



Microsocial analysis of dyadic interactions with toddlers and mothers with borderline personality disorder

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Abstract

Borderline personality disorder (BPD) is known for disruptions in mother-child interaction, but possible underlying patterns of micro-behavior are barely understood. This is the first study examining behavioral dyadic synchrony—the coordinated and reciprocal adaptation of behavior—and regulation on a micro-level and relating it to macro-behavior in mothers with BPD and their toddlers. Twenty-five mothers with BPD and 29 healthy mothers participated with their 18- to 36-month-old toddlers in a frustration-inducing paradigm. Mother and toddler behavior was continuously micro-coded for gaze, affect, and vocalization. Synchrony, operationalized as the simultaneous engagement in social gaze and positive affect, and (co-) regulative behaviors and their contingencies were analyzed and associated with borderline symptom severity, the overall quality of interaction, and child internalizing and externalizing behavioral problems. Dyads with mothers with BPD showed significantly less synchrony compared to dyads with healthy mothers. Low synchrony was associated with high BPD symptom severity and low overall interaction quality. Dyads with BPD used the same amount of regulative behaviors as dyads with healthy mothers. Though both groups equally responded to children's negative emotionality, mothers with BPD were less effective in drawing the dyad back into synchrony. For dyads with BPD, regulative behaviors were negatively associated with child externalizing behaviors. BPD symptomology may reduce the effectiveness of mothers' attempts to attune to their child's needs. An emphasis on synchrony and regulative behaviors may be an important therapeutic target for parenting programs in mothers with BPD.

Keywords Maternal · Regulation · Synchrony · Contingencies · Non-verbal behavior

Introduction

Positive mother-child interactions play a central role in the quality of the mother-child relationship, child development, and the mother's experience of parenting (Feldman et al. 2011b). The dynamic, coordinated, and reciprocal adaptation of mother and child behaviors has been defined as

synchrony. Synchrony has often been operationalized by matched affective behaviors in gaze, vocal, and facial expression (Feldman and Eidelman 2007; Feldman et al. 2010). It supports predictability and familiarity between interacting partners, which is important for dyadic attachment and regulation (Bell 2020; Leclère et al. 2014). Self-regulation is one's ability to manage their emotions and behaviors in order to meet the demands of the situational context (Calkins, 2011). Higher mother-child synchrony has been related to better child self-regulation (Feldman et al., 1999; Hammer et al., 2019), whereas a lack of synchrony in parent-child interactions has been associated with prolonged dyadic disorganization and children's behavioral and temperamental difficulties (Leclère et al., 2014).

When parents and children attune to each other's signals and respond predictably, patterns are formed that lay the foundation for homeostatic rhythms that promote child self-regulation development (Feldman 2007). This is often operationalized as contingency (Harrist and Waugh 2002) or the

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temporally dependent sequence or pairing of behaviors (e.g., maternal autonomy support and child persistence) that occur during parent-child interaction (Harrist and Waugh, 2002). Similar to synchrony, contingency also supports the predictability and familiarity of dyadic exchange. However, instead of emphasizing the matching of parent and child affective, behavioral, or physiological states across time, contingency analyses focus on specific lead-lag relations or behavioral sequences that may be salient for child development (e.g., child angry outburst followed by maternal soothing).

The capacity to regulate affective, behavioral, and bio-physiological states, and recover from distress emerges early in life (Tronick and Beeghly 2011). It is the parent's primary responsibility to recognize, understand, and respond sensitively and contingently to the child's state (co-regulation) since the child's self-regulation ability is limited in infancy (Harrist and Waugh, 2002; Calkins, 2011). Maternal contingent responsiveness to their child has been associated with the child's attempts to elicit social responses from the mother (Mcquaid et al., 2009), suggesting that consistent maternal responses may lay the foundation for the child's need to develop and experience a reliable interaction with their caregivers. Furthermore, consistent parent responses to child behavior may be important for child self-regulation development (Brophy-Herb et al., 2011; Schueler and Prinz, 2013). Maternal sensitivity is associated with less frustration and anger but better regulative abilities in the child, while intrusive behavior and mental representations tinged with anger are associated with more anger and reduced regulative abilities in the child (Feldman et al., 2011a). Therefore, the parent should have the ability to regulate their own distress and to avoid a mutual transfer of distress (DiLorenzo et al., 2021). Difficulties in regulation have been associated with the child's risk of developing psychopathology and higher levels of child externalizing and internalizing problems (Compas et al. 2017).

Borderline personality disorder (BPD) is characterized by emotion dysregulation, instability in self, and interpersonal difficulties, and it has a prevalence of 1.7% in the general population (Gunderson et al., 2018). Symptoms also impact parenthood: mothers with BPD are more likely to engage in maladaptive interactions with their child involving less reciprocal dyadic behavior (Bonfig et al. 2022; Florange and Herpertz 2019). Studies suggest less positive affect in mother and child and more child gaze aversion (White et al. 2011). Other characteristics of BPD like rejection hypersensitivity, alterations in emotion recognition, reduced self-worth and trust, and difficulties in understanding others' mental states and emotions might also play a role in disrupted mother-child interactions (Gunderson et al. 2018; McLaren et al. 2022). Due to emotional dysregulation, coping with distress is especially difficult for individuals with BPD and may impede

mothers' abilities to adaptively and sensitively respond to their children and co-regulate their distress. Interestingly, although Kiel et al. (2011) did not find group differences between mothers with high and low BPD symptoms in their initial responses to their children's distress, mothers with BPD showed less and delayed positive affect in response to child distress and reacted increasingly insensitively, the longer the distress lasted. In other works, mothers with BPD showed more intrusive behaviors in a reunion/repair phase after stressful situations, while their children expressed less self-regulatory behaviors (Apter et al., 2017). Therefore, not being able to offer synchronous mother-child interactions may impair their offspring's ability to build adaptive regulative skills. Consistent evidence suggests that maternal psychopathology may increase children's risks for mental health and regulative difficulties, for example, through an indirect effect of maternal emotion dysregulation (Gratz et al. 2014; Macfie and Swan, 2009).

In summary, the concept of synchrony and regulative behaviors in response to distress is barely understood in mothers with BPD and their children. Many studies use macro-coding to make global characterizations of the quality of mother-child interactions; however, micro-coding of verbal and non-verbal behavior utilizing a moment-to-moment timescale may offer a more dynamic perspective of how parents and children are responding to one another in real time. Taking this approach may shed more light on the importance functional, reciprocal, and regulated interaction has for the quality of the mother-child relationship (Feldman, 2007), maternal satisfaction (Atzil et al., 2011), and child self-regulation development (Beeghly and Tronick, 2011), especially in individuals who are burdened by mental disorders (Florange and Herpertz, 2019). In the present study, we analyzed behavioral synchrony and child and maternal regulative attempts during a frustration-inducing paradigm as a possible trigger of distress to detect underlying mechanisms of disrupted mother-toddler interaction in BPD. We expected (i) a reduced proportion of synchronous states and (ii) differences in maternal and child regulative behaviors (especially less consistent and effective maternal responses) during mother-toddler interactions in dyads with BPD compared to healthy control dyads; we hypothesized that (iii) both dyadic regulative behaviors and synchrony would show effects on child externalizing and internalizing behaviors. Finally, we explored associations of synchrony with (iv) BPD symptom severity to estimate the effects of the disorder on synchrony and with (v) the overall quality of mother-child interaction to further characterize how this micro-coded measure is related to a macro-coded assessment of the interactional context.

Methods

Participants

This sample consisted of 25 mothers with a current diagnosis of BPD (≥ 5 BPD DSM-IV criteria) and their 18- to 36-month-old toddlers. Originally, 27 mothers with BPD participated, but two mothers with BPD had to be excluded due to technical problems with their videotaped session. Additionally, 29 healthy mothers with no current or lifetime psychiatric diagnosis (healthy controls; HC) participated with their toddlers (see Table 1 and Supplementary Table 1 for group characteristics). General exclusion criteria were maternal age less than 18 or greater than 50 years, alcohol or drug (nicotine excluded) dependence over the last 24 months, severe medical illness including neurological disorders and organic brain damage, mother and toddler not living together, current pregnancy, and current breastfeeding. Some mothers with BPD had comorbid diagnoses (posttraumatic stress disorder: $n = 6$; major depression: $n = 9$; anxiety disorder: $n = 7$; obsessive-compulsive disorder: $n = 2$). Seven mothers with BPD took psychotropic medication (SSNRI: $n = 2$; SSRI: $n = 4$; methylphenidate: $n = 1$). Toddlers had no mental disorder in their reported medical history. Participants were recruited through regional in- and outpatient facilities, flyers for example in child care facilities, and online platforms.

Experimental protocol

Participants were screened via telephone for exclusion criteria, participated in an onsite diagnostic interview (see Additional measures), and attended a laboratory session with their toddler at the University Hospital of Heidelberg (03/2019–07/2021). Each participant was informed about the study protocol and gave written informed consent. In an adapted 5-min toy removal paradigm (TR-paradigm; LAB-TAB, Goldsmith et al. 1995; Feldman et al. 2011b), mother

and toddler were seated opposite each other at a table. The toddler received an attractive toy phone from the mother and could play with it for one minute (preTR). Following an audio signal, the mother took the toy away and placed it within the toddler’s view but outside their reach for the next 2 min (TR). Then, the mother gave the toy back for another 2 min (postTR). The mother was instructed to interact with the toddler as they would normally do during the whole paradigm.

Coding

The videotaped interactions during the TR-paradigm were micro-coded on a computerized system (Interact, Mangold International GmbH, version 18.7.7.17). The variables *gaze*, *affect*, and *vocalization* were coded separately for mother and toddler using a timed-event sequential continuous sampling (Feldman 2014). In accordance with previous work (Feldman 2007), synchrony was defined by the proportion of time mother and toddler simultaneously looked at each other and showed positive affect during the session, as a percent (Feldman and Eidelman 2007; Feldman et al. 2011b). Synchrony was extracted for the preTR, TR, and postTR phases.

Additionally, toddler and mother regulative behaviors (i.e., child self-regulation, child seeking mother, maternal co-regulation) during the TR phase were coded (Feldman 2014; Hirschler-Guttenberg et al. 2015). Each category represented the proportion of time spent engaging in each code during the TR phase as a percent. More information on the coding procedure, variables, and composite scores can be found in Supplementary Information.

To analyze dyadic contingencies, a composite score for a *child’s negative emotionality* summarized the frequency of their protest behavior, negative affect, and negative vocalization. Dyadic contingency was operationalized as the likelihood that a criterion behavior was followed by a target behavior within a lag of 3s based on the full length of the previous event during the interaction (Beebe et al. 2016). New contingent events with (1) *child’s negative*

Table 1 Group characteristics for mothers with borderline personality disorder (BPD) and healthy mothers (HC) and their children. *BSL* borderline symptom severity, *CIB-score* overall quality of mother-child interaction, *CBCL* child internalizing and externalizing problems. This data has been published in Bonfig et al. (2022)

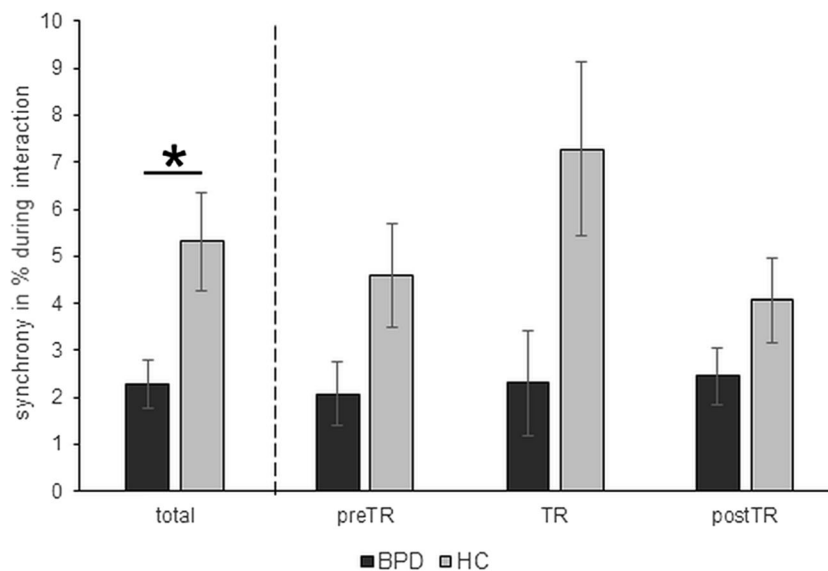
	BPD		HC		t/χ^2_{df}	<i>p</i>
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>		
Age (years)	30.6	7.2	31.9	4.9	− 0.79 _{41,48}	.436
Age child (month)	25.9	6.8	27.1	6.1	− 0.72 ₅₂	.474
Girls/boys	14/11		15/14		0.10 ₁	.753
IPDE symptoms	6.3	1.0	0	0	n.a.	n.a.
BSL	2.4	0.7	1.1	0.2	8.75 _{27,60}	< .001
CIB-score	2.8	0.8	3.5	0.4	− 3.52 _{32,51}	.001
CBCL						
Internalizing	10.0	5.4	5.0	3.8	3.79 _{42,18}	< .001
Externalizing	13.9	5.6	9.0	5.5	3.32 ₅₂	< .001

emotionality followed by maternal co-regulation (consistency) and (2) maternal co-regulation followed by synchrony (effectiveness) were calculated as follows: (1) frequency of child negative emotionality followed by maternal co-regulation divided by all instances of child's negative emotionality, and (2) maternal co-regulation followed by synchrony divided by all instances of maternal co-regulation, respectively (Apter-Levi et al. 2014; Lobo and Lunkenheimer 2020).

Additional measures

All mothers were screened by I. S. (MD) for axis-I disorders using the German versions of the International Neuropsychiatric Interview (M.I.N.I.; Sheehan et al. 1998) and for BPD using the International Personality Disorder Examination (IPDE; Loranger et al. 1994). Additionally, borderline symptom severity (Borderline Symptom List; BSL; Bohus et al. 2007) and child internalizing and externalizing problems (Child-Behavior Checklist for Ages 1½-5; CBCL; Achenbach and Rescorla 2000) were assessed with questionnaires (see Table 1 and Supplementary Table 2). The overall quality of mother-toddler interaction was assessed by behavioral observation in a previous free-play situation, which was macro-coded for maternal, toddler, and dyadic behavior using the well-validated "Coding Interactive Behavior" manual (CIB; Feldman 1998). A total score was calculated to estimate the overall positive quality of mother-toddler interactions, with lower values indicating a less positive quality and higher values indicating a more positive quality (Feldman 1998) (for more information on the method and data of the sample, please see Bonfig et al. (2022)).

Fig. 1 Dyadic synchrony. There was a significant group difference in the total amount of synchrony (% during whole interaction) between dyads with borderline personality disorder (BPD) and healthy controls (HC). Additionally, depicted is the amount of synchrony during the three paradigm phases: baseline (preTR), frustration induction (toy removal; TR), and after TR (postTR)



Data analyses

Data was exported from Interact (Mangold International GmbH) and analyzed using IBM SPSS Statistics 28.0 (IBM, Armonk, NY). Independent *t*-tests for continuous variables and χ^2 tests for categorical variables were used to analyze group differences in behavioral, questionnaire, and demographic data. Synchrony was analyzed by using a repeated-measure analysis of variance (rmANOVA) with group (BPD, HC) as a between-subjects factor and phase (preTR, TR, postTR) as a within-subject factor. Spearman's correlation with Bonferroni correction for multiple testing was used to analyze associations of synchrony with the CIB total score and the BSL for dyads with BPD only. Since data on regulative behaviors and contingencies were not normally distributed, Mann-Whitney *U* tests were used to compare dyads with and without BPD for significant differences. To analyze the effects of synchrony and regulation in mother-toddler interaction on toddler's behavior in dyads with BPD, two regression analyses were conducted each examining (1) synchrony and (2) the sum of mother and child regulative behaviors, respectively, as predictors of children's internalizing and externalizing problems. Results were considered to be significant at $p < .05$. Partial eta squared (η_p^2) was used as a measure of effect sizes.

Results

Synchrony and regulative behaviors

The rmANOVA showed a significant group effect ($F_{1,52} = 5.94$, $p = .018$, $\eta_p^2 = .10$; Fig. 1); dyads with BPD demonstrated lower levels of synchrony compared to HC. There

was no significant effect for condition ($F_{2,104} = 1.72, p = .194, \eta_p^2 = .03$) or a group \times condition interaction ($F_{2,104} = 1.73, p = .195, \eta_p^2 = .03$). Correlation analyses revealed a significant association of synchrony with the CIB total score ($r = 0.45, p = .025$) and with borderline symptom severity (BSL; $r = -0.46, p = .020$) for dyads with BPD (Bonferroni-adjusted threshold value for significance: $p = .025$).

During TR, there was no significant group difference in child self-regulation ($U = 362.50, p = 1.000$), child seeking parent ($U = 419.00, p = .327$), or mother co-regulation ($U = 346.00, p = .775$), nor in the total sum of regulative behaviors across all conditions ($U = 373.00, p = .855$) between dyads with and without BPD (see Fig. 2a).

Contingency in maternal response and co-regulation

Groups did not differ in the frequency ($U = 271.50, p = .110$) of children's negative emotionality. There was no significant group difference in the number of times the mother responded with co-regulation to the child's negative emotionality relative to all instances of the child's negative emotionality ($U = 271.00, p = .492$; subsample of the group with BPD ($n = 22; 88%$) and HC ($n = 22; 79%$) because not all toddlers showed negative emotionality; see Fig. 2b). However, significantly fewer events of maternal co-regulation behaviors were followed by dyadic synchrony relative to all instances of maternal co-regulation in dyads with BPD compared to HC ($U = 461.50, p = .014$; see Fig. 2c).

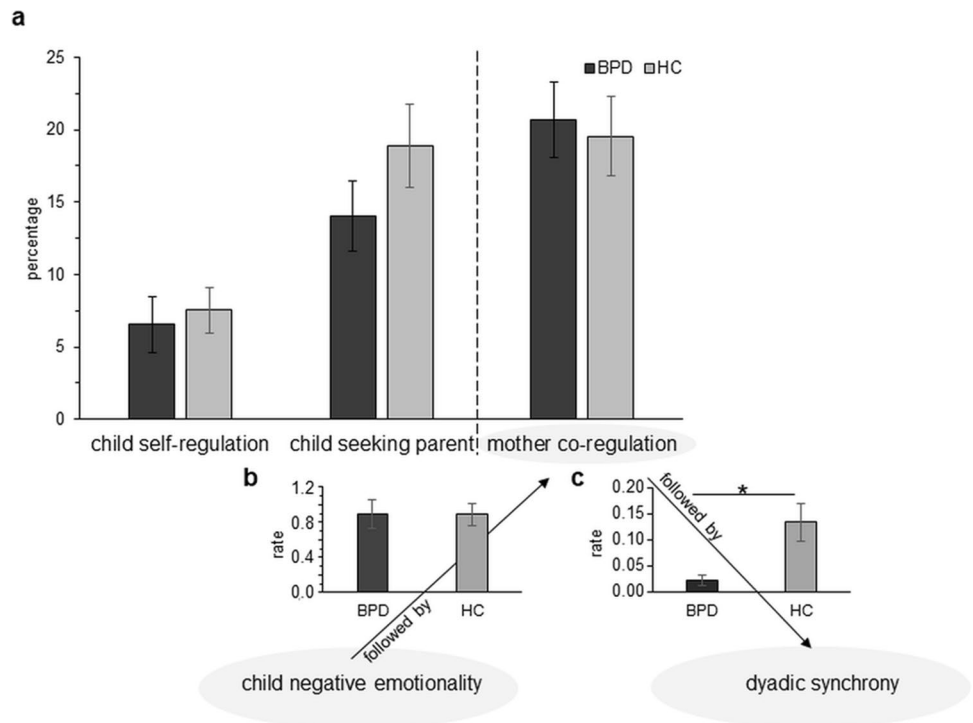
Prediction of child internalizing and externalizing problems

In the group with BPD, the total amount of maternal and child regulative behaviors was a statistically significant predictor of child externalizing problems with a moderate goodness-of-fit (adjusted $R^2 = 0.17, F_{1,23} = 6.03, p = .022, \beta = -0.46$). Lower regulation in the dyad during a frustrating situation was associated with more child externalizing problems. The amount of maternal and child regulative behaviors was only a trend-level predictor of child internalizing problems (adjusted $R^2 = 0.10, F_{1,23} = 3.54, p = .072$). Synchrony did not predict child internalizing or externalizing problems (externalizing: adjusted $R^2 = -0.04, F_{1,23} = 0.15, p = .702$; internalizing: adjusted $R^2 < -0.01, F_{1,23} = 0.98, p = .331$).

Discussion

This is the first study examining behavioral dyadic synchrony and regulation on a micro-level and relating it to macro-behavior in mothers with BPD and their toddlers. The study revealed three major findings: First, mothers with BPD and their toddlers showed less synchrony during interaction compared to healthy dyads. Second, there were no significant differences between dyads with and without BPD in the total amount of regulative behaviors mothers and children used during a frustration-inducing event or in the strength of the contingency between toddlers' negative emotionality

Fig. 2 Regulative behaviors during frustration (TR) and dyadic contingencies. **a** There were no significant differences in the amount of maternal and child regulative behaviors between groups. **b** Groups did not differ in the rate with which mothers responded with co-regulation to children's negative emotionality, but **c** the rate with which maternal co-regulation was followed by dyadic synchrony was lower in dyads with BPD compared to HC. BPD borderline personality disorder, HC healthy control. Arrows visualize contingent events



and mothers' following co-regulative attempts. However, maternal co-regulative attempts were less often linked to subsequent synchrony between mothers with BPD and their toddlers. Third, lower regulation in the dyad during frustration predicted child externalizing problems in dyads with BPD.

We were able to confirm our first hypothesis of reduced synchrony in dyads of mothers with BPD and their toddlers. Lower synchrony levels characterize interactive disruptions on a micro-behavioral level with a reduced matching of mutual gaze and positive affect. The concept of dyadic parent-child synchrony has not been investigated in BPD so far; however, less positive maternal affect and more child gaze aversion have been observed previously (White et al. 2011). Results are in line with prior findings of disrupted social interaction in BPD and could relate to social perceptual biases and difficulties in emotion recognition and processing, social cognition, and empathy (Herpertz et al. 2018; Schneider et al. 2020). Our analyses also showed that the more severe the disorder was, the less synchronous interactions appeared. This means that more severely affected mothers may experience more difficulties in mother-child interactions and may need more support. These findings are in line with results from our previous study showing impaired overall quality of mother-toddler interaction in mothers with BPD (Bonfig et al. 2022). The interactional disturbances could have a negative impact on relationship quality, making mother-child interactions particularly stressful and unrewarding for the mother. The association of higher synchrony with a better overall quality of the mother-toddler interaction (CIB values) in the group with BPD demonstrates that our operationalization of synchrony is a relevant measure for mother-child interaction. It also underlines the importance of engaged, sensitive matching of behaviors and emotional attunement for positive mother-child relationship quality, attachment, and child regulation (Bell 2020; Leclère et al. 2014). Our results also stress that challenges to adaptive mother-child interaction lie not only within mothers with BPD or their children but within the dyad maintaining mutual coordination and flow of behaviors (Florange and Herpertz 2019; Harrist and Waugh 2002). Therapeutic work emphasizing mother-child interaction is therefore particularly important. Synchrony might not only qualify as a marker for dyadic progress, but also offer patients a helpful concept for changes on a behavioral level. Psychoeducation could help parents understand the concept of synchrony, and video-intervention therapy could help them identify their micro-level patterns. Reinforcing positive aspects and changing negative ones through cognitive and behavioral work could improve attunement to their child (Riva et al. 2016). Thus, breaking this vicious cycle of difficult relationship experiences and dysregulation in the context of interactions between mothers with BPD and their

children should be the focus of intervention efforts (Leclère et al. 2014). To date, few treatment programs exist specifically for parents with BPD; they offer modified dialectical behavior therapy, home visits, and group trainings (Florange and Herpertz, 2019; May et al., 2023). Such a program has been piloted by Renneberg & Rosenbach (2016) and is currently tested in a multicenter study (Rosenbach et al. 2022). An understanding of micro-level patterns could well complement these programs and require further empirical support.

Contrary to our second hypothesis, we did not find reduced or increased maternal or child (co-)regulative attempts. This shows that dyads with BPD were fundamentally capable of expressing regulative behaviors during short periods of toddler distress. However, the stress load in our paradigm might have been too mild (2 min) to represent abnormalities more distinctly, as Kiel et al. (2011) were able to show differences between inconspicuous initial responses and increasing abnormalities as task time progressed. Interestingly, mothers with and without BPD responded equally often with co-regulatory attempts to children's negative emotionality. However, maternal co-regulatory attempts were significantly less likely to be followed by matched dyadic synchrony in dyads with BPD. This could indicate a reduced attunement to the child and diminished effectiveness of maternal co-regulation in supporting adaptive parent-child interactions in dyads with BPD. Difficulties in successfully repairing interactions after broken cooperation or exclusion have been reported previously for patients with BPD (King-Casas et al. 2008; Reinhard et al. 2021). Reasons could be an inappropriate matching of timing and/or content of co-regulatory attempts, deviant maternal perception of and response to children's emotional and mental states (Apter et al. 2017; Elliot et al. 2014; Gunderson et al. 2018), or an overall strained interaction and relationship so that co-regulatory attempts have little influence on dyadic quality (Elliot et al. 2014). Maternal emotion dysregulation might have also had a negative effect on the child's emotion regulation abilities and disturbed the dyadic interaction (Gratz et al. 2014). Lastly, child behaviors like model learning and dynamic and reciprocal influences between mother and child through biological and behavioral attunement processes are likely to play an important role here (Di Lorenzo et al., 2021).

Supporting our third hypothesis, reduced dyadic regulation predicted more child externalizing problems in dyads with BPD. Maternal co-regulation, but also child self-regulation, is associated with higher quality mother-child interactions (Beeghly and Tronick 2011). Inadequate co-regulation might compromise the child's development of building a repertoire of behavioral, cognitive, emotional, and biological strategies for regulation (Beeghly and Tronick 2011; Compas et al. 2017), and higher levels of child externalizing problems have been reported (Olson et al. 2017). Our

results confirm this also for toddlers of mothers with BPD. Surprisingly, associations for internalizing problems were only trend-level significant. It could be that dyadic regulatory processes are particularly salient for externalizing problems in infancy or that mothers with BPD may have difficulty identifying internalizing problems in their toddlers.

Synchrony was unrelated to child externalizing or internalizing problems, though prior work in childhood has found evidence that higher child behavior problems may disrupt and reduce synchronous mother-child interactions (Im-Bolter et al. 2015). One explanation for this result may be that synchrony operates differently within dyads with BPD: given maternal dysregulation in BPD, opportunities for toddlers' attunement to maternal signals may be limited and may vary in length before disruptions occur.

Limitations

The study is limited by the small sample size and the inclusion of only mothers in this hard-to-recruit sample of patients with BPD. Results need to be confirmed in larger samples that include fathers and different age and racial/ethnic groups to generalize statements about the effects. Also, the effects of comorbidities need to be analyzed in larger samples. The paradigm was relatively short, so not all altered behaviors might have been captured. The coding system does not allow us to depict all biobehavioral complexities of dyadic processes, and in the future, temporal relations and the qualitative content need to be better captured.

Conclusion

BPD symptomology may reduce the abilities of mother-child dyads for coordinated and attuned dyadic behavior, which we demonstrated by finding reduced synchrony in the interaction of mothers with BPD and their toddlers. Low synchrony was associated with higher BPD symptom severity and reduced overall interaction quality in BPD. Though mothers with BPD may recognize and try to respond to instances of negative emotionality in their toddlers during interaction, BPD symptomology may reduce the effectiveness of mothers' attempts to attune to their toddler's needs. Regulative behaviors in dyads with BPD were negatively associated with child externalizing behaviors, which could indicate adverse effects for toddlers' development. An emphasis on synchrony and regulative behaviors may be an important therapeutic target for parenting programs in mothers with BPD and their children, and future studies are needed to investigate this direction of research.

Supplementary Information The online version contains supplementary material available at <https://doi.org/10.1007/s00737-023-01346-9>.

Author contributions I. S.: conceptualization, data curation, formal analysis, funding acquisition, investigation, methodology, project administration, software, visualization, writing—original draft; A. F.: formal analysis, supervision; writing—review and editing; S. C. H.: conceptualization, supervision, writing—review and editing; F. M. L.: formal analysis, supervision, writing—original draft.

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Declarations

Ethics approval and informed consent The study was approved by the Ethics Committee of the Medical Faculty at Heidelberg University, Germany, and carried out in accordance with the Declaration of Helsinki of 1975, as revised in 2008. All participants gave written informed consent prior to inclusion in the study and received equal monetary compensation for their participation.

Competing interests The authors declare no competing interests.

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References

- Achenbach T, Rescorla L (2000) Child Behavior Checklist 1 ½–5 (German Version). University of Vermont, Burlington
- Apter G, Devouche E, Garez V, Valente M, Genet M-C, Gratier M, Dominguez S, Tronick E (2017) The still-face: a greater challenge for infants of mothers with borderline personality disorder. *J Personal Disord* 31:156–169. https://doi.org/10.1521/pedi_2016_30_243
- Apter-Levi Y, Zagoory-Sharon O, Feldman R (2014) Oxytocin and vasopressin support distinct configurations of social synchrony. *Brain Res* 1580:124–132. <https://doi.org/10.1016/j.brainres.2013.10.052>
- Atzil S, Hendler T, Feldman R (2011) Specifying the neurobiological basis of human attachment: brain, hormones, and behavior in synchronous and intrusive mothers. *Neuropsychopharmacology* 36:2603–2615. <https://doi.org/10.1038/npp.2011.172>
- Beebe B, Messinger D, Bahrack LE, Margolis A, Buck KA, Chen H (2016) A systems view of mother–infant face-to-face communication. *Dev Psychol* 52:556. <https://doi.org/10.1037/a0040085>
- Beeghly M, Tronick E (2011) Early resilience in the context of parent–infant relationships: a social developmental perspective. *Curr*

- Probl Pediatr Adolesc Health Care 41:197–201. <https://doi.org/10.1016/j.cppeds.2011.02.005>
- Bell MA (2020) Mother-child behavioral and physiological synchrony. *Adv Child Dev Behav* 58:163–188. <https://doi.org/10.1016/bs.acdb.2020.01.006>
- Bohus M, Limberger MF, Frank U, Chapman AL, Kühler T, Stieglitz R-D (2007) Psychometric properties of the borderline symptom list (BSL). *Psychopathology* 40:126–132. <https://doi.org/10.1159/000098493>
- Bonfig J, Herpertz SC, Schneider I (2022) Altered hormonal patterns in borderline personality disorder mother-child interactions. *Psychoneuroendocrinology* 143:105822. <https://doi.org/10.1016/j.psyneuen.2022.105822>
- Brophy-Herb HE, Schiffman RF, Bocknek EL, Dupuis SB, Fitzgerald HE, Horodyski M, Onaga E, Van Egeren LA, Hillaker B (2011) Toddlers' social-emotional competence in the contexts of maternal emotion socialization and contingent responsiveness in a low-income sample. *Soc Dev* 20:73–92. <https://doi.org/10.1111/j.1467-9507.2009.00570.x>
- Calkins SD (2011) Caregiving as coregulation: psychobiological processes and child functioning. In: Booth A, McHale SM, Landale NS (eds) *Biosocial foundations of family processes*. Springer Science, pp 49–59
- Compas BE, Jaser SS, Bettis AH, Watson KH, Gruhn MA, Dunbar JP, Williams E, Thigpen JC (2017) Coping, emotion regulation, and psychopathology in childhood and adolescence: a meta-analysis and narrative review. *Psychol Bull* 143:939. <https://doi.org/10.1037/bul0000110>
- DiLorenzo MG, Bucsea O, Rumeo C, Waxman JA, Flora DB, Schmidt LA, Riddell RP (2021) Caregiver and young child biological attunement in distress contexts: a systematic review and narrative synthesis. *Neurosci Biobehav Rev* 132:1010–1036. <https://doi.org/10.1016/j.neubiorev.2021.10.045>
- Elliot RL, Campbell L, Hunter M, Cooper G, Melville J, McCabe K, Newman L, Loughland C (2014) When I look into my baby's eyes... Infant emotion recognition by mothers with borderline personality disorder. *Infant Ment Health J* 35:21–32. <https://doi.org/10.1002/imhj.21426>
- Feldman R (1998) Coding interactive behavior (CIB) manual. Unpublished Manual Bar-Ilan University, pp 1–23
- Feldman R (2007) Parent–infant synchrony and the construction of shared timing; physiological precursors, developmental outcomes, and risk conditions. *J Child Psychol Psychiatry* 48:329–354. <https://doi.org/10.1111/j.1469-7610.2006.01701.x>
- Feldman R (2014) Micro-coding parent–infant interactions. Bar-Ilan University, Israel: unpublished manual
- Feldman R, Eidelman AI (2007) Maternal postpartum behavior and the emergence of infant–mother and infant–father synchrony in preterm and full-term infants: The role of neonatal vagal tone. *Dev Psychobiol* 49:290–302. <https://doi.org/10.1002/dev.20220>
- Feldman R, Greenbaum CW, Yirmiya N (1999) Mother–infant affect synchrony as an antecedent of the emergence of self-control. *Dev Psychol* 35:223. <https://doi.org/10.1037/0012-1649.35.1.223>
- Feldman R, Gordon I, Schneiderman I, Weisman O, Zagoory-Sharon O (2010) Natural variations in maternal and paternal care are associated with systematic changes in oxytocin following parent–infant contact. *Psychoneuroendocrinology* 35:1133–1141. <https://doi.org/10.1016/j.psyneuen.2010.01.013>
- Feldman R, Dollberg D, Nadam R (2011a) The expression and regulation of anger in toddlers: relations to maternal behavior and mental representations. *Infant Behav Dev* 34:310–320. <https://doi.org/10.1016/j.infbeh.2011.02.001>
- Feldman R, Gordon I, Zagoory-Sharon O (2011b) Maternal and paternal plasma, salivary, and urinary oxytocin and parent–infant synchrony: considering stress and affiliation components of human bonding. *Dev Sci* 14:752–761. <https://doi.org/10.1111/j.1467-7687.2010.01021.x>
- Florange JG, Herpertz SC (2019) Parenting in patients with borderline personality disorder, sequelae for the offspring and approaches to treatment and prevention. *Curr Psychiatry Rep* 21:1–8. <https://doi.org/10.1007/s11920-019-0996-1>
- Gratz KL, Kiel EJ, Latzman RD, Elkin TD, Moore SA, Tull MT (2014) Emotion: Empirical contribution: maternal borderline personality pathology and infant emotion regulation: Examining the influence of maternal emotion-related difficulties and infant attachment. *J Personal Disord* 28:52–69. <https://doi.org/10.1521/peidi.2014.28.1.52>
- Goldsmith H, Reilly J, Lemery K, Longley S, Prescott A (1995) Laboratory temperament assessment battery: Preschool version. Unpublished manuscript
- Gunderson JG, Herpertz SC, Skodol AE, Torgersen S, Zanarini MC (2018) Borderline personality disorder. *Nat Rev Dis Primers* 4:1–20. <https://doi.org/10.1038/nrdp.2018.29>
- Hammer AT, Grau JM, Silberman SG, Smith EN (2019) Dyadic synchrony among young Latina mothers and their toddlers: the role of maternal and child behavior. *Infant Behavior and Dev* 57:101378. <https://doi.org/10.1016/j.infbeh.2019.101378>
- Harrist AW, Waugh RM (2002) Dyadic synchrony: Its structure and function in children's development. *Dev Rev* 22:555–592. [https://doi.org/10.1016/S0273-2297\(02\)00500-2](https://doi.org/10.1016/S0273-2297(02)00500-2)
- Herpertz SC, Bertsch K, Jeung H (2018) Neurobiology of criterion A: self and interpersonal personality functioning. *Curr Opin Psychol* 21:23–27. <https://doi.org/10.1016/j.copsyc.2017.08.032>
- Hirschler-Guttenberg Y, Feldman R, Ostfeld-Etzion S, Laor N, Golan O (2015) Self-and co-regulation of anger and fear in preschoolers with autism spectrum disorders: the role of maternal parenting style and temperament. *J Autism Dev Disord* 45:3004–3014. <https://doi.org/10.1007/s10803-015-2464-z>
- Im-Bolter N, Anam M, Cohen NJ (2015) Mother–child synchrony and child problem behavior. *J Child Fam Stud* 24:1876–1885. <https://doi.org/10.1007/s10826-014-9989-1>
- Kiel EJ, Gratz KL, Moore SA, Latzman RD, Tull MT (2011) The impact of borderline personality pathology on mothers' responses to infant distress. *J Fam Psychol* 25:907. <https://doi.org/10.1037/a0025474>
- King-Casas B, Sharp C, Lomax-Bream L, Lohrenz T, Fonagy P, Montague PR (2008) The rupture and repair of cooperation in borderline personality disorder. *science* 321:806–810. <https://doi.org/10.1126/science.1156902>
- Leclère C, Viaux S, Avril M, Achard C, Chetouani M, Missonnier S, Cohen D (2014) Why synchrony matters during mother-child interactions: a systematic review. *PLoS One* 9:e113571. <https://doi.org/10.1371/journal.pone.0113571>
- Lobo FM, Lunkenheimer E (2020) Understanding the parent-child coregulation patterns shaping child self-regulation. *Dev Psychol* 56:1121. <https://doi.org/10.1037/dev0000926>
- Loranger A, Sartorius N, Andreoli A (1994) The World Health Organisation/Alcohol, Drug Abuse and Mental Health Administration International Pilot Study of Personality Disorders. *Arch Gen Psychiatry* 51:215–224. <https://doi.org/10.1001/archpsyc.1994.03950300051005>
- Macfie J, Swan SA (2009) Representations of the caregiver–child relationship and of the self, and emotion regulation in the narratives of young children whose mothers have borderline personality disorder. *Dev Psychopathol* 21:993–1011. <https://doi.org/10.1017/S0954579409000534>
- May A, Balzan R, Williams AS, Wade TD, Paranjothy SM (2023) Interventions for perinatal borderline personality disorder and complex trauma: a systematic review. *Arch Womens Ment Health* 26:295–309. <https://doi.org/10.1007/s00737-023-01313-4>

- McLaren V, Gallagher M, Hopwood CJ, Sharp C (2022) Hypermentalizing and borderline personality disorder: a meta-analytic review. *Am J Psychother* 75:21–31. <https://doi.org/10.1176/appi.psychother.apy.20210018>
- Mcquaid NE, Bibok MB, Carpendale JI (2009) Relation between maternal contingent responsiveness and infant social expectations. *Infancy* 14:390–401. <https://doi.org/10.1080/15250000902839955>
- Olson SL, Choe DE, Sameroff AJ (2017) Trajectories of child externalizing problems between ages 3 and 10 years: contributions of children's early effortful control, theory of mind, and parenting experiences. *Dev Psychopathol* 29:1333–1351. <https://doi.org/10.1017/S095457941700030X>
- Reinhard MA, Padberg F, Dewald-Kaufmann J, Wüstenberg T, Goerigk S, Barton BB, Zülch A, Brandl L et al (2021) Sequential social exclusion in a novel cyberball paradigm leads to reduced behavioral repair and plasma oxytocin in borderline personality disorder. *J Personality Dis* 36:99–115. https://doi.org/10.1521/pedi_2021_35_532
- Renneberg B, Rosenbach C (2016) “There is not much help for mothers like me”: parenting skills for mothers with borderline personality disorder - a newly developed group training program. *Borderline Personal Disord Emot Dysregul* 3:1–7. <https://doi.org/10.1186/s40479-016-0050-4>
- Riva Crugnola C, Ierardi E, Albizzati A, Downing G (2016) Effectiveness of an attachment-based intervention program in promoting emotion regulation and attachment in adolescent mothers and their infants: a pilot study. *Front Psychol* 7:195. <https://doi.org/10.3389/fpsyg.2016.00195>
- Rosenbach C, Heinrichs N, Kumsta R, Schneider S, Renneberg B (2022) Study protocol for a multi-center RCT testing a group-based parenting intervention tailored to mothers with borderline personality disorder against a waiting control group (ProChild*-SP1). *Trials* 23:1–10. <https://doi.org/10.1186/s13063-022-06531-2>
- Sheehan DV, Lecrubier Y, Sheehan KH, Amorim P, Janavs J, Weiller E, Hergueta T, Baker R, Dunbar GC (1998) The Mini-International Neuropsychiatric Interview (MINI): the development and validation of a structured diagnostic psychiatric interview for DSM-IV and ICD-10. *J Clin Psychiatry* 59(20):22–33
- Schneider I, Boll S, Volman I, Roelofs K, Spohn A, Herpertz SC, Bertsch K (2020) Oxytocin normalizes approach–avoidance behavior in women with borderline personality disorder. *Front Psych* 11:120. <https://doi.org/10.3389/fpsyg.2020.00120>
- Schueler CM, Prinz RJ (2013) The role of caregiver contingent responsiveness in promoting compliance in young children. *Child Psychiatry Hum Dev* 44:370–381. <https://doi.org/10.1007/s10578-012-0331-0>
- Tronick E, Beeghly M (2011) Infants' meaning-making and the development of mental health problems. *Am Psychol* 66:107. <https://doi.org/10.1037/a0021631>
- White H, Flanagan TJ, Martin A, Silvermann D (2011) Mother–infant interactions in women with borderline personality disorder, major depressive disorder, their co-occurrence, and healthy controls. *J Reprod Infant Psychol* 29:223–235. <https://doi.org/10.1080/02646838.2011.576425>

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