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Mother–infant interaction and infant development in women at risk of postpartum psychosis with and without a postpartum relapse

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Abstract

Background. This study aimed to investigate mother–infant interaction and infant development in women at-risk of postpartum psychosis (PP), with and without a postpartum relapse.
Methods. 103 women (and their offspring) were included, 43 at-risk-of-PP because of a diagnosis of bipolar disorder, schizoaffective disorder or previous PP, and 60 with no current/previous mental illness or family history of PP. Of the at-risk women, 18 developed a psychiatric relapse within 4 weeks after delivery (AR-unwell), while 25 remained symptom-free (AR-well). Mother–infant interaction was assessed using the CARE-Index at 8 weeks' and 12 months' postpartum and infant development using the Bayley-III at 12 months' postpartum.
Results. Women at-risk-of-PP as a group, regardless of whether they developed a psychiatric relapse within 4 weeks after delivery, had less synchronous mother–infant interactions and had infants with less optimal cognitive, language, motor and socio-emotional development than healthy controls. In particular, boys of at-risk women had the lowest scores in cognitive, language and motor development and in mother–infant interaction, while girls of the at-risk women had the lowest scores in socio-emotional development. The synchrony in the dyad predicted infant cognitive and language development. There was no evidence for a difference in mother–infant interaction nor in infant development between the AR-unwell and AR-well groups.
Conclusions. These results suggest that, while there is a lack of evidence that an early postpartum relapse in women at-risk-of-PP could represent a risk for the infant *per se*, maternal risk for PP may be associated with less optimal mother–infant interaction and infant development.

Introduction

Postpartum psychosis (PP) is the most severe perinatal mental health disorder and occurs in one-two per 1000 deliveries. However, women with a previous diagnosis of bipolar disorder (BD), schizoaffective disorder or PP are at greater risk of suffering from postpartum psychosis than the general population and also have a significant high risk of developing a postpartum depressive relapse (Jones & Craddock, 2001; Viguera et al., 2011; Wesseloo et al., 2016). Considering the severity of PP, it is surprising that, to date, little research has been conducted on mother–infant interaction and infant development in this clinical population, in contrast to the considerable amount of research in perinatal depression (Bind et al., 2021; Liu et al., 2017; Murray, Fiori-Cowley, Hooper, & Cooper, 1996; Stein et al., 2014). Difficulties in mother–infant interaction may be evident early on after delivery, providing an opportunity to intervene already in pregnancy, to promote the well-being of the dyad.

Nowadays it is still not clear whether an episode of postpartum psychosis could represent a risk for the mother interaction and the infant development. Evidence to date suggests that

women with postpartum psychosis (PP) and women with postnatal depression (PND) may have similar difficulties in mother–infant interaction (Hornstein et al., 2006; Noorlander, Bergink, & van den Berg, 2008). Furthermore, research has shown that impairments in mother–infant interaction following a severe postnatal episode may remain even when psychiatric symptoms resolve (Hipwell, Goossens, Melhuish, & Kumar, 2000). More recently, research on maternal bonding towards the infant (Biaggi et al., 2021; Gilden et al., 2020), has reported low evidence for a considerable negative impact of postpartum psychosis on maternal bonding, confirming previous reports (Hornstein et al., 2006; Noorlander et al., 2008). However, there is still limited research on mother–infant interaction in this clinical population. With regards to infant development, a recent study (Chen et al., 2021) has reported an increased risk for Attention-Deficit/Hyperactivity Disorder (ADHD) in the offspring born to women who had experienced PP, while previous research reported no difference in the development of infants born to women with and without PP and healthy controls (McNeil, Persson-Blennow, Binett, Harty, & Karyd, 1988). In summary, only few studies have been conducted in this clinical population, with mixed findings and a variety of methodological limitations, for example in the selection of the healthy controls and in the evaluation of mother–infant interaction not blind to maternal diagnosis.

There is also limited research in women at-risk-of-PP as a group, i.e., regardless of whether they develop a postpartum episode, and therefore, more studies need to be conducted. In fact, while women with BD and affective psychosis are at increased risk of obstetric complications and their infants are at increased risk of less optimal outcomes at birth (Frayne et al., 2019; Judd et al., 2014; Solé et al., 2019; Zhong et al., 2018), less is known about offspring later outcomes, occurring during infancy and childhood. Studies conducted to date have shown that, compared to controls, women at-risk-of-PP report a more negative perceived bonding towards their infants in the first 12 months postpartum (Biaggi et al., 2021; Boekhorst, Beerthuizen, Hillegers, Pop, & Bergink, 2021). Furthermore, there is evidence that women at-risk-of-PP display more difficulties in the interaction with their infants during the first year postpartum (e.g. lower maternal sensitivity, involvement, contact, contingent responsiveness, more tension as well as less infant positive affect, communication and dyadic coordination) and have infants with less optimal developmental outcomes (e.g. more early risk characteristics within 4 years, such as delayed walking and less optimal global functioning at 6 years) compared to controls (Anke et al., 2019, 2020; Henriksson & McNeil, 2004; McNeil & Kaij, 1987; Naslund, Persson-Blennow, McNeil, & Kaij, 1985).

Mother–infant interaction is an important predictor for infant cognitive and socio-emotional development (Leclère et al., 2014; Murray et al., 1996). It potentially represents the most important mediator in the association between perinatal mental illness and child development (Stein et al., 2014), and can play a crucial role and even buffer the negative effects of antenatal stress on the child (Herba, Glover, Ramchandani, & Rondon, 2016). In addition, some of the effects of maternal mental illness on mother–infant interaction and infant development may be moderated by the sex of the child, as it has been shown in several studies in depression. In fact, boys are more susceptible to the effects of PND on cognitive and behavioural development and may also be at greater risk of suffering from a less optimal mother–infant interaction, while girls are more at risk of internalizing problems (Goodman et al., 2011; Murray et al., 1996; Murray, Kempton, Woolgar, & Hooper, 1993; Stein et al., 2014). However, this has never been investigated in women at risk of/with PP.

The current study aims to fill these gaps in the literature and to investigate mother–infant interaction and infant development in women at-risk-of-PP (AR), both in those who do and do not develop a psychiatric relapse within 4 weeks after delivery (the AR-unwell and AR-well, respectively). We also examined whether mother–infant interaction is a predictor of infant development and the role of infant sex on these dimensions in this clinical population. We hypothesised that (1) AR-unwell women would show less optimal interactions with their infants and have infants with less optimal developmental outcomes than AR-well women; and that women at-risk-of-PP as a group would show less optimal mother–infant interactions and infant development than healthy controls; that (2) mother–infant interaction would predict infant development and would explain the association between mental illness and infant development; and finally that, (3) differences in mother–infant interaction and in infant cognitive, language and motor development and adaptive behaviour would be more evident in boys, while differences in emotional development would be more evident in girls.

Methods

Design

This study is part of the Psychiatry Research and Motherhood study – psychosis cohort (PRAM-P), a prospective longitudinal study that recruited and followed-up a group of women at-risk-of-postpartum psychosis and a group of healthy control women (and their offspring) from 25 weeks' gestation (baseline) to 12 months' post partum (Biaggi et al., 2021; Hazelgrove et al., 2021). Symptom severity was assessed at 25 weeks' gestation and postnatally – at 8 weeks'(8w) and 12 months'(12 m) post partum. Mother–infant interaction was assessed at 8w and 12 m post partum, and infant development at 12 m post partum.

Sample

We included 103 women, 43 considered at-risk-of-PP (because of a diagnosis of bipolar disorder, schizoaffective disorder or previous PP) (AR), and 60 healthy controls (HC). The AR women had the following diagnoses: 33 (76.7%) bipolar disorder, 6 (14%) schizoaffective disorder, and 4 (9.3%) previous PP. Healthy controls had to be free from any current or previous psychiatric disorder and family history of PP in their first-degree relatives. AR women were identified from Perinatal Psychiatry Services and HC from King's College Hospital or GP surgeries. Inclusion criteria were: late second or third trimester of a singleton pregnancy, age ≥18 and fluency in English. Exclusion criteria were: uterine anomalies, pregnancy complications, unlikelihood to keep the baby after delivery or contraindication to MRI scan (data on MRI scan are reported separately). AR women were also excluded if their diagnosis was unclear or if they were currently too unwell to participate. The study was approved by the local ethics committee (REC: 10/H0807/14) and participants provided written informed consent for themselves and their offspring.

Measures

Socio-demographic, obstetric and infant related characteristics

We collected socio-demographic, health, obstetric, current pregnancy and infant related information at baseline, 8w and 12 m

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using a semi-structured interview; delivery and neonate characteristics at 6 days' post partum using the maternal discharge summary.

Clinical assessment

We used the Structured Clinical Interview for DSM-IV Axis I Disorders (SCID-I) (First, 1996) supplemented by medical notes, the Hamilton Depression Rating Scale (HAM-D) (Hamilton, 1960), the Young Mania Rating Scale (YMRS) (Young, Biggs, Ziegler, & Meyer, 1978), the Positive and Negative Syndrome Scale (PANSS) (Kay, Fiszbein, & Opler, 1987) and the Global Assessment of Functioning (GAF) (American Psychiatric Association, 1994) to assess previous and current DSM-IV Axis I disorders, symptom severity, global functioning and medication use during pregnancy and in the first 12-month postpartum period. Participants' diagnosis and symptom severity at each time point were confirmed in consensus meetings. The AR women were classified as having a psychiatric relapse (AR-unwell) if, in the first four weeks' post partum (time frame chosen according to the DSM-IV postpartum-onset specifier), they either: (a) met DSM-IV diagnostic criteria for a psychotic, manic, hypomanic, depressive or mixed episode; or (b) had a combination of DSM-IV symptoms that, whilst not meeting diagnostic criteria, impacted on their daily functioning (e.g. their ability to care for the baby or themselves) and/or were of sufficient intensity to require a change in treatment (either pharmacological or management plan). This broader definition was used to capture all affective relapse events as AR women were closely monitored by Perinatal services and most took psychotropic medication to prevent PP, or to treat symptoms as soon as they developed. A severe relapse was considered if, in the first 4 weeks' post partum, women experienced psychotic, manic, mixed symptoms, and/or psychiatric hospitalization (Wesseloo et al., 2016). As maternal IQ is a strong predictor of offspring IQ (Eriksen et al., 2013), we additionally assessed maternal Full-Scale IQ (FSIQ) using the Wechsler Adult Intelligence Scale Revised version (WAIS-R) (Wechsler & De Lemos, 1981) at 30 weeks' gestation, to control for group differences in infant development.

Mother–infant interaction

Mother–infant interaction was assessed at 8w and 12 m with the Child-Adult Relationship Experimental Index (Infant CARE-Index), which was used to code a three-minute video-recorded observation of a free-play interaction. The CARE-index evaluates the quality of the adult-infant interaction from 0 to 15 months (Crittenden, 2010), has been extensively used in research, including with women with severe postpartum mental disorders (Kenny, Conroy, Pariante, Seneviratne, & Pawlby, 2013) as well as in a variety of different cultures (Hautamäki, 2014). The CARE-Index assesses three patterns of interaction for the adult (*Sensitivity, Control* and *Unresponsiveness*) and four for the infant (*Cooperativeness, Compulsiveness, Difficultness* and *Passivity*) as well as *Dyadic Synchrony*, which evaluates the degree of togetherness of the dyad and the level of risk for the infant's future development if that interaction continued. All patterns as well as *Dyadic Synchrony* are scored on a scale 0–14. Scores obtained are clustered in different categories: At risk (0–4); Inept (5–6); Adequate (7–10), Sensitive (11–14). The maternal scales and (separately) the child scales are linearly dependent; therefore, statistical analyses should only include up to two of the maternal scales and up to three of the infant scales (Crittenden, 2010). For this paper, we selected maternal *Control*, infant *Compulsiveness*, infant *Difficultness* and *Dyadic Synchrony*, based on correlation analyses (online Supporting Tables S1 and S2). All video-recorded interactions were scored by three trained raters blind to maternal mental health. The interclass correlation coefficient (ICC) (based on an absolute-agreement, 2-way mixed-effects model) was calculated using SPSS 25 and it ranged from 0.90 to 0.95 for *Dyadic Synchrony* at 8w and 12 m. In terms of infant age at assessment, infants born to AR were significantly older than those of HC at the first time point; at the second time point, infants of the AR-unwell were significantly older than infants of the AR-well (Table 1).

Infant development

Infant development was assessed at 12 m using the Bayley Scales of Infant and Toddler Development (Bayley-III) (Bayley, 2006a), which has been extensively used for both clinical and research purposes (Weiss, Oakland, & Aylward, 2010). The Bayley can be used from 0 to 42 months and consists of a series of standardized play tasks assessing infant *Cognitive, Language* and *Motor* development. A questionnaire completed by the caregiver also assesses infant *Socio-Emotional* development and *Adaptive behaviour*. All developmental domains are independent and have a separate score (adjusted for infant's age). Composite scores range from 40 to 160 ($M = 100$, S.D. = 15) (Bayley, 2006b) and scores of <85, <70 and <55 are cut-off points indicative of a mild, moderate or severe developmental delay. However, the Bayley-III may underestimate developmental delays and, therefore, cut-off threshold values may need to be higher (Bos, 2013; Johnson, Moore, & Marlow, 2014). Infants of the AR-unwell women were significantly older than those of the AR-well (Table 1).

Statistical analyses

Statistical analyses were performed in IBM SPSS Statistics Version 25 (IBM Ltd, UK). Data were first examined for normality of distribution and homoscedasticity. In univariate analyses we first compared AR to HC women, then AR-unwell to AR-well. Continuous data were analysed with Independent samples *t* test or Mann-Whitney *U*, as appropriate. Categorical data were analysed using Pearson's Chi-square test for independence (χ^2). In multivariate analyses we winsorized data that did not meet assumptions for parametric analyses or used bootstrapping (with 1000 samples). Specifically, we conducted factorial ANOVA and ANCOVA to control for the effects of potential confounders, identified in correlation analyses, using Pearson's (r) or Spearman's (r_s), correlation coefficients, as appropriate. When more than two potential confounders were identified, we retained two if they were highly associated ($r \geqslant 0.50$), to ensure adequate power. We also conducted a mixed ANOVA to investigate changes in mother–infant interaction (from 8w to 12 m). Furthermore, we conducted an exploratory analysis, using planned contrasts to test the hypothesis that boys of the AR women would have lower scores in mother–infant interaction and in all infant developmental dimensions than all other groups (AR-females, HC-males, HC- females), apart from socio-emotional development where we hypothesized that girls of AR women would have the lowest scores of all groups. Cohen's *d* was used for effect sizes in univariate comparisons, while partial eta squared (η_p^2) in ANOVAs and ANCOVAs. Finally, we conducted a mediation analysis to examine the *direct* effect of

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Table 1. Socio-demographics, clinical, pregnancy and infant related characteristics

	AR ($n = 43$)	AR-unwell ($n = 18$)	AR-well ($n = 25$)	HC ($n = 60$)	AR v. HC	AR-unwell v. AR-well
Age (years), *M* (S.D.)	32.9 (5.8)	31.2 (6.1)	34.1 (5.4)	33.4 (4.6)	$U = 1218.00$, $z = -0.48$, $p = 0.630$	$t_{(41)} = 1.68$, $p = 0.101$
Marital status, married or cohabiting % (*n*)	74.4 (32)	66.7 (12)	80.0 (20)	88.3 (53)	$\chi^2_{(1)} = 3.36$, $p = 0.067$	$\chi^2_{(1)} = 0.98$, $p = 0.480$
Ethnicity, any white background % (*n*)	62.8 (27)	55.6 (10)	68.0 (17)	78.3 (47)	$\chi^2_{(1)} = 2.99$, $p = 0.084$	$\chi^2_{(1)} = 0.69$, $p = 0.405$
Education, degree or higher % (*n*)	72.1 (31)	66.7 (12)	76.0 (19)	81.7 (49)	$\chi^2_{(1)} = 1.32$, $p = 0.250$	$\chi^2_{(1)} = 0.45$, $p = 0.501$
Employment status, working outside the home or student % (*n*)[1]	62.8 (27)	44.4 (8)	76.0 (19)	83.3 (50)	**$\chi^2_{(1)} = 5.60$, $p = 0.018$**	**$\chi^2_{(1)} = 4.46$, $p = 0.035$**
Index of Multiple Deprivation (IMD), *M* (S.D.)	25.7 (11.7)	26.3 (11.5)	25.2 (12.1)	28.7 (8.9)	$t_{(101)} = 1.46$, $p = 0.147$	$t_{(101)} = -0.31$, $p = 0.762$
Parity, primiparous, % (*n*)	62.8 (27)	61.1 (11)	64.0 (16)	53.3 (32)	$\chi^2_{(1)} = 0.92$, $p = 0.339$	$\chi^2_{(1)} = 0.04$, $p = 0.847$
Pregnancy planned, yes % (*n*)[a]	65.0 (26)	47.1 (8)	78.3 (18)	87.1 (27)	**$\chi^2_{(1)} = 4.51$, $p = 0.034$**	**$\chi^2_{(1)} = 4.18$, $p = 0.041$**
Pleased about the pregnancy, yes % (*n*)[b]	75.0 (24)	62.5 (6)	87.5 (14)	93.1 (27)	$\chi^2_{(1)} = 3.64$, $p = 0.084$[1]	$\chi^2_{(1)} = 2.67$, $p = 0.220$
Mode of delivery, non-instrumental vaginal % (*n*)[c]	57.1 (24)	64.7 (11)	52.0 (13)	60.0 (36)	$\chi^2_{(1)} = 0.83$, $p = 0.773$	$\chi^2_{(1)} = 0.67$, $p = 0.414$
Infant birthweight (g), *M* (S.D.)[c]	3487.2 (537.2)	3372.7 (422.3)	3565.0 (598.7)	3426.1 (505.2)	$U = 1326.00$, $z = 0.45$, $p = 0.654$	$U = 151.00$, $z = -1.58$, $p = 0.115$
Gestational age at birth (weeks), *M* (S.D.)	39.8 (1.5)	39.2 (1.6)	40.2 (1.2)	40.0 (1.9)	$U = 1101.50$, $z = -1.26$, $p = 0.207$	**$U = 136.50$, $z = -2.18$, $p = 0.029$**
Infant gender, male % (*n*)	53.5 (23)	55.6 (10)	52.0 (13)	56.7 (34)	$\chi^2_{(1)} = 0.10$, $p = 0.749$	$\chi^2_{(1)} = 0.05$, $p = 0.818$
Infant feeding method, any breast from birth, % (*n*)	74.4 (32)	77.8 (14)	72.0 (18)	98.3 (59)	**$\chi^2_{(1)} = 13.92$, $p < 0.001$**	$\chi^2_{(1)} = 0.18$, $p = 0.736$
Maternal FSIQ, *M* (S.D.)[d]	96.9 (14.4)	92.1 (15.7)	100.5 (12.5)	105.0 (13.3)	**$t_{(83)} = 2.68$, $p = 0.009$**	$t_{(38)} = 1.90$ $p = 0.065$
Lifetime diagnosis, % (*n*)					–	$\chi^2_{(2)} = 4.16$, $p = 0.121$
Bipolar Affective Disorder Type I or II or Cyclothymia	76.7 (33)	61.1 (11)	88.0 (22)	–		
Schizoaffective Disorder, Bipolar or Affective Type	14.0 (6)	22.2 (4)	8.0 (2)	–		
Psychotic Disorder NOS (PP)	9.3 (4)	16.7 (3)	4.0 (1)	–		
Age (years) at illness onset, *M* (range)[e]	20.2 (11–36)	18.9 (12–32)	21.1 (11–36)	–	–	$U = 167.00$, $z = -0.98$, $p = 0.326$
Duration of illness (years), *M* (range)[e]	12.4 (2–24)	11.6 (3–22)	12.9 (2–24)	–	–	$t_{(39)} = 0.63$, $p = 0.530$
Previous PP, yes % (*n*)	25.6 (11)	27.8 (5)	24.0 (6)	–	–	$\chi^2_{(1)} = 0.08$, $p = 1.000$
Medication use in pregnancy[2], yes % (*n*)	65.1 (28)	77.8 (14)	56.0 (14)	–	–	$\chi^2_{(1)} = 2.19$, $p = 0.139$
Medication use at 8 weeks[2], yes % (*n*)	72.1 (31)	77.8 (14)	68.0 (17)	–	–	$\chi^2_{(1)} = 0.50$, $p = 0.481$
Medication use at 12 months[2], yes % (*n*)	74.4 (32)	83.3 (15)	68.0 (17)	–	–	$\chi^2_{(1)} = 1.29$, $p = 0.309$

Psychiatric relapse in pregnancy (depressive and/or anxiety, manic, hypomanic or mixed symptoms at any time in pregnancy), yes % (*n*)	55.8 (24)	88.9 (16)	32.0 (8)	–	–	**$\chi^2_{(1)} = 13.73$, $p < 0.001$, OR 17.0–95% CI 3.1–92.4**
Infant age at 8-week video (weeks), *M* (S.D.)	13.3 (3.4)	13.2 (3.2)	13.3 (3.6)	11.4 (2.8)	**$U = 1409.50$, $z = 2.85$, $p = 0.004$**	$U = 172.00$, $z = -0.19$, $p = 0.862$
Infant age at 12-month video (months), *M* (S.D.)	13.9 (2.7)	13.0 (0.8)	15.2 (3.8)	13.2 (0.8)	$U = 937.50$, $z = 0.25$, $p = 0.800$	**$U = 237.50$, $z = 2.24$, $p = 0.024$**
Infant age at Bayley (months), *M* (S.D.)	13.9 (1.8)	14.7 (2.3)	13.4 (1.2)	13.4 (0.9)	$U = 1158.00$, $z = 0.29$, $p = 0.775$	**$U = 269.00$, $z = 2.28$, $p = 0.022$**

AR, women at risk of PP; HC, healthy control women; AR-unwell, women at risk of PP who developed a psychiatric episode within 4 weeks after delivery; AR-well, women at risk of PP who remained well within 4 weeks after delivery; [a] $n = 71$ (HC = 31; AR = 40); [b] $n = 61$ (HC = 29; AR = 32); [c] $n = 102$ (HC = 60; AR = 42); [d] $n = 85$ (HC-45; AR = 40); [e] AR $n = 41$. Results provided in bold are statistically significant. [f]Including women employed but currently on maternity or sick leave. [g]Antipsychotics, mood-stabilizers, antidepressants, benzodiazepines or combination. The Index of Multiple Deprivation (IMD) score is a UK government measure of relative deprivation based on the area of living (Noble, M., W.G, Dibben, C., Gan, Smith, Mclennan, D., Anttila, C., et al., 2004. The English Indices of Deprivation. Neighbourhood Renewal Unit. Report to the Office of the Deputy Prime Minister, London).

maternal Group (the exposure, X) on infant development at 12 m (the outcome, Y) and the *indirect* effect of X on Y via mother–infant interaction (the mediator, M), controlling for the effect of potential confounders. We tested this in two separate models, one with mother–infant interaction at 8w and one at 12 m, using the 'PROCESS for SPSS and SAS' macro (version 3.1). The number of bootstrapped samples was set to 5000 as recommended by Hayes (Hayes, 2013).

Results

Socio-demographic and clinical characteristics

Compared to HC, significantly more AR women were unemployed, had an unplanned pregnancy, did not breastfeed their infants and had lower FSIQ (Table 1). AR women had also significantly higher PANSS, HAM-D, YMRS scores and lower GAF scores at baseline, 8w and 12 m post partum than HC (Table 2). Of the 43 AR women, 18 (41.9%) developed a psychiatric relapse within four weeks of delivery (AR-unwell): 8 (44.4%) had symptoms of depression or depression and anxiety, 6 (33.3%) had manic or hypomanic symptoms, 3 (16.7%) had psychotic symptoms and 1 (5.6%) had mixed symptoms. Of these, 10 (55.6%) had symptoms that met DSM-IV diagnostic criteria and 5 (27.8%) had a severe relapse. Twenty-five of the AR women (58.1%) remained symptom-free within four weeks of delivery (AR-well). The AR-unwell women were more likely to be unemployed, to have an unplanned pregnancy, to have their child born at lower gestational age and to have lower FSIQ than the AR-well women. The AR-unwell women were also more likely to have experienced a psychiatric relapse in pregnancy and had higher PANSS and HAM-D and lower GAF scores at baseline, while there was no significant difference in lifetime diagnosis, previous PP, age at illness onset, duration of illness and use of psychotropic medication at baseline, 8w and 12 m (Table 1). However, in the 12 months' post partum, the AR-well also progressively developed psychiatric symptoms (46.5% by 8w and 74.4% by 12 m) and by 12 m, there was no significant difference between the two AR groups in any of the clinical symptoms (Tables 1 and 2).

AR women have less synchronous interactions with their infants than HC

As a group, the AR women had significantly less synchronous interactions with their infants than HC at both 8w and 12 m post partum (Table 3). The difference in *Dyadic Synchrony* at 8w remained significant even after controlling for maternal employment ($F_{(1,90)} = 3.95$, $h^2_p = 0.04$, $p = 0.050$) (online Supporting Table S4). None of the maternal and infant- related factors were associated with *Dyadic Synchrony* at 12 m, therefore these were not included as potential confounders (online Supporting Table S5). There was also no association between medication assumption and *Dyadic Synchrony* at either 8w or 12 m ($r_s = -0.31$, $p = 0.06$; $r_s = -0.29$; $p = 0.08$). The AR group had less optimal scores than HC also in maternal *Control,* infant *Compulsiveness* and *Difficultness,* although these were not statistically significant. There were no significant differences in mother–infant interaction between the AR-unwell and the AR-well at either 8w or 12 m (Table 3). Interestingly, *Dyadic Synchrony* improved significantly from 8w to 12 m in both groups of AR and HC women ($F_{(1,81)} = 29.31$, $p < 0.001$, $h^2_p = 0.27$), with

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Table 2. Symptom severity and global functioning in the AR and HC groups and in the AR-unwell and AR-well groups

	Baseline 25 weeks gestation		PN1 8 weeks PN		PN2 12 months PN		Baseline 25 weeks gestation		PN1 8 weeks PN		PN2 12 months PN	
	AR	HC	AR	HC	AR	HC	AR-unwell	AR-well	AR-unwell	AR-well	AR-unwell	AR-well
PANSS, *M* (S.D.)	34.6 (6.6)	30.4 (1.0)	34.5 (5.8)	30.3 (0.7)	33.8 (5.3)	30.6 (1.9)	38.4 (8.6)	32.2 (3.3)	36.7 (6.9)	33.1 (4.5)	35.9 (7.2)	32.5 (3.2)
	$U = 1972.00$, $z = 5.74$, $p < 0.001$		**$U = 1714.50$, $z = 5.43$, $p < 0.001$**		**$U = 1530.00$, $z = 4.26$, $p < 0.001$**		**$U = 317.50$, $z = 3.18$, $p = 0.001$**		$U = 236.50$, $z = 1.95$, $p = 0.055$		$U = 200.00$, $z = 1.25$, $p = 0.231$	
HAM-D, *M* (S.D.)	6.1 (5.0)	2.7 (2.6)	5.8 (5.4)	1.6 (1.8)	6.1 (7.1)	2.4 (3.2)	9.3 (5.0)	4.1 (3.8)	6.7 (5.0)	5.1 (5.7)	9.0 (9.9)	4.3 (4.0)
	$U = 1771.50$, $z = 3.77$, $p < 0.001$		**$U = 1865.00$, $z = 4.96$, $p < 0.001$**		**$U = 1444.00$, $z = 3.44$, $p = 0.001$**		**$U = 325.00$, $z = 3.36$, $p = 0.001$**		$U = 242.50$, $z = 1.40$, $p = 0.165$		$U = 199.00$, $z = 1.20$, $p = 0.244$	
YMRS, *M* (S.D.)	2.0 (2.3)	0.6 (1.2)	1.0 (1.7)	0.3 (0.7)	1.3 (2.1)	0.3 (0.8)	2.5 (2.6)	1.6 (2.0)	1.6 (2.3)	0.6 (1.0)	2.4 (2.9)	0.6 (1.1)
	$U = 1666.50$, $z = 3.73$, $p < 0.001$		**$U = 1353.50$, $z = 2.64$, $p = 0.008$**		**$U = 1290.50$, $z = 3.08$, $p = 0.002$**		$U = 234.00$, $z = 1.21$, $p = 0.255$		$U = 199.00$, $z = 1.21$, $p = 0.304$		$U = 200.00$, $z = 1.90$, $p = 0.100$	
GAF, *M* (S.D.)	75.8 (10.8)	91.4 (4.2)	74.0 (12.5)	90.0 (6.3)	77.7 (11.2)	87.9 (7.5)	69.7 (10.7)	80.4 (8.5)	65.4 (11.5)	79.5 (10.0)	73.3 (13.3)	79.9 (9.5)
	$U = 165.00$, $z = -7.50$, $p < 0.001$		**$U = 260.00$, $z = -6.70$, $p < 0.001$**		**$U = 398.00$, $z = -4.84$, $p < 0.001$**		**$U = 93.00$, $z = -3.14$, $p = 0.002$**		**$U = 68.50$, $z = -3.53$, $p < 0.001$**		$U = 106.00$, $z = -1.28$, $p = 0.212$	

AR, women at risk of PP; HC, healthy control women; AR-unwell, women at risk of PP who developed a psychiatric episode within 4 weeks after delivery; AR-well, women at risk of PP who remained well within 4 weeks after delivery; (AR) – PANSS missing: baseline = 2, PN1 = 5, PN2 = 6; HAM-D missing: baseline = 2, PN1 = 3, PN2 = 6; YMRS missing: baseline = 3, PN1 = 6, PN2 = 7; GAF missing: baseline = 1, PN1 = 2, PN2 = 7; (HC) – PANSS missing: PN1 = 3, PN2 = 4; HAM-D missing: PN1 = 1, PN2 = 5; YMRS missing: PN1 = 1, PN2 = 4; GAF missing: PN1 = 1, PN2 = 5. Results provided in bold are statistically significant.

no significant maternal *Group* × *Time* interaction ($F_{(1,81)} = 0.00$, $p = 0.976$, $h^2_p = 0.00$).

Infants born to AR women have less optimal developmental outcomes than HC

Compared to infants born to HC women, infants born to AR women had significantly lower scores in *Cognitive*, *Language*, *Motor* and *Socio-Emotional* development at 12 m, while there was no significant difference between the groups in *Adaptive behaviour* (Table 3). After controlling for maternal FSIQ, the difference in *Cognitive* development remained significant ($F_{(1,77)} = 4.18$, $p = 0.044$, $h^2_p = 0.05$). After controlling for maternal employment and FSIQ, the difference in *Language* development remained significant ($F_{(1,76)} = 6.94$, $p = 0.010$, $h^2_p = 0.08$), while the difference in *Socio-Emotional* development became non-significant ($F_{(1,68)} = 0.46$, $p = 0.501$, $h^2_p = 0.01$). As none of the maternal and infant- related factors were associated with *Motor* development, these were not included as potential confounders (online Supporting Table S3). There was no significant difference in any developmental domain nor in infant behaviour between infants born to AR-unwell and infants born to AR-well women (Table 3).

Mother–infant interaction is associated with infant development

Dyadic Synchrony at 8w was positively associated with infant *Cognitive* ($r_s = 0.25$, $p = 0.019$) and *Language* ($r_s = 0.32$, $p = 0.003$) development at 12 m, and maternal *Control* and infant *Compulsiveness* at 8w were negatively associated with infant *Language* development at 12 m (respectively, $r_s = -0.23$, $p = 0.030$; $r_s = -0.37$, $p < 0.001$). Similarly, *Dyadic Synchrony* at 12 m was positively associated with infant *Cognitive, Language* and *Socio-Emotional* development (respectively, $r = 0.29$, $p = 0.006$; $r = 0.49$, $p < 0.001$; $r_s = 0.26$, $p = 0.019$), and infant *Compulsiveness* and *Difficultness at* 12 m were negatively associated with infant *Language* development (respectively, $r_s = -0.32$, $p = 0.002$; $r = -0.22$, $p = 0.043$).

Mother–infant interaction during the first postnatal year predicts infant development at 12 months

We then tested a mediation relationship: whether mother–infant interaction (*Dyadic Synchrony*), which differed between AR and HC women, predicted and mediated the relationship between maternal *Group* and infant development after controlling for potential confounders. As findings of the models including *Dyadic Synchrony* at 8w and 12 m were identical, we report here only those at 8w (Figs 1 and 2), and report those at 12 m in the online Supporting materials.

A more synchronous interaction at 8w predicted better infant *Language* development at 12 m ($b = 1.22$, $t = 2.89$, $p = 0.005$). There was also evidence of a partial mediation, as there was both a significant *direct* effect of maternal *Group* on infant *Language* development ($b = -4.98$, 95% CI [−9.42 to −0.54]) as well as an *indirect* effect via *Dyadic Synchrony* ($b = -1.67$, 95% Boot CI [−3.74 to −0.16]). The corresponding partially standardized indirect effect size estimate was −0.16 (95% Boot CI [−0.34 to −0.02]) (Fig. 1). When maternal FSIQ and employment were included in the model, *Dyadic Synchrony* remained a significant predictor of infant *Language* development ($b = 1.15$, $t = 2.47$,

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Table 3. Mother–infant interaction at 8 weeks' and 12 months' post partum and infant development at 12 months' post partum

	8 weeks					12 months				
					AR v. HC					AR v. HC
	AR	AR-unwell	AR-well	HC	AR-unwell v. AR-well	AR	AR-unwell	AR-well	HC	AR-unwell v. AR-well
Dyadic Synchrony, *M* (S.D.)	4.3 (2.3)	4.0 (2.5)	4.5 (2.1)	5.5 (2.6)	**$U = 758.50$, $z = -2.26$, $p = 0.024$, $d = 0.49$** $U = 157.00$, $z = -0.64$, $p = 0.542$	6.0 (2.9)	5.9 (2.9)	6.0 (3.0)	7.3 (2.9)	**$t_{(86)=} 2.12$, $p = 0.037$, $d = 0.45$** $t_{(35)=} 0.13$, $p = 0.894$
Maternal Control, *M* (S.D.)	5.0 (4.1)	5.9 (4.4)	4.3 (3.8)	3.6 (3.4)	$U = 1216.50$, $z = 1.35$, $p = 0.177$ $U = 217.00$, $z = 1.14$, $p = 0.268$	5.2 (4.0)	5.1 (4.2)	5.2 (4.0)	3.9 (3.6)	$U = 1067.50$, $z = 1.06$, $p = 0.291$ $U = 156.00$, $z = -0.28$, $p = 0.795$
Infant Compulsiveness, *M* (S.D.)	3.1 (3.8)	4.7 (4.6)	1.9 (2.3)	2.1 (3.1)	$U = 1220.00$, $z = 1.44$, $p = 0.149$ $U = 231.50$, $z = 1.61$, $p = 0.121$	2.5 (3.2)	2.5 (3.6)	2.5 (3.1)	1.6 (2.8)	$U = 1099.50$, $z = 1.48$, $p = 0.138$ $U = 162.50$, $z = -0.08$, $p = 0.939$
Infant Difficultness, *M* (S.D.)	3.3 (2.5)	2.7 (2.3)	3.7 (2.5)	3.2 (2.1)	$U = 1.053.00$, $z = 0.06$, $p = 0.950$ $U = 135.00$, $z = -1.29$, $p = 0.209$	3.7 (2.4)	4.0 (2.9)	3.5 (2.2)	3.4 (2.2)	$t_{(86)=} -0.70$, $p = 0.485$ $t_{(35)=} -0.61$, $p = 0.549$
Infant Cognitive development, *M* (S.D.)						105.6 (14.5)	108.0 (11.6)	104.2 (16.1)	112.0 (12.4)	**$t_{(94)} = 2.32$, $p = 0.022$, $d = 0.47$** $t_{(38)} = -0.80$, $p = 0.393$
Infant Language development, *M* (S.D.)						89.8 (11.0)	91.6 (12.3)	88.8 (10.2)	98.2 (10.9)	**$t_{(94)} = 3.69$, $p < 0.001$, $d = 0.77$** $t_{(38)} = -0.79$, $p = 0.436$
Infant Motor development, *M* (S.D.)						94.3 (11.7)	95.3 (11.0)	93.7 (12.3)	100.5 (10.0)	**$t_{(94)} = 2.77$, $p = 0.007$, $d = 0.57$** $t_{(38)} = -0.41$, $p = 0.684$
Infant Socio-Emotional development, *M* (S.D.)						97.9 (14.6)	97.9 (15.7)	97.8 (14.3)	104.6 (14.6)	**$U = 659.00$, $z = -2.31$, $p = 0.021$, $d = 0.46$** $U = 123.50$, $z = -0.51$, $p = 0.619$
Infant Adaptive Behaviour, *M* (S.D.)						93.2 (13.5)	92.3 (16.5)	93.7 (11.8)	96.6 (11.4)	$U = 871.00$, $z = -0.48$, $p = 0.630$ $U = 133.00$, $z = -0.34$, $p = 0.749$

AR, women at risk of PP; HC, healthy control women; AR-unwell, women at risk of PP who developed a psychiatric episode within 4 weeks after delivery; AR-well, women at risk of PP who remained well within 4 weeks after delivery; CARE-Index 8w – AR $N = 38$ (AR-unwell = 17; AR-well = 21), HC – $N = 55$; CARE-Index 12 m – AR $N = 37$ (AR-unwell = 15; AR-well = 22), HC – $N = 51$; Bayley (Cognitive, Language and Motor)- AR- $N = 40$ (AR-unwell = 15; AR-well = 25)- HC = 56; Bayley (Socio-Emotional and Adaptive behaviour) – AR – $N = 35$ (Socio-Emotional: 23 AR-well and 12 AR-unwell; Adaptive Behaviour: 22 AR-well and 13 AR-unwell) – HC – $N = 53$. Results provided in bold are statistically significant.

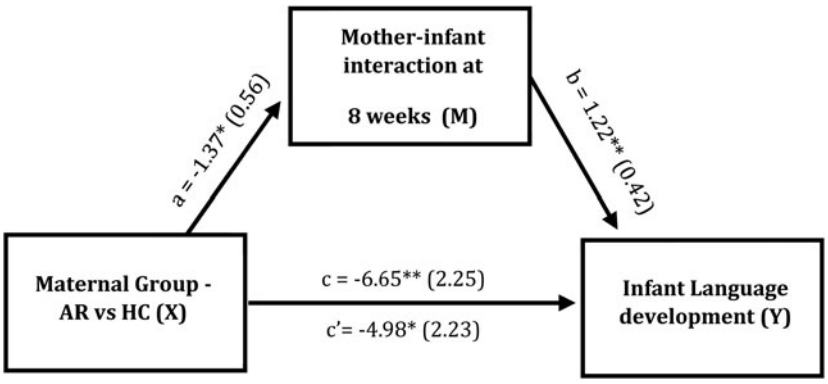

Figure 1. Mediation model – Infant Language development. Figure of the hypothesized mediation model with maternal Group (AR v. HC) as the predictor variable (X), infant Language development at 12 months (Bayley-III) as the outcome variable (Y) and mother–infant interaction (Dyadic Synchrony-CARE-Index at 8 weeks) as the mediating variable (M). A, b, c and c': path coefficients representing unstandardized regression weights and standard errors. $^{*}p < 0.05$, $^{**}p < 0.01$. Maternal FSIQ and employment were inserted in a second step analysis as potential confounders.

$p = 0.016$), but was no longer a partial mediator ($b = -1.17$, 95% Boot CI [−3.41 to 0.28]).

With regards to infant *Cognitive* development, a more synchronous interaction at 8w predicted better infant development at 12 m ($b = 1.11$, $t = 2.04$, $p = 0.045$), but was not a significant mediator in the relationship between maternal *Group* and infant *Cognitive* development ($b = -1.52$, 95% Boot CI [−3.77 to 0.05]) (Fig. 2). When controlling for maternal FSIQ, *Dyadic Synchrony* remained a significant predictor of infant *Cognitive* development ($b = 1.71$, $t = 2.05$, $p = 0.044$).

Boys of AR women present the lowest cognitive, language and motor developmental scores and have the least synchronous interactions with their mothers at 12 months, while girls of AR women have the lowest socio-emotional development scores

The planned comparisons of the effect of maternal case *Group* (AR) and infant male *Sex v.* all other groups on infant *Cognitive*, *Language* and *Motor* development were all statistically significant, indicating that male infants of the AR women had lower scores than all other groups in all of these dimensions (Table 4). The planned comparison of the effect of maternal case *Group* (AR) and infant female *Sex* on infant *Socio-Emotional* development was statistically significant, indicating that the female infants of the AR women had lower scores than all other groups. The planned comparison of the effect of maternal case *Group* (AR) and infant male *Sex v.* all other groups on *Dyadic Synchrony* at 12 m was statistically significant, while it only reached a trend for statistical significance at 8w, suggesting that women of the AR group with male infants had the least synchronous interactions compared to the other groups (Table 4).

Discussion

In this prospective longitudinal study we investigated mother–infant interaction and infant development in women at risk of postpartum psychosis and in those at risk who suffered a postpartum relapse within four weeks after delivery.

We have found that women at-risk-of-PP, regardless of whether or not they develop a postpartum relapse, have less synchronous interactions with their infants at both 8 weeks' and 12 months' post partum and have infants with less optimal cognitive, language, motor and socio-emotional development at 12 months, compared to healthy controls. Our data also provide no evidence for a difference in mother–infant interaction or in infant development between women at-risk-of-PP who do and do not develop a psychiatric relapse in the early postpartum period. Our results are consistent with a previous research, which found no differences in developmental outcomes of infants born to women at-risk-of-PP who developed or did not develop the illness after delivery (McNeil et al., 1988) and with studies reporting differences in mother–infant interaction and infant development in women with a history of affective psychosis and bipolar disorder in comparison to healthy controls (Anke et al., 2019, 2020; Henriksson & McNeil, 2004; McNeil & Kaij, 1987).

These findings suggest that for a child's development, a postpartum episode in women at-risk-of-PP may not be more important than the mother's previous diagnosis of an affective psychosis. Therefore, these results highlight the need to target all women at-risk-of-PP when considering potential preventative interventions. It is indeed possible that factors associated with the woman's lifetime diagnosis, such as a history of childhood maltreatment and of adverse life events, may have a negative effect

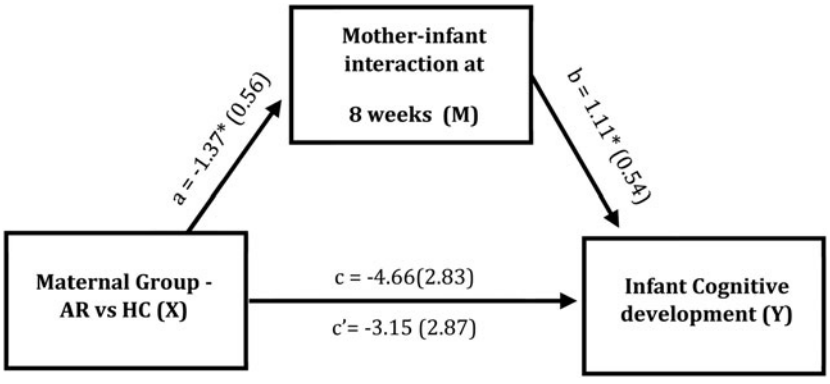

Figure 2. Mediation model – Infant Cognitive development. Figure of the hypothesized mediation model with maternal Group (AR v. HC) as the predictor variable (X), infant Cognitive development at 12 months (Bayley-III) as the outcome variable (Y) and mother–infant interaction (Dyadic Synchrony-CARE-Index at 8 weeks) as the mediating variable (M). $^{*}p < 0.05$. A, b, c and c': path coefficients representing unstandardized regression weights and standard errors. Maternal FSIQ was inserted in a second step analysis as potential confounder.

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Table 4. Mother–infant interaction and infant development in boys and girls

	AR females	AR males	HC females	HC males	Planned comparisons[1]
Dyadic Synchrony at 8w, *M* (S.D.)	4.5 (2.7)	4.0 (1.9)	5.8 (2.9)	5.2 (2.4)	−1.20 (S.E. = 0.65, 95%CI [−2.49 to 0.09]), $F_{(1,89)} = 3.41$, $p = 0.068$
Dyadic Synchrony at 12 m, *M* (S.D.)	7.0 (2.7)	5.1 (2.9)	7.1 (3.4)	7.4 (2.5)	**−2.12 (S.E. = 0.73, 95%CI [−3.58 to −0.66]), $F_{(1,84)} = 8.34$, $p = 0.005$**
Infant Cognitive development, *M* (S.D.)	112.1 (11.5)	99.8 (14.7)	112.5 (11.1)	111.7 (13.5)	**−12.33 (S.E. = 3.19, 95%CI [−18.66 to −6.01]), $F_{(1,92)} = 14.98$, $p < 0.001$**
Infant Language development, *M* (S.D.)	94.5 (10.9)	85.6 (9.5)	98.7 (11.3)	97.8 (10.8)	**−11.38 (S.E. = 2.65, 95%CI [−16.64 to −6.11]), $F_{(1,92)} = 18.42$, $p < 0.001$**
Infant Motor development, *M* (S.D.)	96.6 (10.9)	92.1 (12.3)	102.1 (10.6)	99.2 (9.6)	**−7.17 (S.E. = 2.66, 95%CI [−12.45 to −1.89]), $F_{(1,92)} = 7.26$, $p = 0.008$**
Infant Socio-Emotional development, *M* (S.D.)	93.8 (8.4)	101.7 (18.1)	106.3 (13.4)	103.3 (15.5)	**−9.95 (S.E. = 3.93, 95%CI [−17.75 to −2.14]), $F(1,84) = 6.42$, $p = .013$**

AR, women at risk of PP; HC, healthy control women; AR-unwell, women at risk of PP who developed a psychiatric episode within 4 weeks after delivery; AR-well, women at risk of PP who remained well within 4 weeks after delivery; Bayley (Cognitive, Language and Motor): 32 HC males, 24 HC females, 21 AR males, 19 AR females; Bayley Socio-Emotional: 30 HC males, 23 HC females, 18 AR males, 17 AR females; CARE-Index 8 weeks: 30 HC males, 25 HC females, 19 AR males, 19 AR females; CARE-Index 12 months: 30 HC males, 21 HC females, 20 AR males, 17 AR females. Results provided in bold are statistically significant. [1]Planned comparisons of AR-male infants v. all other groups (AR-females, HC males, HC females) on Cognitive, Language, Motor development, Dyadic Synchrony at 8 weeks and Dyadic Synchrony at 12 months. Planned comparison of AR-female infants v. all other groups (AR-males, HC males, HC females) on Socio-Emotional development.

on child's development. These factors could indeed affect child development in different ways, for example through alterations in biological factors, such as cortisol, and this should be investigated in future studies.

Interestingly, our results differ from those reported in depression, which have shown that perinatal depression can represent a risk factor for both mother–infant interaction and child development (Bind et al., 2021; Murray et al., 1996; Stein et al., 2014), particularly if depression is severe and persistent (Netsi et al., 2018). This may be explained by the fact that symptoms of PP (particularly psychotic symptoms) usually resolve earlier than those of perinatal depression, resulting in the child being exposed to maternal symptoms for a shorter period of time (Murray & Hipwell, 1995), given that a longer symptom duration has been associated with more adverse child outcomes (Murray, Halligan, & Cooper, 2010). It is also possible that only severe episodes or specific symptoms affect the child. Infants can, in fact, be exposed to various presentations, even in case of frank PP, as they can experience an overactive, agitated, irritable or depressed mother, or a mother with rapid mood swings or a variety of psychotic symptoms (Hipwell & Kumar, 1997). We could not investigate this in the current study due to the limited sample size. Another possible explanation for the lack of difference between the two AR groups is the potential impact of psychiatric symptoms developed after four weeks' post partum. In fact, by eight weeks' and 12 months' after delivery many of the at-risk women who had remained well in the first four weeks, had also developed psychiatric symptoms, and these may have impacted both mother–infant interaction and infant development. This would be consistent with our previous evidence from this sample where we similarly found that women at-risk-of-PP reported a less optimal quality of perceived bonding towards the infant in the first year postpartum than healthy controls, while no difference was observed between the AR-well and the AR-unwell. This was explained by the fact that a considerable number of at-risk women developed psychiatric symptoms after four weeks, and these affected their emotional bonding towards their infants (Biaggi et al., 2021). However, considering the relatively small number of women in the AR-unwell group, the finding of no difference between the two AR groups in mother–infant interaction and infant development will need to be confirmed in future studies with larger samples.

It should also be noted that, although the developmental scores of infants of women at-risk-of-PP (particularly those of boys) were significantly lower than controls, most were not indicative of significant delays. However, as mentioned earlier, the Bayley-III may underestimate developmental delays, and researchers and clinicians have warned that its cut-off threshold values may need to be increased (Bos, 2013; Johnson et al., 2014). Therefore, it is important to consider that, when using the new suggested cut-off, some of the lower developmental scores that we identified become indicative of significant delays. To this end, a new version of the Bayley (Bayley-IV) is currently undergoing further validation and standardization (Aylward & Zhu, 2019).

In terms of mother–infant interaction, we should highlight that in both at-risk and control women, interactions became more synchronous over time, in line with the normative improvement that occurs from the neonatal period to 12 months, as mothers and infants get to know each other and improve their level of attunement to one another (Fuchs, Mohler, Resch, & Kaess, 2015), as previously shown also in depressed women (Bind et al., 2021). Nevertheless, dyads of the at-risk group continued to remain at higher developmental risk for the child at

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12 months. In fact, they were classified as 'at Risk' for child development at 8 weeks and as 'Inept' at 12 months, indicating that the interaction was still not adequate, and an intervention might be advisable.

Therefore, these findings are clinically meaningful, also because a high Dyadic Synchrony is associated with more optimal cognitive, emotional and behavioural child development and with a secure attachment (Harrist & Waugh, 2002; Leclère et al., 2014). In particular, we found that, in this clinical population, a better mother–infant interaction during the first year postpartum (higher dyadic synchrony, less maternal control, infant compulsiveness and difficultness) is associated with better infant developmental outcomes at 12 months. Specifically, the level of synchrony in the dyad as early as 8 weeks' post partum predicts both infant cognitive and language development at 12 months. These findings clearly resemble those in PND where disturbances in the mother–infant interaction at two months predicted less optimal infant cognitive development at 18 months (Murray et al., 1996).

However, our data show that Dyadic Synchrony was only a partial mediator in the relationship between maternal risk for PP and infant language (but not cognitive) development, contrary to what observed in PND (Milgrom, Westley, & Gemmill, 2004; Murray et al., 1993). These results suggest that mother–infant interaction is an important contributing factor in the association between maternal *Group* and infant *Language* development, although it does not completely explain the difference observed between the AR and HC groups in this dimension. It is possible that mother–infant interaction plays more of a role in mediating the relationship between PP (rather than maternal risk for PP) and infant development, or that other or more specific characteristics of the mother–infant interaction better explain differences in infant development. To this end, a previous study also showed that, although lower maternal sensitivity and higher remoteness and less infant engagement at 2 months' post partum significantly predicted worse infant cognitive performance at 18 months, these did not explain the lower cognitive scores of the boys of women with PND (Murray et al., 1996). On the contrary, in another study, the same authors found that speech of depressed women at 2 months post partum, which was less focused on the infant experience, largely accounted for the negative effects of PND on boys' cognitive development at 18 months (Murray et al., 1993).

Finally, we report here that boys of women at-risk-of-PP show the lowest scores in cognitive, language and motor development, while girls of these women show the lowest scores in socio-emotional development. Although this was an exploratory analysis, given the relatively small numbers, the results are consistent with findings in offspring of women with PND (Goodman et al., 2011; Milgrom et al., 2004; Stein et al., 2014). In fact, they suggest that even in women at risk of PP, boys are more susceptible to maternal mental health in their cognitive development while girls are more at risk in their emotional development. Furthermore, we found that, at 12 months, and at trend level also at 8 weeks, women at-risk-of-PP with boys had the least synchronous interactions compared to all other groups. Previous studies on infant sex and mother–infant interaction in depression reported mixed findings, with some research reporting that mothers had less optimal interactions with boys than girls (Murray et al., 1993) and others not finding any sex difference (Sidor, Kunz, Schweyer, Eickhorst, & Cierpka, 2011). Results of this study in women at-risk-of-PP confirm those of a study previously conducted in women with a history, or recent experience of a severe mental illness, which found that mothers were more sensitive towards girls than boys (Rigby, Conroy, Miele-Norton, Pawlby, & Happé, 2016).

Strengths and limitations

This study has numerous strengths, including the longitudinal design and the evaluation of mother–infant interaction and infant development in women at-risk-of, or with PP during the first year postpartum, a time of increased challenges for mothers (and fathers), even more for those experiencing a severe mental illness. Furthermore, the participant selection of cases and controls followed strict inclusion/exclusion criteria, clinical notes were obtained and consensus meetings were held to confirm diagnoses and symptoms. Mother–infant interaction was scored blind to maternal mental health.

There are also some important limitations to consider. We were unable to study separately the women who developed frank PP due to the small number of women with these episodes. Women at-risk-of-PP were recruited from specialist perinatal mental health services and were closely monitored throughout the perinatal period, which probably contributed to a relatively low rate of frank PP. Furthermore, we used a broader definition of PP to capture relapse of affective symptoms in the early postpartum period; nevertheless, we are confident that we are not evaluating PND, which most of the time has a later onset (Biaggi et al., 2021; Doucet, Dennis, Letourneau, & Blackmore, 2009; Hazelgrove et al., 2021). However, considering the relatively small number of women in our groups, these results will need to be replicated in future studies.

Furthermore, we did not evaluate father-infant interaction, which may also play an important role in infant development (Sethna et al., 2017), together with other factors, including the availability of social support. The role of these factors on infant development in this clinical population will need to be investigated in future studies.

In summary, this study provides novel findings on mother–infant interaction and infant development in the offspring of women at-risk-of-PP with and without a postpartum relapse. Although these findings will need to be confirmed in larger studies, they provide important information and suggest that all women at-risk-of-PP may benefit from support in interacting with their infants and promoting their development during the perinatal period, as this time offers a unique opportunity for interventions to promote the long-term well-being of the dyad.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/S0033291723002568

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Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of the relevant national and institutional committees on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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