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INTERACTIVE COORDINATION OF CURRENTLY DEPRESSED INPATIENT MOTHERS AND THEIR INFANTS DURING THE POSTPARTUM PERIOD

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ABSTRACT: In healthy mother–infant dyads, interactions are characterized by a pattern of matching and mismatching interactive states with quick reparation of mismatches into matches. In contrast, dyads in which mothers have postpartum depression show impaired mother–infant interaction patterns over the first few months of the infant's life. The majority of studies that have examined such interaction patterns have drawn on community samples rather than on depressed inpatient samples of mothers who were in a state of current depression at the time of assessment. To date, no study has investigated specific microanalytic patterns of interactive coordination between depressed German mothers and their infants using the Face-to-Face Still-Face paradigm (FFSF). The primary goal of this study was to evaluate specific patterns of dyadic coordination and the capacity for repairing states of miscoordination in an inpatient sample of postpartum currently depressed mothers and their infants as compared with a healthy control group. A sample of 28 depressed inpatient German mothers and their infants (age range = 1–8 months, *M* age = 4.06 months) and 34 healthy dyads (range = 1–8 months, *M* age = 3.89 months) were videotaped while engaging in the FFSF. A focus was placed on the play and reunion episodes. Compared with healthy dyads, dyads with depressed mothers showed less coordination of positive matched states and longer latencies when repairing interactive mismatching states into positive matched states. Clinical implications are discussed.

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MUTUAL AFFECT REGULATION AND INTERACTIVE COORDINATION

Empirical findings from a number of studies have highlighted the pivotal importance of specific patterns of mother–child interaction for infants' affect regulation during the first 6 months of life (Beebe, Lachmann, & Jaffe, 1997; Stern, 1995; Weinberg & Tronick, 1998). Interaction patterns are defined as characteristic behavior sequences in which mother and child exert a mutual influence on one another. These patterns comprise the self-regulatory and interactive competencies of both partners.

In the Mutual Regulation Model (Tronick, 1998, 2003, 2007; Tronick & Cohn, 1989), the interactive regulation of affect is conceived of as a continuous moment-to-moment process, in which each partner adjusts to the behavior of the other (Tronick, 1998; Tronick & Cohn, 1989). The behavior of one partner during the interaction can be predicted by the behavior of the other in both positive and negative affective states. The Mutual Regulation Model characterizes the interaction as a flexible process in which affective interactive "matches" (i.e., coordinated behavioral and affective states) and "mismatches" (i.e., uncoordinated behavioral and affective states) occur, with mismatches frequently and quickly being repaired back to interactional matching states ("interactive repair"). According to Tronick (2007), interactive repair processes are of vital developmental importance; the experience that negative affective states can successfully and reliably be transformed into positive states results in a sense of self-efficacy in infants as well as helps them learn effective interactive strategies for affect regulation.

POSTPARTUM DEPRESSION

Postpartum depression represents the most common maternal psychiatric disorder, occurring in 10 to 15% of women (Harvey & Pun, 2007; Reck et al., 2008). It is related to impaired functioning and also impacts the child of the affected mother, with psychological and behavioral problems occurring beyond infancy and into childhood (Hay et al., 2001; Moehler et al., 2007; Murray, Fiori-Cowley, Hooper, & Cooper, 1996; Ramchandani, Stein, Evans, & O'Connor, 2005; Weinberg & Tronick, 1998).

Postpartum depression also is known to negatively influence maternal interaction behavior and mother–infant interaction (Feldman, 2007; Field, Healy, Goldstein, & Guthertz, 1990; Field et al., 2007; Reck et al., 2004; Reck et al., 2006; Stanley, Murray, & Stein, 2004; Tronick & Reck, 2009; Tronick & Weinberg, 1997; Weinberg, Olson, Beeghly, & Tronick, 2006). In the context of postpartum depression, some findings have indicated that the capacity for repairing mismatched, uncoordinated states is impaired in mother–infant interactions. In a sample of toddlers and their mothers, Jameson, Gelfand, Kulcsar, and Teti (1997) found that currently depressed mothers were less likely to repair interrupted interactions and that depressed mother–infant dyads displayed less interactive coordination in a laboratory play situation. In their study on vocal coordination in mother–infant pairs, Zlochower and Cohn (1996) found that currently depressed mothers were less responsive to their 4-month-old infants and less predictable in their timing of interactive behavior as compared with healthy mothers. These results have suggested that the infants of depressed mothers may be less able to follow the behavior of their mothers, resulting in reduced synchrony.

Despite the high health risks for both mother and child which are associated with depression in the postpartum period and the established central role of early mother–infant interaction quality for infant development, only a few studies have examined samples of mothers with clinically

diagnosed current depression (Cohn, Campbell, Matias, & Hopkins, 1990; Field et al., 2007; Zlochower & Cohn, 1996). Indeed, the majority of studies have included a mixture of clinically diagnosed current and remitted cases (Jameson et al., 1997; Stanley et al., 2004; Weinberg & Tronick, 1998) or have employed self-report questionnaires to evaluate current depressive symptoms (Brennan et al., 2000; Field, Healy, Goldstein, & Perry, 1988; Field et al., 1990; Righetti-Veltema, Conne-Perréard, Bousquet, & Manzano, 2002; Weinberg et al., 2006).

Furthermore, many studies of depressed mothers and their infants have exclusively examined face-to-face interaction and have not included the Face-to-Face Still-Face (FFSF) paradigm (e.g., Feldman, 2007; Field et al., 1990; Jameson et al., 1997; Zlochower & Cohn, 1996). The FFSF is an experimental paradigm in which the mother is instructed to remain unresponsive to the infant, thus evoking a prolonged state of mismatch. Still-face examinations have been conducted with infants between 1 and 12 months of age (for an overview, see Adamson & Frick, 2003). Tronick (2007) postulated that the still face represents an experimental model of maternal emotional rejection and an interactive stressor for the infant (Cohn & Tronick, 1989; Field, Vega-Lahr, Scafidi, & Goldstein, 1986; Haley & Stansbury, 2003). The paradigm specifically assesses how mother–infant dyads manage emotionally stressful situations, and in particular, in the reunion phase in which both mother and infant are faced with the challenge of reestablishing interactive coordination following the preceding, artificially generated, and prolonged mismatch (e.g., Weinberg & Tronick, 1996). Using the FFSF, Weinberg et al. (2006) demonstrated that differences between dyads with healthy mothers and dyads with depressed mothers are more likely in the reunion as compared with the play phase. They showed that mother–son dyads in which mothers had high depression scores engaged in more negative interactions in the stressful and challenging reunion episode following the still-face episode as compared with the play phase. A study by Field et al. (2007) also revealed a greater share of positive affectivity in the play phase as compared with the reunion phase in both the healthy and the depressive groups.

In summary, few systematic studies currently exist which have examined interactive coordination between currently depressed mothers and their infants using the FFSF. Furthermore, to our knowledge, no study has examined mismatch–reparation latency using the FFSF in an inpatient sample of depressed mothers. In addition, no study has investigated interactive coordination between depressed German mothers and their infants.

The goal of this study therefore was to examine the relationship between current maternal depression and infant and maternal affective behavior, with a particular focus on the dyadic features of mother–infant interactions. To evaluate the interactions of currently depressed mothers and their infants across different contexts (including stressful situations), we applied the FFSF paradigm developed by Tronick, Brazelton, and Als (1978; see also Adamson & Frick, 2003). The study in particular examined the play and reunion phases, which would seem appropriate for the assessment of interactive competence and coordination across different contexts.

Three different types of interactive matches were evaluated: (a) positive, (b) object-related, and (c) negative matches. Besides including positive face-to-face interactive behavior (positive matches), we also considered it important to include a measure of coordinated object focus between mother and child as a precursor of joint attention. Recent studies have shown that depressed mothers engage in joint attention significantly less than their nondepressed counterparts (Goldsmith & Rogoff, 1997; Jameson et al., 1997) and that their ability to initiate interaction using the toddler's focus of attention is impaired (Henderson & Jennings, 2003). We employ the term *negative matching* to refer to the time during which mother and infant were simultaneously in a negative affective state. The negative-matching category was formed according to Tronick

et al. (2005). However, note that in contrast to "positive matches" and "object-related matches," "negative matches" do not constitute a "coordinated interaction," which is assumed to exert a positive influence on the infant's regulation competence. A favorable reaction to child negativity would be complementary maternal behavior (e.g., social monitor/neutral vocalizations, social monitor/positive vocalizations).

We hypothesized that compared to dyads with healthy mothers, those with depressed mothers would show less positive matching, fewer object-related matches, and a higher number of negative matches in both the play and reunion episodes of the FFSF.

While the capacity for repairing mismatched states (interactive repair) previously has not been subject to evaluation, we specifically expected depressed mothers and their infants to show longer mismatch–reparation latencies.

With regard to differences in interactive coordination between the play and reunion phases, we hypothesized that both groups would show fewer positive matches, fewer object-related matches, and more negative matches in the more challenging reunion phase following the stressful still-face episode.

The influence of infant age and sex on the target parameters was examined in confounder analyses. In the group of depressed mothers and their infants, we also analyzed the influence of comorbidity and medication (antidepressants, neuroleptics, benzodiazepines) on the degree of mother–infant interactive coordination.

METHOD

Participants

The clinical sample comprised 28 inpatient mothers with current depressive disorders. At the time of interaction assessment, all mothers and their children were receiving inpatient treatment at the mother–infant unit of the psychiatric University Hospital Heidelberg. The mother–infant unit is part of a depression ward, where together depressed mothers and their infants receive psychiatric and psychotherapeutic treatment. Between September 2001 and November 2006, eligible mothers were approached by their therapist and informed about the present study. Exclusion criteria included insufficient knowledge of the German language and a diagnosis of schizophrenia or the presence of psychotic symptoms.

Due to the model character of the inpatient treatment unit at Heidelberg, which was established in 2001, generalizability of the study sample to other samples of hospitalized mothers and infants is likely. The contents of the treatment offered by the unit as well as data for comparison with the therapeutic concepts of other mother–infant units at both a national and an international level already have been published (e.g., Fricke, Fuchs, Weiss, Mundt, & Reck, 2006; Reck, 2008). In most cases, inpatients of mother–infant units are admitted to open general psychiatric wards, as also is the case in Heidelberg. Assessment of the indication for inpatient treatment is based on two factors: the psychiatric diagnosis of the mother according to the International Classification of Diseases (ICD-10; Dilling, Mombour, & Schmidt, 2005) and the severity of impairment in managing daily life activities. To be accepted for inpatient treatment together with their infants, affected mothers must show disorders which are so severe that they are not able to manage daily life at home by themselves or to provide adequate care to their children.

In all European hospitals, the ICD-10 is the mandatory (see national guidelines for the treatment of depression, DGPPN, 2010) system which is used to assign diagnoses when individuals

are admitted to the hospital. Such units thus offer the opportunity for specific treatment, a positive influence on the mother–infant relationship, and the prevention of child developmental disorders in a patient group which has so far been inadequately catered for. University Hospital Heidelberg currently plays a leading role in the development of guidelines for inpatient mother–infant therapy in Germany.

All depressed mothers were diagnosed according to the ICD-10 (Dilling et al., 2005). Diagnoses were made by experienced psychiatrists and psychologists working in the mother–infant unit based on 1-hr psychiatric assessments. From the second year of the study period onward, depressive participants ($n = 19$; 68%) were additionally diagnosed according to the internationally more widely used Diagnostic and Statistical Manual of Mental Disorders, fourth edition (*DSM-IV*; American Psychiatric Association, 1994) criteria using the Structured Clinical Interview, German translation (SCID; Wittchen, Wunderlich, Gruschwitz, & Zaudig, 1997). The healthy control sample ($n = 34$) was recruited from local maternity clinics. All healthy control mothers were diagnosed using the SCID to exclude mothers with current or past psychiatric disorders. Further exclusion criteria also included previous treatment in a psychotherapeutic setting and an inability to effectively communicate in German. To summarize, all participants in the group of depressive mothers were, in the context of their admission to the hospital, diagnosed using a clinical interview which was based on ICD-10 criteria. In the group of control mothers, a current or previous mental disorder was ruled out using the SCID. In the depressive group, 19 mothers (68%) took part in the SCID in addition to the clinical interview which was based on the ICD-10. With the exception of the first 9 mothers in the group with depression, all participants were thus diagnosed using the SCID. ICD-10 diagnoses of depression are considered to be comparable to the diagnoses of the *DSM-IV* (Mombour et al., 1990; Philipp, Maier, & Delmo, 1991).

The sum score of the single *DSM-IV*-based SCID criteria was used as an indirect measure of disorder severity and is included for descriptive reasons (depressed mood: 94%; diminished interest: 88%; significant weight change: 59%; insomnia or hypersomnia: 53%; psychomotor agitation or retardation: 65%; fatigue or loss of energy: 94%; feelings of worthlessness or guilt: 82%; diminished ability to concentrate: 76%; thoughts of death, suicidal ideation: 88%). Depression severity in the present sample was characterized by an average of 7.0 ($SD = 1.2$) SCID single criteria, with an interquartile range (25–75th percentile) of 6 to 8 SCID criteria.

Unsurprisingly, 21 (75%) of the depressed mothers received pharmaceutical medication as part of their treatment. At the time of assessment, 16 (57%) of these depressed mothers were treated with antidepressants; 2 (7%) with antidepressants and neuroleptics at the same time; 1 (4%) with antidepressants and benzodiazepines; and 1 (4%) with antidepressants, neuroleptics, and benzodiazepines. One single mother (4%) was treated with neuroleptic medication.

As also would be expected, 13 (46%) of the depressed mothers had comorbid disorders. Anxiety disorders were the most frequently occurring secondary Axis I diagnosis ($n = 14$). One single mother met the criteria for an eating disorder. Four mothers were diagnosed with agoraphobia, 4 with comorbid obsessive compulsive disorders, and 4 with a specific phobia (blood, heights, flying). Three depressive mothers fulfilled the criteria for panic disorder or generalized anxiety disorder. Two mothers suffered from posttraumatic stress disorder, and 1 mother met criteria for social phobia. Four mothers were diagnosed with more than one anxiety disorder in addition to depression.

All participating infants met the following criteria: a gestational age of no less than 36 weeks, all Apgar values >6, and no congenital abnormalities. Control infants were comparable to the infants of depressed mothers with regard to age and sex. Infants' age upon

entering the study ranged from 1 to 8 months, with a mean age of 4.06 months for the children of depressed mothers and 3.89 months for those of healthy mothers. There were 17 male and 11 female infants in the group of depressed mothers, and 24 male and 10 female infants in the group of healthy mothers.

No significant group differences were found with regard to demographic variables. Healthy mothers had a mean age of 33 years ($SD = 4$, range = 25–40), and depressed mothers had a mean age of 32 years ($SD = 4.7$, range = 25–43). Mothers in both groups had an average of 1.6 children ($SD = 0.8$, range = 1–4). The distribution of education levels did not statistically differ across groups: 18 (53%) of the control and 8 (29%) of the depressed mothers had completed higher education, 5 (15%) healthy and 7 (25%) depressed mothers had qualified for university entrance, 10 (29%) healthy and 9 (32%) depressed mothers had completed intermediate secondary education, 1 (3%) healthy and 2 (7%) depressed mothers had completed low-level secondary education, and only 1 depressed mother (4%) had no school-leaving qualification.

Procedures and Measures

Assessment of mother–infant interaction.

FFSF paradigm . Mother–infant interactions were assessed using the FFSF paradigm during the first week following hospital admission. All women in the depressed group were in a current episode of depression at the time of assessment. Mothers participating in the study were videotaped on the day or within the first week of clinical diagnosis and were still in a depressive episode when dyadic interaction was videotaped. Assessment took place in the video laboratory of the research unit at the psychiatric University Hospital of Heidelberg. Infants were seated and secured in an infant chair facing their seated mother. One camera in the research room focused on the infant, and a second camera was aimed at on the mother. A microphone hung from the ceiling above dyads. A single image comprising a simultaneous frontal view of the mother and the infant was produced by transmitting the images from the two cameras into a video recorder through a digital timer and a split-screen generator.

The FFSF paradigm comprises three episodes, each lasting 2 min (Tronick et al., 1978; Weinberg et al., 2006). In the initial *face-to-face baseline interaction*, mothers are instructed to engage with their infant in a "normal" manner, playing with them without the aid of toys and without using a pacifier. This is followed by the *still-face episode*. Here, mothers are instructed to keep a still face. The final episode is the *reunion episode*, in which mothers are instructed to re-engage in face-to-face play with their infant.

Coding of mother–infant interactions. Infants' and mothers' behavior was coded using the Noldus Observer Video-Pro coding system, a system which inspects and analyzes analog and digital video recordings on a frame-by-frame basis, and based on the microanalytical Infant and Caregiver Engagement Phases (ICEP; Tronick et al., 2005; Weinberg & Tronick, 1999). The ICEP system includes a set of mutually exclusive, interactive engagement phases for both the infant and the caregiver. The phases combine information from the infant's and caregiver's faces, direction of gaze, and vocalizations (see Appendix A for detailed information). ICEP codes for the infant are: Negative Engagement (further divided into Withdrawn and Protest), Object/Environment Engagement, Social Monitor, and Social Positive Engagement. ICEP codes for the caregiver are: Negative Engagement (further divided into Withdrawn and Hostile/Intrusive), Non-Infant-Focused Engagement, Social Monitor/No

TABLE 1. *Interrater Reliability in a Randomly Selected Subsample of 14 Dyads*

	Cohen's κ[a]	95% Confidence Interval
Infant Engagement Phases		
Protest	0.75	0.69–0.81
Object/Environment Engagement	0.77	0.71–0.83
Social Monitor	0.83	0.77–0.87
Social Positive Engagement	0.82	0.73–0.89
Caregiver Engagement Phases		
Social Monitor/No or Neutral Vocalizations	0.70	0.63–0.76
Social Monitor/Positive Vocalizations	0.79	0.74–0.85
Social Positive Engagement	0.71	0.63–0.79

[a] $p < .001$

Vocalizations or Neutral Vocalizations, Social Monitor/Positive Vocalizations, and Social Positive Engagement.

Reliability of ICEP phases. Independent raters scored all mother–infant interactions. Coders were blind to the hypotheses of the study and to maternal psychiatric status. Infant and caregiver ICEP phases were coded twice. To ensure reliable use of the ICEP codes, raters were required to review didactic material, become familiar with the manual, and rate and review several videotapes together with the trainer. Rating discrepancies between the coder and the trainer were discussed and resolved during training. To assess interrater reliability, 23% of the videos ($n = 14$ dyads) were randomly selected and coded by two independent and trained coders. Mean Cohen's κ was used as a measure of interrater reliability (Bortz, 1992), and was 0.79 for the infant codes and 0.77 for the mothers' codes. These values are similar to those reported in previous studies (Tronick et al., 2005; Weinberg, Tronick, Cohn, & Olson, 1999). κ values for the individual infant and caregiver engagement phases are listed in Table 1. In the randomly chosen subsample of 14 dyads, Negative Engagement and Withdrawn were never coded for the infant; thus, it was not possible to compute a κ score for these codes. Similarly, the codes Negative Engagement, Hostile/Intrusive, and Withdrawn were not assigned in the subsample of caregivers; thus, it was not possible to calculate κ values.

Questionnaires/Instruments

Diagnostic interviews. Two instruments were used to diagnose maternal disorders: the SCID for Axis I (Wittchen et al., 1997) and the ICD-10 (Dilling et al., 2005). The SCID represents a standard assessment instrument. The diagnoses according to ICD-10 (which, in contrast to the SCID, is a nosology and not a standard assessment instrument) were assessed using a clinical interview conducted by trained psychiatrists. ICD-10 diagnoses of depression are considered to be comparable to *DSM-IV* diagnoses (Mombour et al., 1990; Philipp et al., 1991). In contrast to its predecessors, ICD-10 largely follows the conceptual guidelines of the *DSM-IV*, resulting in few overall differences and a good degree of comparability between the two classification systems. Of particular relevance to the present study, the ICD-10 concepts of depressive episode

TABLE 2. *Combination of Individual Engagement Phases of Mother and Infant to Form Dyadic Matches*

	Infant and Caregiver Engagement Phases Codes	
	Infant	Caregiver
Positive Match	• Social Monitor • Social Positive Engagement	• Social Monitor/Positive Vocalizations • Social Positive Engagement
Object-Related Match	• Object/Environment Engagement	• Social Monitor/No Vocalizations or Neutral Vocalizations • Social Monitor/Positive Vocalizations • Social Positive Engagement
Negative Match	• Negative Engagement • Protest • Withdrawn	• Negative Engagement • Hostile/Intrusive • Withdrawn

(F32) and receding depressive episode (F33) and the *DSM-IV* concept of major depressive episode show so many similarities that some authors have criticized the use of different terms (Mombour et al., 1990; Philipp et al., 1991).

Sociodemographic data. Each participant completed an information sheet assessing sociodemographic data such as age, number of children, and educational level.

For each patient, the SCID or the ICD-10 and the sociodemographic questionnaire were administered and applied by the same experienced clinicians. Questionnaires were administered to inpatient depressed mothers during the first week of their hospitalization. Healthy mothers were interviewed and administered the questionnaires during a visit to the laboratory.

The study protocol was approved by the independent ethics committee of the University Medical Faculty, Heidelberg. Patient confidentiality was in no way breached. Written informed consent was obtained after study procedures had been fully explained.

Data Analyses

Dependent measures. Matching states were defined as the simultaneous exhibition of the same affective-behavioral state by the mother and her infant (Tronick & Cohn, 1989; Tronick & Weinberg, 1997; see Appendix B for the individual-engagement-code data). There were three types of matches, reflecting the fact that both exchange with a social partner and mutual engagement with inanimate objects were classified as coordinated states (see Table 2 for detailed information on the combination of individual engagement phases of mother and infant to form dyadic matches).

- *Positive match:* Infant and mother are involved in social play, and the dominating affect quality is positive. We considered it important to conduct the analyses without the neutral caregiver code *social monitor/neutral vocalizations* since the frequent occurrence of this code may indicate less sensitive maternal interactive behavior (e.g., criteria for

social monitor/neutral vocalizations is the absence of a positive tone while speaking with the infant). The neutral infant code *social monitor*, which is based on the infant's direction of gaze, can be seen as a clearly positive interaction signal; infant gaze avoidance is seen as a risk factor in later cognitive development (Laucht, Esser, & Schmidt, 2002).

- *Object-related match:* The infant attends to or plays with an object while the mother shows infant-related positive or neutral engagement. Objects include the infant's hands, feet, stomach, or clothing; the mother's body (e.g., trunk, hands, jewelry); and objects that are part of the laboratory setting (e.g., chair strap, side of the chair, cameras, or curtains). The caregiver's face does not constitute an object.
- *Negative match:* Infant and mother show parallel negative engagement. The infant displays protest or withdrawn behavior in the interaction with his or her mother and the mother matches the infant's affective-behavioral state by showing intrusive, hostile, or withdrawn behavior.

Despite a planned analysis of *negative matches*, this was not possible due to their infrequent occurrence across the entire sample. While negative engagement was shown by infants of both healthy mothers (play: 6% of time; reunion: 13% of time) and depressive mothers (play: 5% of time; reunion: 16% of time), negative maternal engagement was coded only in the depressive group (play: 3% of time; reunion: 4% of time). The percentage of time in which mothers and infants were assigned negative codes was thus very low and temporally too uncoordinated to enable a calculation of the percentage of time in which dyadic negative matching was evident (for further details, see the Discussion).

The following dependent measures were calculated for each of the two remaining matching types (positive matches and object-related matches):

- *Proportion of Matching States:* The proportion of time in which matching states were shown was calculated by dividing the total time in which matching occurred by the total length of the play and reunion episode, respectively.
- *Reparation Rate:* This is the change from a mismatching state to a matching state, and was calculated using the absolute frequency/phase.
- *Interactive-Repair Latency:* Interactive repair is defined as the time span from match offset to match onset. Interactive-repair latency was calculated as the average mismatch duration (i.e., the average time span between the end of one match and the start of the next match).
- *Latency of First Match:* This variable was calculated as the time in seconds needed by dyads to establish their first matching state.

Statistical tests. Using the ICEP, mother–infant interactions were analyzed second by second and on an event-coding basis. Behavior intervals were derived based on the completely coded time stream. Dependent measures were analyzed in a 2 (depressed vs. healthy

group) × 2 (play vs. reunion episode) design. Parametric methods (e.g., multivariate analysis of variance) could not be used due to highly skewed distributions (e.g., floor effects in maternal negativity) and heterogeneous variances. Accordingly, nonparametric tests were applied, with the Mann–Whitney test (Lehmann, 1998) used for group comparisons of one dependent variable and the multivariate generalized Wilcoxon test for the group comparison of more than one dependent variable (Lachin, 1992; Wei & Lachin, 1984). The multivariate generalized Wilcoxon test is a directional test (i.e., test for stochastically ordered hypotheses) and is based on a multivariate generalization of the Wilcoxon–Mann–Whitney test. To discern potential Episode × Group interaction effects, such as whether dyads with depressed mothers showed different changes from the play to the reunion episode as compared with healthy dyads, differences between the play and the reunion episode were calculated, and group comparisons of these differences were conducted using nonparametric tests (e.g., Mann–Whitney test). To detect trends over monotonously ordered groups (e.g., nondepressed vs. depressed vs. depressed + comorbid mothers), the Jonckheere–Terpstra test (JT) was applied (Lehmann, 1998).

We calculated the Kaplan–Meier estimator (Cox & Oakes, 1984) to analyze differences between the latency of the first match in the play versus the reunion episode and log-rank tests (Kalbfleisch & Prentice, 1980) for group comparisons of latency.

The influences of infant gender, infant age, and maternal education were tested in an exploratory manner using mixed linear models (SAS mixed procedure; i.e., models that permit data to exhibit nonconstant variability; SAS, 2005). A covariance analysis (ANCOVA) was performed to replicate effects of depression when including child age as a covariate (ANCOVA; Winer, Brown, & Michels, 1991). Differences between mothers with and without medication and with and without a comorbid disorder (mostly anxiety) were descriptively analyzed using the multivariate rank test (Wei & Lachin, 1984). All calculations were performed using SPSS (2003) and SAS (2005).

RESULTS

Analysis of Matching Data

Proportion of matching states. With regard to positive matches, healthy mothers and their infants showed a higher degree of interactive coordination as compared with depressed mothers and their infants (see Table 3). Dyads with depressed mothers showed significantly lower proportions of positive matches in the play episode. Changes between the play and the reunion episodes did not significantly differ between groups with respect to positive or object-related matches. However, a trend was observed for object-related matches, with depressed mothers showing a higher percentage of matching than did healthy dyads in the play episode and a lower percentage of matching than did healthy dyads in the reunion episode.

Reparation rate. The rate with which mismatching states were repaired into positive matches was lower among dyads with depressed mothers as compared with those with healthy mothers (see Table 4). This group difference applied both globally and to repair rates calculated separately for the reunion phase.

TABLE 3. *Mean Proportions of Positive and Object-Related Matching States in Percent According to Episode (Play vs. Reunion) and Group (Healthy vs. Depressed Mothers)*

	Positive Match		Object-Related Match	
	Dyads With Healthy Mothers	Dyads With Depressed Mothers	Dyads With Healthy Mothers	Dyads With Depressed Mothers
Play Episode				
M	33	17	44	53
SE	4	4	5	5
Reunion Episode				
M	32	24	5	45
SE	4	5	5	5
Episode Difference (*Z*)[a]				
Play		−3.05**		−1.3
Reunion		−1.66		−.78
Play to reunion change (Z)[b]		−1.76		−1.74
Global group difference (Z)[c]		2.56**		−.18

[a]Group difference in each phase (two-sided Mann–Whitney test); [b]group difference in change values (reunion-differences − play-differences) from play to reunion episode (two-sided Mann–Whitney test); [c]group difference in combined play and reunion episodes are included (two-sided multivariate Wilcoxon test).
$^{*}p \leq .05$. $^{**}p \leq .01$. $^{***}p \leq .001$.

TABLE 4. *Mean Reparation Rate for Positive and Object-Related Mismatches According to Episode (Play vs. Reunion) and Group (Healthy vs. Depressed Mothers)*

	Positive Match		Object-Related Match	
	Dyads With Healthy Mothers	Dyads With Depressed Mothers	Dyads With Healthy Mothers	Dyads With Depressed Mothers
Play Episode				
M	7.8	5.3	8.2	7.4
SE	.8	.7	1.0	.9
Reunion episode				
M	8.6	6.1	8.6	8.5
SE	.8	1.0	.7	1.0
Episode Difference (Z)[a]				
Play		−1.83		−.16
Reunion		−1.96*		−.09
Play to Reunion Change (Z)[b]		−.18		−.13
Global Group Difference (Z)[c]		2.21*		.15

[a]Group difference in each phase (two-sided Mann–Whitney test); [b]group difference in change values (reunion-differences − play-differences) from play to reunion episode (two-sided Mann–Whitney test); [c]group difference in combined play and reunion episodes are included (two-sided multivariate Wilcoxon test).
$^{*}p \leq .05$. $^{**}p \leq .01$. $^{***}p \leq .001$.

TABLE 5. *Mean Latency of Interactive Repair in Seconds (i.e., mean length of time from mismatch to match) According to Episode and Group*

	Positive Match		Object-Related Match	
	Dyads With Healthy Mothers	Dyads With Depressed Mothers	Dyads With Healthy Mothers	Dyads With Depressed Mothers
Play Episode				
M	9.7	16.7	8.2	6.0
SE	1.3	2.8	1.4	1.2
Reunion Episode				
M	9.5	9.3	6.0	7.5
SE	1.2	1.4	1.0	1.3
Episode Difference (Z)[a]				
Play	−2.23*		−1.29	
Reunion	−.11		−1.17	
Play to Reunion Change (Z)[b]	−1.78		−2.58**	
Global Group Difference (Z)[c]	.03		.47	

[a]Group difference in each phase (two-sided Mann–Whitney test); [b]group difference in change values (reunion-differences − play-differences) from play to reunion episode (two-sided Mann–Whitney test); [c]group difference in combined play and reunion episodes are included (two-sided multivariate Wilcoxon test).
* $p \leq .05$. ** $p \leq .01$. *** $p \leq .001$.

Interactive-repair latency. There were no overall group differences in the latency of mismatch repairs (see Table 5). However, in the play episode, dyads with depressed mothers took significantly longer to repair mismatches into positive matches as compared with the control dyads. Group differences also were observed between the play and reunion phases with respect to object-related matching reparations. Dyads with healthy mothers terminated matching gaps faster in the reunion phase than they did in the play phase whereas dyads with depressed mothers needed more time for interactive repair in the reunion as compared with the play phase.

Latency of first match. There were significant group differences in the latency of first match (see Figure 1). Within the first 3 s, 50% of the control dyads were in a positive matching state in both the play and reunion episodes. In contrast, 50% of the dyads with depressed mothers showed positive matching states after 12 s in the play episode and after 18 s in the reunion episode. These differences can be seen in the flatter slope of the Kaplan–Meier curves for dyads with depressed mothers (Figure 1). Group differences between the curves were significant in the play episode, $\chi^2(1, n = 62) = 3.7$, $p = .05$, and in the reunion episode, $\chi^2(1, n = 62) = 10.7$, $p = .001$.

For object-related matches (see Figure 2), there was no significant difference between the curves of the two groups in the play episode, $\chi^2(1, n = 62) = 2.4$, $p = .122$, or the reunion episode, $\chi^2(1, n = 62) = .6$, $p = .43$. In the play episode, 50% of both groups showed object-related matches after 1 s. In the reunion episode, it took 4 s for 50% of dyads with healthy mothers to show object-related matches, and 3 s for dyads with depressed mothers.

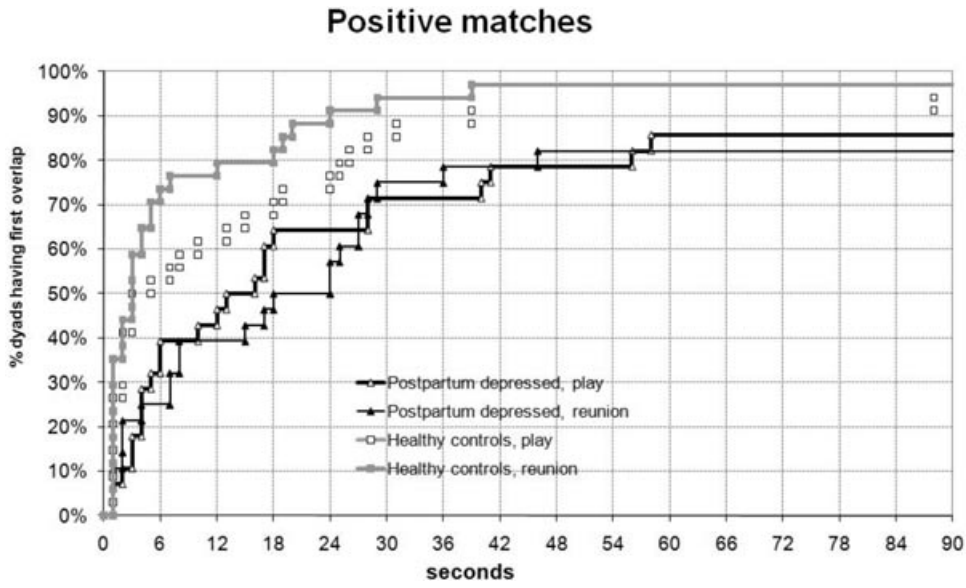

FIGURE 1. Cumulative probability of first onset of positive dyadic match according to episode and group (Kaplan–Meier method).

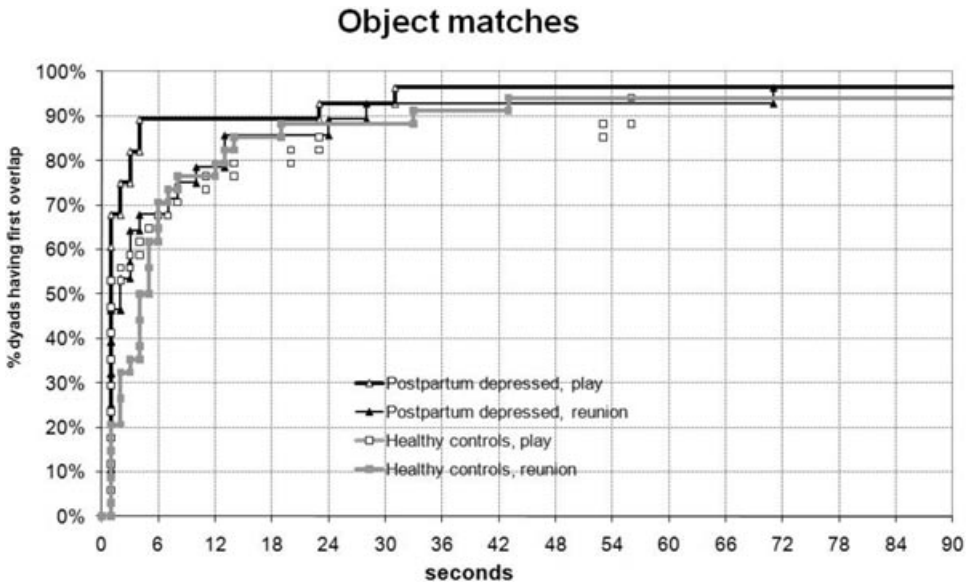

FIGURE 2. Cumulative probability of first onset of object-related dyadic match according to episode and group (Kaplan–Meier method).

Effects of Confounders

We found almost no correlations between independent or dependent variables and maternal education, positive matches: $r = 0.21$, $p = .11$; object matches: $r = 0.1$, $p = .44$, infant gender, positive matches: $r = -0.03$, $p = .80$; object matches: $r = -0.14$, $p = .30$, or even infant age and positive matches, $r = -0.06$, $p = .66$. One exception was that object matches were found to be higher with increasing infant age, $r = 0.43$, $p < .001$. An ANCOVA, however, revealed no between-group effect when infant age was included as a covariate, $F = 0.10$, $p = .753$. Based on this lack of effects, we concluded that interactional differences between dyads with depressed mothers and those with healthy mothers were not dependent on third variables.

An exploratory power analysis revealed that the sample sizes in the present study are large enough to show that covariate-associated differences—which were well below 10% (e.g., in matching percentage, with respect to gender, education, age, etc.)—may be regarded as equivalent with sufficient power (>0.90, power analysis of two-sample t test for testing equivalence using differences).

Effects of Psychiatric Comorbidity and Medication

Overall, we found no associations between interaction patterns and psychotropic medication. There was no correlation between interactional parameters and all forms of medication, point-biserial correlation for positive matches: $r = 0.09$, $p = .65$; object matches: $r = -0.30$, $p = .13$, or antidepressant medication, positive matches: $r = -0.07$, $p = .72$; object matches: $r = -0.14$, $p = .47$.

Differences in interaction patterns were found, however, with respect to comorbidity. Mothers with comorbid disorders showed a significantly lower proportion of positive matches as compared with healthy controls, play: $z = -2.98$, $p < .01$; reunion: $z = -1.87$, $p = .03$. Since the majority of mothers with a comorbid disorder were diagnosed with anxiety disorders ($n = 14$), we also tested the effect of comorbidity for this specific group; these mothers also showed a significantly lower proportion of positive matches compared to that of healthy mothers, play: $z = -3.81$, $p < .01$; reunion: $z = -2.73$, $p < .01$.

With respect to positive matches, there were significant trends (test for monotonous trend over groups: controls, depressed, depressed + comorbidity). There was a positive-matching decrease for the play phase, JT $= -3.79$, $p < .01$, and for the reunion, JT $= -2.13$, $p = .03$. There were no trends in object matches.

DISCUSSION

The present study provides new insights into the microanalytical characteristics of mother–infant interaction in an inpatient sample of depressed mothers and their infants. No previous study has videotaped a hospitalized sample engaging in the FFSF while in a current episode of depression; therefore, this is the first study to have maximized the temporal proximity between depression diagnosis and videotaped interactions. Moreover, very few studies have analyzed microanalytical patterns in the mother–infant dyad (e.g., interactive-repair latency or latency to first match) or examined effects of depression with respect to the different episodes of the FFSF.

Our findings on coordination confirm the primary hypothesis that dyads with depressed mothers show poorer positive affective matching. Compared to the group of depressed mothers, control mothers displayed significantly more positive matched behavior with their infants, both globally and in the play episode. The microanalytical evaluation of specific patterns of dyadic coordination revealed a clear association between current postpartum depression and the capacity for repairing states of miscoordination. The rate with which mismatching states were repaired into positive matches was lower in the group of depressed mothers as compared with that of the control group, both globally and in the play episode. Coordination problems in dyads with depressed mothers also were evident in the increased length of time which they needed to repair mismatching states back to positive matching states in the play episode (interactive-repair latency). Compared to healthy controls, depressed mothers and their infants also took more time to initiate their first positive and object-related matches at the beginning of play and reunion episodes (latency of first match).

The finding that depressed mothers and their infants show less positive matching behavior is in accordance with a study by Feldman (2007), in which fewer positive interactions were found between infants and their depressed mothers. The poorer interactive coordination and reparatory organization of moment-by-moment interactions observed in the clinical as compared to the nonclinical group may carry negative implications with regard to the development of infants' sense of control and interactive skills. Infants in this group are likely to feel more helpless in overcoming negative affective states of their own and the dyad.

In contrast to the findings of Weinberg et al. (2006), our data revealed no significant interaction effects between infant gender, maternal depression, and still-face episode; however, Weinberg et al. did not employ a clinical diagnosis of major depression, and depression mood ratings were 4 weeks old. In their study, maternal mood ratings were assessed when infants were 2 months old, and video assessment took place 4 weeks later when infants were thus 3 months old whereas dyads in our study were videotaped while mothers were in a current depressive episode. Interestingly, the effects of depression in our study, in contrast to those of Weinberg et al.'s study, were particularly evident in the play phase and not in the reunion phase (see positives matching and interactive-repair latency). This may indicate that depressed mothers put in more effort, are more attentive and sensitive, and are more comparable with a control group following the stress of the still-face phase. This finding warrants further evaluation in future studies.

There was no significant association between the quality of mother–infant interaction and medication. The fact that only 75% of our depressed sample received psychotropic medication may reflect a tendency of women in the postpartum period to refuse medication because of their desire to breastfeed and their concerns that simultaneously using antidepressants may cause harm to their infants. With respect to comorbidity, however, there were significant trends (controls, depressed, depressed + comorbidity) with decreasing positive matches in comorbid patients.

Several limitations of the present study should be noted. First, although typical of many microanalytical studies, our sample size was relatively small. In addition, analysis of negative matches was limited by a lack of negative-code occurrences. This limitation may result from a deficient graduation of negative-behavior codes in the ICEP system, where the various engagement codes are defined very strictly; it is, for instance, not possible to code mere maternal

overstimulation. In line with this, the ICEP data of a large sample of cocaine-exposed and nonexposed infants collected by Tronick et al. (2005) have indicated a low representation of negative ICEP codes. These findings have confirmed the reduced ability of the ICEP to capture negative interaction behavior, in particular on the part of the mother. Furthermore, the low degree of negativity in our study might reflect a general tendency of relevant studies to infrequently code negativity. Weinberg et al. (2006), for example, generated a dyadic negative-matching category which is comparable to that examined in our study, with negative matching indicating that both mother and infant displayed negative affect at the same time. They found that negative affect was shown 18% of the time across the whole infant group and 6% of the time across the group of mothers. These findings are comparable with those reported in the current study. A further important point with regard to the lack of negative findings in our microanalytical approach might be that the frequency with which negativity is coded potentially varies according to the coding system used. Studies which have coded a greater degree of negative interaction behavior would appear to have employed macroanalytical approaches (e.g., Feldman, 2007; Field et al., 1988; Field et al., 1986) in which low negativity thresholds (e.g., maternal intrusiveness) were applied.

A further limitation of the present study is that other factors (e.g., parental genetic contributions, income, life events) which were not considered may be responsible for the relationship between depression and dyadic interaction behavior.

While variation in infant age was larger than desired, a high degree of variation was inevitably introduced by the employed selection criteria of current depressed mothers being hospitalized together with their infants. Since ANCOVAS revealed that depression-related effects persisted after controlling for infant age, the current study indicates a generalizability of the relationship between impaired mother–infant interaction and postpartum depression across a range of infant ages.

CONCLUSION

The present findings provide new insights into the dyadic microanalytical characteristics of clinically depressed inpatient mothers and their infants in the context of the FFSF paradigm. Long-term studies are required to increase understanding of the developmental consequences of diminished levels of dyadic coordination and interactive repair for infant behavior, physiology, and cognitive processes (Abelkop & Frick, 2003). Future studies should focus on the long-term course of postpartum depression to guide specific mother–infant- and also father–infant-centered interventions. Our findings suggest that interventions should take aspects of dyadic organization into account and that it may be fruitful to focus on reparation processes. From a clinical perspective, the potentially negative effect of specific patterns of mother–infant interaction on infant learning processes (Stanley et al., 2004) as well as affective development (Jaffe, Beebe, Feldstein, Crown, & Jasnow, 2001) means that in addition to therapy for maternal depression, interventions focusing on the mother–infant dyad also should be considered when treating depressed inpatient mothers and their infants. In the future, the application of video-supported therapy techniques, which can be used to enhance maternal self-efficacy experiences by providing feedback on maternal competencies and also to improve mother–infant interaction would appear

to represent a promising approach. Such interventions may help to prevent developmental disorders when implemented in the first months of life.

APPENDIX A: INFANT–CAREGIVER ENGAGEMENT PHASES

Infant Engagement Phases

Negative Engagement: The infant is in a negative affective state and must display negative facial expression and/or crying vocalizations. Negative engagement is coded if it is impossible to differentiate between "Protest" and "Withdrawn."

Protest: The infant is protesting and often displays facial expressions of anger or is crying.

Withdrawn: The infant is minimally engaged with the caregiver and often shows a sad facial expression and/or whimpering vocalizations.

Object/Environment Engagement: The infant looks at distal or proximal objects while displaying an interested or a neutral facial expression.

Social Monitor: The infant looks at the adult's face with a neutral or an interested facial expression.

Social Positive Engagement: The infant looks at the adult's face while displaying a facial expression of joy.

Caregiver Engagement Phases

Negative Engagement: The adult is negative, intrusive, hostile, or withdrawn. Negative Engagement is coded if it is impossible to differentiate between "Hostile/Intrusive" and "Withdrawn."

Hostile/Intrusive: The adult's interactive style is characterized by behavior ranging from annoyance to aggression and hostility. Typically, a tense or an angry facial expression is displayed. The adult's voice may sound loud and angry.

Withdrawn: The adult is minimally engaged with the baby. Typically, a sad or flat facial expression is displayed. The adult may be silent or speak in a flat, monotone voice.

Non-Infant-Focused Engagement: The adult is involved in a non-infant-focused activity.

Social Monitor/No Vocalizations or Neutral Vocalizations: The adult watches the baby while his or her facial expressions are neutral. The adult can be silent or vocalize to the baby in a neutral manner.

Social Monitor/Positive Vocalizations: The caregiver's gaze is focused on the infant. Although his or her facial expressions are neutral, she vocalizes to the baby in a positive manner (e.g., she may use "baby talk").

Social Positive Engagement: The caregiver expresses positive affect such as laughter and vocalizes to the baby in a positive tone.

APPENDIX B

Mean Proportions of Individual-Engagement-Phase Data in Percent According to Episode (Play vs. Reunion) and Group (Healthy vs. Depressed Mothers)

	Dyads With Healthy Mothers		Dyads With Depressed Mothers	
	Play Episode	Reunion Episode	Play Episode	Reunion Episode
Infant Protest				
M	6	12	5	14
SE	3	4	4	5
Infant Withdrawn				
M	–	1	–	2
SE	–	1	–	1
Infant Object/Environment Engagement				
M	45	5	56	5
SE	5	5	5	6
Infant Social Monitor				
M	36	37	25	34
SE	5	5	5	6
Infant Social Positive Engagement				
M	9	8	4	5
SE	2	3	1	1
Mother Hostile/Intrusive				
M	–	–	–	1
SE	–	–	–	1
Mother Withdrawn				
M	–	–	3	3
SE	–	–	2	2
Mother Social Monitor/No or Neutral Vocalizations				
M	27	34	42	41
SE	4	5	5	5
Mother Social Monitor/Positive Vocalizations				
M	55	67	43	51
SE	4	4	5	6
Mother Social Positive Engagement				
M	11	11	6	7
SE	2	3	1	2

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