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Research paper

Early mother-infant interactions within the context of childbirth-related posttraumatic stress symptoms

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ABSTRACT

Background: Childbirth may lead to perinatal mental health issues, such as childbirth-related posttraumatic stress symptoms (CB-PTSS), depression, and anxiety. Despite well explored mother-infant interactions in the context of maternal depression and anxiety, only limited studies investigated mother-infant interactions in the context of CB-PTSS, which is the aim of the present study.

Methods: One-hundred mother-infant dyads in the French speaking part of Switzerland were classified into three groups: birth-related symptoms (BRS, i.e., symptoms of re-experiencing and avoidance) (n = 20), general symptoms (GS, i.e., symptoms of negative cognition and mood and hyperarousal) (n = 46), and non-symptomatic (NS) (n = 34) based on maternal report on PTSD Checklist for DSM-5 (PCL-5). At six months postpartum, mother-infant interactions were video-recorded and their quality was assessed using the Global Rating Scale. Data was analyzed using ordinal logistic and negative binomial regressions.

Results: In the adjusted model, mothers in BRS group engaged in more frequent coercions compared to the NS group ($B = -1.46$, $p = 0.01$, 95%CI = −2.63, −0.36) and showed lower reciprocity in their interactions with their infants compared to the GS group (B = 1.21, $p = 0.03$, 95%CI = 0.05, 2.37).

Limitations: The use of a cross-sectional design limited the exploration of how consistent these findings are regarding mother-infant interactions between groups over time.

Conclusions: Mothers with higher BRS may need support to improve interactions with their infants. Future studies should consider longitudinal design to observe mother-infant interaction changes between CB-PTSS groups over time.

1. Introduction

Maternal mental health problems, including maternal childbirth-related posttraumatic stress symptoms (CB-PTSS), can affect the way mothers interact with their infants (Golds et al., 2022; Ionio and Di Blasio, 2014). Maternal CB-PTSS refers to PTSS experienced by mothers following childbirth that disrupt daily activities but do not meet the diagnostic criteria for PTSD based on the Diagnostic and Statistical Manual of Mental Disorders, 5th edition (DSM-5) (American Psychiatric Association, 2022; Horsch et al., 2024). According to DSM-5, as in PTSD, CB-PTSS can be classified into four symptom clusters: re-experiencing (e.g., repeated, disturbing, and unwanted memories of traumatic childbirth), avoidance (e.g., avoiding memories, thoughts, or feelings related to the traumatic childbirth), negative cognition and mood (e.g., feeling distant from other people), and hyperarousal symptoms (e.g., feeling jumpy or easily startled) (American Psychiatric Association, 2022; Horesh et al., 2021). These four symptom clusters can be classified into two factors: birth-related symptoms (BRS, i.e., re-experiencing and avoidance symptoms) and general symptoms (GS, i.e., negative cognition and mood and hyperarousal symptoms) based on previous studies

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using exploratory factor analysis (Ayers et al., 2018; Sandoz et al., 2022). It is conceivable that various facets of PTSS may associate differently with various aspects of the mother-infant relationship. GS were associated with less bonding, whereas BRS were not (Nakić Radoš et al., 2020). Nevertheless, the two factors of CB-PTSS have not been explored in the context of mother-infant interactions – something our study will address.

Good-quality mother-infant interactions are characterized by positive affect as well as engaging dyadic exchanges that have been consistently associated with enhanced cognitive outcomes in infants (Copeland et al., 2022). Moreover, maternal sensitivity also plays an important role in the interactions (Milgrom et al., 2004). Maternal sensitivity denotes a mother's capacity to comprehend her infant's cues and to respond to them in a timely way, adjusting her actions accordingly, thus providing external support for the infant's emotional regulation and social exchanges (Ainsworth et al., 1979; Baker and McGrath, 2011; Feldman, 2012; Jaffe et al., 2001; Rattaz et al., 2022). When mothers lack sensitivity, interactions between mothers and their children are disruptive, leading to problems with child emotion regulation and lower socioemotional development, such as behavior problems and poor social competences at 36 months of age (Leerkes et al., 2009).

Despite the prevalence of maternal CB-PTSS of 12.3 % reported by a recent meta-analysis summarizing data from studies worldwide (Heyne et al., 2022), research on mother-infant interactions within the context of maternal CB-PTSS is still limited with mixed results. A recent meta-analysis focused on the associations between maternal CB-PTSS and mother-infant relationships found that more severe maternal CB-PTSS were associated with poorer quality of mother-infant relationships (Frankham et al., 2023). However, this study mixed together data on the quality of mother-infant bonding and mother-infant interactions (Frankham et al., 2023). Frankham et al. (2023) only included one study that specifically investigated mother-infant interactions, which found that higher maternal CB-PTSS was associated with lower sensitivity during interactions with their children and mothers being less effective at structuring social interaction at six months postpartum (Feeley et al., 2011).

To further understand the impact of maternal CB-PTSS on mother-infant interactions, researchers have utilized the still-face stress paradigm. The still-face stress paradigm is an experimental approach to assess the infant's reactions to socio-emotional stress that consists of three phases: (1) an initial episode of a normal interaction serving as a baseline, (2) the 'still-face' episode where the mother becomes unresponsive and maintains a neutral facial expression, and (3) a reunion phase where normal interaction is resumed (Tronick et al., 1978). During the still-face stress paradigm (Tronick et al., 1978) mothers with higher CB-PTSS displayed more avoidance (e.g., did not look directly at their infants during play and reunion in still-face paradigm) and more intrusive behavior (e.g., touching or making noise to catch the infant's attention) to their three months old infants (Ionio and Di Blasio, 2014). Their infants showed more crying and disorganized behaviors during the free-play and avoidance or looking away in the still-phase compared to dyads with less CB-PTSS (Ionio and Di Blasio, 2014).

However, another study found no correlations between maternal CB-PTSS and quality of mother-infant interactions at three months postpartum (Parfitt et al., 2013). Differences in populations, sample sizes, and measurement instruments among these three studies could contribute to different findings (Feeley et al., 2011; Ionio and Di Blasio, 2014; Parfitt et al., 2013). Therefore, associations between maternal CB-PTSS and quality of mother-infant relationships need further exploration.

The purpose of this study was to investigate differences in the quality of mother-infant interactions in the context of different symptom clusters of maternal CB-PTSS. We hypothesized that mother-infant interactions would be different between groups. However, we did not specify the direction of the hypothesis because our study is among the first to investigate the two factors of CB-PTSS (i.e., BRS, GS), and we do not have sufficient existing knowledge to confidently establish a directional hypothesis.

2. Methods

2.1. Participants

To determine the differences in mother-infant interactions between groups in the context of CB-PTSS, we classified participants into three groups: BRS, GS, and non-symptomatic (NS) based on maternal report on PTSD Checklist for DSM-5 (PCL-5) (see below in the instruments section for more detail). Medium-to-large effects were expected based on a previous study (Feeley et al., 2011). A total sample of 75 dyads would be sufficient to detect a significant effect of 2 = 11.8 % with a power of 80 %, while a total sample of 90 dyads would permit to detect effects larger than 10 %.

The present study consisted of two phases. In phase 1 (retrospective), we utilized data from the control group (n = 38) of a randomized controlled trial on the prevention of CB-PTSD following emergency cesarean section (NCT 03576586) (Deforges et al., 2023; Sandoz et al., 2019). Phase 2 was conducted to achieve the required total sample size and included a broader range of participants for language and mode of childbirth. Phase 2 inclusion criteria were mothers speaking French or English with term (gestational weeks ≥37) healthy infants, who gave written consent. Exclusion criteria were insufficient French or English language skills to participate, current psychotic illness, intellectual disability, severe illness of mothers or infants, alcohol abuse or illegal drug use during pregnancy. In the end, we collected n = 62 in phase 2, which altogether makes a total sample size of n = 100 mother-infant dyads.

2.2. Procedure

In phase 1, women were recruited when they underwent emergency cesarean section at a Swiss University Hospital from to July 2018 to July 2022. The procedure detailed below only concerned phase 2, for a detailed explanation of the procedure in phase 1, please refer to the study protocol (Sandoz et al., 2019). Nevertheless, both phases followed a similar procedure for data collection. The local ethics committee approved the studies for phases 1 (2017–02142) and 2 (2022–00716).

In phase 2, recruitment and data collection took place between August 2022 and September 2023. We distributed advertisements seeking participants in the development unit at a French-speaking Swiss University Hospital, day cares, clinics of gynecologists, and pediatricians. Additionally, we posted advertisement online on the Swiss University Hospital website and on social media platforms (Instagram, Facebook, LinkedIn) allowing us to reach more people.

Eligible participants received further explanations about the research, including the purpose of the study, procedures, risks and benefits, and approximate duration of the study. They were informed that the participation in the study was entirely voluntary. Further, once they agreed to participate, they were required to sign a written informed consent. All mother-infant dyads with infants approximately up to six months old were eligible for recruitment. Data collection was scheduled for when the infants were approximately six months old.

We asked participants to complete maternal self-report questionnaires online using the Research Electronic Data Capture (REDCap) (Harris et al., 2009). About one week later, mothers and infants were invited to the University Hospital to film the interactions. The session took place in a single room equipped with two moveable cameras mounted on opposite walls. Mothers were instructed to play with their infants as they would at home using a standardized set of toys provided by the researchers without any restriction on movements aside from not blocking the cameras. All mother-infant dyads used the same set of toys. Free-play sessions were recorded for 15 min. In cases where participants (n = 47) could not come to the hospital due to scheduling conflicts or

Table 1
Participant characteristics and significance tests for comparison between CB-PTSS groups ($n = 100$).

Variables	NS (n = 34)	BRS (n = 20)	GS (n = 46)	*P* value
Mothers (n = 100)				
Maternal age (years) – mean (S·D)	34.41 (4.42)	32.30 (4.54)	33.52 (3.79)	0.34[a]
Nationality N (%)				
Swiss	24 (70.59)	11 (55)	28 (60.87)	0.635[b]
European	8 (23.53)	7 (35)	13 (28.26)	
Non-European	2 (5.88)	1 (5)	4 (8.70)	
Missing values		1 (5)	1 (2.7)	
Relationship status N (%)				
Single	4 (11.76)	2 (10)	9 (19.57)	0.45[b]
Married / cohabitating	29 (85.29)	16 (80)	35 (76.09)	
Separated / divorced		1 (5)		
Other	1 (2.94)		1 (2.17)	
Missing values		1 (5)	1 (2.17)	
Education N (%)				
Secondary education	1 (2.94)			0.68[b]
Higher secondary education	2 (5.88)			
Apprenticeship	5 (14.71)	5 (25)	9 (19.57)	
University or university of applied sciences	25 (73.53)	14 (70)	34 (73.91)	
Other	1 (2.94)		2 (4.35)	
Missing values		1 (5)	1 (2.17)	
Parity N (%)				0.71[b]
Primipara	20 (58.82)	14 (70)	29 (63.04)	
Multipara	14 (41.18)	6 (30)	17 (36.96)	
Mode of childbirth N (%)				0.87[b]
Vaginal birth	15 (44.12)	10 (50)	21 (45.65)	
Planned cesarean section	1 (2.94)		1 (2.17)	
Vacuum-assisted vaginal	1 (2.94)	2 (10)	2 (4.35)	
Forceps delivery	1 (2.94)			
Emergency cesarean section	16 (47.06)	8 (40)	22 (47.83)	
History of past trauma N (%)				0.01*[b]
Yes	4 (11.76)	9 (45)	16 (34.78)	
No	30 (88.24)	10 (50)	29 (63.04)	
Missing values		1 (5)	1 (2.17)	
Maternal depression symptoms - median (IQR)	3.50 (3.75)	7 (3.75)	7.50 (8.50)	0.01*[a]
Maternal anxiety symptoms - median (IQR)	3 (3)	5 (2.50)	7 (3.75)	0.01*[a]
Maternal CB-PTSS - median (IQR)	2 (2.75)	10.50 (5)	11 (11)	0.01*[a]
Infants (n = 100)				
Sex of the infant N (%)				
Girls	18 (52.94)	12 (60)	21 (45.65)	0.54[b]
Boys	16 (47.06)	8 (40)	25 (54.35)	
Gestational weeks - median (IQR)	40 (2)	40.35 (1.10)	40 (1.5)	0.01*[a]
Birthweight (gram) - mean (S·D)	3316 (433)	3358 (592)	3369 (485)	0.86 [a]
APGAR at 5 min - median (IQR)	10 (1)	9 (1)	9 (1)	0.01*[a]

Note: Non-symptomatic (NS), Birth-Related Symptoms (BRS), General Symptoms (GS). Please note some variables are presented as median and Interquartile Range (IQR) because the data were not normally distributed.
[a] Kruskal-Wallis test.
[b] Chi-square test.

transportation difficulties, appointments were scheduled at their homes. The same procedure was followed during these home visits, with the same set of toys but only one camera was used. Please see supplementary file Table 2 for more details on the distribution of data collected at home and in the hospital across CB-PTSS groups. Table 3 of supplementary file differentiates home and hospital in terms of mother-infant interactions.

2.3. Instruments

Sociodemographic and obstetrical data were collected through maternal self-report questionnaire, as reported in Table 1.

2.3.1. Maternal CB-PTSS

PTSD Checklist for DSM-5 (PCL-5) is a 20-item self-report questionnaire assessing PTSD over the past month (Weathers et al., 2013). The traumatic event in the questionnaire was named as "traumatic childbirth". Participants responded using a Likert scale from 0 (not at all) to 4 (extremely), with a higher score indicating symptoms (Weathers et al., 2013). The French version of the PCL-5 showed strong validity (Ashbaugh et al., 2016). In our study, Cronbach's alpha for PCL-5 was 0.89, indicating a strong internal consistency.

Symptoms are counted when they are present as a score of two or higher (American Psychiatric Association, 2022). Based on participants' responses to the PCL-5, they were divided into three groups (NS, BRS, GS). Dyads were assigned to the BRS group if the mother scored two or higher on any of the BRS-related items (items 1 through 8 and 10 to 11). Conversely, if her score was two or higher on any of the GS-related items (items 9 and 12 through 20), the dyad was placed in the GS group. If none of the items scored two or higher, the dyad was classified into the NS group. In cases where mothers' total scores for both BRS and GS were equal, we prioritized assigning her and her infant to the BRS group. This was based on studies demonstrating that re-experiencing symptoms (BRS) were linked to less positive infant outcomes, specifically in motor development (Garthus-Niegel et al., 2017). Moreover, re-experiencing symptoms are considered as core features of CB-PTSS (Deforges et al., 2023; Iyadurai et al., 2019).

2.3.2. Mother-infant interactions

The Global Rating Scale (GRS), a parent-child interaction coding scheme (Murray and Karpf, 2000), was used to code three minutes (from

Table 2
Descriptive data of Global Rating Scale.

	Total (n = 100) – Median (IQR)	NS (n = 34) – Median (IQR)	BRS (n = 20) – Median (IQR)	GS (n = 46) – Median (IQR)
Infant emotional tone[1]	4 (1)	3.5 (1)	3 (1)	4 (1)
Infant self-regulation[1]	5 (1)	4.5 (1)	5 (1)	5 (1)
Maternal emotional tone[1]	4 (1)	4 (1)	4 (0.25)	4 (1)
Maternal positive expressed emotion[2]	0 (1)	0 (1)	0 (1)	0 (2)
Maternal coercions[2]	0 (1)	0 (1)	0 (1)	0 (1)
Maternal sensitivity[1]	4 (2)	3.5 (2)	3.5 (2.25)	4 (2)
General atmosphere[1]	4 (1)	4 (2)	4 (2)	4 (1)
Reciprocity[1]	4 (1)	4 (0.75)	4 (1)	5 (1)

Note: Non-symptomatic (NS), Birth-Related Symptoms (BRS), General Symptoms (GS). Please note results are presented as median and IQR because the data were not normally distributed.
[1] Range from 1 to 5.
[2] Event count.

Table 3
Comparison of GRS between groups – unadjusted model (ordinal logistic regression and negative binomial regression).

	NS (n = 34)		BRS (n = 20)	GS (n = 46)	
	Coefficient	P value (95%CI)	Reference group	Coefficient	P value (95%CI)
Infant emotional tone[1]	0.01	0.97 (−1.02, 1.04)	Ref	0.72	0.15 (−0.26, 1.70)
Infant self-regulation[1]	−0.45	0.41 (−1.54, 0.63)	Ref	−0.17	0.73 (−1.21, 0.85)
Maternal emotional tone[1]	0.11	0.83 (−0.93, 1.15)	Ref	0.51	0.31 (−0.47, 1.50)
Maternal positive expressed emotion[2]	0.45	0.37 (−0,55, 1.46)	Ref	0.52	0.27 (−0.43, 1.48)
Maternal coercions[2]	−0.33	0.50 (−1.33, 0. 64)	Ref	−0.25	0.59 (−1.18, 0.67)
Maternal sensitivity[1]	0.25	0.62 (−0.77, 1.28)	Ref	0.65	0.18 (−0.31, 1.61)
General atmosphere[1]	−0.02	0.96 (−1.06, 1.02)	Ref	0.29	0.55 (−0.68, 1.28)
Reciprocity[1]	0.01	0.97 (−1.00, 1.03)	Ref	0.79	0.12 (−0.20, 1.80)

Note: Non-symptomatic (NS), Birth-Related Symptoms (BRS), General Symptoms (GS).
[1] Ordinal logistic regression.
[2] Negative binomial regression.

minute three to six) out of 15 minutes video-taped mother-infant interactions and assess its quality. We utilized a three-minute duration for coding the interactions, consistent with the methodology of previous studies (Parfitt et al., 2013; Salih et al., 2023). Beginning the coding at minute three of the interaction session was deliberate as it allowed us to exclude the initial warm-up period. Interactions were coded by three reliable coders who previously got trained and completed the reliability test, with interrater reliabilities ≥0.79 for all the subscales of GRS. This coding scheme had been used by several studies looking into mother-infant interactions in various clinical conditions (Cooper et al., 2009; Ionio et al., 2022; Neri et al., 2015; Seager et al., 2018).

The standardized and validated coding scheme includes nine subscales which assess infant behaviors (two scales), maternal behaviors (five scales), and joint behaviors (two scales). Infant subscales include emotional tone and self-regulation. Emotional tone of infants refers to how content the infant is during interactions, while self-regulation measures how well infants regulate their emotional and physical responses to certain events during the interactions (Murray and Karpf, 2000).

Maternal subscales include positive and negative expressed emotions, maternal coercions or intrusions, maternal emotional tone, and sensitivity (Murray and Karpf, 2000). Maternal expressed emotions are comments from the mothers that could be positive, affectionate, complimentary, or negative and critical, directed at the infant. To score these maternal expressed emotions, we needed to transcribe and translate the interactions into French or English. Maternal coercions or intrusive behavior refers to forceful positioning or guidance that cut across or disrupt the infant's activity. Maternal emotional tone pertains to the level of contentment displayed during interaction. Maternal sensitivity refers to how attuned the mother is to the infant's signals.

Joint subscales include general atmosphere and reciprocity during play. Reciprocity assesses whether there is turn-taking and sharing attention during interactions. General atmosphere refers to whether the mother and infant's overall contact is pleasant or disharmonious (discordant and conflictual). In total, we had nine subscales to assess mother-infant interactions. All subscales were coded on a 5-point rating scale, with higher scores indicating better outcomes (e.g., more sensitive, more self-regulated), except for positive and negative expressed emotions, and maternal coercions, which were measured as event counts. In the analysis, each subscale was analyzed separately.

2.3.3. *Maternal mental health*

Maternal depression and anxiety symptoms were measured as potential covariates as studies had shown these to be often comorbid with CB-PTSS (Milgrom et al., 2004; Parfitt et al., 2013; Rousseau et al., 2023). Maternal depression symptoms were measured with the Edinburgh Postnatal Depression Scale (EPDS), a self-report questionnaire evaluating the severity of postnatal depression symptoms over the past week (Cox et al., 1987). The 10 items are scored on a 4-point Likert scale from 0 to 3, with a higher total score indicating higher severity. The French version of the EPDS has been validated (Guedeney and Fermanian, 1998). In our study, Cronbach's alpha for EDPS was 0.85, indicating a strong internal consistency.

Anxiety symptoms were measured with the anxiety subscale of the Hospital Anxiety and Depression Scale (HADS-A). This self-report questionnaire consists of 7 items evaluating the severity of postnatal anxiety symptoms over the past week (Zigmond and Snaith, 1983). Items are scored on a 4-point Likert scale from 0 to 3, with a higher total score indicating higher severity. The French version of the HADS, has been previously validated (Bocéréan and Dupret, 2014). In our study, Cronbach's alpha for HADS-A was 0.77, indicating a moderate level of internal consistency.

2.4. *Statistical analyses*

The statistical analyses were conducted with the software R, version 4.1.3 (R Core Team, 2021). A normality check was done for each variable with Shapiro-Wilk test. Normal distributed data (maternal age,

Table 4
Comparison of GRS between groups – adjusted model (ordinal logistic regression and negative binomial regression).

	NS (n = 34)		BRS (n = 20)	GS (n = 46)	
	Coefficient	P-value (CI)	Reference group	Coefficient	P-value (CI)
Infant emotional tone[1]	0.70	0.27 (−1.26, 0.97)	Ref	0.84	0.12 (−1.92, 0.22)
Infant self-regulation[1]	−0.31	0.65 (−1.67, 1.05)	Ref	−0.12	0.84 (−1.29, 1.05)
Maternal emotional tone[1]	0.44	0.51 (−0.86, 1.74)	Ref	0.47	0.41 (−0.64, 1.59)
Maternal positive expressed emotion[2]	0.35	0.52 (−0.75, 1.48)	Ref	0.08	0.86 (−0.93, 1.12)
Maternal coercions[2]	−1.46	0.01 (−2.63, −0.36)*	Ref	−0.30	0.48 (−1.14, 0.55)
Maternal sensitivity[1]	0.49	0.44 (−0.77, 1.76)	Ref	0.48	0.38 (−0.60, 1.56)
General atmosphere[1]	0.50	0.45 (−0.80, 1.80)	Ref	0.46	0.41 (−0.64, 1.57)
Reciprocity[1]	0.63	0.33 (−0.65, 1.92)	Ref	1.21	0.03 (0.05, 2.37)*

Note: Non-symptomatic (NS), Birth-Related Symptoms (BRS), General Symptoms (GS). Adjusted for total score of CB-PTSS, maternal depression and anxiety symptoms, past trauma, APGAR, gestational weeks.
[1] Ordinal logistic regression.
[2] Negative binomial regression.

infants' birthweight) is presented in mean and standard deviation (SD), while data with non-normal distribution (PCL-5, HADS-A, EPDS, APGAR, gestational week) is presented in median and interquartile (IQR) in Table 1. CB-PTSS group differences in sociodemographic and obstetrical data were examined with Kruskal Wallis (for continuous variables) or Chi-Square (for categorical variables) tests, as indicated in Table 1.

Table 2 shows the descriptive data of mother-infant interactions at six months postpartum. Results from the main analysis are presented in Table 3 and Table 4. For the main analysis, since the data on GRS subscales were not normally distributed, ordinal logistic regression was applied to investigate group differences of six subscales of the GRS with Likert scales (i.e., infant emotional tone, infant self-regulation, mother emotional tone, maternal sensitivity, atmosphere of the interactions, and reciprocity). Group differences for maternal positive/negative expressed emotion and maternal coercions were analyzed using negative binomial regression because they were calculated as event counts, unlike other GRS subscales, which were rated on a Likert scale. None of the mothers expressed negative emotion, thus, this maternal subscale of the GRS was excluded from the analysis.

The BRS group was chosen as the reference group for ordinal logistic and negative binomial regression analysis because our study focus on CB-PTSS and their impact on mother-infant interactions. *Re*-experiencing symptoms, which are integral to the birth-related symptoms group, represent core features of CB-PTSS (Iyadurai et al., 2019). These symptoms are recognized as potential drivers of other PTSS such as hypervigilance, negative mood, and impaired concentration (Deforges et al., 2023; Iyadurai et al., 2019). Therefore, using the BRS group as the reference facilitates a direct and detailed examination of how the presence or absence of BRS influences mother-infant interactions, in comparison to NS and GS groups.

There were no missing values in the main variables, except for maternal positive expressed emotion, where data from two participants were missing because researchers were unable to recognize the language used. This occurred because mothers were instructed to interact naturally as they would at home with their infants, sometimes resulting in the use of their native languages. Missing sociodemographic and obstetrical data is shown in Table 1. Since the percentage of the missing data was small (<3 %), a listwise or case deletion approach was applied, where we did not include the missing values in the analysis (Kang, 2013). Moreover, for maternal negative expressed emotion, the score was zero for all mothers; thus, we did not present it in Table 2 and did not include it in further analysis.

3. Results

3.1. Descriptive statistics

A total of 100 mother-infant dyads participated. Among these, 34 dyads were in NS group, 20 in BRS group, and 46 in GS group. In total, the mean age of participants was 33.58 years (SD = 4.19). Overall, 63 % (n = 63) of mothers were Swiss and 80 % (n = 80) were married, cohabitated, or were in a relationship. The majority of mothers (73 %, n = 73) had received a university education, and were primipara (63 %, n = 63). The number of mothers who had a vaginal birth or underwent unplanned cesarean section were the same (46 %, n = 46). There were 51 female (51 %) and 49 male (49 %) infants. Further details on participant demographic information for each group is presented in Table 1. For comparison based on phases of data collection, please see Table 1 of the supplementary file.

We also examined the differences between groups in terms of sociodemographic, obstetrical, and maternal mental health data using Kruskal Wallis (for continuous variables) or Chi-Square (for categorical variables) tests. We found six variables (history of past trauma, EPDS, HADS-A, PCL-5, gestational weeks, APGAR score) were significantly different ($p < 0.05$), as shown in Table 1. Moreover, a higher proportion of mothers in BRS group had a history of past trauma compared to the GS and NS groups. Mothers in the GS group had higher EPDS, HADS-A, and PCL-5 compared to those in the BRS and NS groups. Table 2 provides a comprehensive overview of scores across various subscales of the GRS, including median values and interquartile ranges (IQR) in general and for each group (NS, BRS, GS).

3.2. Differences of mother-infant interactions between groups

We employed negative binomial regressions to analyze maternal positive expressed emotion and maternal coercions, as they were measured as event counts. Additionally, ordinal logistic regression analysis was conducted for assessing variables measured on a Likert scale, including maternal emotional tone, maternal sensitivity, infant emotional tone, infant self-regulation, general atmosphere, and reciprocity. The unadjusted model of negative binomial and ordinal logistic regression analysis indicated no significant group differences in any of the GRS subscales ($p > 0.05$) during free-play mother-infant interactions, as presented in Table 3.

As some of the sociodemographic, obstetrical, and maternal health data (see Table 1) showed significant differences between groups, we added these six variables in the adjusted model. In Table 4, the adjusted model showed that the BRS group had significantly more frequent maternal coercions compared to the NS group ($B = -1.46, p = 0.01$, 95% CI = −2.63, −0.36) and showed lower reciprocity in their interactions with their infants compared to the GS group ($B = 1.21, p = 0.03$, 95%CI = 0.05, 2.37). In terms of maternal coercions, dyads in the NS group had a substantially lower incidence rate compared to the BRS group (IRR = 0.23). Regarding reciprocity, the odds ratio (OR = 3.38) indicates that dyads in the GS group had approximately 3.38 times higher odds of having higher reciprocity compared to the BRS group, which served as the reference. Finally, we conducted a sensitivity analysis to test

whether the phase of the recruitment influenced the results (please see supplementary file Table 4 and Table 5). For each regression, we included interaction terms for the two phases to assess whether the association between CB-PTSS groups and the dependent variables (mother-infant interactions) varied across phases. All interactions were statistically nonsignificant, except for the dependent variable 'positive expressed emotion' in the adjusted model. However, the model including the interaction term did not show significantly better fit compared to the model without it. Therefore, we conclude that there is no evidence supporting a different effect across the two phases.

4. Discussion

The objective of this study was to explore the differences of mother-infant interactions between groups based on different maternal CB-PTSS clusters (BRS, GS, and NS) at six months postpartum. Our study demonstrates that mother-infant interactions (infant emotional tone, infant self-regulation, maternal emotional tone, maternal expressed emotion, maternal coercions, maternal sensitivity, general atmosphere, and reciprocity) at six months postpartum did not differ significantly between groups of maternal CB-PTSS. However, after adjusting for covariates, we found that mothers in the BRS group engaged in more frequent coercions compared to the NS group and showed lower reciprocity in interactions with their infants compared to the GS group.

Our finding regarding the maternal coercions / intrusive behavior is in line with a study by Ionio and Di Blasio (2014) who also found that mothers with more CB-PTSS were more intrusive during their interactions with their infants. They suggested that mothers with more symptoms were feeling more anxious and insecure when the attentions of the infants were not on them, thus mothers touched their infants more and made more noise to re-focus their infant's attentions onto them (Ionio and Di Blasio, 2014). Despite similar findings, there were differences in our study and the study by Ionio and Di Blasio (2014). They used a still-face stress paradigm at three months, while our study used a free-play (normal social interaction) paradigm at six months. Moreover, we used a different instrument to code the interactions. In our coding, not all maternal touch was counted as coercions. Maternal behaviors were only rated as coercive when they interrupted infant activities. Finally, Ionio and Di Blasio (2014) did not distinguish between BRS and GS. Our study clearly indicates that the BRS are particularly related to maternal coercive behaviors.

In addition, our findings suggest higher levels of reciprocity during mother-infant interactions in the GS group compared to the BRS group. This indicates that increased symptoms related to re-experiencing and avoidance in mothers are associated with less reciprocity during interactions, in contrast to those experiencing more symptoms related to negative cognition and hyperarousal. This could imply that mothers affected by re-experiencing symptoms might be distracted, potentially resulting in reduced attentiveness to their child's signals. Similarly it could be suggested that mothers with more avoidance symptoms may not be able to pay full attention to their infant during the interaction and thus miss some important cues their infant sends. Indeed, Ionio and Di Blasio (2014) reported that mothers with high CB-PTSS scores did not directly look at their infants' faces during play and reunion sessions during a still-face paradigm and that their infants tended to look away during still-episode that might contribute to less reciprocity during interactions. Nevertheless, these were two different paradigms (free-play and still-face), and future research is thus needed to confirm our findings.

In contrast to a study by Feeley et al. (2011), we did not find differences in maternal sensitivity between groups. Different study samples might contribute to this different finding, as in Feeley et al. (2011) the participants were mother-infant dyads whose infants had been hospitalized in the NICU. Moreover, Feeley et al. (2011) did not control for maternal depression and anxiety that were comorbid with maternal CB-PTSS (Horsch et al., 2024). Nevertheless, Rousseau et al. (2023) also found that more severe and persistent CB-PTSS were related to lower maternal sensitivity. Although Rousseau et al. (2023) controlled for maternal depression and anxiety, their infants were younger (four months old) than ours which might explain our different results. It is reasonable to assume that interactions occurred closer to the event of birth, when traumatic, may result in maternal CB-PTSS more strongly associated with less sensitivity during interactions.

In examining other outcomes across CB-PTSS groups in the adjusted models, such as infant emotional tone, infant self-regulation, maternal emotional tone, maternal expressed emotion, and general atmosphere, no statistically significant differences were observed. These non-significant findings align with the study by Parfitt et al. (2013), although they used the sum score of CB-PTSS as did others (Feeley et al., 2011; Ionio and Di Blasio, 2014; Muller-Nix et al., 2004) rather than grouping based on symptom factors as we did. It is important to note that comparisons with previous studies (Feeley et al., 2011; Ionio and Di Blasio, 2014; Muller-Nix et al., 2004) are challenging due to the utilization of differing measurement tools such as the Emotional Availability Scale and Care Index, which have different subscales and measures different aspects of the interactions (Biringen et al., 2000; Crittenden, 2004), except for maternal coercion and sensitivity that are mentioned in all the instruments. Therefore, while our findings contribute to the understanding of mother-infant interaction in the context of maternal CB-PTSS, caution is warranted when contextualizing them alongside prior research using different methodologies and measures.

One of the innovative aspects of this study is that we grouped dyads based on their symptom classifications (i.e., NS, BRS, and GS) instead of using the total score calculation or classification based on certain cut-off points as in previous studies (Feeley et al., 2011; Ionio and Di Blasio, 2014; Muller-Nix et al., 2004; Parfitt et al., 2013). This provides a new insight on the quality of mother-infant interactions in terms of symptom clusters. However, potential bias may arise in dyads classification for mothers with equal BRS and GS total scores when assigning them to the BRS group, as this has not been thoroughly investigated in previous research. Our decision was informed by studies indicating that BRS, particularly re-experiencing symptoms, serve as core features of CB-PTSS (Iyadurai et al., 2019) that trigger other symptoms (Deforges et al., 2023; Iyadurai et al., 2019) and have been associated with less positive infant outcomes (Garthus-Niegel et al., 2017). Nevertheless, the additional analysis, where we did not include dyads with mothers who had equal BRS and GS total scores, showed the same conclusion as the analysis with the inclusion of these participants (please see supplementary Table 4 and Table 5).

Moreover, our study included a larger sample size compared to previous studies on mother-infant interactions in the context of CB-PTSS (Feeley et al., 2011; Ionio and Di Blasio, 2014). However, this study has some limitations. We found no significant results in the unadjusted models. In adjusted models, where several covariates were included without adjustment for multiple testing, significant findings were found in two subscales (i.e., maternal coercive behaviors and reciprocity) out of eight subscales of mother-infant interactions. Given the exploratory nature of this study, we did not conduct statistical adjustment (García-Pérez, 2023; Rubin, 2021). Therefore, the results should be interpreted cautiously as the significance of these findings may be influenced by not accounting for covariates in the power analysis.

Aside from that, we did not extensively measure maternal prenatal mental health, which might influence the results, as prenatal anxiety symptoms might be associated with quality of mother-infant interactions (Parfitt et al., 2013). Furthermore, we did not assess general PTSD symptoms (unrelated to childbirth) that could also affect parent-child relationships (Creech and Misca, 2017; Greene et al., 2018). Moreover, we did not take into account any measure of the co-parents. The use of a cross-sectional design limited the exploration of how consistent these findings are regarding mother-infant interactions between groups over time. Even though this design was sufficient for our study aim, it would be helpful if future studies could include

longitudinal studies to provide additional insights into the long-term implications of maternal CB-PTSS on mother-infant interactions, as one study suggested that the persistence of CB-PTSS across different timepoints is associated with mother-infant interactions (Rousseau et al., 2023). Furthermore, further studies should examine whether our findings can be replicated when the mother-infant interactions take place in a still-face stress paradigm to explore how interactions differ under stressful conditions versus non-stressful ones to provide a comprehensive understanding of how maternal behavior and infant responses vary across different caregiving contexts.

In conclusion, our results indicate that PTSS specifically related to childbirth are associated with a higher frequency of maternal coercions and lower reciprocity during interactions with their infants at six months postpartum compared to mothers exhibiting no symptoms or experiencing general PTSS. Interventions aimed at tackling birth-related symptoms should be prioritized (compared to general symptoms when the resources are limited) to improve their interactions with their infants, making them less coercive and fostering improved reciprocity. However, our results also suggest that mothers experiencing these symptoms might feel reassured, as other aspects of interactions (i.e., maternal sensitivity, emotional tone, infant self-regulation) did not differ significantly between mothers with and without symptoms. Therefore, mothers could improve their interactions with their infants without excessive concern about potentially putting their infants at risk due to the consequences of the CB-PTSS they experience.

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CRediT authorship contribution statement

Sella Devita: Writing – review & editing, Writing – original draft, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Laura Bozicevic:** Writing – review & editing, Investigation, Conceptualization. **Camille Deforges:** Writing – review & editing, Investigation. **Laura Ciavarella:** Writing – review & editing, Investigation. **Jean-François Tolsa:** Writing – review & editing, Supervision. **Vania Sandoz:** Writing – review & editing, Supervision, Methodology, Investigation, Conceptualization. **Antje Horsch:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Conceptualization.

Declaration of competing interest

The authors declared no potential conflicts of interest. Antje Horsch is on the management board of COST Action 22114.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jad.2024.08.025.

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