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Don't worry, be (moderately) happy: Mothers' anxiety and positivity during pregnancy independently predict lower mother–infant synchrony

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Abstract

Maternal positivity and mother–infant synchrony have been linked, independently, to beneficial infant outcomes; however, research that has examined relations between the two has found that higher positivity is associated with lower synchrony. Methodological issues may inform this counter-intuitive association and clinical theory supports its validity. This study examined the theory that heightened positivity associated with anxiety is a way of avoiding negative emotion and contributes to lower synchrony because it interferes with appropriate responding to infant cues. We examined mothers' (N = 75) self-reported anxiety and verbal expression of positivity during pregnancy in relation to mother–infant synchrony at 6 months post-partum. Verbal positivity was assessed using linguistic analysis of interviews about pregnancy experiences. Mother and infant affect and gaze were coded during interaction and synchrony was computed as the correlation between mother and infant behaviors. Higher verbal positivity and anxiety during pregnancy independently predicted lower mother–infant synchrony, suggesting distinct pathways to the same degree of synchrony with potentially different consequences for infant development.

Keywords

Mother–infant interaction; Synchrony; Positive emotion; Maternal anxiety

1. Introduction

During infancy, parenting is typically represented by images of happy babies and happy mothers, which may place pressure on mothers to be overly positive when interacting with their infants. Developmental research may have added to this pressure by promoting the role of shared mother-infant positivity (e.g., Mäntymaa et al., 2015), which tends to discourage anything but positive emotion expression by mothers. Although maternal positivity is consistently associated with healthy socioemotional (e.g., Eisenberg et al., 2005) and cognitive (e.g., Ryan, Martin, & Brooks-Gunn, 2006) outcomes in children, this may be, in part, because research has tended to use measures of positivity that encompass aspects of warm, sensitive parenting beyond positive affect (Harrist & Waugh, 2002) or has focused on problematic forms of diminished positivity, as in parental depression. Of note, a high degree of maternal positive affect towards infants is not culturally universal (Keller et al., 2005;

Tronick & Beeghly, 2011). Therefore, the large body of work promoting the benefits of high levels of positivity in parenting should be interpreted thoughtfully in light of limitations of existing research, cultural variation, and research that supports exposing infants to a broad and balanced array of emotions (e.g., Malatesta, Culver, Tesman, & Shepard, 1989).

Excessive maternal positivity may actually impede accurate, attuned responses to infant cues. Theories of parent–infant co-regulation propose that dynamic adaptation of each partner to the other is fundamental to infants' developing emotion regulation (e.g., Tronick, 2007). This suggests that mothers need to provide variety in their emotion expressions, not maintain one-note positivity. The call and response between infant and parent is often characterized as synchrony, which measures temporal dyadic coordination and has been related to numerous beneficial outcomes (Feldman, 2007), but has also been subject to inconsistencies in measurement and definition, including confounding measures of synchrony with parenting positivity (Harrist & Waugh, 2002).

Although past research has linked high levels of maternal positivity and high levels of synchrony, *independently*, to beneficial outcomes, the few studies that have examined relations between the two constructs have found that higher levels of maternal positive affect have been found to be associated with lower mother–infant synchrony (Feldman, Granat, & Gilboa-Schechtoman, 2005; Moore et al., 2013). Given the emphasis on shared positive affect as the goal of mother–infant interaction, an association between lower synchrony and greater maternal positive affect may initially seem counter-intuitive. However, when considering the definition of synchrony as the temporal coordination of partners' states, independent of affective valence (e.g., Feldman, 2007) and positivity in terms of specific measures (e.g., verbal positivity, facial positive affect) rather than global measures of warm, sensitive parenting, the findings make more sense. A mother who maintains high levels of positive affect when interacting with her infant may not be responsive to the ebb and flow of infants' cues and, thus, may not provide the structured variability of mismatch and repair that helps to shape infants' learning of social contingency (Tronick, 2007).

High levels of positivity, therefore, may be problematic if they are non-contingent and contribute to an inflexible and invariant affective experience for infants. For example, mothers with high levels of anxiety have been found to maintain positive affect irrespective of infant cues (Feldman, 2007; Feldman et al., 2005). Because anxiety is associated with avoidance of negative emotions (Aldao, Nolen-Hoeksema, & Schweizer, 2010), some evidence indicates that high levels of expressed positive affect by mothers may reflect this form of avoidance coping (e.g., Borelli, West, Decoste, & Suchman, 2012). In support of this, an evaluation of 11 mothers with anxiety disorders from a community sample (Feldman et al., 2005) revealed that anxious mothers scored higher than others on displays of positive affect and motherese, and that anxious mothers' behaviors were often not matched to infants' states and signals. Maternal anxiety has also been related to intrusiveness with infants (Biringen, 1990; Cox, Owen, Lewis, & Henderson, 1989), with that intrusiveness characterized by more rapid and intense responses than other mothers (Feldman, Greenbaum, Mayes, & Erlich, 1997). Therefore, although prior work has focused on lower synchrony in relation to maternal depression, which assumes diminished positive affect (e.g., Field, Healy, Goldstein, & Guthertz, 1990) and, thus, implies that greater positive

affect is preferable, research is accumulating to suggest that a surfeit of positivity, particularly if it is associated with anxiety, may also diminish mother–infant synchrony.

In light of research emphasizing the importance of parent–infant synchrony for healthy development, new work identifying maternal factors that contribute to synchrony is warranted. Greater synchrony has been found to predict better self-regulation and compliance, fewer behavior problems, and healthy social–emotional adjustment later in childhood (Feldman, 2007; Feldman & Eidelman, 2004; Feldman, Greenbaum, & Yirmiya, 1999). As early as three months of age, lower levels of mother–infant synchrony have been associated with higher physiological arousal and atypical vagal reactivity in infants during face-to-face interaction with their mothers (Moore & Calkins, 2004). This is likely because attuned, timely responding to infant cues is thought to foster a connection characterized by reciprocity and trust, ultimately promoting a sense of efficacy in restoring calm that grows the infant's capacity for self-regulation.

2. The current study

The current study aimed to contribute to a more nuanced understanding of the role of mothers' positivity in infant development by examining relations among maternal positivity, anxiety, and mother–infant synchrony. To the extent that heightened maternal positivity is a function of anxiety and avoidance of negative emotion, high levels could indicate unresponsiveness to infants' cues. This would suggest that the relation between higher maternal positivity and lower synchrony is mediated by anxiety.

To assess maternal positivity, we measured mothers' verbal expression of positivity using linguistic analysis of the frequency of positive emotion words during the third trimester of pregnancy. By asking mothers to talk specifically about the positive and negative aspects of their pregnancies, we intended to tap into a tendency to accentuate the positive even when talking about difficult experiences related to childbearing. Conducting interviews prior to infants' births afforded an assessment of maternal positivity independent of child characteristics and allowed us to determine whether maternal contributors to lower mother–infant synchrony could be ascertained prior to childbirth.

Although rarely studied as an index of maternal affect, the frequency of emotion-related words that individuals use when describing their experiences has robust associations with personality, behavior, relationship quality, and mental health (Pennebaker, Mehl, & Niederhoffer, 2003; Seider, Hirschberger, Nelson, & Levenson, 2009) and is stable and reliable across time and topic (Pennebaker & King, 1999; Pennebaker & Stone, 2003). One study that did use linguistic analysis of interviews with mothers (Borelli et al., 2012) conceptualized high rates of positive emotion words as avoidance of negative affect and found that substance-abusing mothers who used positive emotion words more frequently than other mothers during a parenting interview were observed to be less sensitive to their children's cues. Furthermore, attachment research has found that mothers who did not freely verbalize negative affect were more likely to have children later classified as insecurely attached (Malatesta et al., 1989; Ritter, Bucci, Beebe, Jaffe, & Maskit, 2007), suggesting

that verbal avoidance of negative emotions may influence the quality of mother–infant interactions and emerging relationships.

Guided by prior research (Borelli et al., 2012; Feldman, 2007; Feldman et al., 2005; Moore et al., 2013), we proposed the following aims and hypotheses:

1. Our primary aim was to examine whether maternal positivity was related to mother–infant synchrony and, if so, to test whether anxiety explained the relation between higher maternal positivity and lower mother–infant synchrony. We hypothesized that: (a) higher verbal expression of positivity during pregnancy, measured as frequency of positive words during interviews about positive and negative pregnancy experiences, would predict lower mother–infant synchrony; (b) higher levels of maternal anxiety during pregnancy would predict lower mother–infant synchrony; and (c) anxiety would mediate the relation between higher verbal positivity and lower mother–infant synchrony, consistent with theories of anxiety as avoidance of negative emotion (e.g., Aldao et al., 2010).
2. Our secondary aim, conditional on finding a relation between verbal positivity and synchrony, was to understand better how pre-partum verbal expression of positivity during an adult interaction could be manifested in post-partum mother–infant synchrony. We proposed that mothers' verbal positivity during pregnancy would be related to mothers' facial positive affect during mother–infant interaction. This was supported by research finding that mothers' use of positive emotion words during a parenting interview was related to behavior with their infants (Borelli et al., 2012) and to trait theories of positivity, including work finding that mothers' positive affect when interacting with their infants had a trait component related to mothers' prior positive affect, and an independent component specific to infants' concurrent positive affect (Moore, Cohn, & Campbell, 1997). We proposed that the relation between mothers' verbal expression of positivity during pregnancy and later mother–infant synchrony would be explained by mothers' positive affect during interaction with their infants, suggesting a trait-like positivity that is independent of infant behavior (Moore et al., 1997).

3. Method

3.1. Participants

The current study drew data from a larger study of fetal neurobehavioral development and the ontogeny of the mother–child relationship (blinded for review) that recruited pregnant women from an urban community through local advertisements and postings. Participants included in the current study (N = 75) had complete data for procedures (described below), were non-smoking, and had singleton, uncomplicated pregnancies and births. Women were on average 32.29 years of age (SD = 4.41). Most women (66.7%) were primiparous. At the time of data collection, women had completed an average of 17.29 years of school (SD = 1.92), and the majority (96%) was married. Most (73.3%) of the women identified themselves as non-Hispanic White, 12% as African American, and 14.7% as Asian. At the post-partum assessment, infants (41% female) were, on average, 27.10 weeks of age (SD = 1.23).

3.2. Procedures

3.2.1. Questionnaires—The State-Trait Anxiety Inventory (STAI; Spielberger & Gorsuch, 1983) was administered to participants at 36 weeks gestation and at 6 months post-partum to assess anxiety concurrent with pregnancy interviews and with observations of mother–infant interaction. The STAI is a 40-item self-report measure that produces two 20-item scales, distinguishing state-and trait-based anxiety. It has been previously validated and widely used in research with mothers during pregnancy and post-partum.

Because symptoms of anxiety and depression are highly correlated (Clark & Watson, 1991), participants' depressive symptoms were assessed to examine whether effects were specific to anxiety. The 10-item Edinburgh Postnatal Depression Scale (EPDS; Cox, Holden, & Sagovsky, 1987) was completed by participants at 36 weeks gestation and at 6 months post-partum. The EPDS has good psychometrics, including sensitivity and sensitivity, validity, and reliability when used with women during the perinatal period (Cox et al., 1987).

3.2.2. Pregnancy interviews—Semi-structured interviews were conducted for all mothers by the same research assistant at 36 weeks gestation. During the approximately 10-min interview, the interviewer asked women to reflect on the uplifting and the distressing aspects of pregnancy. Questions focused on common pregnancy experiences such as feeling the baby move, nausea, heartburn, sharing news with family, and worries about giving birth. Women were randomly assigned to begin the interview with questions relating to uplifting or distressing experiences. Interviews were audio-recorded for later transcription by a group of trained research assistants naïve to study hypotheses.

Text files of transcribed interviews were first edited to include only mothers' spoken words (removing interviewer speech and non-word utterances, e.g., "sneezes," "laughs"). Edited text files were analyzed using Linguistic Inquiry and Word Count software (LIWC; Pennebaker, Booth, & Francis, 2007). LIWC is text analysis software that calculates word counts in numerous dimensions of language, including categories tapping psychological, social, and biological constructs. LIWC has been widely used across a variety of experimental paradigms and has a robust ability to predict meaningful outcomes and individual differences in cognitive and attentional focus, emotionality, and social relationships (Tausczik & Pennebaker, 2010). To assess verbal positivity and negativity in the current study, variables that indicated frequencies of positive and negative word use were computed as a percentage of total word use for each participant.

3.2.3. Mother–infant interaction—Post-partum maternal behavior was observed during a structured mother–infant interaction, the Face-to-Face Still-Face (FFSF; Tronick, Als, Adamson, Wise, & Brazelton, 1978), which was conducted during a laboratory visit when infants were approximately six months old. The FFSF was composed of three 2-min episodes—normal play, still-face, and reunion. Infants were placed in a secure play seat opposite their mothers. Mothers were instructed to play normally with their infants for 2 min (normal play), then to turn away for 15 s. Upon turning back, mothers were instructed to adopt a neutral expression and not to respond to their infants in any way (still-face). After 2 min, mothers were instructed to turn away again for 15 s and then to return to interacting

with their infants (reunion). Mothers were assured that they could stop the procedure at any time and that the researcher would stop the interaction if the baby became too fussy.

Interactions were videorecorded using a split-screen procedure: two cameras (one for infant, one for mother) were used to record the procedure, and videos were later combined and time stamped. Following prior research (Moore & Calkins, 2004), mothers' and infants' affect was coded as positive, neutral, or negative, or as obscured if coders were unable to see a mother's or infant's face. Coders naïve to study hypotheses were first trained to reliability using existing video recordings of FFSF interactions. To assess inter-observer reliability for this study, 15% of FFSF interactions were randomly double coded. Agreement was calculated as both coders observing the same behavior within 1 s of each other and quantified using kappa to correct for chance agreement. Overall, coders reliably identified mother and infant affect, k = .89 for mothers and infants, and gaze, k = .78 for mothers and .80 for infants. For each mother and infant, the percentages of time spent expressing positive and negative affect were calculated as a function of total valid (i.e., not missing or obscured) time in each interactive (normal play and reunion) episode.

3.2.4. Mother–infant synchrony—Following prior research (Cohn & Tronick, 1988; Moore & Calkins, 2004), synchrony was computed as the correlation between mother–infant affective behaviors. First, each mother's and each infant's degree of positive engagement at each second of the interaction was computed separately. Information from affect and gaze was combined to derive a scaled score on a 6-point scale (i.e., a value of (1) was assigned if the individual displayed negative affect and gaze away, (2) if negative affect and gaze toward partner, (3) if neutral affect and gaze away, (4) if neutral affect and gaze toward, (5) if positive affect and gaze away, and (6) if positive affect and gaze toward). This method yielded a score for each infant and for each mother at each second that represented the degree of social engagement displayed by the individual at that second with a 1 representing peak negative disengagement and a 6 representing peak positive engagement.

To assess synchrony, the Pearson correlation between mothers' and infants' social engagement scores was computed separately for each dyad and separately for the normal play and reunion episodes. Whether or not each synchrony score (i.e., correlation coefficient) was statistically significant was also coded dichotomously. Synchrony scores with a positive sign indicated dyads whose affective behaviors moved in the same direction over the course of the interaction (i.e., as infants became more positively engaged, mothers became more positively engaged) and synchrony scores with a negative sign indicated dyads whose affective behaviors moved in opposite directions (i.e., as infants became less positively engaged, mothers became more positively engaged).

4. Results

Mothers rarely showed negative affect during the FFSF (54 showed no negative affect, only 3 showed negative affect more than 7% of the time). Therefore, mothers' negative affect was not considered in preliminary or main analyses.

4.1. Preliminary analyses

4.1.1. Correlations among study variables—As seen in Table 1, mothers' state and trait anxiety were stable between pre- and post-partum assessments and significantly correlated with each other at each assessment. Trait anxiety at pre- and post-partum assessments was unrelated to mothers' pre-partum verbal positivity, mothers' positive affect in the FFSF, or mother–infant synchrony. Therefore, trait anxiety was not considered in main analyses. Depressive symptoms were stable across pre- and post-partum assessments and significantly correlated with trait and state anxiety.

Relevant to the proposed mediation model, mothers' pre-partum verbal positivity and pre- and post-partum state anxiety were correlated with mother–infant synchrony during normal play of the FFSF. However, state anxiety at both assessments was unrelated to mothers' verbal positivity during pregnancy interviews or mothers' positive affect during the FFSF.

Consistent with the method for computing synchrony, mothers' positive affect was correlated with synchrony in normal play and reunion episodes of the FFSF. Infants' positive affect was significantly correlated with synchrony only in the reunion episode. Mothers' positive affect was correlated with infants' negative affect during normal play and with infants' positive and negative affect during the reunion episode.

Relevant to the aim of understanding how pre-partum verbal positivity could be manifested in post-partum synchrony, mothers' pre-partum verbal positivity was correlated with mothers' positive facial affect during the normal play episode of the FFSF, suggesting modest trait-like positivity across time and domains. Consistent with trait affect theories, mothers' and infants' affect was stable between normal play and reunion episodes.

Mothers' verbal positivity during pregnancy interviews, positive affect during the FFSF, mothers' pre- and post-partum state anxiety, and mother–infant synchrony were unrelated to maternal age, education, race, number of children, and infant sex. Therefore, demographic variables were not included as covariates in main analyses.

4.1.2. Descriptive statistics—As seen in Table 2, mothers used significantly more positive emotion words than negative emotion words during pregnancy interviews. Mothers' state anxiety symptoms increased slightly, albeit significantly, between the pre- and post-partum assessments. Mothers were significantly more positive during the normal play than reunion episode of the FFSF. Infants' were more negative during the reunion episode than normal play (Table 3).

Mean levels of the dependent variable in main analyses, synchrony, did not differ significantly between the normal play and reunion episodes. Synchrony scores ranged from −.21 to .76 in the normal play episode and −.22 to .66 in the reunion episode. Skewness and kurtosis statistics indicated that synchrony scores were normally distributed. Twelve dyads in the normal play episode had synchrony scores with negative signs, indicating that the dyads' affective behaviors moved in opposite directions (e.g., as infants became less positively engaged, mothers became more positively engaged). However, the magnitude of the negatively signed synchrony scores was generally very small, about half were less than .

10 in magnitude, and none was statistically significant, suggesting low synchrony. Similarly, in the reunion episode, only four dyads had synchrony scores with negative signs and only one of these was greater than .04 in magnitude and was statistically significant.

4.1.3. Mother–infant behavioral components of synchrony—Because synchrony was computed as a function of mothers' and infants' affective behaviors, to provide a context for understanding maternal pre-partum predictors of mother–infant synchrony, we examined the relative contributions of mothers' and infants' facial affect during the FFSF to mother–infant synchrony. Mothers' positive affect and infants' positive and negative affect were regressed on synchrony scores, separately for the normal play and reunion episodes. Consistent with prior research (Moore et al., 1997), during the normal play episode, mother's positive affect, $B = -.28$, $p < .05$, and infants' positive affect, $B = .26$, $p < .05$, were independent determinants of mother–infant synchrony, Adjusted $R^2 = .09$, $F(3, 69) = 3.26$, $p < .05$. Infant negative affect, $B = .08$, $p = .55$, had no effect on synchrony during normal play. During the reunion episode, mothers' positive affect, $B = -.56$, $p < .01$, infants' positive affect, $B = .36$, $p < .05$, and infants' negative affect, $B = -.26$, $p < .05$, independently predicted synchrony, Adjusted $R^2 = .32$, $F(3, 60) = 10.71$, $p < .001$). Therefore, infant affect was included as a covariate in main analyses to isolate specific effects of maternal factors on mother–infant synchrony.

4.2. Main analyses

Because predictors (mothers' pre-partum verbal positivity during pregnancy interviews and mothers' pre-partum state anxiety) were unrelated to mother–infant synchrony during the reunion episode of the FFSF, only synchrony during the normal play episode was examined in main analyses.

1. Does anxiety explain the relation between mothers' positivity and mother–infant synchrony? Hierarchical regression analysis with mother–infant synchrony during the normal play episode as the dependent variable was used to test the mediation hypothesis. To control for effects of infant behavior, infant positive affect during normal play was entered in the first step. Mothers' pre-partum verbal positivity was entered in the second step and mothers' pre-partum state anxiety was entered in the final step. Mediation would be confirmed if the relation between verbal positivity and synchrony was reduced after adding state anxiety to the model (Baron & Kenny, 1986). In the second step, mothers' verbal positivity was a significant predictor of synchrony, $B = -.26$, $p < .05$. In the final step, mothers' verbal positivity, $B = -.24$, $p < .05$, and mothers' pre-partum state anxiety, $B = -.36$, $p < .01$, independently predicted mother–infant synchrony, controlling for infant behavioral positivity, which was not a significant predictor in the full model, Adjusted $R^2 = .10$, $F(3, 69) = 3.87$, $p < .05$. Thus, the mediation hypothesis was not confirmed. Although maternal depressive symptoms were unrelated to mother–infant synchrony, because anxiety and depressive symptoms were highly correlated, we conducted a second hierarchical regression analysis and added maternal pre-partum depressive symptoms to the analysis in the final step along with pre-partum anxiety. Results were similar to the initial analysis. Mothers'

verbal positivity, $B = -.24$, $p < .05$ and mothers' pre-partum state anxiety, $B = -.40$, $p < .01$, independently predicted mother–infant synchrony, controlling for maternal depressive symptoms, $B = .08$, $p = .53$, and infant positive affect, $B = .13$, $p = .23$. Thus, the part of anxiety that was uncorrelated with maternal depressive symptoms predicted mother–infant synchrony.

2. To better understand how pre-partum verbal expression of positivity during an adult interaction could be manifested in later mother–infant synchrony, we examined whether the relation between mothers' pre-partum verbal positivity and post-partum mother–infant synchrony would be mediated by mothers' positive facial affect during mother–infant interaction. Hierarchical multiple regression was used to test the mediation model. In the first step, infant positive affect during the FFSF was added to control for effects of infants' behavior on synchrony. In the second step, mothers' pre-partum verbal positivity was added to the model, significantly predicting synchrony, $B = -.26$, $p < .05$. When mothers' positive affect during the FFSF was added in the final step, pre-partum verbal positivity was no longer a significant predictor, $B = -.19$, $p = .11$, and mothers' positive affect was a significant predictor, $B = -.25$, $p < .05$. This indicated that mothers' concurrent positive affect during mother–infant interaction explained the relation between pre-partum verbal positivity and post-partum mother–infant synchrony. Infant positive affect was not a significant predictor of mother–infant synchrony in the full model, Adjusted $R^2 = .12$, $F(3, 69) = 4.13$, $p < .01$. As a follow-up analysis, regression analysis was used to predict mother–infant synchrony from concurrent (post-partum) anxiety and mothers' concurrent positive affect. Mothers' post-partum state anxiety ($B = -.27$, $p < .05$) and mothers' positive affect during normal play of the FFSF ($B = -.27$, $p < .05$) were independent and significant predictors of mother–infant synchrony. Infant behavioral positivity did not significantly predict mother–infant synchrony in the full model (Adjusted $R^2 = .09$, $F(3, 63) = 3.23$, $p < .05$). Thus, the independent effects of concurrent positive affect and state anxiety mirrored the independent effects of pre-partum verbal positivity and state anxiety.

5. Discussion

Mothers tend to use positive and exaggerated expressions when interacting with their infants (Fernald, 1992) and shared positive affect has been promoted in both popular and scientific discourses as the goal of mother–infant interaction (e.g., Mäntymaa et al., 2015). However, growing evidence, including results of the current study, suggests that high levels of maternal positivity may characterize mother–infant exchanges that are lower in synchrony (Borelli et al., 2012; Feldman et al., 2005; Moore et al., 2013), a quality of dyadic coordination theorized to promote regulatory development by scaffolding infants' ability to attain and maintain calm, attentive states (Feldman, 2007).

Our primary hypothesis that anxiety would explain the relation between higher maternal positivity and lower mother–infant synchrony was not confirmed. Theoretically, mothers high in anxiety might enhance positivity to avoid negative emotions (Aldao et al., 2010) or to meet expectations that mothers should be happy and positive with their infants. Contrary to our predictions and prior research (e.g., Borelli et al., 2012; Feldman et al., 2005), neither

trait nor state anxiety was related to mothers' verbal positivity or positive affect when interacting with their infants. This may be because earlier work used clinical samples of mothers with anxiety disorders (Feldman et al., 2005) or substance-abusing mothers (Borelli et al., 2012), who may have had higher levels of anxiety or heightened perceptions of others' expectations relative to mothers in our low-risk sample.

In fact, we found that higher anxiety and higher positivity independently predicted lower synchrony. This finding suggests that there are multiple ways to achieve the same degree of synchrony and that those different ways could be related to different infant outcomes. Lower synchrony as a function of anxiety suggests an interaction that may be characterized by high arousal rather than high or low affect, consistent with research finding that intrusiveness and rapid, high intensity responses to infants' behavior are typical of mothers higher in anxiety (Biringen, 1990; Cox et al., 1989; Feldman et al., 1997). This pace and intensity could increase infants' arousal without providing effective support for regulation.

On the other hand, if lower synchrony were a function of high maternal positivity, the interaction may not provide sufficient contingency or structured variability to help shape infants' learning of social contingency (Tronick, 2007). Alternatively, high positivity could reflect an interaction that is structured and supported by mothers' trait positive affect in a way that provides predictability and consistency, independent of infants' behavior, and, thus, promotes beneficial outcomes. High levels of positivity, therefore, may be problematic only if they are non-contingent and contribute to an inflexible and invariant affective experience for infants. Research that incorporates measures of synchrony, distinct measures of maternal affect, and child outcomes is needed to determine under what conditions high maternal positivity represents effective or ineffective support for infants' development.

Findings highlight the need to adopt more a complex conceptualization and measurement of synchrony. In particular, optimal levels of synchrony have not been determined. Synchrony that is very high could indicate rigidity, and, therefore, moderate levels of synchrony may be preferable. Of note, highly synchronous interactions where both partners are negative are different from highly synchronous interactions where both partners are positive and different from highly synchronized interactions where individuals move together in time but in different directions (e.g., as a mother becomes more positively engaged an infant becomes less positively engaged). Note that, in this sample, there were no dyads with high mutual negativity because mothers were rarely negative, and there were relatively few dyads where the partners' affective behaviors were synchronized in opposite directions; even in those cases the magnitude of the negatively signed synchrony scores was small. Furthermore, there were no dyads with statistically significant negatively signed synchrony scores in the normal play episode, suggesting that most cases of synchrony in this sample described dyads that moved together in time in the same affective direction. Overall, consistent with prior research (Moore et al., 2013), findings of the current study suggested that future research should incorporate measures of synchrony and affective valence as orthogonal dimensions to better describe the quality of dyadic interactions.

The second aim of the study was to understand how pre-partum verbal expression of positivity during an adult interaction could be manifested in later mother–infant synchrony.

The use of linguistic analysis of mothers' positivity was a novel aspect of the study. Although linguistic analysis has had strong theoretical and empirical support in assessing emotions and behavior in adult social relationships (Tausczik & Pennebaker, 2010), with one exception (Borelli et al., 2012), we found it had not been used in research on maternal positivity and mother–infant interaction. The findings that mothers' pre-partum verbal positivity was related to mothers' positive affect during mother–infant interaction is consistent with theories of trait affect and the longitudinal design allowed for stronger interpretation that higher trait-like maternal positivity contributed to lower dyadic synchrony during normal play. Furthermore, mothers' concurrent post-partum positive affect mediated the relation between earlier verbal positivity during pregnancy and mother–infant synchrony, suggesting that trait-like maternal positivity is a specific determinant of synchrony, independent of infant behavior (Moore et al., 1997). This finding also provides support for using pre-partum measures of maternal functioning to predict the quality of post-partum dyadic interactions, consistent with prior research (Cox et al., 1989) finding associations between mothers' psychological functioning during the second trimester of pregnancy, including anxiety and depression, and diminished sensitivity at three months post-partum.

There are additional aspects of the findings that deserve discussion. First, only state, not trait, anxiety, both pre- and post-partum, was related to mother–infant synchrony, suggesting that anxiety that is situational to pregnancy and caring for an infant may make mothers less responsive to infant cues. Second, depression was unrelated to synchrony and anxiety predicted lower synchrony, controlling for depressive symptoms. This indicated that aspects of anxiety that are uncorrelated with depression predicted lower mother–infant synchrony. The tripartite model (Clark & Watson, 1991) states that anxiety and depression share general distress, and that physiological arousal discriminates anxiety, whereas low positive affect discriminates depression. This also supports the possibility, discussed above, that lower synchrony as a function of anxiety may be due to rapid, high intensity responses to infants, rather than to the affective tone of the interaction.

Third, although synchrony was computed as the correlation between mothers' and infants' affective behaviors, when mothers' verbal positivity and anxiety were included in the model, infants' affect was not a significant predictor of mother–infant synchrony during normal play, suggesting that maternal qualities may be stronger determinants of synchrony during normal play interactions than infant behavior. Related to this, mothers' verbal positivity and maternal anxiety were unrelated to synchrony in the reunion episode of the FFSF, even though mother's verbal positivity during pregnancy was related to mothers' positive affect during both the normal play and reunion. Although the degree of synchrony did not change significantly between the two episodes, the determinants of synchrony in the reunion episode were different from those of synchrony in the normal play episode. In the normal play episode, only maternal behaviors and characteristics were determinants of synchrony. In the reunion episode, which presents mothers and infants with the challenge of restoring their prior interaction, both mothers' and infants' affective behaviors, and both infant negative and positive affect contributed to synchrony. Together, the finding that there were different patterns of synchrony in the two contexts of the FFSF without a difference in level of synchrony, along with the main finding that maternal positivity and anxiety were

independent predictors of synchrony emphasize that there are multiple ways to achieve the same rate of synchrony.

The current study used a predominantly Caucasian, middle-class sample with levels of anxiety that were normative during the post-partum period. Future research should examine whether high levels of maternal positivity that are a function of anxiety predict lower synchrony in clinical or high-risk samples, and in more diverse samples, given differences in parenting styles across socioeconomic status and culture. Furthermore, research on father–infant dyads may result in different findings, given some evidence that mothers are more stable and consistent and fathers more variable (Feldman, 2007) and that infants play a greater role in the organization of dyadic interactions with their fathers than with their mothers (Moore et al., 2013).

The current study advances the understanding of mother–infant synchrony, a quality of parent–infant interaction that has been consistently related to beneficial infant outcomes (Feldman, 2007), but has also been subject to inconsistencies in definition and measurement (Harrist & Waugh, 2002). Overall, findings emphasized the need to consider the various ways that dyads could achieve the same degree of synchrony and whether these different patterns represent distinct influences on infants' development. In addition, research is needed to identify optimal levels of synchrony and to integrate information about affective valence with temporal coordination with the goal of characterizing dyadic qualities that promote healthy affective balance and effective emotion regulation for infants.

Abbreviations

FFSF Face-to-Face Still-Face

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Table 1

Correlations among study variables.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
(1) Verbal Pos	–														
(2) Verbal Neg	.14	–													
(3) Pre State Anx	.05	−.07	–												
(4) Pre Trait Anx	−.15	.07	.59**	–											
(5) Pre Depression	−.01	.08	.54**	.74**	–										
(6) Post State Anx	.02	−.08	.71**	.54**	.48**	–									
(7) Post Trait Anx	−.22	.05	.49**	.78**	.61**	.64**	–								
(8) Post Depression	−.05	.12	.32**	.55**	.62**	.60**	.76**	–							
(9) Mother Pos NP	.24*	−.02	.10	.03	−.07	.10	−.02	.01	–						
(10) Mother Pos RE	.32**	−.03	.01	−.04	−.10	−.08	−.11	−.09	.54**	–					
(11) Infant Pos NP	−.11	−.04	−.08	−.08	−.16	−.08	−.05	−.07	.22	.35**	–				
(12) Infant Neg NP	−.01	.00	−.02	−.13	.03	−.12	−.11	−.08	−.36**	−.30*	−.34**	–			
(13) Infant Pos RE	.06	.12	.08	−.03	−.10	−.05	−.10	−.06	.14	.30*	.51**	−.19	–		
(14) Infant Neg RE	−.10	.04	−.02	−.01	.01	.00	−.07	−.01	−.14	−.32**	−.03	.35**	−.27*	–	
(15) Synchrony NP	−.27*	−.13	−.38**	−.19	−.16	−.31**	−.12	−.23	−.25*	−.12	.18	.09	−.00	−.00	–
(16) Synchrony RE	−.02	−.01	−.06	−.14	−.08	.12	−.04	−.00	−.21	−.37**	−.13	.04	.27*	−.18	.11

Notes: Pos = Positive; Neg = Negative; Pre = Pre-partum; Post = Post-partum; Anx = Anxiety; NP = Normal Play of the FFSF; RE = Reunion of the FFSF.

* $p < .05$ level (2-tailed).

** $p < .01$ level (2-tailed).

Table 2

Descriptive statistics for mothers' positive and negative emotion words during pregnancy interviews and pre- and post-partum anxiety and depressive symptoms.

Variable	Pre-partum *M* (SD)	Post-partum *M* (SD)	*t*	*df*
% Positive words	4.12 (0.90)	–	–	–
% Negative words	.26 (0.24)	–	–	–
State anxiety	30.13 (8.00)	32.68 (8.75)	−2.80*	68
Trait anxiety	32.96 (7.96)	34.00 (8.88)	−1.50	68
Depressive symptoms	5.19 (3.63)	4.93 (3.55)	.69	67

* $p < .01$.

Table 3

Descriptive statistics for mother and infant facial affect and mother–infant synchrony in the FFSF.

Variable	Normal play *M* (SD)	Reunion *M* (SD)	*t*	*df*
Mother positive affect	.85 (.14)	.76 (.21)	4.02**	66
Infant positive affect	.26 (.24)	.22 (.23)	1.60	67
Infant negative affect	.11 (.14)	.24 (.33)	−3.55*	67
Synchrony	.20 (.20)	.22 (.16)	−7.91	62

* $p < .01$.

** $p < .001$.