2007)), a Japanese version of which has been fully validated and standardised (Ogura & Watanuki, 2004). Briefly, we conducted a face-to-face interview with the each infant's caregivers (all but one were the infant's mother) and asked questions listed in the CDI to enhance objectivity of the evaluation process.

The CDI have two versions according to age of the subject: the "Words and Gestures form" and the "Words and Sentences form". The "Words and Gestures form" is appropriate for use with 8- to 18-month-olds and generates scores for phrase and word comprehension, word production, and use of communicative and symbolic gestures. The "Words and Sentences form" is designed for 16- to 30-month-olds and thus is not suitable for this study. The "Words and Gestures form" of the CDI comprises three domains in verbal communication skills and two in non-verbal communication skills. We used these non-verbal communication skills domains ("Early Gestures" and "Late Gestures": (Bavin et al., 2008; Fenson et al., 2007)). In the present study, we do not use these verbal communication scores of the "Words and Gestures form" but use non-verbal communication skills domains along with the aim of this study.

The "Early Gestures" domain has two subdomains: "First Communicative Gestures" (e.g. Extending an arm to show you something he or she is holding) and "Games and Routines" (e.g. Playing peekaboo), composed of 18 items. The "Later Gestures" domain has three subdomains: "Actions with Objects" (e.g. Eating with a spoon or fork), "Pretending to be a Parent" (e.g. Putting a doll or a stuffed animal to bed) and "Imitating Other Adult Actions" (e.g. Sweeping or mopping), composed of 45 items. Internal consistency of the items was satisfactory: Early Gestures domain alpha = 0.77, and Later Gestures domain alpha = 0.87.

To facilitate interpretation of findings for non-verbal communication skills, we transformed the scores of each domain (Early Gestures and Later Gestures) into z-scores with a mean of 0 and SD of 1, stratified by infants' gender. This stratification was necessary because communicative skills are known to emerge at different timepoints and in different fashions between girls and boys (Eriksson et al., 2012). As such, standardisation of each domain of CDI scores was conducted along gender strata in the original version of the CDI(Fenson et al., 1993, 2007).

2.3.3. Demographic and perinatal factors

Relevant information on demographic and birth-related factors of the participating mothers, their partners, and their infants was extracted from HBC Study and included age of the mothers as well as partners, annual household income in million Japanese Yen (110 JPY = 1 USD as of July 1, 2016), and years of maternal education. All demographic data were collected at face-to-face interviews conducted during the second trimester of the index pregnancy. Infants' gestational age at birth, gender, birth order, and mothers' previous history of childbirth were collected through medical records obtained from our research sites.

2.3.4. Choice of factors potentially influencing associations of interest

After examining the literature, we decided to focus on the following three factors to determine what, if any, association they may have with maternal postpartum depression: maternal history of depression or anxiety prior to childbirth, breastfeeding practices, and recent maternal depressive symptoms, as follows.

First, we selected maternal history of depression or anxiety prior to childbirth given reports that maternal prenatal depression is an antecedent of perinatal and postnatal depressive symptoms (Evans, Heron, Francomb, Oke, & Golding, 2001) and is associated with a range of developmental outcomes among infants (Kingston et al., 2012). In addition, combined history of depressive and anxiety disorders is a best predictor for postpartum depression (Matsumoto et al., 2011; Mori et al., 2011). Second, we selected breastfeeding practice because difficulties with breastfeeding have been associated with maternal depression after childbirth and are reportedly associated with poor cognitive outcome of infants (Feldman & Eidelman, 2003). Third, we selected recent maternal depressive symptoms because maternal depressive symptoms during the first year after childbirth, not limited to postpartum period, have been repeatedly reported to be associated with reduced or slow general cognitive development of infants (Sohr-Preston & Scaramella, 2006), likely due to negative effects of poor maternal responsiveness and limited frequency of play with infants (Bornstein, Tamis-Lemonda, Hahn, & Haynes, 2008; Tamis-LeMonda et al., 2012). In the framework of HBC Study, recent maternal depressive symptoms were measured at 40 weeks (approximately 10 months) after childbirth.

2.3.4.1. Potential explanatory factor 1: mother's history of depression and anxiety prior to childbirth. Psychiatric disorders prior to childbirth was evaluated during the third trimester of the index pregnancy by trained clinical psychologists and psychiatrists, using the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I: (First, Spitzer, Gibbon, & Williams, 1996)). Members of the interview team, including four of the authors (EK, ST, NT, KJT), have been trained through official workshops in Japan. We defined a history of depression or anxiety as a current or past diagnosis of major depressive disorders, bipolar disorders, dysthymia, panic disorder with or without agoraphobia, specific phobia, social phobia, obsessive compulsive disorder, or adjustment disorder. We combined depressive and anxiety disorders, although co-occurrence is possible, and among 119 parturients with past or current history of depressive/anxiety disorder, 82 (69%) had history of depressive disorder only, 21 (18%) anxiety disorder only, and 16 (13%) both depressive and anxiety disorder. We did not consider other psychiatric disorders given the small number of participating parturients with such disorders and the lack of any reported associations between those disorders and maternal depressive symptoms after childbirth.

2.3.4.2. Potential explanatory factor 2: breastfeeding practices. Breastfeeding practice was evaluated in a cumulative manner. In the present study, participating mothers were interviewed at 1, 4, 6, 10, and 14 months after giving birth. At each interview, mothers were asked about breastfeeding practices over the previous four weeks—specifically, whether their infant(s) had been breast-fed, bottle-fed, mixed, or neither, regardless of separate provision of other foods or liquids. This information clarified whether or not the infant had been weaned, and how long the infant had been provided breast milk. From these interview findings, we were able to develop a variable reflecting history of breastfeeding by the age of 14 months, which was categorised as "Never breastfed" (mothers with no history of breastfeeding at and after the first month after childbirth), "Ever breastfed but had been weaned by 14 months" (mothers with history of breastfeeding at or after the first month after childbirth but had weaned their infant by age 14 months), and "Not yet weaned".

2.3.4.3. Potential explanatory factor 3: recent maternal depressive symptoms. We treated recent maternal depressive symptoms measured at 40 weeks differently from the prior measurements during the first month and at 10 weeks as only depressive symptoms occurring within three months after childbirth have been linked to postpartum depression (Halbreich & Karkun, 2006; Kendell, Chalmers, & Platz, 1987). We used this variable as a proxy for depressive symptoms closely prior to or potentially concurrent with development of non-verbal communication skills.

2.4. Procedure

We built a series of linear regression (hierarchical regression) models to assess the association of maternal depressive symptoms defined by EPDS scores with infants' z-transformed Early Gestures and Later Gestures scores measured with CDI. EPDS scores were treated as both categorical and continuous variables in analyses, because influence derived from EPDS does not necessarily show linear relationship to CDI scores. When treated as a categorical variable, three levels of depressive symptoms were adopted, as described earlier: low (0 to 8 points), medium (9 to 12 points) and high (13 points and over) levels. If categorical and continuous treatments lead to similar results, the results based on categorical variables will be reported in detail and the results based on continuous variables will be described as footnotes.

We examined the association of maternal EPDS scores during the first month and 10 weeks after childbirth, respectively, with two non-verbal communication skills scores (Early Gestures and Later Gestures), controlling for the exact timing of the 14-month measurement of CDI, as the timing actually varied between 13 and 15 months of age. We regarded this adjustment as obligatory and named this Model 1.

We then determined the influence of potential confounding factors—including demographic, perinatal factors, and EPDS score measured at different time points (e.g. within four weeks or at 10 weeks)—on associations of interest by incorporating them into Model 1. Candidates for potential confounding factors were age of the parturients and their partners at the infants'

Table 1
Characteristics of the participating mothers and infants.

	N (%) or mean (SD)	Range
MOTHERS' CHARACTERISTICS		
Age (years)	31.8 (5.1)	17–44
Age of the partner (years)	33.5 (5.8)	18–53
Household income (million JPY)	6.1 (2.8)	1.0–27.0
History of education (years)	13.9 (1.9)	6–23
History of depression and/or anxiety prior to childbirth (%)	119 (13%)	
Depressive symptoms, EPDS scores		
During the first month postpartum	4.4 (3.8)	0–22
0–8 point (at low level)	836 (88%)	
9–12 points (at medium level)	68 (7%)	
13 points and over (at high level)	47 (5%)	
At 10 weeks postpartum	2.6 (3.0)	0–28
0–8 point (at low level)	904 (95%)	
9–12 points (at medium level)	37 (4%)	
13 points and over (at high level)	10 (1%)	
At 40 weeks postpartum (Recent depressive symptoms)	2.3 (2.9)	0–23
0–8 point (at low level)	911 (96%)	
9–12 points (at medium level)	27 (3%)	
13 points and over (at high level)	13 (1%)	
INFANTS' CHARACTERISTICS		
Gender (%Male)	478 (50%)	
Birth order		
1	475 (50%)	
2	352 (37%)	
3+	124 (13%)	
Twin births	30 (3%)	
Gestational age at birth (weeks)	38.9 (1.6)	29.6–42.1
History of breastfeeding by 14 months of age		
Never breastfed	18 (2%)	
Ever breastfed but already weaned	588 (62%)	
Not yet weaned	345 (36%)	
Non-verbal communication skills: McArthur-Bates CDI at 14 months of age		
Early Gestures	11.7 (2.8)	1–23
Later Gestures	16.5 (6.7)	0–44

CDI, Communicative Development Inventories; EPDS, Edinburgh Postnatal Depression Scale

birth, years of education of the mother, annual household income, parity, and gestational age of the infant at birth. Gender of the infant was considered as a forced covariate even when non-verbal communication skills were z-transformed along two gender strata (Kleinbaum, Kupper, Muller, & Nizam, 1998). If any of these variables showed p-value of over 0.05, it was removed from the model to develop Model 2. Ultimately, age of the mother, years of education of the mother, and gender and gestational age of the infant at birth, and EPDS score were deemed factors that should be retained in Model 2 for preliminary analyses. We next investigated whether or not any potential associations could be further influenced by three potential explanatory factors, namely, maternal history of depression or anxiety prior to childbirth, breastfeeding practices, and recent maternal depressive symptoms. In the final, Full Model was then developed by simultaneously testing all three potential explanatory factors in addition to Model 2.

All analyses were conducted using Stata version 13.1 (StataCorp, College Station, TX, USA), with a *p*-value of 0.05 set as significant. To account for clustering of estimates stemming from inclusion of twins and infants born to the same mother in separate pregnancies during the enrolment period, we opted to use the clustering options together with robust standard errors, included with the Stata software.

3. Results

3.1. Characteristics of study participants

Characteristics of the 951 infants and their mothers are shown in Table 1. Mean age of mothers enrolled in our study did not differ markedly from the concurrent mean age of parturients in Japan, according to official national statistics. Mean age for annual household income, maternal education level, maternal history of depression/anxiety, and EPDS scores during the first month and at 10 weeks postpartum were comparable with findings from our previous studies (Matsumoto et al., 2011; Mori et al., 2011). As such, prevalence of depressive symptoms during the first month postpartum was estimated as 12%, slightly lower than or comparable with other Japanese data (18.2% after 1 month (Tamaki et al., 1997); 13.6% after 3 weeks (Yamashita, Yoshida, Nakano, & Tashiro, 2000)).

Table 2
Associations of EPDS scores as measures of maternal depressive symptoms during the first month or at 10 weeks postpartum, with z-score-transformed Early Gestures scores: regression coefficients (95% confidence intervals).

	Model 1	Model 2	Full Model
EPDS scores during the first month postpartum			
Low	0 (referent)	0 (referent)	0 (referent)
Medium	+0.04	−0.00	−0.01
	(−0.21 to +0.29)	(−0.24 to +0.24)	(−0.25 to +0.23)
High	−0.51	−0.52	−0.50
	(−0.81 to −0.21)	(−0.86 to −0.17)	(−0.85 to −0.14)
EPDS scores at 10 weeks postpartum			
Low	0 (referent)	0 (referent)	0 (referent)
Medium	−0.13	+0.13	+0.02
	(−0.48 to +0.22)	(−0.24 to +0.49)	(−0.37 to +0.41)
High	−0.58	−0.27	−0.46
	(−1.27 to +0.11)	(−1.02 to +0.49)	(−1.19 to +0.25)

CDI, Communicative Development Inventories; EPDS, Edinburgh Postnatal Depression Scale.
Model 1: Adjusted for the timing of the measurement of CDI.
Model 2: Model 1 with further adjustment for potential confounders [maternal age and education, gestational age at birth] and for EPDS scores.
Full Model: Model 2 with further adjustment for maternal history of depression/anxiety prior to childbirth, breastfeeding practices, and recent depressive symptoms.
EPDS score as a continuous variable (Full Model): EPDS score during the first month postpartum was significantly associated with Early Gesture scores (coefficient = −0.025, 95%CI: −0.048 to −0.002), whereas EPDS score at 10 weeks postpartum was not significantly associated with Early Gesture scores (coefficient = −0.012, 95%CI: −0.045 to +0.021).

Table 3
Associations of EPDS scores as measures of maternal depressive symptoms during the first month or at 10 weeks postpartum, with z-score-transformed Later Gestures scores: regression coefficients (95% confidence intervals).

	Model 1	Model 2	Full Model
EPDS scores during the first month postpartum			
Low	0 (referent)	0 (referent)	0 (referent)
Medium	+0.12	+0.07	+0.03
	(−0.13 to +0.37)	(−0.17 to +0.32)	(−0.21 to +0.27)
High	−0.43	−0.46	−0.46
	(−0.74 to −0.12)	(−0.79 to −0.12)	(−0.79 to −0.13)
EPDS scores at 10 weeks postpartum			
Low	0 (referent)	0 (referent)	0 (referent)
Medium	−0.02	+0.21	+0.06
	(−0.31 to +0.26)	(−0.09 to +0.51)	(−0.26 to +0.37)
High	−0.58	−0.32	−0.74
	(−1.25 to +0.08)	(−0.98 to +0.34)	(−1.40 to −0.08)

CDI, Communicative Development Inventories; EPDS, Edinburgh Postnatal Depression Scale.
Model 1: Adjusted for the timing of the measurement of CDI.
Model 2: Model 1 with further adjusted for potential confounders [maternal age and education, gestational age at birth] and for EPDS scores.
Full Model: Model 2 with further adjustment for maternal history of depression/anxiety prior to childbirth, breastfeeding practices, and recent depressive symptoms.
EPDS score as a continuous variable (Full Model): EPDS score during the first month postpartum was significantly associated with Later Gesture scores (coefficient = −0.023, 95%CI: −0.045 to −0.001), whereas EPDS score at 10 weeks postpartum was not significantly associated with Later Gesture scores (coefficient = −0.025, 95%CI: −0.058 to +0.008).

3.2. Association of maternal depressive symptoms during the first month or 10 weeks postpartum with non-verbal communication skills of infants at age 14 months

The association of EPDS categorical scores measured during the first month or at 10 weeks postpartum, with non-verbal communication skills are shown in Tables 2 (Early Gestures) and 3 (Later Gesture). Regression coefficients and 95% confidence intervals (CIs) are presented, along with findings for each model (Model 1 to Full Model) that incorporate adjustments for potential confounders and explanatory factors for the associations.

As for the prediction of Early Gestures scores, high level of EPDS score (≥13 points) during the first month postpartum was significantly and inversely associated with Early Gestures scores in infants, all supported in Model 1, 2 and Full Model (Table 2, upper half and Fig. 1, left). The magnitude of the effect was −0.50 in the Full Model, indicating that Early Gestures scores in infants whose mothers had a high level of depressive symptoms during the first month after birth were approximately half an SD below normal. However, high level of EPDS score (≥13 points) at 10 weeks postpartum was not significantly associated with Early Gestures scores in infants (Table 2, lower half and Fig. 1, right). Medium level of EPDS score (9–12 points) both during the first month and at 10 weeks postpartum showed no significant association with Early Gestures scores (Table 2 and Fig. 1).

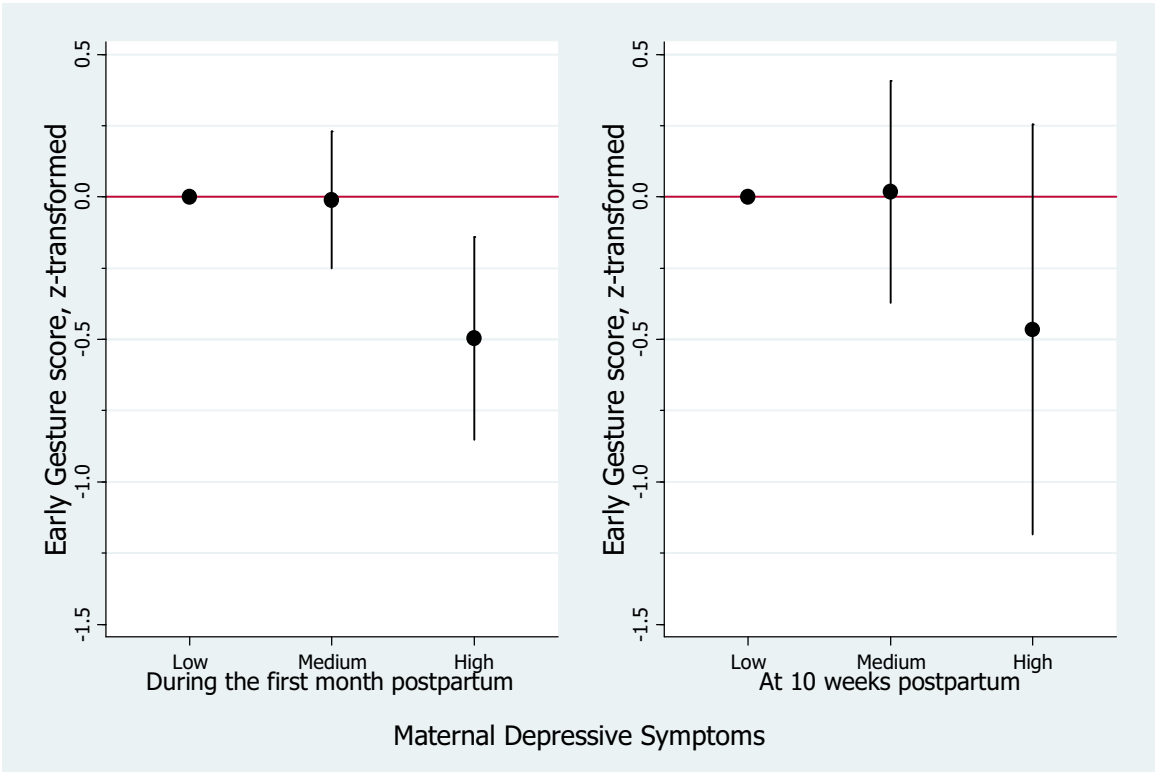

Fig. 1. Regression coefficients and 95% confidence intervals for associations of maternal depressive symptoms with non-verbal communication skills (Early Gestures scores) of infants at 14 months of age.
Maternal depressive symptoms were measured using the Edinburgh Postnatal Depression Scale during the first month or at 10 weeks after childbirth, and scores were categorised into three levels: low (0–8 points), medium (9–12 points), and high (13 points or higher). Early Gesture scores were z-transformed, based on measures of the participating 14-month-old infants using the MacArthur-Bates Communicative Development Inventories. Point estimates and 95% confidence intervals for regression coefficients for the three levels of maternal depressive symptoms are shown, with the low-level group used as the referent category. Regression coefficients were estimated after adjustment for maternal age, maternal education level, infant gestational age at birth, maternal history of depression or anxiety, breastfeeding practices, and recent maternal depressive symptoms at 40 weeks postpartum.

As for the prediction of Later Gestures scores, high level of EPDS score (≥13 points) during the first month postpartum was significantly and inversely associated with Later Gestures scores in infants, all supported in Model 1, 2 and Full Model (Table 3, upper half and Fig. 2, left). The magnitude of the effect was −0.46 in the Full Model, indicating that Later Gestures scores in infants whose mothers had a high level of depressive symptoms during the first month after birth were approximately half an SD below normal. Similarly, high level of EPDS score (≥13 points) at 10 weeks postpartum was also significantly and inversely associated with Early Gestures scores in infants (Table 3, lower half and Fig. 2 right). The magnitude of the effect was −0.74 in the Full Model, indicating that Later Gestures scores in infants whose mothers had a high level of depressive symptoms at 10 weeks after birth were 0.7SD below normal. On the other hand, medium level of EPDS score (9 to 12 points) both during the first month and at 10 weeks postpartum showed no significant association with Early Gestures scores (Table 3 and Fig. 2).

4. Discussion

In the present study, we observed that maternal depressive symptoms, measured using the EPDS during the first month postpartum, were significantly associated with reduced Early and Later Gesture CDI scores in their infant at 14 months of age. These associations were not accounted for by any demographic or perinatal variables, nor by potential explanatory variables of maternal depression/anxiety prior to childbirth, breastfeeding practices by 14 months, or maternal depression at 40 weeks (recent depressive symptoms). In contrast, maternal depressive symptoms at 10 weeks postpartum were not associated with reduced Early Gesture scores, but were associated with reduced Later Gesture scores. Our present findings cannot be easily attributed to cultural factors, as frequency and morphology of communicative gestures are universal across human cultures (Liszkowski, Brown, Callaghan, Takada, & de Vos, 2012). To our knowledge, this is the first large-scale study reporting that maternal postpartum depressive symptoms during the first month after childbirth can be a significant predictor of an infant's non-verbal communication skills during the second year of life.

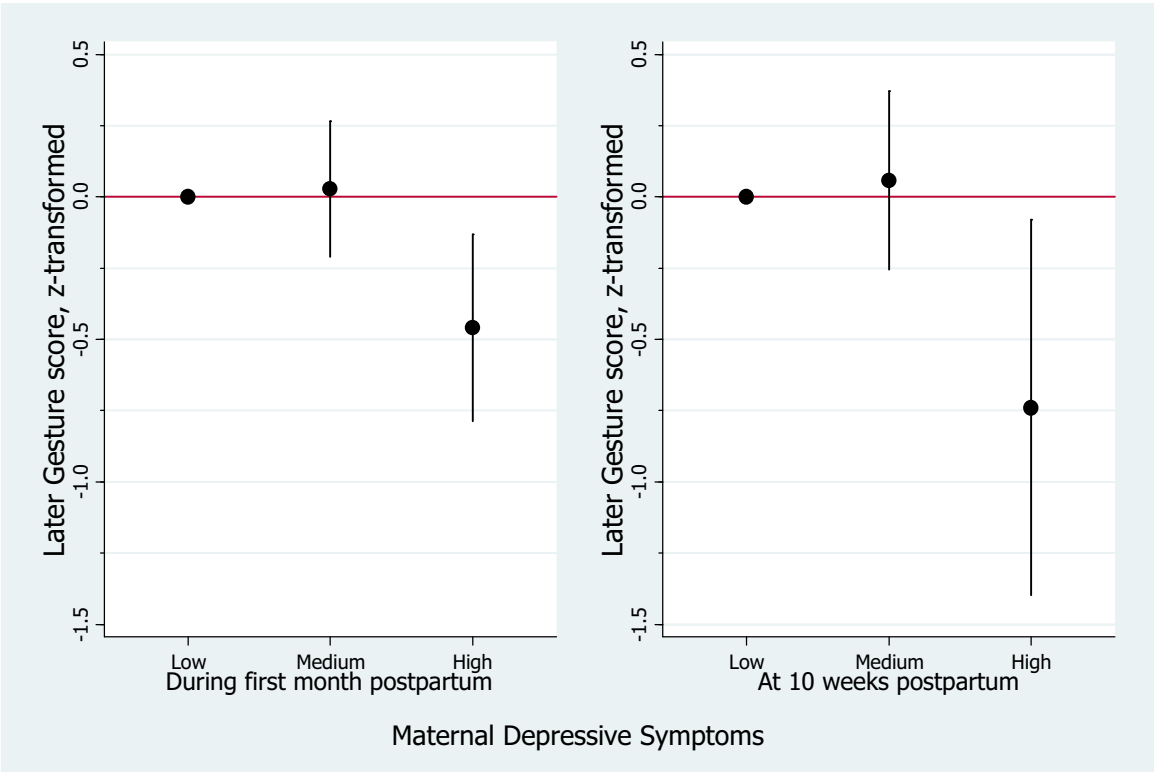

Fig. 2. Regression coefficients and 95% confidence intervals for associations of maternal depressive symptoms with non-verbal communication skills (Later Gestures scores) of infants at 14 months of age.
Maternal depressive symptoms were measured using the Edinburgh Postnatal Depression Scale during the first month or at 10 weeks after childbirth, and scores were categorised into three levels: low (0–8 points), medium (9–12 points), and high (13 points or higher). Later Gesture scores were z-transformed, based on measures of the participating 14-month-old infants using the MacArthur-Bates Communicative Development Inventories. Point estimates and 95% confidence intervals for regression coefficients for the three levels of maternal depressive symptoms are shown, with the low-level group used as the referent category. Regression coefficients were estimated after adjustment for maternal age, maternal education level, infant gestational age at birth, maternal history of depression or anxiety, breastfeeding practices, and recent maternal depressive symptoms at 40 weeks postpartum.

4.1. Interpretation of results

In the present study, Early Gesture and Later Gesture scores represented developmental status of infants' use of communicative and symbolic actions and gestures. In principal, these gestures are expected to be independent of verbal expression (Fenson et al., 2007). According to the authors of the CDI, Early Gesture is composed of two categories: "First Communicative Gestures" and "Games and Routines". The "First Communicative Gestures" category is a potential predictor of emergence of speech and includes deictic gestures of giving, showing, pointing, reaching, and conventional communicative gestures. The "Games and Routines" category reflects early social interactive bases and includes playing peekaboo and patty cake and singing. Items listed in these two categories have been reported to emerge well before 1 year of age. Later Gestures is composed of three categories: "Actions with Objects", "Imitating Other Adult Actions", and "Pretending to Be a Parent". Both the "Actions with Objects" and "Imitating Other Adults" categories are indicators of understanding objects around them and uses of these objects, which are connected with representational skills and accommodative acts. "Pretending to be a Parent" reflects prototypes of symbolic gestures. Some items listed in these three categories have been known to emerge during the first year of life, although others tend to appear during the second year of life (Fenson et al., 2007). Given these previous findings regarding the developmental timeline of Early Gestures and Later Gestures, our findings suggest that postpartum depressive symptoms of mothers, particularly during the first month after childbirth, may adversely affect early social interactions as well as representation and accommodation.

One important aspect of our study is that the significant association of maternal depressive symptoms during the first month postpartum with reduced Early/Later Gestures scores in infants was confirmed not only when such depressive symptoms were evaluated in a categorical manner but also in a continuous manner. However, of note, only high depressive symptoms scores were associated with hindered development of Early/Later Gestures, and relatively few participants in the present study (e.g. N = 47, 5% during the first month postpartum) had such high scores (13 points and over on EPDS). This can point towards two interpretations. One is that infants with mothers of mild depressive symptoms (i.e. 9–12 points) and

infants with mothers of severe symptoms (i.e. 13 points and over) are clinically quite different. The other interpretation is that mothers with clinical need of intervention are those who scored 13 points and over with EPDS.

While maternal depressive symptoms during the first month postpartum were significantly associated with both Early and Later Gestures, symptoms at 10 weeks postpartum were significantly associated only with Later Gesture. Postpartum depressive symptoms occurring at 10 weeks therefore may not adversely affect early patterns of social interaction. However, this conclusion remains arguable, as relatively few mothers had a high EPDS score at 10 weeks (N = 10, 1%), leading to wide CIs and lack of significance in findings. Indeed, in Table 2 for Early Gesture, the regression coefficient for a high level of EPDS score at 10 weeks postpartum in the Full Model was −0.46 (95% CI: −1.19 to +0.25), equivalent to the corresponding coefficient for a high level of EPDS score during the first month postpartum in the Full Model (−0.50). Taken together, our present findings tentatively suggest that maternal depressive symptoms not only during the first month but also at 10 weeks postpartum have a detrimental effect on Early/Later Gestures scores of infants at 14 months of age.

4.2. Factors potentially influencing the associations

In addition to our investigation into a potential association between postpartum maternal depressive symptoms and infant development, we also attempted to determine why such an association exists and what factors influence or induce the association. We therefore identified three candidate explanatory factors that might account for the observed associations.

The first candidate factor was maternal depression and anxiety prior to the index childbirth, as depression during pregnancy falls on the continuum connected with postpartum depression (Lancaster et al., 2010; Lyell et al., 2012). Given that these prepartum depressive symptoms tend to emerge between 18 and 32 weeks gestation (Evans et al., 2001), we were able to accurately and consistently detect pregnant parturients with a definite diagnosis of major depressive disorders or related conditions using our study protocol. Of note, depression/anxiety during pregnancy has been reported to have detrimental effects on infant neurodevelopment (Hyde, O'Callaghan, Bor, Williams, & Najman, 2012; Suri, Lin, Cohen, & Altshuler, 2014), and this effect may be further confounded by administration of antidepressants (Oberlander et al., 2010; Robinson, 2015). Thus, the association of postpartum maternal depression with infant gesture development might have been due to the presence of depression/anxiety prior to childbirth. However, our data indicate that such explanations were unlikely, as the magnitude of the associations did not signficiantly diminish even after adjusting for history of depression/anxiety prior to birth, as represented by the regression coefficients of Full Model (with adjustment for history of depression/anxiety prior to birth) versus those of Model 2 (with no adjustment for history of depression/anxiety prior to birth).

The second candidate factor was breastfeeding practice. In clinical settings, some mothers with depressive symptoms after childbirth are placed on antidepressants. Given that some antidepressants are contraindicated in breastfeeding mothers, the mothers may have to quit breastfeeding while on their medication. Further complicating matters, difficulties in early breastfeeding experiences have been reported to increase risk of mothers developing postpartum depressive symptoms (Watkins, Meltzer-Brody, Zolnoun, & Stuebe, 2011). Difficulties in breastfeeding have also been associated with poor cognitive outcome of infants, due to insufficient nutrition and hindered development of the mother-child relationship (Feldman & Eidelman, 2003). Indeed, we did notice a decrease in the regression coefficient for the association between depressive symptoms and gesture development, particularly between a high level of maternal depressive symptoms during the first month postpartum and Early Gesture scores (Table 3, comparison of Model 2 and Full Model), implying some potential influence of breastfeeding practice on the association. However, the associations remained statistically significant in the Full Model, where the effect due to breastfeeding practices was further adjusted for prenatal depression. This persistent association thus implies that the partial association between maternal depressive symptoms and Early Gestures adjusted for breastfeeding practices stems not from hindered development of the mother-child relationship but potentially from the small number of parturients with prenatal depression placed on antidepressant medications (N = 8). It is also worth considering that breastfeeding practice was not a confounder nor an effect modifier, but might be a mediator of the association. This should be further addressed using mediation analysis methodology.

The third candidate factor was recent depressive symptoms in mothers. Studies have suggested that issues with infants' cognitive development may be induced by maternal depressive symptoms that co-occur or have emerged recently, which can inhibit development of the mother-child relationship (Bifulco et al., 2004; Dietz, Jennings, Kelley, & Marshal, 2009). Such issues are particularly likely to occur when the depressive symptoms are observable from six months postpartum and onward, when mother-child communication is critical (Sohr-Preston & Scaramella, 2006). In the present study, however, the magnitude of the associations did not diminish even after adjusting for depressive symptoms at 40 weeks postpartum, as represented by the regression coefficient of Full Model (with adjustment for depressive symptoms at 40 weeks postpartum) versus those of Model2 (without adjustment for depressive symptoms at 40 weeks postpartum). Quite the contrary, the coefficients actually increased to some degree, implying that depressive symptoms at 40 weeks may reduce risk of low Early/Later Gesture scores. This unexpected finding may have been due to mere chance or bias resulting from the small number of subjects with high EPDS scores at 40 weeks postpartum (n = 13, 1%), and thus further interpretation of our results should be made with caution.

4.3. Clinical and research implications

Findings from the present study have helped to further understanding of the risk of developmental delays conferred on infants of mothers with postpartum depressive symptoms. This risk was independent of prenatal maternal psychopathology, breastfeeding practices, or recent depressive symptomatology of the mother. Clinicians should consider closely monitoring communicative development of infants of mothers with postpartum symptoms, particularly those with EPDS of 13 points or higher.

In neuropediatric contexts, developmental delay in non-verbal communication skills has been reported to be a predictor of emergence of autism and autism spectrum disorders (Luyster et al., 2011; Zwaigenbaum et al., 2013). Indeed, a recent study pointed out that delay in non-verbal communication skills development is more relevant to the emergence of autism spectrum disorder than is language skill development (Miniscalco, Rudling, Råstam, Gillberg, & Johnels, 2014). We previously found that some mothers with familial risk of developing autism spectrum disorders, known as broad autism phenotype, are slightly at increased risk of developing postpartum depression (Asano et al., 2014), implying that depressive symptom after childbirth among mothers may mediate a familial risk and risk for developmental alteration in infants in some mother and child dyads. However, a recent study suggested that delay in non-verbal communication skills development is not specific to autism or autism spectrum disorder but other language disorders (Brignell et al., 2016). At best, we have no data to test this, and thus we should be conservative to interpret this further.

4.4. Limitations

Several limitations to the present study warrant mention. First, our study had a relatively short follow-up period for infants (14 months), and we therefore lack data on whether the detrimental effect on non-verbal communicative development resulting from maternal postpartum depressive symptoms is a chance finding. However, we maintain that the period under examination is particularly crucial for development of communication skills, since most children progress in these months from pre-linguistic to symbolic communication (Longobardi, Rossi-Arnaud, & Spataro, 2012). We therefore maintain that the observation period was suitable for evaluating emerging non-verbal communication skills. Second, we did not evaluate the role of parental input on gestures as a moderating factor in the association between maternal depressive symptoms and non-verbal communication skill development, despite evidence indicating that parental variability in gesture use is related to the child's variability in gesture use, with children whose parents frequently gesture producing more of their own gestures (Rowe & Goldin-Meadow, 2009). Third, we did not directly evaluate the mother-child relationship in a structural manner. Maternal responsiveness compromised by postpartum depressive symptoms can induce language delay in the child, indicating the clear influence of the mother-child relationship on the child's development (Bifulco, Moran, Jacobs, & Bunn, 2009). However, while maternal responsiveness at 10 months after childbirth has been reported to predict delay in verbal communication skills of infants at 12 months of age (Paavola, Kunnari, & Moilanen, 2005), no such delay has been reported for non-verbal communication skills, which were the focus of the present study. This inconsistency implies that the influence of maternal depressive symptoms on risk of developmental delay in infants differs for verbal and non-verbal communication skills. We therefore believe that lack of assessment of the mother-child relationship did not substantially affect the validity of our findings. Fourth, validity of maternal interview using CDI may be of concern, because maternal recall of child behaviours is usually biased. Unfortunately, we have no potential remedy for this, nor had we data to check sensitivity of this caregiver-based information. Fifth, there is lack of information that may limit interpretation of our data. One example is a negative impact of breastfeeding. In the present study, breastfeeding was measured to see whether breastfeeding practices account both for maternal depressive symptom after childbirth and for infant's neurodevelopment; however, breastfeeding can be a "burden" for some mothers (Shloim et al., 2015), resulting perhaps in negative impact on maternal mental health as well as mothers' relationship with their infants. In relation to this, maternal anxiety during postpartum period as well as at the timing of measuring infants with CDI. Maternal anxiety can co-occur with depression during postpartum period (Fairbrother, Janssen, Antony, Tucker, & Young, 2016; Goodman, Watson, & Stubbs, 2016), which can inhibit social-emotional development but may promote expressive communication (Koutra et al., 2013). Therefore, attitude to breastfeeding may be investigated as a mediator of breastfeeding effect to infants, and co-occurring anxiety may be included in the further analyses of maternal depressive symptoms onto neurodevelopment of the infants. Finally, as we have discussed above, assessment of causation should be performed cautiously. Even though we have measured maternal depressive symptoms and non-verbal communication skills in infants in a serial manner, a number of factors we have not measured may functions as mediators, confounder, or colliders (Textor, Hardt, & Knuppel, 2011) and thus make the association of our interest inappropriately distorted.

In conclusion, we found that maternal depressive symptoms over the first 10 weeks postpartum predict developmental delay in non-verbal communication skills of infants at 14 months of age. Further, this association was not induced by known confounders or potential explanatory factors, including maternal depression/anxiety prior to childbirth, breastfeeding practices, or recent maternal depressive symptoms. Maternal postpartum mood, likely independent of later emergence of depression or a poor mother-child relationship, may influence development of early social skills.

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