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Associations of maternal postpartum depressive and anxiety symptoms with 4-month infant and mother self- and interactive contingency of gaze, affect, and touch

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Abstract

Maternal depression and anxiety are associated with infant and mother self- and interactive difficulties. Although maternal depression and anxiety usually co-occur, studies taking this comorbidity into account are few. Despite some literature, we lack a detailed understanding of how maternal depressive and anxiety symptoms may be associated with patterns of mother–infant interaction. We examined associations of maternal postpartum depressive and anxiety symptoms with infant and mother self- and interactive patterns by conducting multi-level time-series models in a sample of 56 Turkish mothers and their 4-month infants. Time-series models assessed the temporal dynamics of interaction via infant and mother self- and interactive contingency. Videotaped face-to-face interaction was coded on a 1s time base for infant and mother gaze and facial affect, infant vocal affect, and mother touch. Results indicated that mothers with high depressive symptoms were vulnerable to infants looking away, reacting with negative touch; their infants remained affectively midrange, metaphorically distancing themselves from mothers' affect. Mothers with high anxiety symptoms were vulnerable to infants becoming facially dampened and mothers reacted with negative facial affect. Altered infant and mother self-contingency patterns were largely opposite for maternal depressive and anxiety symptoms. These patterns describe foundational processes by which maternal postpartum mood is transmitted to the infant and which may affect infant development.

Keywords: Maternal postpartum depressive symptoms; Maternal postpartum anxiety symptoms; Mother–infant face-to-face communication; Microanalysis; Self- and interactive contingency; Temporal dynamics of interaction

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Introduction

Postpartum mothers with depressive symptoms commonly have some anxiety symptoms; similarly, postpartum mothers with anxiety symptoms commonly have some depressive symptoms (Farr et al., 2014; Feldman, 2007a; Reck et al., 2008). But studies taking this comorbidity into account are few (see Field, 2018). Examining the temporal dynamics of mother–infant face-to-face interaction at 4 months, we aim to evaluate the contributions of depressive and anxiety symptoms to infant and mother interactive patterns, in a Turkish sample. By including the high depressive and high anxiety symptom groups in the same statistical models, any overlap of the associations of high depressive and anxiety symptoms with mother–infant interaction was accounted for. The 4-month mother–infant face-to-face interaction is a window of opportunity to identify altered interactive micro-processes which predict later infant development in the context of maternal postpartum risk (Beebe et al., 2010; Feldman, 2007b; Jaffe et al., 2001).

Maternal postpartum depression is the least diagnosed mental health disorder (Ko et al., 2012), although its prevalence is high, ranging from 18% to 40% (Field, 2010; Hahn-Holbrook et al., 2018). The prevalence of maternal postpartum anxiety is similarly high, ranging from 13% to 40% (Field, 2018; Wisner et al., 2013). Moreover, postpartum maternal depressive and anxiety symptoms have implications for infant development beyond the postpartum period (Beeghly et al., 2017). Infants of mothers with depression and anxiety are at risk for problematic developmental trajectories. Infants of mothers with depression are more vulnerable to self-regulation difficulty in the first year (Granat et al., 2017; Krzeczowski et al., 2021); lower attachment security in toddlerhood (Beeghly et al., 2017; Murray, 1992); lower social, cognitive, and language development in the first 3 years (Murray & Cooper, 1997; Slomian et al., 2019); and less social engagement and empathy, and higher psychopathology symptoms, at age 6 years (Apter-Levy et al., 2013). Infants of mothers with anxiety are also at risk for less optimal developmental outcomes, such as compromised socio-emotional, language, cognitive, and motor development (Ali et al., 2013; Field, 2018), and more internalizing/externalizing symptoms (Barker et al., 2011; Glasheen et al., 2010). Thus, high prevalence rates and lasting effects on infant development underline the importance of depressive and anxiety symptoms in the postpartum period.

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Self- and interactive difficulties associated with maternal depression and anxiety

During face-to-face interactions, mothers with high depressive symptoms are at risk for more variability in gaze and affect (Beebe *et al.*, 2008), either withdrawn or intrusive touch patterns (Beebe *et al.*, 2008; Feldman, 2011; Field, 2010; Mantis *et al.*, 2019), lower contingent gaze coordination with infant gaze (Beebe *et al.*, 2008; Feldman, 2007b), lower likelihood of affectionate touch during moments of mutual gaze (Feldman, 2007b; Granat *et al.*, 2017), less positive and more neutral affect (Aktar *et al.*, 2017), and a vigilant facial affect interactive coordination (Beebe *et al.*, 2008). During face-to-face interaction, their infants are at risk for difficulties such as more variability in gaze and facial affect (Beebe *et al.*, 2008; Væver *et al.*, 2020), sustained gaze-off behavior (Væver *et al.*, 2020), blunted affect (Aktar *et al.*, 2017), more self-soothing behaviors while engaging with mother (Manian & Bornstein, 2009), lower interactive coordination in gaze (Beebe *et al.*, 2008; Feldman, 2007b; Granat *et al.*, 2017), and lower responsiveness (Field, 2018; Reck *et al.*, 2018).

During face-to-face interaction, mothers with high anxiety symptoms are at risk for exaggerated, intrusive and over-engaged/controlling maternal behavior (Kaitz *et al.*, 2010), highly stimulating interactive behavior in gaze and affect (Feldman, 2007b; Granat *et al.*, 2017), and altered mother touch variability (Beebe *et al.*, 2011). Beebe *et al.* (2011) also documented maternal vigilant visual monitoring of the infant while withdrawing from coordinating with infant affect, suggesting a picture of anxious mothers as over-aroused or fearful, which may lead to vigilance, but adapting to their arousal or fear through emotional distancing. During face-to-face interaction, infants of anxious mothers are at risk for longer durations of gaze at the mother and increased emotionality (Aktar *et al.*, 2017), altered vocal affect variability (Beebe *et al.*, 2011), both higher (Beebe *et al.*, 2011) and lower infant engagement (Feldman *et al.*, 2009; Stein *et al.*, 2012), and engaging with less positive and more negative affect (Crugnola *et al.*, 2016; Reck *et al.*, 2018). Thus, both maternal depressive and anxiety symptoms have been associated with self- and/or interactive difficulties through different communication channels such as gaze, affect, and touch.

Comorbidity of maternal depression and anxiety

Although maternal postpartum depressive and anxiety conditions are generally comorbid risk factors (Farr *et al.*, 2014; Feldman, 2007a; Reck *et al.*, 2008), many studies do not take comorbidity into account. Thus, comorbidity may have confounded prior findings. However, some recent studies have addressed comorbidity. When analyzing the effects of maternal depression and anxiety on mother–infant interaction, two approaches to comorbidity have involved forming separate groups of mothers with depression and mothers with anxiety; or controlling statistically for one symptom level (e.g., maternal anxiety) in order to identify the contributions of the other symptom level (e.g., maternal depression). For example, while statistically controlling each risk for the other, Crugnola *et al.* (2016) examined associations of maternal anxiety symptoms and depressive symptoms with mother–infant face-to-face interaction at infant age 3 months. Analyzing both risk factors together, only anxiety symptoms showed significant associations. Maternal anxiety symptoms were associated with increased maternal negative affect and shorter duration of

maternal positive affect, longer duration of infant negative affect, and more dyadic affective mismatches (infant negative–mother positive). Assellmann *et al.* (2018) examined 3 groups: mothers with lifetime anxiety-only (without depression), lifetime depression-only (without anxiety), and comorbid lifetime anxiety and depression. The infants of mothers with lifetime anxiety-only and infants of mothers in the comorbid group (but not infants in the depression-only group) showed more object-touch and distancing behavior in the reunion episode of the still-face paradigm at 4 months, interpreted as an infant adaptation to heightened stress.

Whereas the above studies identified interaction patterns associated primarily with anxiety, some studies addressing comorbidity have identified *different* interactive difficulties associated with maternal depression and anxiety. Feldman (2007b) documented that mothers with clinical depression and their infants showed lower levels of synchrony in three modalities: lower mutual gaze, less co-vocalization, and lower coordination of mother touch with moments of mutual gazing, creating a cycle of disengagement, flat affect, and no affect sharing. Feldman also documented that mothers with clinical anxiety had a highly stimulating behavioral profile: not allowing the infant moments of down-regulation, such as moments of no vocalization, neutral affect, or gaze aversion. Examining 9-month mother–infant interaction in the same data set, Granat *et al.* (2017) compared 3 groups of mothers: depression-only diagnosis (anxiety screened out), anxiety-only diagnosis (depression screened out), and a control group (no anxiety or depression diagnosis). Both depression and anxiety diagnosis groups showed risk, but the depression group showed greatest risk: the lowest probability of mutual gaze and “touch synchrony” (mutual gaze with mother affectionate touch), which suggests a withdrawn interactive style. The control group showed a midrange probability of these behaviors, and the anxiety group showed the highest probability, which suggests a highly arousing interactive style. In a study of mother–infant interaction at 3–5 months, Aktar *et al.* (2017) examined total lifetime maternal depressive symptoms, and total lifetime maternal anxiety symptoms, with each risk statistically controlling for the other. Higher lifetime maternal depressive symptoms were associated with longer durations of flat/neutral affect in mothers and infants. In contrast, higher lifetime maternal anxiety symptoms were associated with longer infant durations of positive and negative affect, and longer infant gaze-on behavior. Despite a few studies which address comorbidity, we still do not have a sufficiently detailed understanding of how maternal depressive and anxiety symptoms may be associated with different patterns of mother–infant interaction, our goal.

Temporal dynamics of 4-month mother–infant interactions

Contingent patterns of mother–infant interaction establish the foundation of infant development in socio-emotional, cognitive, and regulatory domains (Beebe *et al.*, 2010; Feldman, 2007a; Messinger *et al.*, 2012; Tronick & Beeghly, 2011). Contingency is defined as a temporal relation between events that involves sequential constraint (Tarabulsky *et al.*, 1996). From the first months of life, infants detect the predictability of events, and temporally contingent “if-then” sequences of behavior; and they generate expectancies of what will happen next, in the self and in the partner (Haith *et al.*, 1988; Sameroff, 2010). They are sensitive to the ways in which their behaviors are contingently responded to (Bigelow & Power, 2014; Lavelli & Fogel, 2002). Contingent

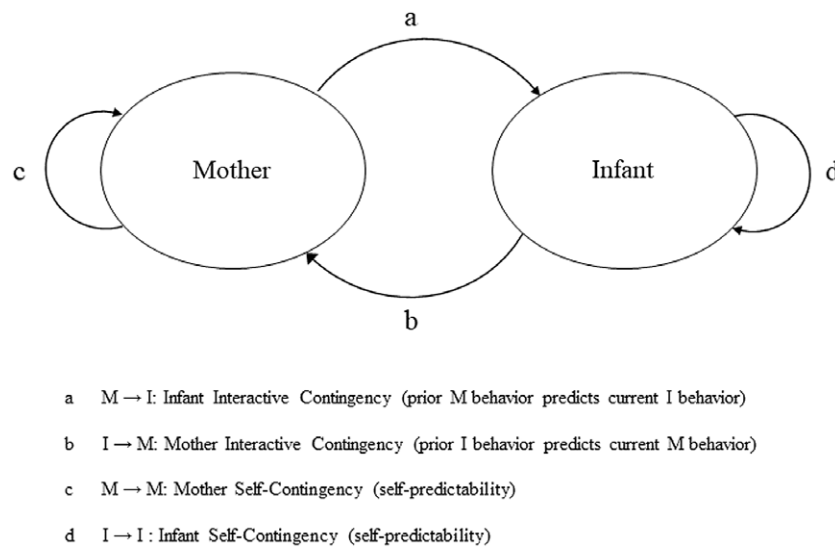


Figure 1. Illustration of self- and interactive contingency

processes of early interactions shape infant communicative capacity, information processing, and the procedural representation of interpersonal events (Beebe et al., 2010; Bornstein & Manian, 2013; Feldman, 2007a; Jaffe et al., 2001).

We use a dyadic systems view of communication examining the contributions of self- and interactive contingent processes in both infant and mother (Beebe et al., 2016). Sameroff (1983, 2010) also viewed self-regulatory and other-regulatory activity as intimately related, and he argued that they should be considered elements of a single system (see also Fogel, 1993). To operationalize self- and interactive contingency during face-to-face interaction, we code infant and mother behaviors second-by-second in different communication modalities (gaze, affect, touch), generating multiple time-series of high temporal resolution, and we define self- and interactive contingency using time-series models (Beebe et al., 2016, 2018, 2020). This approach addresses the *temporal dynamics* of interaction, the contingent process of relating from moment-to-moment.

Each individual coordinates with the partner's behavior, termed interactive contingency (lagged cross-correlation), while also regulating her own behavior with variations in self-predictability, termed self-contingency (autocorrelation) (see Figure 1) (Beebe et al., 2010, 2016). Interactive contingency measures the individual's likelihood of adjusting his/her behavior to the partner's just prior behavior. It generates interpersonal expectations of "how I affect you" and "how you affect me" (Beebe et al., 2010). Self-contingency measures the individual's likelihood of maintaining (or changing) behavior from moment-to-moment (Beebe et al., 2016; Messinger et al., 2012). It provides a way of procedurally sensing where one's own behavior is tending in the next second, generating expectancies of degree and pattern of self-variability. As an example, infant facial affect interactive contingency measures adjustments the infant is likely to make following the mother's just prior behavior, from moment-to-moment; infant facial affect self-contingency measures how predictably infant degrees of positive to negative facial expressions unfold from moment-to-moment. These contingency processes are rapid and largely out of awareness. Whereas most prior research has examined maternal interactive contingency, much less research has examined infant interactive contingency, and relatively little research has addressed self-contingency (for exceptions see Beebe et al., 2008, 2010, 2011, 2016, 2018, 2020; Chow et al., 2010; Lavelli et al., 2022; Messinger et al., 2012).

Interactive Contingency: The Optimum Midrange Model.

Both heightened and lowered interactive contingencies have been associated with insecure attachment, or disorganized attachment, and midrange values with secure attachment (Beebe et al., 2010; Jaffe et al., 2001; Mitsven et al., 2021). Similarly, Bornstein and Manian (2013) showed that midrange contingent coordination was associated with optimal maternal sensitivity. Thus, in an *optimal midrange model*, both heightened (vigilant) and lowered (withdrawn) contingency has indexed social distress or risk (see also Granat et al., 2017; Kaitz & Maytal, 2005), or less maternal sensitivity (Beebe & Steele, 2013).

Self-Contingency. Lower self-contingency indexes a more varying process; higher self-contingency indexes a more predictable, less varying process. Prior work indicated that infant and mother lower self-contingency was in general associated with maternal depression (Beebe et al., 2008), anxiety (Beebe et al., 2011), self-criticism and dependency (Beebe et al., 2007), infant prematurity (Beebe et al., 2018; Lavelli et al., 2022), 12-month infant insecure attachment patterns (Beebe et al., 2010), and the trauma of being pregnant and widowed on 9/11 (Beebe et al., 2020).

Examining maternal postpartum high (vs. low) depressive symptoms and 4-month face-to-face interaction with a temporal dynamics approach, Beebe et al. (2008) documented altered 4-month self- and interactive contingency patterns. The possible comorbidity of maternal anxiety was not considered. Specifically, infants of mothers with high (vs. low) postpartum depressive symptoms had lowered contingent gaze coordination with mother gaze. Mothers with high postpartum depressive symptoms had similarly lowered contingent gaze coordination with infant gaze, but also heightened contingent facial affect coordination with infant facial affect. This interactive contingency picture provides an example of the midrange model: both lowered (withdrawn) coordination in gaze, and heightened (vigilant) coordination in facial affect, indexed depression risk. Their self-contingency patterns of gaze, facial affect, and touch were more variable.

Examining 4-month maternal anxiety symptoms and 4-month face-to-face interaction with the temporal dynamics approach, without controlling for maternal depression, Beebe et al. (2011) found that infants of mothers with higher (vs. lower) anxiety symptoms had heightened contingent facial affect coordination with mother facial affect, but lowered contingent vocal affect coordination with mother touch, consistent with a midrange

model. Mothers with higher (vs. lower) anxiety symptoms had lowered facial affect coordination with infant facial affect, but heightened contingent touch coordination with infant vocal affect, consistent with a midrange model. Maternal self-contingency patterns of touch were more variable, but infant patterns of vocal affect were less variable/more predictable. Thus, findings by separate studies indicated that both maternal depressive and anxiety symptoms informed altered temporal dynamics of interaction, self- and interactive contingency.

Communication modalities of gaze, affect, and touch

Simultaneous signals in multiple communication modalities are generated during face-to-face communication and infants apprehend these multiple modalities (Beebe et al., 2010; Murray & Cooper, 1997; Tronick, 2007). In the current study, we coded infant and mother gaze (on/off partner's face), and ordinal scales (positive to negative) of infant and mother facial affect, infant vocal affect, and mother touch, second-by-second (see also Beebe et al., 2010, 2016, 2020). These are all central behaviors of mother–infant face-to-face communication (Beebe et al., 2020, 2016; Feldman, 2007b; Tronick, 1989). Of the 9 possible combinations of modality pairings, we examined four: (1) *Infant gaze-mother gaze*. Mutual gaze is the foundation of the face-to-face encounter (Stern, 1985), and in prior research this pairing generated altered interactive patterns associated with maternal depressive and anxiety symptoms (Beebe et al., 2008; Granat et al., 2017). (2) *Infant gaze-mother touch*. Mother touch may reduce infant gaze aversion (Feldman et al., 2010); altered infant gaze-mother touch interactive patterns have been associated with maternal and infant risk (see Beebe et al., 2018; Feldman, 2007b; Granat et al., 2017). (3) *Infant facial affect-mother facial affect* assesses affect sharing (Beebe et al., 2010, 2016; Messinger et al., 2012); interactive patterns in this modality pairing have been identified in the context of risk factors (Beebe et al., 2008, 2011, 2020). (4) *Infant vocal affect-mother touch*. Maternal touch may dampen infant vocal distress (Feldman et al., 2010; Montiroso & McGlone, 2020) and played a role in interactive difficulties associated with maternal anxiety (Beebe et al., 2011).

Cultural context

The majority of studies on mother–infant face-to-face interaction come from Western samples. Studies addressing early mother–infant interaction in non-Western cultures are few. The available studies suggest that it is not the presence and level of contingent maternal response that varies across individualistic and collectivistic cultures, but rather differences in maternal use of communication modalities such as gaze, facial affect, and touch, and tendencies to activate or suppress certain infant behaviors (see, e.g., Kärtner et al., 2008; Keller & Otto, 2009; Lavelli et al., 2019).

Turkey is mainly considered a non-Western collectivist culture, where intergenerational interdependence is culturally fostered, and the development of a “related self” model is adaptive. Indeed, family dynamics in Turkey are different from both typical Western and Eastern family types (Kagitcibasi & Ataca, 2005; Kagitcibasi, 2005) and reflect a blend of both collectivistic and individualistic tendencies. Modern urban Turkish families fit better with a family model of psychological interdependence (Kagitcibasi, 2007): the autonomy of the growing child is not seen as a threat to family well-being, but psychological closeness is highly valued. In urban middle-to-high-class areas of Turkey, nuclear families are widespread, but grandparent co-parenting is still common; fathers participate in

infant care more (Salman-Engin et al., 2018). Nevertheless, mothers seem to be the primary caregivers in both urban and rural areas of Turkey (Özdemir et al., 2020).

In Turkey, best described with non-Western collectivist values, maternal caregiving includes culturally adaptive levels of physical intrusiveness, proactive caregiving behaviors, and parental control (Kagitcibasi, 2005, 2007; Sümer & Kagitcibasi, 2010). Mesman et al. (2016) found that maternal beliefs about sensitive caregiving in Turkey had a high match (68%) with the ideal sensitive mother criterion in a data set including 15 countries, implying a high cross-cultural similarity. However, two recent studies also indicated some culture-specific modes of maternal sensitive caregiving in Turkey, and the influence of maternal psychological symptoms (Aran et al., 2020) and socioeconomic conditions on maternal sensitivity (Aran et al., 2021). The Turkish mothers with high psychological symptoms (Aran et al., 2020), and mothers in an economically disadvantaged sample (Aran et al., 2021), were less sensitive and contingent during interactions in home observations. Although we have some data indicating cross-cultural similarities and differences in sensitive maternal caregiving in the Turkish context, to the best knowledge of the authors, the present study is the first examination early mother–infant face-to-face interaction in a Turkish cultural context, as well as the first examination of its temporal dynamics, and its association with maternal postpartum symptoms.

Aims

We aimed to assess the associations of maternal postpartum depressive and anxiety symptoms with the temporal dynamics of 4-month interactions of gaze, affect, and touch, in a Turkish sample. To address the comorbidity of depressive and anxiety symptoms, we examined the contributions of maternal postpartum depressive and anxiety symptoms to 4-month infant and mother self- and interactive contingency patterns by conducting multi-level time-series models of which included depressive and anxiety symptoms at the same time.

This study contributes to the available literature in several ways. Whereas most mother–infant interaction research has been conducted in Western cultures (see for exceptions Bornstein et al., 2012; Hsu & Lavelli, 2005; Keller & Otto, 2009), our study provides a view from a non-Western cultural context, in a middle-class Turkish sample. We examined depressive and anxiety symptoms earlier than most studies (4–6 weeks postpartum), at a time when mothers tend to suffer more (Beeghly et al., 2017; Field, 2010, 2018). Our measure of the temporal dynamics of interaction via self- and interactive contingency, assessed through multi-level models, is relatively rare (Chow et al., 2010; Cole et al., 2004).

Hypotheses

Interactive contingency

The optimum midrange model of interactive contingency informed the hypotheses below. In this model, both poles of heightened and lowered interactive contingency may be associated with risk (see Beebe et al., 2010; Bornstein & Manian, 2013; Jaffe et al., 2001; Mitsven et al., 2021). We do not specify communication modalities of gaze, affect, and touch in the following hypotheses due to the scarcity of directly relevant research.

(1a) Based on prior work documenting that lowered infant interactive contingency, specifically lowered infant engagement with maternal engagement was associated with maternal depression (Beebe et al., 2008; Field et al., 2009; Granat et al., 2017), we

hypothesized that infants of mothers with high (vs. low) postpartum depressive symptoms will have lowered interactive contingent coordination with their mothers, a less engaged/more withdrawn interactive pattern.

(1b) Based on prior work documenting both lowered and heightened infant interactive contingency of engagement in the context of maternal anxiety (Beebe et al., 2011; Granat et al., 2017; Reck et al., 2018), we hypothesized that infants of mothers with high (vs. low) postpartum anxiety symptoms will have both lowered and heightened interactive contingent coordination (in different modalities) with their mothers.

(1c) Based on prior work documenting both withdrawn and intrusive maternal interactive patterns in the context of maternal depression (Beebe et al., 2008; Feldman, 2011; Field et al., 2009; Granat et al., 2017; Mantis et al., 2019), we hypothesized that mothers with high postpartum depressive symptoms will have both lowered and heightened contingent coordination (in different modalities) with their infants.

(1d) Based on prior work documenting vigilant interactive patterns in the context of maternal anxiety (Beebe et al., 2011; Granat et al., 2017), we hypothesized that mothers with high postpartum anxiety symptoms will show heightened contingent coordination with their infants.

Self-contingency

Prior work documented that lower self-contingency patterns have primarily been associated with risk (Beebe et al., 2008, 2010, 2011, 2020), informing the hypotheses below. We do not specify communication modalities of gaze, affect, and touch due to the scarcity of directly relevant research.

(2a) Based on prior work (Beebe et al., 2008, 2020; Vaever et al., 2020) documenting more variable self-contingency patterns in the context of maternal depression, we hypothesized that mothers with high (vs. low) postpartum depressive symptoms and their infants will have lower (more variable) self-contingency.

(2b) Based on Beebe et al. (2011, 2020) documenting primarily more variable self-contingency patterns in the context of maternal anxiety, we hypothesized that mothers with high (vs. low) postpartum anxiety symptoms and their infants will have lower (more variable) self-contingency.

Method

Participants

Fifty-six Turkish mother–infant dyads participated. All were Turkish in origin. Mothers were married, with mean age of 29.61 ($SD = 3.71$); 57.1% had a college degree. In work status, 65.5% had a full-time job, 10.9% worked from home, 1.8% were unemployed, and 21.8% were homemakers. Of 43 mothers who identified themselves working or unemployed, 87.2% were on maternity leave, and 12.8% did not plan to return to work. Although mothers were the primary caregivers of their infants, 73.2% of them indicated that fathers or extended family members were participating in infant care, and 8.9% of the dyads were living with extended family. Fathers had a mean age of 31.41 ($SD = 3.67$), and 53.6% had a college degree. Infants were first-born singletons (18 girls, 38 boys), healthy by maternal self-report, mean gestational age 38.75 weeks, mean birth weight 7 lb.; 64.3% had cesarean births, a preference of choice in Turkey (see Deniz, 2021). Sample characteristics are presented in Table 1.

Table 1. Sample characteristics

Variable	Mean (SD)	Minimum-Maximum
Maternal age (years)	29.61 (3.71)	19-40 (years)
Paternal age (years)	31.41 (3.67)	25-40 (years)
Infant gestational age (weeks)	38.75 (1.03)	37-41 (weeks)
Infant birth weight (lb.)	7 (0.28)	6.11-8.67 (lb.)
Infant age (days)	35.86 (6.59)	23-48 (days)
Variable	%	<i>n</i>
Maternal education		
High school	7.1	4
Some college	3.6	2
College graduate	57.1	32
Graduate	32.1	18
Maternal work status		
Full-time job	65.5	36
Working from home	10.9	6
Unemployed	1.8	1
Homemaker	21.8	12
Missing	–	1
Maternal postpartum work status		
On maternal leave	87.2	41
Did not plan to return to work	12.8	6
Missing	–	9
Paternal/extended family help for infant postpartum care		
Yes	73.2	41
No	26.8	15
Living conditions		
Nuclear family	91.1	51
Extended family	8.9	5
Paternal education		
Secondary school	1.8	1
High school	12.5	7
Some college	10.7	6
College graduate	53.6	30
Graduate	21.4	12
Paternal work status		
Full-time job	83.9	47
Part-time job	1.8	1
Self-employment	5.4	3
Owner of the business	8.9	5
Infant Sex		
Female	32.1	18
Male	67.9	38
Type of birth		
Cesarian	64.3	36
Normal	35.7	20

Procedures

The study was conducted according to guidelines in the Declaration of Helsinki; written informed consent was obtained from the parent prior to data collection. The Hacettepe University Ethics Committee (#35853172/431-3728) and General Directorate Public Health (#7350377/604.02) approved study procedures.

Inclusion criteria were: mothers minimum 18 years old, married, primiparous, in the postpartum period 4–6 weeks after birth. Infant inclusion criteria were: minimum 37 weeks gestational age, minimum weight 5 lb., absence of serious birth complications by nurse report, and healthy by maternal report. Turkish mother–infant dyads were recruited from local Governmental Family Health Centers in Ankara, Turkey. Nurses at the centers checked the medical records to identify dyads that fit the research inclusion criteria, contacted the mothers, and obtained permission for us to describe the research to mothers over the phone. Research assistants scheduled 4–6 week home visits with mothers who volunteered to participate.

A team of two people, the first author and a research assistant, made home visits at 4–6 weeks and watched the baby while mothers filled out self-report assessments of depressive and anxiety symptoms, as well as a sociodemographic form which determined whether a maternal psychiatric disorder requiring medication was present. When the infant turned 4 months old, mothers were invited to the 4-month lab visit to videotape mother–infant face-to-face interaction.

A total of 66 dyads were initially recruited and participated in the 4–6 week home visits. Of these 66 dyads, 57 completed the 4-month lab visit. Four of the infants had health problems following the first home visit, and 5 of the mothers did not respond to telephone calls, or were not willing to schedule a 4-month lab visit. One dyad was excluded from the sample because she used her ring as a toy during the videotaped interaction.

We investigated possible differences in maternal age and total years of education between mothers who visited the lab at 4 months and those who did not, by independent samples *t*-tests. Mothers who visited the lab at 4 months ($M = 17.63$, $SD = 3.24$) completed a higher number of years in formal education than mothers who did not visit ($M = 13.35$, $SD = 3$) ($t(64) = 3.89$, $p = .00$). A marginal statistical difference in maternal age ($t(64) = 1.85$, $p = .07$) also indicated that mothers who visited the lab at 4 months ($M = 29.61$, $SD = 3.71$) tended to be older than mothers who did not ($M = 27.20$, $SD = 4.29$).

4-6 Week Home Visit was conducted by the first author and a research assistant, when infants were mean age 35.86 days ($SD = 6.59$). Mothers filled out self-report scales. A **Socio-Demographics Form** collected information on maternal age, education, working status, and type of birth; infant gestational age, sex, birth weight, and current health status. **Maternal postpartum depressive symptoms** were evaluated with the *Center for Epidemiological Studies – Depression* (CES-D) scale (Radloff, 1977), appropriate for community samples, adapted for a Turkish sample (Tatar & Saltukoglu, 2010). **Maternal postpartum anxiety symptoms** were evaluated with the *State-Trait Anxiety Inventory* (Spielberger et al., 1970), appropriate for community samples, adapted for a Turkish sample (Öner & Le Compte, 1985). We used Trait Anxiety in the statistical analyses.

4-Month Lab Visit. Mothers were invited to bring their infants to the lab to videotape mother–infant interaction in accordance with the infant’s sleep/feeding schedule. Mothers were instructed to play face-to-face with infants as they would at home for

approximately 10 minutes, without toys. The infant was in an infant seat, and the mother was seated opposite. Two cameras, mounted on tripods, produced a split-screen view of face/upper torsos of each partner (see Figure 2).

Coding of interactive behaviors

The first uninterrupted 2.5 minutes of interaction (standard in the literature: see Beebe et al., 2008, 2011, 2016; Tronick, 2007) were coded on a 1-sec time base with ordinal behavioral scales of infant and mother gaze, infant and mother facial affect, infant vocal affect, and mother touch (see Beebe et al., 2010) by coders blind to maternal depressive/anxiety symptom groups. Table 2 presents behaviors coded. Mothers and infants were coded separately. Cohen’s Kappa assessed inter-rater agreement on 20% of the sample: *infant mean Kappa*: gaze $K = .82$; vocal affect $K = .83$; infant facial affect $K = .86$; *mother mean Kappa*: gaze $K = .84$; touch $K = .85$; facial affect $K = .86$.¹

High (vs. low) maternal depressive and anxiety symptom groups

High (vs. low) maternal depressive and anxiety symptom groups were generated. The CES-D clinical cutoff of 16+ (Radloff, 1977) was used to generate the high depressive symptom group ($n = 22$, $m = 23.091$, $sd = 6.768$), 39% of the group; mothers with scores < 16 constituted the low depressive symptom group ($n = 34$, $m = 10.735$, $sd = 3.369$). Feldman’s (2007a) suggestion of 43+ as the clinical cutoff for maternal anxiety symptoms was used to generate the high anxiety symptom group ($n = 23$, $m = 49.565$, $sd = 6.215$), 41% of the group; mothers with SAT scores < 43 constituted the low anxiety symptom group ($n = 33$, $m = 35.091$, $sd = 4.850$). Thirteen mothers scored high on both depressive and anxiety symptoms at 6 weeks. Six-week postpartum depressive and anxiety symptoms were correlated ($r = .38$, $p < .01$). By including the depressive and anxiety groups in the same time-series models (see below), the shared variance, that is, any overlap of the associations of high (vs. low) depressive and anxiety symptoms with the temporal dynamics, was accounted for.

Data analysis: self- and interactive contingency

We used multi-level time-series models to operationalize self- and interactive contingency. These models are designed to quantify patterns over time, here the course of behavior second-by-second. They allow us to evaluate the degree of predictability within individuals (self-contingency [autocorrelation]), and between two individuals (interactive contingency [lagged cross-correlation]) (see Beebe et al., 2008, 2010, 2011, 2016, 2018, 2020). Whereas traditional time-series approaches model each dyad individually and enter model coefficients into analyses of variance, the multi-level time-series approaches used here (Littell et al., 2006; Singer & Willett, 2003) have many advantages.²

¹This same second-by-second data set was previously evaluated for across-group self- and interactive contingency, with a different type of time-series model, and published in a peer-reviewed journal by Kahya et al. (2022).

²Multi-level time-series approaches model the group as a whole and estimate both group-level “fixed effects” across the sample, and individual variation in those effects, termed “random effects.” Random effects include variation in the mean and variance of the dependent variable across observations, variation in the linear change in the dependent variable over time, and between-dyad variation in the auto-regressive effect. Multi-level models make more appropriate statistical assumptions, have increased power, and generate more accurate estimates of parameters, using empirical Bayesian (maximum likelihood) techniques (rather than ordinary least squares) which take into account prior distributions.

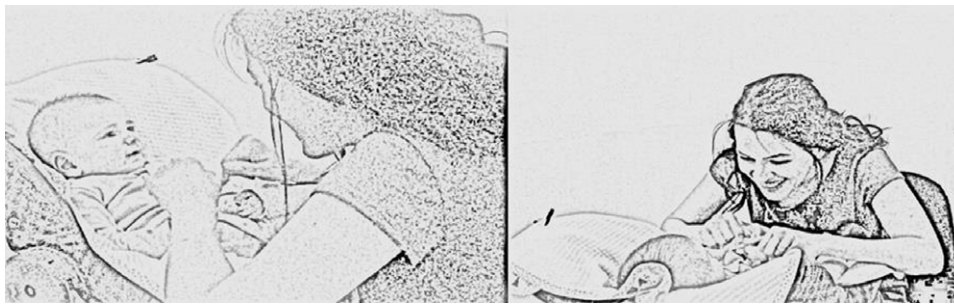


Figure 2. The mother–infant face-to-face interaction video recording

Table 2. Behaviors coded

Variable	Range	Codes
Infant/Mother Gaze	(1, 0)	On (1) -off (0) partner’s face
Mother Facial Affect	(90-10)	Mock-surprise (90), smile-3, smile-2, smile-1, “oh-face,” interest-4, interest-3, interest-2, interest-1, neutral, “woe” face, negative face (frown/grimace/ tight compressed lips), scrunch face, threat face (10)
Infant Facial Affect	(85-20)	High-positive smile (85), low-positive smile, neutral/interest-2, neutral/ interest-1, neutral, mild-negative (frown/ grimace), high negative (pre-cry/cry-face) (20)
Infant Vocal Affect	(6-1)	High-positive (6), neutral/ positive, none, fuss/whimper, angry-protest, cry (1)
Mother Touch	(11-1)	Affectionate (stroke, kiss) (11), static (hold, provide finger for infant to hold), playful (tap, tickle), none, caregiver, jiggle/bounce, infant-directed oral touch, object-mediated, centripetal (body-center: face, body, head), rough (scratch, push, pinch), high intensity/ intrusive (1)

The multi-level time-series models were run via SAS proc mixed (linear mixed models). We tested conditional effects of high (vs. low) depressive symptoms, and high (vs. low) anxiety symptoms on self- and interactive contingency, in the same models, so that any overlap of associations with each symptom level was accounted for that of the other. Beta values are represented as standardized effect sizes. Standardized fixed effects were used for hypothesis-testing with significance level set at $p < .05$ (two-tailed).

Individual Seconds (lags) Time-series Analysis. The conditional effects of high (vs. low) depressive symptoms, and high (vs. low) anxiety symptoms on self- and interactive contingency were tested in individual seconds time-series models. This approach applies a precise lens to the microstructure of differences in high vs. low symptom groups. Using a moving 4-s window³, three prior lags are evaluated for each second’s association with the current second (L1 → t_0 ; L2 → t_0 , L3 → t_0) in one model, where each lag controls for the other two (Beebe et al., 2018, 2020). In these models, t_0 represents the current second being predicted, L1 represents 1s prior, L2 represents 2s prior, and L3 represents 3s prior. The

³Choice of a 4-s window size was based on prior work (Beebe et al., 2007, 2016) in which we estimated the number of seconds over which lagged effects were significant and their magnitude for the pairs as a whole (fixed model estimates). Typically, the prior 3s sufficed to account for these lagged effects on the subsequent behavior (t_0) (see Beebe et al., 2010).

estimated coefficient for the effects of these lagged variables on t_0 over the duration of the interaction (150 sec) indicates the level of self- or interactive contingency: the larger the coefficient, the stronger the contingency. Each analysis included both self- and interactive contingency; thus, estimated coefficients of one form of contingency controlled for the other.

Each model predicts the self and interactive contingency of one partner. Figure 3 depicts *infant* self- and interactive contingency. For example, using the modality pairing of mother gaze, infant gaze, the model predicting the infant assesses (a) infant self-contingency by using infant gaze behavior in the prior secs (L1, L2, and L3) to predict infant gaze behavior at t_0 , controlling for prior mother gaze (L1, L2, and L3); (b) infant interactive contingency by using mother gaze behavior in the prior secs (L1, L2, and L3) to predict infant gaze behavior at t_0 , controlling for prior infant gaze (L1, L2, and L3). Any significant finding in the model makes the model interpretable, self- and/or interactive contingency.

High (vs. low) depressive and anxiety symptom groups were both tested within the same models. We thus evaluated associations between depressive symptoms and 4-month infant and mother temporal dynamics, and between anxiety symptoms and 4-month infant and mother temporal dynamics, with each symptom level accounting for that of the other. The fixed effects models included intercept, control variables (infant sex, maternal education and age), maternal high (vs. low) depressive and anxiety symptom groups in relation to behavior at t_0 , lagged effects of self-behavior and partner behavior (self- and interactive contingency), and the interaction term between high (vs. low) depressive (anxiety) symptom group and self- and interactive contingency. Per communication modality, per partner, we analyzed 150 s x 56 dyads = 8,400 s, generating adequate power to detect high (vs. low) depressive and anxiety symptom associations.

In the following equation example, we predict mother face (in the modality pairing of mother face–infant face) as a function of high (vs. low) depressive and anxiety symptoms at 6 weeks:

$$\begin{aligned}
 mface_{it} = & b_0 + \beta_1 isex_i + \beta_2 medu_i + \beta_3 mage_i + \beta_4 dep_i + \beta_5 anxty_i \\
 & + \beta_6 mface_{it-1} + \beta_7 mface_{it-2} + \beta_8 mface_{it-3} + \beta_9 iface_{it-1} + \beta_{10} iface_{it-2} + \beta_{11} iface_{it-3} \\
 & + \beta_{12} mface_{it-1} * dep_i + \beta_{13} mface_{it-2} * dep_i + \beta_{14} mface_{it-3} * dep_i \\
 & + \beta_{15} iface_{it-1} * dep_i + \beta_{16} iface_{it-2} * dep_i + \beta_{17} iface_{it-3} * dep_i \\
 & + \beta_{18} mface_{it-1} * anxty_i + \beta_{19} mface_{it-2} * anxty_i + \beta_{20} mface_{it-3} * anxty_i \\
 & + \beta_{21} iface_{it-1} * anxty_i + \beta_{22} iface_{it-2} * anxty_i + \beta_{23} iface_{it-3} * anxty_i + \epsilon_{it}
 \end{aligned}$$

In this equation, $mface_{it}$ represents mother face of the i -th mother at time t , b_0 is the random intercept, $isex$ represents infant sex, $medu$ represents mother education, $mage$ represents mother age, dep and $anxty$ represent depressive and anxiety symptom groups at 6 weeks, ϵ is random error of AR (1). The three terms $\beta_6 mface_{it-1} + \beta_7 mface_{it-2} + \beta_8 mface_{it-3}$ represent mother self-contingency (autocorrelation): predicting mother

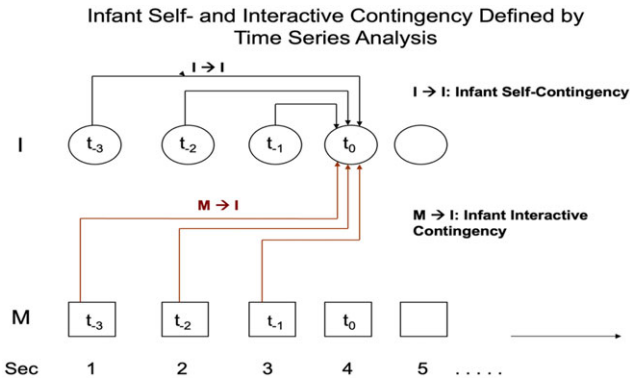


Figure 3. Infant self- and interactive contingency defined by individual seconds time-series models

face at t₀ from her face at t₁, t₂, and t₃. The three terms $\beta_{9}iface_{it-1} + \beta_{10}iface_{it-2} + \beta_{11}iface_{it-3}$ represent mother lagged cross-correlation: predicting mother face at t₀ from infant face at t₁, t₂, t₃.

Analysis of Predicted Values: Descriptive Explication of Time-series Models. The multi-level time-series models are abstract; they identify differences in contingency levels between mothers with high (vs. low) depressive (anxiety) symptoms, but they cannot specify patterns of behaviors which might explain differences between groups. Further *post-hoc descriptive* analyses are required. Our *analysis of predicted values* is a post-hoc *explication* of significant results from the time-series models; there is no additional significance testing. Consistent with prior work, to identify sources of differences between groups, predicted values at t₀ for groups with high (vs. low) depressive (anxiety) symptoms were calculated directly from the time-series models, across all dyads. This *analysis of predicted values* identifies specific patterns of behavioral predictors across L1, L2, and L3 that contribute to absolute group differences at t₀ (Beebe et al., 2018, 2020; Searle & Gruber, 2016). For each significant finding, per modality pairing, the predicted probability of behavior at t₀ (probability of gaze-on, or probability of level of behavioral code for ordinal behavioral scales) was calculated, as a function of every possible combination of behavioral codes for mother at L1, L2, and L3, and infant at L1, L2, and L3. Thus, given that mothers and infants of both groups have identical behavioral codes in the prior three seconds, what combination of prior behaviors of mother/infant contributed the most to the differences in the current moment (t₀)? And what is the sequential behavioral pattern of these differences, from behaviors in the prior moments to the current moment (t₀)?

To identify the behaviors which most contributed to differences between high (vs. low) depressive (anxiety) symptom groups, we examined the absolute differences of the probability distribution of predicted values and we *ranked* these absolute differences from highest to lowest. We noticed that the opposite ends of the distribution generated interpretable differences between high and low symptom groups. For example, using the gaze modality, one end of the distribution indicated the patterns at t₀ given infant gaze-on in the prior seconds; and the opposite end indicated the patterns at t₀ given infant gaze-off in the prior seconds. This logic applied to all behavioral codes. Continuing with the infant gaze example (paired with mother gaze), we noticed that, given infant gaze-off in the prior moment, infants of high (vs. low) anxiety symptom mothers had a higher probability of returning to gaze-on. But given infant gaze-on in the prior moment, these infants had a

Table 3. Infant self- and interactive contingency at 4 months predicted by maternal postpartum 6-week depressive and anxiety symptoms

	Infant self-contingency (I → I)		Infant interactive contingency (M → I)	
	L1	L2	L1	L2
I Gaze-M Gaze				
High depressive symptoms	↑			
High anxiety symptoms	↓			
I Gaze-M Touch				
High depressive symptoms	↑			
High anxiety symptoms	↓			
I Facial Affect-M Facial Affect				
High depressive symptoms		↓		↓
High anxiety symptoms	↓	↑		
I Vocal Affect-M Touch				
High depressive symptoms	↓			
High anxiety symptoms				

I = Infant; M = Mother.
Using multi-level individual seconds time-series models, current behavior at t₀ was predicted from the 3 prior individual seconds; L1 = one sec prior; L2 = two sec prior.
Because L3 (three sec prior) generated no significant findings, we omitted it here.
Each second controlled for the other two.
Entries represent increased (↑) contingency or decreased (↓) contingency with maternal high (vs. low) depressive or anxiety symptoms.
I → I = infant self-contingency; M → I = infant interactive contingency.

higher probability of changing to gaze-off. We thus examined absolute differences at the two ends of the probability distribution, which represent codes at one end of the scale (such as the positive end of the facial affect scale), and codes at the opposite end of the scale (such as the negative end of the facial affect scale). At each end of the probability distribution, we examined the 10 highest absolute differences. These two ends of the probability distribution are presented in each probability explication table. We dubbed the 10 highest absolute differences in the top half of the distribution as the “top 10” and the 10 highest absolute differences in the bottom half of the distribution as the “bottom 10.” If for example the top 10 show how positive behaviors of a particular scale operate, the bottom 10 often show how negative behaviors of that same scale operate; or vice versa. For details, see Supplement Tables S1a–S4f.

Results

We present the results of the time-series models using maternal 6-week postpartum high (vs. low) depressive and anxiety symptom groups to predict first infant, and then mother, self- and interactive contingency at 4 months, along with descriptive explications. The results are organized by modality. For each modality, we present the findings for depression and anxiety. Infant sex, maternal education, and maternal age were controlled in these models, although they did not show any associations with maternal depressive and anxiety symptoms or with self- and interactive contingencies.

Tables 3 and 4 present summaries of these infant, and mother, time-series models, respectively, organized by each modality

Table 4. Mother self- and interactive contingency at 4 months predicted by maternal postpartum 6-week depressive and anxiety symptoms

	Mother self-contingency (M → M)			Mother interactive contingency (I → M)		
	L1	L2	L3	L1	L2	L3
I Gaze-M Gaze						
High depressive symptoms		↑				
High anxiety symptoms	↑	↓				
I Gaze-M Touch						
High depressive symptoms		↓	↑		↑	
High anxiety symptoms						
I Facial Affect-M Facial Affect						
High depressive symptoms			↓			
High anxiety symptoms	↑				↑	
I Vocal Affect-M Touch						
High depressive symptoms		↓	↑			
High anxiety symptoms						

I = Infant; M = Mother.

Using multi-level individual seconds time-series models, current behavior at t_0 was predicted from the 3 prior individual seconds; L1 = one sec prior;

L2 = two sec prior; L3 = three sec prior.

Each second controlled for the other two.

Entries represent increased (↑) contingency or decreased (↓) contingency with maternal high (vs. low) depressive or anxiety symptoms.

M → M = mother self-contingency; I → M = mother interactive contingency.

pairing. Depressive and anxiety symptom groups are depicted side-by-side, for ease of comparison.

Postpartum depressive and anxiety symptoms predicting infant behavior

Infant Gaze Self-Contingency was predicted by both maternal depressive and anxiety symptoms from L1, but in opposite directions. Two modality pairings were examined: infant gaze-mother gaze, infant gaze-mother touch; both gave similar results:

(a) analyzed with mother gaze, infant gaze self-contingency was higher (more predictable) with high (vs. low) depressive symptoms ($\beta = 24.076$, $p < .0001$, Table S1a), but lower (more variable) with high (vs. low) anxiety symptoms ($\beta = -12.251$, $p = 0.023$, Table S1a);

(b) analyzed with mother touch, infant gaze self-contingency was higher (more predictable) with high (vs. low) depressive symptoms ($\beta = 23.308$, $p < .0001$, Table S2a), but lower (more variable) with high (vs. low) anxiety symptoms ($\beta = -11.539$, $p = 0.031$, Table S2a).

Probability explication indicated that (i) when infants were looking at mother at L1, infants of mothers with high (vs. low) depressive symptoms were more likely to sustain looking at t_0 (Table S1b, Table S1e), but infants of mothers with high (vs. low) anxiety symptoms were more likely to look away at t_0 ; (ii) when infants were looking away at L1, infants of mothers with high (vs. low) depressive symptoms were more likely to remain looking away at t_0 , whereas infants of mothers with high (vs. low) anxiety symptoms were more likely to look back at mother at t_0 (Table S1c, Table S1f).

Infant Facial Affect Self-Contingency (analyzed with mother facial affect) (a) was predicted by both maternal high (vs. low) depressive and anxiety symptoms, in opposite directions, from L2;

(b) was also predicted by maternal high (vs. low) anxiety symptoms from L1.

(a) From L2, infant facial affect self-contingency was lower (more variable) with high depressive symptoms ($\beta = -0.074$, $p = 0.017$, Table S3a), but higher (more predictable) with high anxiety symptoms ($\beta = 0.152$, $p < .001$, Table S3a). (i) *Depressive symptoms*: Probability explication patterns showed that given infant facial affect tending toward the midrange of mild-negative to neutral/interest at L2, or tending toward the most positive at L2, infants of mothers with high (vs. low) depressive symptoms were less likely to sustain negative or positive affect, respectively, at t_0 ; and instead, infants were more likely to move into midrange affect (Table S3b). (ii) *Anxiety symptoms*: In contrast, given infant facial affect tending toward high positive at L2, or tending toward the most negative at L2, infants of mothers with high (vs. low) anxiety symptoms were more likely to sustain positive, or negative affect, respectively, at t_0 (Table S3c).

(b) From L1, infant facial affect self-contingency was also lower with high anxiety (but not with depressive symptoms) symptoms ($\beta = -0.061$, $p = 0.026$, Table S3a). Probability explication patterns indicated that, given infant facial affect tending toward mild-negative to neutral/interest at L1, in the context of high positive affect at L2, infants of mothers with high (vs. low) anxiety symptoms were more positive (within the mild-negative to neutral/interest range) at t_0 (Table S3c). In contrast, given infant facial affect tending toward mild-negative to neutral/interest at L1, in the context of the most negative affect at L2, infants of mothers with high (vs. low) anxiety symptoms were less positive (within the mild-negative range) at t_0 (Table S3c). Thus, infants of mothers with high anxiety symptoms were more likely to return to, and in that sense to sustain positive, and negative, affect.

Infant Facial Affect Interactive Contingency (analyzed with mother facial affect) was predicted by maternal depressive symptoms, but not anxiety symptoms. Infants of mothers with high (vs. low) depressive symptoms were less coordinated with mother facial affect, from L1 ($\beta = -0.040$, $p = 0.049$, Table S3a). Probability explication patterns showed that, given mothers expressed negative facial affect at L1, infants of mothers with high (vs. low) depressive symptoms were more likely to be affectively midrange at t_0 , remaining largely in the neutral/interest range, not moving in the direction of mother's affect. Given mothers expressed positive facial affect at L1, infants of mothers with high (vs. low) depressive symptoms were more likely to be affectively midrange (neutral/interest) at t_0 , again not moving in the direction of mother's affect. Thus, infants of mothers with high (vs. low) depressive symptoms were less contingently coordinated with mother positive or negative facial affect and largely remained affectively midrange (Table S3b).

Infant Vocal Affect Self-Contingency (analyzed with mother touch) was predicted by maternal depressive symptoms, but not anxiety symptoms: infant vocal affect self-contingency was lower (more variable) with high (vs. low) depressive symptoms ($\beta = -0.074$, $p = 0.001$, Table S4a). Probability explication showed that, given infant vocal affect was negative at L1, infants of mothers with high (vs. low) depressive symptoms were more likely to become positive at t_0 ; given infant vocal affect was high positive at L1, infants were likely to decrease toward neutral/positive vocal affect at t_0 (Table S4b). Thus, infants of mothers with high (vs. low) depressive symptoms were less likely to sustain negative or positive vocal affect.

Postpartum depressive and anxiety symptoms predicting mother behavior

Mother Gaze Self-Contingency (analyzed with infant gaze) was predicted by both maternal depressive and anxiety symptoms.

(a) From L2, mothers with high depressive and anxiety symptoms showed opposite patterns. With high (vs. low) depressive symptoms, mother gaze self-contingency from L2 was higher (more predictable) ($\beta = 16.108, p = 0.015$, Table S1d), but with high (vs. low) anxiety symptoms, mother gaze self-contingency was lower (more variable) ($\beta = -20.512, p = 0.001$, Table S1d). Probability explication showed that, given mothers were looking at infants at L2, mothers with high (vs. low) depressive symptoms were more likely to sustain looking at t_0 (Table S1e), but mothers with high (vs. low) anxiety symptoms were more likely to look away at t_0 (Tables S1f). Given mothers were looking away at L2, mothers with high (vs. low) depressive symptoms were more likely to remain looking away at t_0 (Table S1e), but mothers with high (vs. low) anxiety symptoms were more likely to look back at the infant at t_0 . Thus, mothers with high depressive symptoms were more likely to sustain looking, and to sustain looking away; whereas mothers with high anxiety symptoms were more likely to shift, from looking to looking away, and from looking away to looking.

(b) From L1, mothers with high anxiety symptoms showed self-contingency patterns similar to those of mothers with high depressive symptoms. Mother gaze self-contingency was higher (more predictable) with high (vs. low) anxiety symptoms from L1 ($\beta = 18.050, p = 0.018$, Table S1d). Given mothers were looking at the infant at L1, in the context of not looking at L2, mothers with high (vs. low) anxiety symptoms were more likely to sustain looking at t_0 ; given mothers were looking away at L1, in the context of looking at the infant at L2, mothers with high (vs. low) anxiety symptoms were more likely to remain looking away at t_0 (Table S1f). Thus, mothers with high anxiety symptoms could take on either a more predictable gaze self-contingency pattern from L1, or a more variable gaze self-contingency pattern from L2. In contrast, mothers with high depressive symptoms showed only one self-contingency pattern, more stable, as described above: more likely to sustain looking, and more likely to sustain looking away.

Mother Touch Self-Contingency was predicted by maternal depressive symptoms, but not anxiety symptoms, in two modality pairings, with similar results (mother touch-infant gaze, mother touch-infant vocal affect). With high (vs. low) depressive symptoms:

(a) Mother touch self-contingency (analyzed with infant gaze) was lower (more variable) from L2 ($\beta = -0.084, p = .032$, Table S2d), but higher (more predictable) from L3 ($\beta = 0.073, p = 0.024$, Table S2d).

(b) Mother touch self-contingency (analyzed with infant vocal affect) was lower (more variable) from L2 ($\beta = -0.075, p = 0.02$, Table S4c), but higher (more predictable) from L3 ($\beta = 0.067, p = 0.005$, Table S4c).

Probability explication indicated that, given mother touch tending toward negative patterns at L2, in the context of tending toward positive patterns at L3, mothers with high (vs. low) depressive symptoms were more likely to show more positive touch patterns at t_0 ; in contrast, given mother touch tending toward positive patterns at L2, in the context of tending toward negative patterns at L3, mothers with high (vs. low) depressive symptoms were more likely to shift toward more negative (rough) touch patterns at t_0 (Table S2e, Table S4d). Thus, mothers with

high (vs. low) depressive symptoms were more likely to shift positive and negative touch patterns from L2, but more likely to sustain positive or negative touch patterns from L3.

Mother Touch Interactive Contingency (analyzed with infant gaze) was predicted by maternal depressive symptoms, but not anxiety symptoms: mothers with high (vs. low) depressive symptoms were more coordinated with infant gaze ($\beta = 0.128, p = 0.029$, Table S2d). Probability explication indicated that given infants looking at mothers at L2, mothers with high (vs. low) depressive symptoms had more positive touch patterns at t_0 ; but given infants looking away at L2, mothers with high (vs. low) depressive symptoms had more negative (rough) touch patterns at t_0 (Table S2e). Thus, mothers with high (vs. low) depressive symptoms contingently responded to infant gaze-on with positive touch patterns, but responded to infant gaze away with negative touch patterns.

Mother Facial Affect Self-Contingency (analyzed with infant facial affect) was predicted by both maternal depressive and anxiety symptoms, but in opposite directions. Mother facial affect self-contingency was lower (more variable) with high (vs. low) depressive symptoms from L3 ($\beta = -0.061, p = 0.020$, Table S3d), but higher (more predictable) with high (vs. low) anxiety symptoms from L1 ($\beta = 0.069, p = 0.009$, Table S3d). Probability explication indicated that, given mother facial affect tending toward the most negative or most positive affect at L3, mothers with high (vs. low) depressive symptoms were more likely to transform positive or negative affect into the interest range at t_0 (Table S3e). In contrast, given mother facial affect was the most positive or negative at L1, mothers with high (vs. low) anxiety symptoms were more likely to sustain positive or negative affect at t_0 (Table S3f).

Mother Facial Affect Interactive Contingency (analyzed with infant facial affect) was predicted from L2 by maternal anxiety symptoms, but not depressive symptoms. Mothers with high (vs. low) anxiety symptoms were more coordinated with infant facial affect ($\beta = 0.076, p = 0.049$, Table S3d). Probability explication showed that, given infants expressed positive facial affect at L2, mother facial affect was more positive in mothers with high (vs. low) anxiety symptoms at t_0 , thus more closely coordinating with the infant facial affect. But, given infants expressed negative facial affect at L2, mother facial affect was more likely to be in the negative range in mothers with high (vs. low) anxiety symptoms at t_0 , again more closely coordinating with the infant facial affect, but going below the usual empathic woe-face into the negative facial affect range (Table S3f). Thus, mothers with high (vs. low) anxiety symptoms contingently responded to infant positive facial affect by going in the same direction, toward positive facial affect patterns; but they contingently responded to infant negative facial affect with their own negative facial affect patterns. In contrast, mothers with low anxiety symptoms contingently responded to infant negative facial affect with sympathetic woe-face.

Table 5 summarizes the findings of gaze, affect, and touch, indicating dyads with postpartum high (vs. low) depressive and high (vs. low) anxiety symptoms⁴.

⁴In response to reviews, we analyzed patterns of temporal dynamics at 4 months in dyads with both high maternal 6-week depressive and high maternal 6-week anxiety symptoms ($n = 13$; see Table S9 and related explanation [Table S9, note 2] in Supplement). Overall, the comorbid analysis generated very little that was new. Most of the findings followed the pattern of results that we had documented for either dyads with high maternal depressive symptoms or dyads with high maternal anxiety symptoms: only one infant pattern was new.

Table 5. Summary findings of maternal postpartum depressive and anxiety symptoms

	Self-contingency I → I & M → M		Interactive contingency I → M & M → I	
	High Depressive Symptoms	High Anxiety Symptoms	High Depressive Symptoms	High Anxiety Symptoms
I Gaze – M Gaze	<i>I Gaze (L1) & M Gaze (L2) more predictable:</i> Sustained looking; Sustained looking away	(a) <i>I Gaze (L1) & M Gaze (L2) more variable:</i> Looking away → looking at; Looking at → looking away (b) <i>M Gaze (L1) more predictable:</i> Looking → looking; Looking away → looking away		
I Gaze – M Touch	<i>I Gaze (L1) more predictable:</i> Sustained looking; Sustained looking away (a) <i>M Touch (L3) more predictable:</i> Pos-to-pos/neg-to-neg (b) <i>M Touch (L2) more variable:</i> Pos-to-neg/neg-to-pos	<i>I Gaze (L1) more variable:</i> Looking away → looking at; Looking at → looking away	<i>M Touch heightened-coordination with I Gaze (L2):</i> I look → M positive touch I look away → M intrusive/rough touch	
I Affect – M Affect	<i>I Facial (L2), I Vocal (L1) & M Facial (L3) more variable:</i> Positive-to-midrange; Negative-to-midrange	(a) <i>I Facial (L2) & M Facial (L1) more predictable:</i> Sustained positive; Sustained negative (b) <i>I Facial (L1) more variable:</i> Return to positive; Return to negative	<i>I Facial lowered-coordination with M Facial (L1):</i> M pos → I mild neg to neutral/ interest facial affect range M neg → I mild neg to neutral/ interest facial affect range	<i>M Facial heightened-coordination with I Facial (L2):</i> I positive → M positive I negative → M negative

I = Infant, M = Mother; Neg = Negative; Pos = Positive.

I → I = infant self-contingency; M → I = infant interactive contingency.

M → M = mother self-contingency; I → M = mother interactive contingency.

I Affect integrates self-contingency findings of infant facial affect (analyzed paired with M Facial Affect) and infant vocal affect (analyzed paired with M Touch).

Discussion

We identified strikingly different patterns of the temporal dynamics of self- and interactive contingency in 4-month mother–infant interactions of gaze, affect, and touch, in mothers with high (vs. low) postpartum depressive symptoms, and in mothers with high (vs. low) postpartum anxiety symptoms. The findings have implications for both risk and resilience, as well as for clinical intervention.

Comparison of pictures of high postpartum depressive and anxiety symptoms

Patterns of *interactive contingency* at 4 months were very different in dyads with high maternal postpartum depressive symptoms, and in dyads with high maternal postpartum anxiety symptoms. With high (vs. low) depressive symptoms, mothers were vulnerable to infants looking away, and they reacted with negative touch. Their infants remained midrange in facial affect as mothers rose toward high positive facial affect, or dampened toward high negative facial affect, metaphorically distancing themselves from mothers' affect. In contrast, with high anxiety symptoms, mothers were vulnerable to infants becoming dampened or negative in facial affect, and they reacted with negative facial affect themselves.

Dyads with high maternal postpartum depressive and anxiety symptoms were largely opposite in *self-contingency* at 4 months: (a) *Gaze*. Mothers with high depressive symptoms and their infants had more predictable, more sustained patterns of looking as well as looking away, suggesting *the management of high-arousal*. On the other hand, mothers with high postpartum anxiety symptoms and

their infants had more variable patterns of looking and looking away, metaphorically an *attentional uncertainty*. (b) *Affect*. Mothers with high postpartum depressive symptoms and their infants showed patterns of moving into the affective midrange: they dampened negative affect by shifting upward into somewhat more positive, midrange expressions of interest; but they also dampened positive affect by shifting downward into less positive, midrange expressions of interest, metaphorically *minimizing both positive and negative affect*. In contrast, mothers with high postpartum anxiety symptoms and their infants showed patterns of sustaining both positive and negative affect, metaphorically *maximizing positive and negative facial affect*. (c) *Touch*. Mothers with high postpartum depressive symptoms had a variable touch pattern, metaphorically a *positive/negative touch uncertainty*. In contrast, mothers with high postpartum anxiety symptoms had no findings in touch.

The picture of 4-month interaction with maternal postpartum depressive symptoms

Infant Gaze–Mother Gaze. With high (vs. low) maternal postpartum depressive symptoms, mothers and infants both showed heightened self-contingency patterns of sustained looking, and sustained looking away, likely making the gaze system more salient. This finding did not fit our hypothesis of lower self-contingency (see Table 6, 2a). The gaze system had two modes: (a) The sustained looking pattern is interpreted as gaze vigilance, likely heightening arousal for both. Similarly, Beebe et al. (2008) found that, with higher maternal postpartum depressive symptoms, each partner looked at the other's face for a greater amount of time. (b) The

Table 6. Evaluation of hypotheses

<i>(1) Interactive Contingency</i>	<i>Hypothesize: Lowered or Heightened Contingency</i>	<i>Partner/Modality</i>	<i>Hypothesis upheld</i>
(1a) Hypothesis: Infants of mothers with high postpartum depressive symptoms will have lowered interactive contingent coordination with their mothers. (1a) Finding: Given mothers expressed either the most negative or the most positive facial affect, infants of mothers with high postpartum depressive symptoms were more likely to be in the mild-negative to neutral/interest facial affect range.	Lowered	Infant Facial Affect	Yes
(1b) Hypothesis: Infants of mothers with high postpartum anxiety symptoms will have both lowered and heightened interactive contingent coordination (in different modalities) with their mothers. (1b) Finding: None.	Non-significant	None	No
(1c) Hypothesis: Mothers with high postpartum depressive symptoms will have both lowered and heightened contingent coordination (in different modalities) with their infants. (1c) Finding: Given infants looked at mothers, mothers with high postpartum depressive symptoms were more likely to touch positively; but when infants looked away, they were more likely to resort to rough/intrusive touch.	Heightened	Mother Touch	Partially
(1d) Hypothesis: Mothers with high postpartum anxiety symptoms will show heightened contingent coordination with their infants. (1d) Finding: Given infants expressed positive facial affect, mothers with high anxiety symptoms were more likely to express positive facial affect; but when infants expressed negative facial affect, they were more likely to express negative facial affect.	Heightened	Mother Facial Affect	Yes
<i>(2) Self-Contingency</i>	<i>Hypothesize: Lower</i>	<i>Partner/Modality</i>	<i>Hypothesis upheld</i>
(2a) Hypothesis: Mothers with high postpartum depressive symptoms and their infants will have lower (more variable) self-contingency.			
(2a) Findings: <i>Infant and Mother Affect</i> Mothers with high postpartum depressive symptoms and their infants both had more variable affect self-contingency patterns. Given mothers & infants tending toward the highest negative or the most positive affect, both mothers and infants were more likely to express midrange affect levels (mild-negative/neutral-interest).	Lower	Mother Facial Affect Infant Facial Affect Infant Vocal Affect	Yes
<i>Infant and Mother Gaze</i> Mothers with high postpartum depressive symptoms and their infants both had more predictable gaze self-contingency patterns. They were more likely to show sustained looking as well as sustained looking away.	Higher	Mother Gaze Infant Gaze	No
<i>Mother Touch</i> Mothers with high postpartum depressive symptoms had two different touch self-contingency patterns. From 2s prior, mothers had more variable touch patterns: positive to negative, or negative to positive. From 3s prior, mothers had more predictable touch patterns: sustained positive or sustained negative.	Both Lower & Higher	Mother Touch	Yes in Mother Touch 2s prior No in Mother Touch 3s prior
(2b) Hypothesis: Mothers with high postpartum anxiety symptoms and their infants will have lower (more variable) self-contingency.			
(2b) Findings: <i>Infant and Mother Gaze</i> (i) Mothers with high anxiety symptoms and their infants both had more variable gaze self-contingency patterns, mothers from 2s prior and infants from 1s prior. When they were looking, they were more likely to look away; when they were looking away, they were more likely to look back. (ii) Moreover, mothers with high anxiety symptoms had also a more predictable gaze pattern from 1s prior. They were more likely sustain looking if they were looking 1s prior; and they were more likely to sustain looking away if they were looking away 1s prior.	Both Lower & Higher	Mother Gaze Infant Gaze	Yes in Infant Gaze Yes in Mother Gaze 2s prior No in Mother Gaze 1s prior
<i>Infant and Mother Affect</i> (i) Mothers with high anxiety symptoms and their infants had more predictable facial affect self-contingency patterns, mothers from 1s prior, and infants from 2s prior. Given mothers and infants were tending toward either positive or negative facial affect, mothers and infants were both more likely to sustain that affect. (ii) Infants of mothers with high anxiety symptoms also had a second more variable facial affect self-contingency pattern from 1s prior: given infants were tending toward mild-negative-to-neutral-interest 1s prior, they were more likely to increase the level of affect.	Both Lower & Higher	Mother Facial Affect Infant Facial Affect	Yes in Infant Facial Affect 1s prior No in Mother Facial Affect & Infant Facial Affect 2s prior

sustained looking away pattern likely facilitated down-regulation of arousal for both (Field, 1981). Similar to our findings, Væver et al. (2020) documented more sustained looking away in infants of mothers with postpartum depression diagnosis. Examining maternal depression, Granat et al. (2017) showed a lowered probability of mutual gaze, suggesting more mother and infant gaze-off. Sustained looking away may be a risk factor.

Infant Gaze-Mother Touch. In dyads with high (vs. low) maternal postpartum depressive symptoms, in *interactive contingency* mothers welcomed infant looking with positive touch patterns, which may facilitate sustained infant looking, possibly a resilience factor. But these mothers were vulnerable to their infants looking away, reacting with negative touch, likely a risk factor. This finding of heightened interactive contingency partially upholds our hypothesis (see Table 6, 1c). Beebe et al. (2020) documented that mothers who had been pregnant and widowed on 9/11 also responded to infant looking with more positive touch patterns, suggesting that this pattern may also function as a risk feature. It may be a maternal effort to secure infant visual engagement (see Beebe et al., 2020). In the current study, as long as infants looked, they received positive maternal touch; but when infants needed to look away, they received intrusive/rough touch: a rough, aggressive countering of the need to down-regulate arousal, a risk factor. The maternal rough touch response suggests the depth of the mother's need for her infant's visual engagement. Other studies have found intrusive touch patterns associated with maternal depressive symptoms (Beebe et al., 2008; Feldman, 2011; Field et al., 2009).

In mothers with high (vs. low) postpartum depressive symptoms, maternal touch self-contingency patterns showed both more predictable positive touch and negative touch, as well as more variable positive-to-negative touch, and negative-to-positive touch. This finding partially fits our hypothesis of more variable maternal touch patterns (see Table 6, 2a). Similar to our findings, Beebe et al. (2008) found more variable maternal touch in mothers with high postpartum depressive symptoms. Mantis et al. (2019) found that mothers with higher depressive symptoms were less likely to sustain positive touch. We propose that these mixed maternal touch self-contingency patterns, metaphorically *positive/negative touch uncertainty*, (a) indicate the mother's own uncertainty about what would work best to engage her infant, and (b) generate an ongoing context of uncertainty for the infant about the mother's positive or negative touch, likely destabilizing, and likely a risk factor.

We suggest that the interactive pattern of maternal rough/intrusive touch reaction to infant looking away, and the infant's more sustained looking away pattern, operated as a system in which each likely affected the other. Moreover, this pattern occurred in the context of the maternal self-contingency pattern of maternal positive/negative touch uncertainty. Consistent with our work documenting that self- and interactive contingency patterns are "co-constituted," each affecting the other (Beebe et al., 2016), all three processes likely operated together, heightening their impact.

Infant Affect-Mother Affect. With high (vs. low) maternal postpartum depressive symptoms, self-contingency patterns of both mothers and infants were lower, more variable, fitting our hypothesis (see Table 6, 2a). Both mothers and infants showed patterns of *minimizing* both positive and negative affect, by shifting affect toward the midrange. Similarly, Aktar et al. (2017) found that mothers with depressive symptoms and their infants expressed less positive and more neutral affect, tending to stay more affectively midrange. A tendency to stay affectively midrange limits the ability of both partners to express both joy and distress,

and thus is likely a risk factor. On the other hand, working to stay in the affective midrange keeps the interaction less aroused, less emotional, which may balance the negative maternal touch patterns, and thus may be a resilience factor in this context. In the long run, it is likely a risk factor, a topic for future research.

With high (vs. low) maternal postpartum depressive symptoms, infants showed an *interactive contingency* pattern of being less engaged or withdrawn, confirming our hypothesis (see Table 6, 1a). When mothers became either affectively positive, or affectively negative, infants responded in the affective midrange. We infer infant emotional distancing. The infant interactive contingency pattern of emotional distancing, and the infant self-contingency pattern of working to stay in the affective midrange, together may operate to balance the mother's negative touch pattern. These infant patterns may be adaptive in the short run in protecting the infant from the potentially profound effects of maternal depression (see Esposito et al., 2017; Hakanen et al., 2019; Hernandez-Reif et al., 2006). But in the long run, this adaptation may have other unwanted effects, such as blunting the emotional connection, a topic for future research.

The picture of 4-month interaction with maternal postpartum anxiety symptoms

Infant Gaze-Mother Gaze. (i) With high (vs. low) maternal postpartum anxiety symptoms, mothers and infants had more variable gaze self-contingency patterns: looking was likely to be followed by looking away, and looking away by looking. This finding confirms our hypothesis of lower self-contingency, in the gaze modality (see Table 6, 2b). It likely introduces a destabilizing context into the system, metaphorically an *attentional uncertainty* in both partners, likely a risk factor. Rapidly changing infant looking and looking away patterns was associated with infant resistant attachment scores at 12 months in Margolis et al. (2019). This gaze pattern suggests an agitation, a difficulty in regulating arousal through gaze. These more variable looking patterns likely make it harder for infants to anticipate moments of mutual gaze, the foundation of the face-to-face encounter. (ii) Whereas the above self-contingency finding was visible when considering the predictability pattern from two seconds prior, mothers also had a second pattern of more predictable gaze self-contingency, more sustained looking and looking away, when considering the predictability pattern from one second prior. This finding does not confirm our hypothesis (see Table 6, 2b). Some studies of maternal anxiety suggest that anxiety is associated with more looking, but using different methods (e.g. Aktar et al., 2017, infants showed longer durations of looking at mother's face; Beebe et al., 2011, mothers showed greater percent time looking; Granat et al., 2017, dyads showed greater probability of mutual gaze). Thus, we see a consistent attentional uncertainty pattern in the infant, but a mixed attentional pattern in mothers, both more variable and more sustained looking patterns.

Infant Affect-Mother Affect. In self-contingency, mothers with high postpartum anxiety symptoms and their infants showed patterns of sustaining both positive and negative affect, *maximizing* affect and likely generating heightened arousal. This more predictable self-contingency pattern does not confirm our hypothesis (see Table 6, 2b). This finding suggests that the system has two affective modes, positive and negative; and once in one mode, it is sustained. Sustaining positive affect is likely a resilience factor (see Beebe et al., 2023); sustaining negative affect is a risk factor, as shown for example by Margolis et al. (2019), where more

sustained infant negative vocal affect was a risk factor for infant disorganized attachment. Similar to our finding of maximizing affect, other studies of maternal anxiety have documented higher levels of both positive and negative facial affect, in both infants and mothers (Aktar *et al.*, 2017; Kaitz *et al.*, 2010).

In interactive contingency patterns, mothers with high (vs. low) postpartum anxiety symptoms heightened their coordination with infant positive affect by responding with their own positive facial expressions. This maternal pattern sustains positive dyadic cycles, potentially a resilience factor. It could also suggest “*working too hard*” to keep her infant positive (see Beebe *et al.*, 2020). Similarly, assessing maternal anxiety symptoms and mother–infant interaction at 3 months, Crugnola *et al.* (2016) documented longer periods of positive affect associated with maternal anxiety symptoms, again suggesting the need for positive engagement in these mothers. Mothers with high anxiety symptoms also heightened their coordination with infant negative affect, responding with their own negative affect (frown/grimace expressions). Mothers with low anxiety symptoms, by contrast, were more likely to show a sympathetic “*woe-face*” when infants became negative, a more optimal “*joining*” of infant distress (see Beebe *et al.*, 2010).

Maternal positive response to infant positive affect may provide a sense of “*recognition*” for the infant, a potential resilience factor. But maternal negative affect response to infant distress (rather than the more optimal empathic *woe-face* response) is likely destabilizing for the infant and may sustain negative dyadic cycles, likely a risk factor. Moreover, it suggests a maternal disappointment reaction to infant distress, a maternal difficulty in empathic acknowledgment of infant distress. This difficulty suggests the depth of the mother’s need for her infant to express positive affect. We suggest that the mother’s vulnerability to infant distress may be in part a reaction to the infant’s pattern of more sustained dampened/negative affect; and vice versa. Other studies have found less maternal sensitivity to infant distress associated with maternal anxiety (Ierardi *et al.*, 2019; Nicol-Harper *et al.*, 2007) and disorganized attachment (Beebe *et al.*, 2010).

Patterns of interaction seen through a cultural lens

We can further discuss some of our findings through a non-Western cultural lens by considering relational (interdependent) and autonomous (independent) parenting strategies (Kagitcibasi, 2007; Keller, 2007, 2009). In general, relatedness is a cultural socialization goal in Turkish families (Sümer & Kagitcibasi, 2010). In relational parenting strategies, the child’s relatedness is a socialization goal; parenting is parent-centered; mothers avoid negative emotionality through extensive body contact, body stimulation, and the continuous monitoring of negative infant signals (Keller, 2009; Lavelli *et al.*, 2019). Particularly as Turkish families become educated, middle-class, and live in cities, autonomous parenting strategies are also seen (Kagitcibasi, 2007). In autonomous parenting strategies, the child’s autonomy is a socialization goal; mothers see infants as separate mental beings with needs, preferences, and wishes; dyads co-regulate the expression of positive emotionality through eye-contact, smiling, and positive vocalizations (Keller, 2009; Lavelli *et al.*, 2019). In non-Western, middle-class mother–infant samples such as the current one, both autonomous and relational value systems tend to co-occur (Kagitcibasi, 2007; Keller, 2009, 2013; Lavelli *et al.*, 2019; Schmidt *et al.*, 2023). The interactive patterns we documented in our urban, educated, middle-class Turkish sample seem to reflect co-occurring relational and autonomous parenting strategies.

Keller (2009, 2013) suggested that both distant and proximal modes of communication tend to co-occur in these non-Western, middle-class, urban samples with autonomous-relational orientations. Consistent with Keller’s work, mothers with high depressive symptoms interacted with their infants by coordinating their touch with infant gaze behavior. Infant gaze can be considered a distal communication channel, and mother touch a proximal channel. The pattern of maternal negative touch to infant gaze away in mothers with high depressive symptoms may reflect the relatedness value system of mothers as the leading, directing, and controlling partners, and the socialization goals of child obedience and respect. In this context, the infant is not seen as an independent agent with autonomous choice who may look away in the services of self-regulatory needs (e.g., down-regulating arousal). Moreover, negative touch to infant looking away pattern in the context of high maternal postpartum depressive symptoms may reflect the exaggerated level of relational cultural tendency of Turkish mothers’ physical intrusiveness (Sümer & Kagitcibasi, 2010).

In non-Western rural contexts, prohibition of negative affect is typical, consistent with a relational orientation; in more westernized, urban, middle-class families, shared positive emotion is a socialization goal, consistent with an autonomous orientation (Keller, 2007, 2009). In mothers with high postpartum anxiety symptoms, we see both tendencies: mothers and infants maximized positive facial expressions, on the one hand; but mothers were also prone to not validating infant negative facial affect (Keller & Otto, 2009; Lavelli *et al.*, 2019; Schmidt *et al.*, 2023). Thus, maternal risk of higher postpartum anxiety symptoms might exaggerate the normative emotion socialization goals of optimizing positive emotion and minimizing negative emotion. Thus, viewed through a cultural lens, some of the patterns of interaction that we documented fit what is known about non-Western, urbanized, middle-class samples.

Clinical implications

Mother–infant face-to-face interaction is a key pathway through which maternal difficulties in mood are played out and into which clinicians may intervene (Tronick, 1989). The specificity of our findings suggests possible avenues of intervention. In the context of high maternal depressive symptoms, we see a mother who needs her infant to look. We might begin, for example, by empathizing with the mother’s need for her infant to look, and by empathizing with her rough/intrusive touch reaction to her infant looking away, recognizing the mother’s need. We could notice that her infant tends to look away for longer periods, which is hard for mothers. We could investigate the meaning of looking away for this mother. We might be able to help the mother trust in her infant’s return to mutual gaze.

With high anxiety symptoms, we see a mother who needs her infant to be positive, and who is likely disappointed when her infant shows distress. We might begin by helping her sense her own arousal, empathizing with a feeling of uncertainty conveyed by her more variable gaze patterns, and perhaps investigating the meaning of the uncertainty. We could notice with her how happy she becomes when her infant is happy, but how unhappy she becomes when her infant shows distress. We could notice the infants’ tendency to stay dampened/distressed for longer periods, which is hard for mothers. We could empathize with her distress/disappointment reaction to her infant’s distress, and investigate the meaning of her own distress and particularly her memory of how her own distress was responded to. Fostering the mother’s ability to

empathize with her own distress, as well as with the infant's distress, may increase the infant's ability to respond positively.

Limitations

Maternal depressive and anxiety symptoms were evaluated with self-report, rather than diagnostic interview measures. In our design, 6-week depressive and anxiety symptoms each accounted for the other, an advantage; but we did not include the possible influence of 4-month maternal depressive and anxiety symptoms, a limitation. Although the data analysis approach provided adequate power, our sample size might have prevented us from detecting some associations. Additionally, future research could explore the temporal dynamics of infant and mother self- and interactive contingency in mothers with comorbid high maternal postpartum depressive and anxiety symptoms. In our exploration of this issue in our very small sample of mothers meeting this criterion ($n = 13$) (see Supplement Table S9), the results did not substantially differ from the current findings. Moreover, we do not know how prenatal maternal mood problems (Korja et al., 2017), or genetic or neuroendocrine pathways altered by maternal mood, may have contributed to the patterns we documented (Choi et al., 2019; Ulmer-Yaniv et al., 2018), nor do we know the later developmental outcomes of the self- and interactive patterns we documented. These are important avenues for future research. Our low-risk, educated, urban sample of Turkish mothers limits the generalizability of our findings, which are not likely to hold for less educated, rural dyads with lower socioeconomic status. Finally, we did not evaluate family-level variables such as symptom levels of paternal or other secondary caregivers, maternal marital satisfaction, or maternal perceived social support, which may have implications for maternal mood and mother–infant relationship quality (Røsand et al., 2012; Stapleton et al., 2012), significant directions for future research.

Conclusion

Analyzing the temporal dynamics of 4-month infant and mother self- and interactive contingency during face-to-face interaction allowed us to identify different pictures of communication difficulties at 4 months associated with maternal postpartum depressive symptoms, and maternal postpartum anxiety symptoms. Self-contingency was far more affected than interactive contingency, consistent with prior work (Beebe et al., 2008, 2018, 2020). The picture of self-contingency findings was largely opposite for maternal postpartum depressive symptoms and anxiety symptoms. Moreover, the interactive contingency findings for maternal postpartum depressive symptoms and anxiety symptoms revealed very different vulnerabilities. Infant developing expectancies of these altered contingency patterns constitute one process by which maternal mood and distress might be transmitted to the infant and alter the trajectory of infant development.

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