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Within-individual relationships between mother-to-infant bonding and postpartum depressive symptoms: a longitudinal study

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Abstract

Background. Although the importance of the dynamic intra-individual relationship between mother-to-infant bonding and postpartum depressive symptoms has been widely recognized, the complex interplay between them is not well understood. Furthermore, the potential role of prenatal depressive symptoms and infant temperament in this relationship remains unclear. This study aims to examine the bidirectional influence of mother-to-infant bonding on postpartum depressive symptoms within individuals and to elucidate whether prenatal depressive symptoms and infant temperament would influence deviations from stable individual states.
Methods. Longitudinal data were collected from 433 women in early pregnancy. Of these, 360 participants completed the main questionnaires measuring impaired mother-to-infant bonding and postpartum depressive symptoms at least once during the postpartum period. Data were collected at early and late pregnancy and several postpartum time points: shortly after birth and at one, four, ten, and 18 months postpartum. We also assessed prenatal depressive symptoms and infant temperament. A random-intercept cross-lagged panel model was used.
Results. Within-individual variability in mother-to-infant bonding, especially anger and rejection, significantly predicted subsequent postpartum depressive symptoms. However, the inverse relationship was not significant. Additionally, prenatal depressive symptoms and difficult infant temperament were associated with greater within-individual variability in impaired mother-to-infant bonding and postpartum depressive symptoms.
Conclusions. The present study demonstrated that the within-individual relationship between mother-to-infant bonding and postpartum depressive symptoms is likely non-bidirectional. The significance of the findings is underscored by the potential for interventions aimed at improving mother-to-infant bonding to alleviate postpartum depressive symptoms, suggesting avenues for future research and practice.

Introduction

Mother-to-infant bonding refers to the affection a mother feels for her infant (Kinsey & Hupcey, 2013). Although mother-to-infant bonding is a critical aspect of postpartum life, it varies among mothers. Some mothers experience impaired bonding, characterized by decreased affection and parenting behaviors that may affect their children's development (Fuchs, Möhler, Reck, Resch, & Kaess, 2016; Kinsey & Hupcey, 2013; Muzik et al., 2013; Yoshida, Yamashita, Conroy, Marks, & Kumar, 2012). Understanding the factors contributing to mother-to-infant bonding and its impairment is essential for healthy parent–child relationships and child development.

Mothers with impaired mother-to-infant bonding often have comorbid postpartum depression (Tichelman et al., 2019). Postpartum depressive symptoms can interfere with mothers' parenting behaviors, resulting in less responsive interactions than mothers without postpartum depression (Barrett & Fleming, 2011; O'Hara et al., 2013). Consequently, mothers' depressive symptoms may negatively affect their infants' cognitive, emotional, motor, and language development (Slomian, Honvo, Emonts, Reginster, & Bruyère, 2019).

The relationship between mother-to-infant bonding and postpartum depressive symptoms involves a complex interplay of potential reciprocal influences. Several cross-sectional studies have suggested such a reciprocal influence by reporting a positive association between impaired mother-to-infant bonding and postpartum depressive symptoms (Dubber, Reck, Müller, & Gawlik, 2015; Mazúchová, Kelčíková, Maskalová, Malinovská, & Grendár, 2021; Motegi et al., 2020; Nolvi et al., 2016; Nonnenmacher, Noe, Ehrenthal, & Reck, 2016; Taylor, Atkins, Kumar, Adams, & Glover, 2005; Tsuchida et al., 2019). However, the cross-sectional design of these studies inherently limited their ability to delineate the direction of causality or elucidate the mechanisms underlying the relationship.

To address these limitations, longitudinal studies have examined the bidirectional and causal relationships between these two variables (Kasamatsu et al., 2020; Kerstis et al., 2016; Muzik et al., 2013; O'Higgins, Roberts, Glover, & Taylor, 2013; Radoš, Matijaš, Anđelinović, Čartolovni, & Ayers, 2020; Stuijfzand, Garthus-Niegel, & Horsch, 2020), and some show that postpartum depressive symptoms can predict later impairment in mother-to-infant bonding (Kasamatsu et al., 2020; O'Higgins et al., 2013). Wouk et al. (2019) found that mothers who did not experience positive emotions during infant feeding at two months postpartum had heightened depressive symptoms at six months and one year. Importantly, when models that include autoregression are used, the progressive relationship between the two variables may disappear. For instance, when both mother-to-infant bonding impairment and Edinburgh Postnatal Depression Scale (EPDS) scores were considered concurrently as independent variables, EPDS scores were not predictive of mother-to-infant bonding impairment at one year (O'Higgins et al., 2013). Similarly, a structural equation modeling analysis incorporating autoregressive and bidirectional paths between mother-to-infant bonding impairment and EPDS scores showed that the impact of mother-to-infant bonding impairment on postpartum depressive symptoms was significant but not vice versa (Ohara et al., 2017).

Distinguishing between between-individual and within-individual variation is essential for modeling the dynamic interplay between variables within individuals (Hamaker, Kuiper, & Grasman, 2015). Previous studies of the relationship between mother-to-infant bonding and postpartum depressive symptoms have predominantly used between-individual analyses, which examine the relative positioning of individuals within a population (Dubber et al., 2015; Mazúchová et al., 2021; Motegi et al., 2020; Nolvi et al., 2016; Nonnenmacher et al., 2016; Taylor et al., 2005; Tsuchida et al., 2019). However, these analyses do not account for within-individual relationships, which refer to the associations between variables within each individual. Critically, findings derived from between-individual analyses should not be extrapolated to within-individual, as they may be overestimated or, in certain cases, directionally reversed (Hamaker et al., 2015). To understand the psychological mechanisms in postpartum mothers, it is necessary to distinguish and separately examine between- and within-individual relationships.

Beck (2001) underscored antenatal depressive symptoms as a key predictor of postpartum depression, and research showed that antenatal depressive symptoms predict lower postpartum mother-to-infant bonding (Hare, Kroll-Desrosiers, & Deligiannidis, 2021; Rossen et al., 2016). Moreover, infant temperament was also identified as a predictor of postpartum depressive symptoms (Beck, 2001; Zhao & Zhang, 2020). Temperament reflects an infant's propensity to respond to their environment and is recognized as a factor that shapes parenting behavior (Belsky, 1984). Multiple studies have suggested that difficulty in soothing reduces parenting efficacy, hinders the development of bonding, and exacerbates depressive symptoms (Edhborg, Matthiesen, Lundh, & Widström, 2005; Nolvi et al., 2016). Understanding the factors contributing to deviations from stable components within individuals can aid in predicting emotional instability and fluctuations in mental state.

Our study aimed to explore the dynamic relationship between mother-to-infant bonding and postpartum depressive symptoms at both the between- and within-individual levels while considering the roles of antenatal depressive symptoms and infant temperament. Thus, we propose the following hypotheses: Based on previous research, we anticipated a positive correlation between mother-to-infant bonding and postpartum depressive symptoms at the individual level. However, due to the limitations of generalizing between-individual findings to within-individual relationships (Hamaker et al., 2015), making specific predictions regarding within-individual associations is challenging. This study employs a random intercept cross-lagged panel model (RI-CLPM; Hamaker et al., 2015). The RI-CLPM allows the modeling of stable, between-individual differences and temporal, within-individual dynamics between two or more constructs. Second, we expected antenatal depressive symptoms and perceived difficult infant temperament to positively predict within-individual fluctuations in mother-to-infant bonding and postpartum depressive symptoms.

Method

Participants and procedures

This study included women enrolled in the Chiba Study of Mother and Child Health (C-MACH) who agreed to participate during their first trimester between 2014 and 2015. All participants gave birth at three local hospitals in the National Capital Region of Japan. A detailed description of the longitudinal birth study has been published previously (Sakurai et al., 2016). The survey collected demographic information and depressive symptoms using the Center for Epidemiological Studies Depression Scale (CES-D) during pregnancy. The Mother-to-Infant Bonding Scale (MIBS) and the EPDS were administered at several time points: shortly after birth (0 mo) and one month (1 mo), four months (4 mo), ten months (10 mo), and 18 months (18 mo) postpartum. At one month and four months postpartum, the participants evaluated their infants' temperaments based on crying patterns and reactions to being held. A total of 433 pregnant women provided written informed consent during early pregnancy. Due to various reasons such as miscarriage, stillbirth, change of hospital, relocation, or non-response to the questionnaire, the number of participants dwindled to 379 during childbirth. The analysis targeted 360 participants who responded to the MIBS and EPDS at least once. See Tables 1 and 2 for the number of responses collected for each variable.

We ran a sensitivity power analysis using the powRICLPM R package (Mulder, 2023), which allows power analysis for RI-CLPM. Our primary objective was to determine the minimum standardized cross-lagged coefficient at which the power exceeds 80%. We based our simulations on Model 2 (see Statistical analysis). Based on the Monte Carlo simulations, our sample size ($N = 360$) exceeded 80% power to detect cross-lagged effects of 0.10 in most parameter combinations. For a detailed procedure and result, please refer to the online Supplementary Information and Table S1.

The Biomedical Research Ethics Committee of the Graduate School of Medicine, Chiba University, approved the study (ID:451, 1199, 1218, and 1239). This study was also approved by the Research Ethics Committee of the University of Fukui (ID:20220091).

Measures

Mother-to-infant bonding scale

The MIBS is a self-rated questionnaire designed to assess bonding feelings with infants (Taylor et al., 2005; Yoshida et al.,

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Table 1. Demographic information

Characteristic	*N*	*N* = 433
Maternal age at early pregnancy (years)	396	32.58 (4.43)
Parity	390	
Primiparous		167 (43%)
Multiparous		223 (57%)
Child sex	379	
Male		197 (52%)
Female		182 (48%)
Gestational age (week)	370	39.07 (1.19)
Birth weight (g)	375	3101.11 (362.76)
Marital status	332	
Married		330 (99%)
Single		2 (0.6%)
Household income	338	
< 2 000 000 yen		1 (0.3%)
2 000 000 yen – 3 999 999 yen		60 (18%)
4 000 000 yen – 5 999 999 yen		107 (32%)
6 000 000 yen – 7 999 999 yen		89 (26%)
8 000 000 yen – 9 999 999 yen		41 (12%)
10 000 000 yen – 11 999 999 yen		24 (7.1%)
12 000 000 yen – 14 999 999 yen		10 (3.0%)
15 000 000 yen – 19 999 999 yen		3 (0.9%)
> 20 000 000 yen		3 (0.9%)
Education	351	
Junior high school		7 (2.0%)
High school		80 (23%)
Professional training college, junior college, or technical college		135 (38%)
University or graduate school		129 (37%)
Depression history	357	15 (4.2%)

[a]Mean (s.d.); *n* (%).

2012). A high score indicates poor mother-to-infant bonding. This study used the total score (0–30 points) of the 10 items. The MIBS showed adequate reliability in the present study at each time point (see Table 2). Yoshida et al. (2012) suggested that the MIBS has a two-factor structure. Lack of affection, composed of four items, reflects a lack of affection toward one's baby (lack of affection's $\alpha = 0.72$ at the hospital; 0.66 at 1 month postpartum; 0.64 at 4 months postpartum; 0.7 at 10 months postpartum; 0.6 at 18 months postpartum). Anger/rejection, composed of four items, reflects feelings of anger or rejection toward one's baby (Anger/rejection's $\alpha = 0.35$ at the hospital; 0.56 at 1 month postpartum; 0.59 at 4 months postpartum; 0.57 at 10 months postpartum; 0.57 at 18 months postpartum). The present study explored these two factors, in addition to the total score, to investigate the aspects of mother-to-infant bonding associated with postpartum depressive symptoms in greater detail.

Table 2. Descriptive statistics and correlations of MIBS and EPDS at each time point

	Variable	Mean	s.d.	*N*	Skewness	Kurtosis	α	1	2	3	4	5	6	7	8	9	10
1	MIBS_hospital	2.62	2.62	350	1.60	3.32	0.71										
2	MIBS_1mo	2.41	2.48	328	1.66	3.58	0.75	0.61									
3	MIBS_4mo	1.97	2.37	322	2.11	6.46	0.76	0.42	0.62								
4	MIBS_10mo	2.34	2.68	297	2.35	8.54	0.77	0.46	0.63	0.66							
5	MIBS_18mo	2.72	2.54	247	1.27	1.66	0.73	0.41	0.52	0.60	0.63						
6	EPDS_hospital	5.22	4.18	348	1.33	2.23	0.84	0.52	0.38	0.26	0.31	0.29					
7	EPDS_1mo	4.73	3.81	329	1.34	2.50	0.83	0.37	0.43	0.21	0.22	0.26	0.54				
8	EPDS_4mo	4.05	3.49	319	1.65	3.97	0.82	0.26	0.33	0.47	0.38	0.40	0.37	0.47			
9	EPDS_10mo	4.00	3.51	301	1.65	3.49	0.81	0.31	0.39	0.39	0.49	0.32	0.38	0.42	0.60		
10	EPDS_18mo	4.09	3.42	249	1.34	1.62	0.80	0.21	0.35	0.33	0.45	0.50	0.29	0.38	0.60	0.64	

Note: MIBS, mother-to-infant bonding scale; EPDS, Edinburgh postnatal depression scale; mo, month; α, Cronbach's alpha.

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Edinburgh postnatal depression scale

The EPDS is a commonly utilized self-rating tool for screening postnatal depression (Cox, Holden, & Sagovsky, 1987; Okano, 1996). It includes 10 items and the total score ranged from 0 to 30, with higher scores indicating more severe depressive symptoms. The EPDS was used to quantify postpartum depressive symptoms as a continuous variable. The reliability of the EPDS in this study was satisfactory at each time point (see Table 2).

Center for epidemiological studies depression scale

The CES-D is a self-reported instrument used to measure depressive symptoms in the general population. This scale has been shown to exhibit moderate to high positive correlations with depression symptoms rated by clinicians through interviews (Weissman, Sholomskas, Pottenger, Prusoff, & Locke, 1977). It comprises 20 items†[1], with respondents rating the frequency of their depression-related symptoms in the previous week. The total score ranged from 0 to 60, with higher scores indicating more severe depressive symptoms. The CES-D was used to assess depressive symptoms during pregnancy. It was administered twice (during the first and last trimesters of pregnancy), and the average score was used in the analyses. The reliability of the CES-D in this study was satisfactory (early pregnancy: $\alpha = 0.82$; late pregnancy: $\alpha = 0.83$).

Infant temperament

Infant temperament was assessed at one and four months postpartum using three items: the frequency and ease of soothing the baby's crying; perceived difficulty in holding the baby due to fussiness, crying, or stiffness; and whether there were instances where the baby's crying could not be comforted. The items were adapted from the checklist utilized in The Japan Environment and Children's Study, a large-scale birth study (Morokuma et al., 2018; Nakahara et al., 2020). The answers were combined into a single variable reflecting the baby's difficult temperament using principal component analysis (PCA). A higher score on this composite variable indicates a more irritable temperament, characterized by frequent crying, difficulty soothing, and difficulty holding. The parallel analysis indicated that a single principal component was appropriate. The eigenvector from the one-month PCA was used to create a principal component score for temperament at four months.

Statistical analysis

We first calculated the bivariate correlations between the MIBS and EPDS scores at each time point. We also calculated the intra-class correlation coefficients for MIBS and EPDS. It represents the proportion of between-individual variance in the total variance. This step confirms the existence of significant within-individual variance, thereby justifying the use of the RI-CLPM.

The RI-CLPM, which splits the observed variables into between- and within-individual components, was employed to analyze the temporal dynamics between mother-to-infant bonding impairment and postpartum depressive symptoms (Hamaker et al., 2015; Mulder & Hamaker, 2021). The random intercepts were latent variables with the observed MIBS and EPDS scores as its indicators, and fixing all the factor loadings to 1. Within-individual components are the deviations between expected and observed scores for an individual at each time point, and the RI-CLPM allows us to focus on the within-individual association by separating out the random intercepts.

We compare the goodness of fit of the four RI-CLPM models using the Satorra–Bentler scaled chi-square difference test. Model 1, the baseline model, included no constraints on the time-invariant parameters. Models 2, 3, and 4 included time-invariant constraints for the correlations and cross-lagged and autoregressive coefficients between within-individual components, grand means, and both coefficients and grand means, respectively.

Subsequent models introduced the MIBS subscale scores (lack of affection and anger/rejection) instead of the total MIBS score (Model 5), depressive symptoms during pregnancy (Model 6), and infant temperament (Model 7) as predictors. Time-invariant constraints were imposed on the paths from depressive symptoms during pregnancy to the within-individual components of the MIBS and EPDS at all five-time points.

Finally, sensitivity analyses were performed by introducing control variables, such as the age at early pregnancy, education, household income, parity, gestational age, child sex, birth weight, and depression history. In addition, to consider the influence of marital status on the results, we omitted two unmarried participants and conducted the analysis.

We employed the maximum likelihood robust (MLR) estimator to accommodate modest deviations from normality (Kline, 2015) and handled missing data using full information maximum likelihood estimation. As delineated in Table 2, all indicators exhibited slightly positive values for skewness and kurtosis, yet they did not surpass the thresholds indicative of serious non-normality (skewness beyond ± 3.0 and kurtosis beyond ± 10.0; Kline, 2015).

All analyses were conducted using R 4.2.1 and the lavaan package (Rosseel, 2012).

Results

Descriptive statistics

Descriptive statistics of MIBS and EPDS at each time point are presented in Table 2. MIBS and EPDS scores were positively correlated at the same time points. Furthermore, the MIBS scores positively correlated with the EPDS scores of the subsequent wave and vice versa.

Intra-class correlation coefficients

The intra-class correlations for the MIBS and EPDS scores were 0.55 and 0.46, respectively. The intraclass correlations indicated a well-balanced representation of both between-individual variance (variations among different mothers) and within-individual variance (changes within the same mother over time) in the MIBS and EPDS scores, thereby highlighting the significance of considering both inter-and intra-individual variability in the analysis.

RI-CLPM of MIBS and EPDS

Table 3 presents the results of the model comparisons of each RI-CLPM model. Among the different models tested, Model 2, which included time-invariant constraints on the cross-lagged and autoregressive coefficients and correlations, did not show a significant decrease in model fit compared with the baseline model and had the lowest Bayesian information criterion values. Based on these findings, we selected Model 2 for subsequent analyses and interpretations.

†The notes appear after the main text.

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Table 3. Model fit indices and comparisons of the RI-CLPM

Model	Time invariant constraints	CFI	RMSEA	AIC	BIC	χ^2	Df	$\delta\chi^2$	δDf	p Value
Model 1 (Base)	None	0.99	0.04	14 315.61	14 486.60	28.80	21			
Model 2	Coefficients between within-individual components	0.99	0.04	14 322.31	14 431.12	50.00	37	21.29	16	0.17
Model 3	Grand means	0.95	0.08	14 363.49	14 503.39	76.66	29	52.76	8	0.00
Model 4	Both	0.94	0.07	14 378.09	14 455.82	100.06	45	69.49	24	0.00

Note: RI-CLPM, random intercept cross-lagged panel model; CFI, comparative fit index; RMSEA, root mean squared error of approximation; AIC, Akaike information criterion; BIC, Bayesian information criterion.

The relationship between the random intercepts of the MIBS and the EPDS was examined within the context of the RI-CLPM to explore the association between the two factors at the between-individual level. Consistent with previous research and our hypotheses, we observed a significant positive correlation between the time-invariant components of MIBS and EPDS (online Supplementary Table S2 and Fig. 1).

Online Supplementary Table S2 and Fig. 1 present the significant positive correlations observed between the within-individual components of MIBS and EPDS at each time point. These findings indicate that an individual's deviation from the average level of mother-to-infant bonding at a specific point likely corresponds to a similar deviation in postpartum depressive symptoms.

2Analysis of the dynamics among variables at the within-individual level and the cross-lagged coefficients of the within-individual components showed that changes in the MIBS within an individual significantly predicted subsequent changes in the EPDS. This finding suggests that if an individual's mother-to-infant bonding deteriorates at a specific time point beyond the individual-average level, postpartum depressive symptoms at the subsequent time point are expected to be more severe than the individual-average. In contrast, the cross-lagged coefficients from the EPDS to the MIBS were not significant. This indicates that the temporary exacerbation of postpartum depressive symptoms beyond the individual-average level may not significantly influence fluctuations in mother-to-infant bonding.

RI-CLPM of the MIBS subscales and EPDS

We conducted an analysis using the RI-CLPM with two MIBS subscales. For Model 5, the total MIBS score in Model 2 was replaced with the lack of affection and anger/rejection scores. This model demonstrated an acceptable fit (*CFI* = 0.97, *RMSEA* = 0.043).

Regarding within-individual variations, deviations from the individual-average level of anger/rejection at one-time point positively predicted next deviations from the individual-average level of postpartum depressive symptoms (online Supplementary Table S3 and Fig. 2). This finding suggests that if an individual experiences a higher level of anger/rejection toward their child than in their usual state, their postpartum depressive symptoms will be more severe at the next time point. However, deviations from the individual-average lack of affection levels did not significantly contribute to deviations from individual-average EPDS levels at the next time point.

Impact of prenatal depressive symptoms and infant temperament on within-individual variations of postpartum MIBS and EPDS scores

Prenatal depressive symptoms

We examined the impact of prenatal depressive symptoms on within-individual variations in MIBS and EPDS scores. In Model 2, we introduced the prenatal CES-D score as an explanatory variable and assessed its paths to the within-individual components of the MIBS and EPDS. Model 6 demonstrated an acceptable fit (*CFI* = 0.98, *RMSEA* = 0.046).

Notably, the CES-D scores significantly and positively predicted the within-individual component scores of the MIBS and EPDS (online Supplementary Table S4). This indicates that higher levels of antenatal depressive symptoms are associated with greater deviations from the average levels of both mother-to-infant bonding impairment and postpartum depressive symptoms.

Infant temperament

We subsequently examined the impact of infant temperament at one and four months postpartum on the within-individual components of the MIBS and EPDS at the same time points. Model 7 demonstrated an acceptable fit (*CFI* = 0.96, *RMSEA* = 0.059).

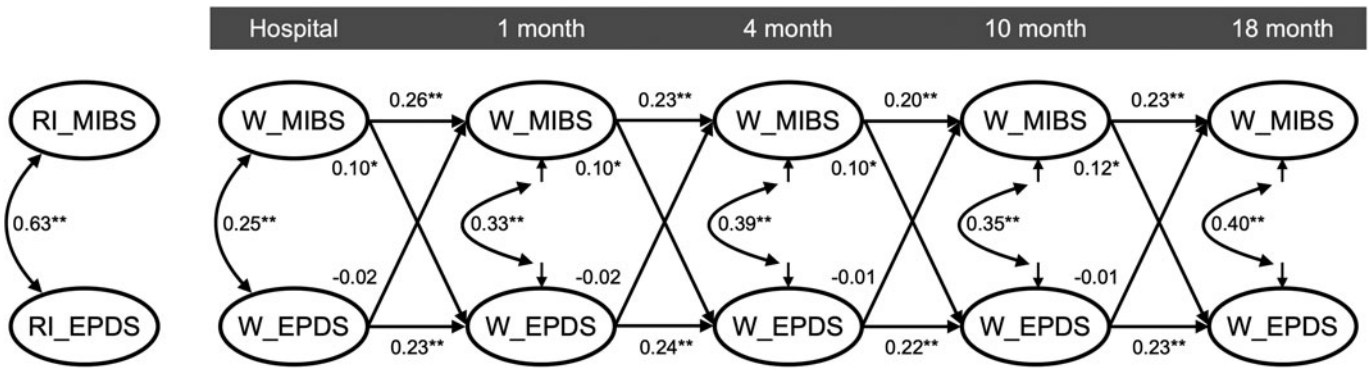

Figure 1. Standardized path coefficients from Model 2 for the Mother-to-infant Bonding Scale (MIBS) and the Edinburgh Postnatal Depression Scale (EPDS). * $p < 0.05$, ** $p < 0.01$. RI, random intercept; W, within-individual component.

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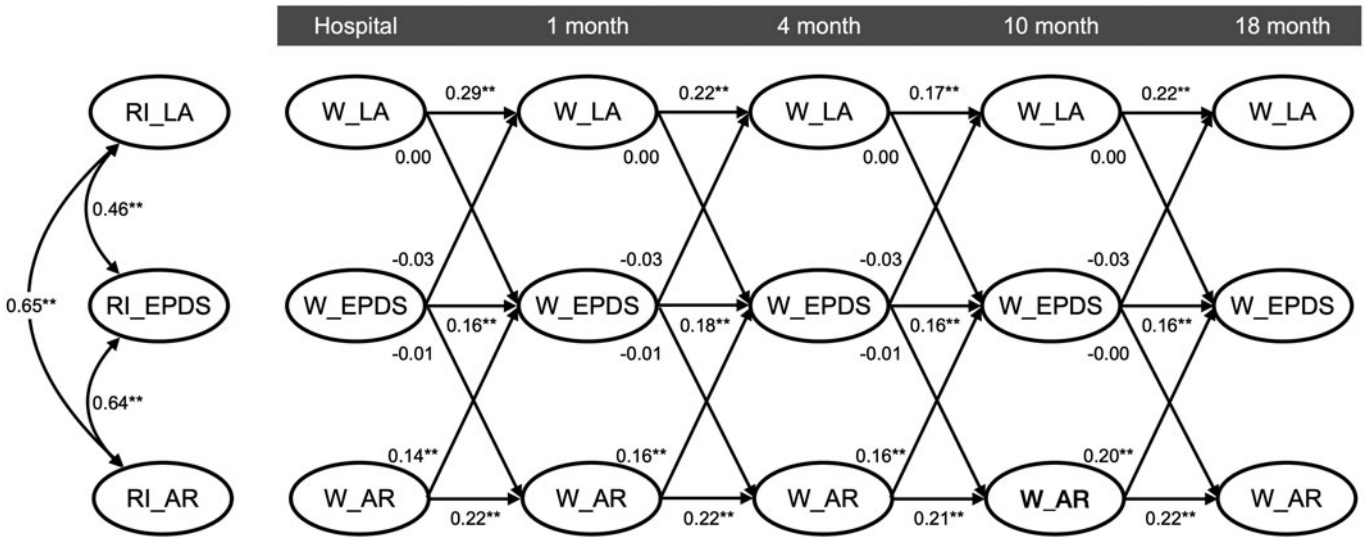

Figure 2. Standardized path coefficients from Model 5 for the Lack of affection (LA) and Anger/rejection (AR) from the Mother-to-infant Bonding Scale and the Edinburgh Postnatal Depression Scale (EPDS). Correlations between within-individual components are omitted for improved visibility. See online Supplementary Table S3 for their values. * $p < 0.05$, ** $p < 0.01$. RI, random intercept; W, within-individual component.

At one and four months postpartum, a difficult infant temperament positively predicted deviations from stable MIBS and EPDS scores (online Supplementary Table S5). This finding suggests that mothers who perceived their infants difficult displayed lower levels of mother-to-infant bonding and increased postpartum depressive symptoms compared to their own average levels.

Sensitivity analysis

Sensitivity analyses included control variables in each RI-CLPM model. The models showed a good fit (online Supplementary Table S6). Generally, higher income levels correlated with lower MIBS scores, and older maternal age and no depression history correlated with decreased EPDS scores, aligning with previous research (Bottino, Nadanovsky, Moraes, Reichenheim, & Lobato, 2012; Tichelman et al., 2019). Overall, including these control variables produced similar results with main analyses (online Supplementary Tables S7–S10). Online Supplementary Table S11 shows the results of Model 2 in the data set except for two unmarried participants. Again, this model did not significantly change the results. Thus, our findings remain robust when considering the influence of these control variables.

Discussion

This study investigated the relationship between mother-to-infant bonding impairment and postpartum depressive symptoms at the within-individual level. Using the RI-CLPM, we demonstrated that at the between-individual level, mothers who experienced mother-to-infant bonding impairment were more likely to display postpartum depressive symptoms. In addition to the between-individual associations, our results further demonstrated that when mothers exhibited a higher degree of mother-to-infant bonding impairment than the individual-average levels, these were followed by occasions when they experienced higher postpartum depressive symptoms than the individual-average levels. However, deviations in postpartum depressive symptoms did not significantly influence mother-to-infant bonding impairment at subsequent time points. In addition, prenatal depressive symptoms and difficult infant temperament were associated with exacerbations of mother-to-infant bonding impairments and postpartum depressive symptoms.

This study employed RI-CLPM to examine the separate contributions of between- and within-individual variations. Consistent with previous studies (Dubber et al., 2015; Mazúchová et al., 2021; Motegi et al., 2020; Nolvi et al., 2016; Nonnenmacher et al., 2016; Taylor et al., 2005; Tsuchida et al., 2019), we observed a positive correlation between time-invariant mother-to-infant bonding impairments and postpartum depressive symptoms. Our results revealed a novel within-individual relationship: Increases in mother-to-infant bonding impairment predicted subsequent increases in postpartum depressive symptoms within individuals. Notably, this relationship was unidirectional because changes in postpartum depressive symptoms did not significantly predict subsequent changes in mother-to-infant bonding impairments. According to Orth et al. (2022), benchmarks for interpreting standardized cross-lagged effects in RI-CLPM are 0.03 for small, 0.07 for medium, and 0.12 for large effects. In our study, the standardized cross-lagged effects from the MIBS to the EPDS ranged from 0.10 to 0.12, indicating medium to large effect sizes. The analysis revealed a particularly notable influence when focusing on the anger/rejection subscale of the MIBS, with standardized cross-lagged effects ranging from 0.14 to 0.20. This is greater than either the effects of total MIBS or the lack of affection subscale. Contrastingly, the standardized cross-lagged effects from the EPDS to the MIBS were less than the small effect (0.03) and were not statistically significant. These findings suggest focusing on anger/rejection toward the infant may be worthwhile to better understand their influence on postpartum depressive symptoms. Previous meta-analyses have shown that self-esteem is a robust factor and mechanism underlying postpartum depression (Beck, 2001; Zhao & Zhang, 2020). Self-esteem refers to one's satisfaction with oneself and the degree of alignment between one's ideal and actual selves (Silber & Tippett, 1965). Low self-esteem is associated with feelings of guilt and shame (Budiarto & Helmi, 2021), and parental guilt has been linked to depressive symptoms

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(Derella & Milan, 2021). The highest reports of guilt tend to occur when caregivers direct their anger and actions toward the child (Rotkirch & Janhunen, 2010). In our study, mothers may have experienced guilt and shame when they felt anger/rejection and there was a significant discrepancy between their ideal image of parenting and their actual experience. This decrease in self-esteem may have triggered an increase in depressive symptoms.

The finding that postpartum depressive symptoms do not necessarily exacerbate mother-to-infant bonding impairments in the same individual may initially appear inconsistent with the results of many cross-sectional studies. However, O'Higgins et al. (2013) reported that the effect of postpartum depressive symptoms becomes non-significant when postpartum depressive symptoms and mother-to-infant bonding are simultaneously entered as independent variables, with later mother-to-infant bonding as the dependent variable. Moreover, several interventional studies indicated that improvements in postpartum depressive symptoms do not directly lead to enhanced mother-to-infant bonding (O'Mahen et al., 2014; Posmontier, Neugebauer, Stuart, Chittams, & Shaughnessy, 2016). This suggests that the experience of postpartum depressive symptoms alone may not be sufficient to determine the formation of mother-to-infant bonding at the between- and within-individual levels.

The current findings also indicate that prenatal depressive symptoms and infant temperament play a significant role in the intra-individual variations in postnatal mental health. Mothers with higher prenatal depressive symptoms experience greater fluctuations in their mother-to-infant bonding and postpartum depressive symptoms. Furthermore, the model incorporating prenatal depressive symptoms revealed an interesting trend where the cross-lagged effect from MIBS to EPDS within individuals became non-significant. This study focused on the nearly 50% intra-individual variance observed in the MIBS and EPDS scores. However, it is equally critical to consider the remaining variance accounted for by inter-individual differences. Prenatal depressive symptoms might play a significant role in explaining both inter-individual and intra-individual variances. Prenatal depression is a significant risk factor for postpartum depression (Beck, 2001; Zhao & Zhang, 2020), and while the necessity for early intervention is widely acknowledged, the mechanisms underlying the persistence of depressive symptoms throughout the perinatal period remain largely unexplored. Our findings pave the way for a more nuanced understanding of instability in postpartum mental health, particularly by highlighting the significance of deviations from a stable state.

Additionally, the perception of an infant having a difficult temperament plays a role in the temporary exacerbation of mother-to-infant bonding and postpartum depressive symptoms. Dealing with a baby who frequently cries and has difficulty soothing can be stressful and emotionally taxing. Crying is a parenting stressor; when a baby cannot be soothed, parents' sense of efficacy can decrease situationally (Verhage, Oosterman, & Schuengel, 2013). Furthermore, mothers who frequently experience an inability to soothe their crying infants often report more severe postpartum depressive symptoms (Radesky et al., 2013). These results emphasize the need for individualized support according to the temperament of the infant.

Our study had several limitations. First, the MIBS, EPDS, and CES-D utilized in this study are all self-reporting measures. While these measures are widely used and have been validated, self-report methods might not fully capture the nuances and complexities of mental health. Future research should integrate clinical interviews to provide a more comprehensive assessment of mothers' mental health. Second, our study lacked a control group or an examination of other populations. Our sample predominantly comprised married and well-educated Japanese women, which may constrain the broader applicability of our findings, as cultural variations might influence parenting norms and associated feelings of guilt (Rotkirch & Janhunen, 2010). Additionally, due to sample size and power issues, we were unable to conduct a moderation analysis to split the sample in this study. In the future, it would be significant to examine whether the association between mother-to-infant bonding and postpartum depressive symptoms is moderated for groups with depressive symptom severity, marital status, and parity in a larger sample size. Third, in this study, the three-item checklist used to assess infant difficult temperament has not been confirmed for reliability and validity, lacking the extensive item range found in standardized tools. Consequently, it is not guaranteed to fully encapsulate the multifaceted nature of infant temperament. Future research is encouraged to utilize tools for a more valid and comprehensive evaluation of infant temperament. Finally, our study focused exclusively on the mother-to-infant dyad and neglected the potential influence of other family members. Future research should investigate the dynamics of these relationships within the broader family context.

This study applied the RI-CLPM to mother-to-infant bonding and postpartum depressive symptoms, key postnatal mental health concerns. We found that deterioration in mother-to-infant bonding was significantly predictive of subsequent increases in postpartum depressive symptoms. Specifically, feelings of anger/rejection emerged as significant predictors. However, the effects of postpartum depressive symptoms on mother-to-infant bonding were not statistically significant. This underscores that their interactions are not reciprocal, shedding light on facets that differ from inter-individual perspectives. These findings have profound implications for practical interventions. Interventions targeting mother-to-infant bonding may improve subsequent mother-to-infant bonding and postpartum depressive symptoms. Focusing on intra-individual dynamics makes it plausible that interventions aimed at improving mother-to-infant bonding, particularly reducing feelings of anger/rejection toward the child, might alleviate postpartum depressive symptoms. For example, given that reappraisal techniques and mindfulness interventions have been shown to be effective in reducing anger (Szasz, Szentagotai, & Hofmann, 2011; Wright, Day, & Howells, 2009), their use postnatally could potentially enhance mother-to-infant bonding, thereby preventing escalation of postpartum depressive symptoms. In light of existing research demonstrating a significant link between prenatal and postnatal bonding experiences (Tichelman et al., 2019), interventions for pregnant women regarding feelings of bonding with their fetus may also be effective. In addition, our research has demonstrated that prenatal depressive symptoms and difficult child temperament contribute to pronounced fluctuations in both mother-to-infant bonding and postpartum depressive symptoms. Recent research has highlighted that mood unpredictability and instability during the perinatal period have a negative impact on child development (Glynn et al., 2018; Ugarte & Hastings, 2023). Therefore, interventions tailored to prenatal depressive symptoms and infant temperament that may precede mood instability may promote postpartum emotional stability and benefit both mother and child; future empirical studies are warranted.

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

Data availability. The R code and Rmarkdown files used for data analysis and manuscript preparation are shared in the Open Science Framework (https://osf.io/7pu8r/?view_only=444ad74e63574341a15f1041ac5efeef). The raw data were part of an ongoing large longitudinal study and are available upon request from the corresponding author.

Notes

[1] Because of an error in the questionnaire setup, only 18 of the 20 items of the CES-D were used. To rectify this, the full 20-item CES-D was administered to the same sample 18 months postpartum. The correlation between the total scores of the 20 items and 18 items was very high ($r = 0.98$, $p < 0.001$), suggesting that the 18-item version was an adequate reflection of depressive symptoms. Consequently, we decided to proceed with the analyses using the 18-item version.

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