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Using the Actor-Partner Interdependence Model to assess maternal and infant contributions to mother-infant affective exchanges during the Still-Face Paradigm

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ABSTRACT

This study describes maternal and infant contributions to dyadic affective exchanges during the Still-Face Paradigm (SFP) in an understudied mostly low-income sample. One hundred eleven mothers and their 7-month-old infants were videotaped during the SFP to analyze how a social stressor affects mother-infant positive and negative affective exchanges during interaction. The SFP includes 3 episodes: baseline, maternal still-face, and reunion. Maternal and infant positive and negative affect were scored by masked reliable coders. Data were analyzed using the Actor-Partner Interdependence Model to test the hypotheses that each partner's affectivity during the baseline episode would predict their own affectivity during the reunion episode (actor effects). We also expected that each partner's affectivity during the baseline episode would influence the other partner's affectivity during the reunion episodes (partner effects). After controlling for infant sex and maternal education, results provided evidence for actor effects for maternal and infant positive affect, and for partner effects for maternal baseline positive affect to infant positive affect during the reunion. One significant partner effect was observed for negative affect: Infant negativity during baseline predicted greater maternal negativity during reunion. Findings confirm that both mothers and infants contribute to dyadic affective processes during the SFP but specific findings vary depending on the affective valence in question. Clinical implications and future research are discussed.

1. Introduction

The bidirectionality of parent-child relationships is a concept that has only come into the spotlight in the past 50 years (Bell, 1968; Grusec & Hastings, 2007). Before this shift in thought, scientists assumed that the direction of influence in parenting passed solely from parent to child (Bell, 1968; Kuczynski, 2003). Today, most developmental scientists contend that an ongoing dynamic bidirectional transaction occurs between parent and child throughout ontogeny that mutually influences both members of the dyad

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(Kuczynski, 2003; Sameroff & Chandler, 1975; Sameroff, 2010). Additionally, bidirectionality has multiple definitions and been studied under various names and differing theoretical presumptions, including 'coordination,' 'coregulation,' 'mutuality,' 'affect attunement,' and 'intersubjectivity' (Feldman, 2003; Fogel, 1993; Murray & Trevarthen, 1986; Stern, Hofer, Haft, & Dore, 1985; Tronick & Cohn, 1989; Weinberg, Tronick, Cohn, & Olson, 1999; Yogman, 1982). Bidirectionality also has been evaluated in different temporal frames, using either microanalytic measures (e.g., Beebe et al., 2016; Weinberg et al., 1999) or global measures assessed across contexts (e.g., Kogan & Carter, 1996; Martinez-Torteya et al., 2014; Morelan, Menke, Rosenblum, Beeghly, & Muzik, 2016).

Despite the multitude of terms, operational definitions, and abundance of findings, the nature of these bidirectional processes remains understudied, particularly among mother-infant dyads from low-income urban backgrounds (for an exception, see Kogan & Carter, 1996). It is important to study these processes in low-income cohorts because, although individual differences in parenting and infant behavior in low-income cohorts exist (McLoyd, 1998), higher socioeconomic stress is robustly linked to decreased maternal responsiveness and increased infant affect regulatory problems (Evans, Boxhill, & Pinkava, 2008). For example, in an extensive analysis using seven waves of data from the National Longitudinal Survey of Youth, Bradley and Corwyn (2003) found that socioeconomic status (SES) was negatively correlated with maternal responsiveness. Furthermore, Camfferman (2013) examined maternal risk status on infants' physiological and behavioral response to a perturbation in maternal behavior during mother-infant interaction (i.e., maternal still-face) and found that infants from a high-risk group had higher levels of sympathetic activity than lower-risk infants, which indicates more stress. There especially has been a scarcity of research investigating mother-infant positive and negative affective exchanges in low-income samples using sophisticated statistical modeling, such as the Actor Partner Interdependence Model (APIM). Such studies could provide a greater understanding of maternal and infant contributions to mother-infant interactive processes in this population, which could help practitioners tailor more effective clinical prevention and intervention efforts for dyads at-risk for maladaptive mother-infant interactions (Adamson & Frick, 2003; Evans et al., 2008; Mesman, van IJzendoorn, & Bakermans-Kranenburg, 2009).

The central goal of the current study was to address this gap in the literature by evaluating mother-infant bidirectional affective processes at 7 months postpartum in an understudied low-income sample. Dyads were videotaped in the Still-Face Paradigm (SFP, Tronick, Als, Adamson, Wise, & Brazelton, 1978), a widely-used procedure designed to evaluate how exposure to a social stressor (maternal still-face) affects infant reactivity and mother-infant social interaction. The SFP extends the natural mismatches that occur in mother-infant interaction to produce a prolonged stressful situation for both mother and infant (Tronick et al., 1978). Specifically, we focused on the bidirectionality of maternal and infant positive and negative affective processes across the two interaction episodes of the SFP (baseline play and reunion).

In the current study, we utilized a recent innovation in statistical modeling to evaluate our goals: the Actor-Partner Interdependence Model (APIM, Fitzpatrick, Gareau, Lafontaine, & Gaudreau, 2016). The APIM was designed to measure and account for the level of interdependence within interpersonal relationships (Cook & Kenny, 2005) and has been used to evaluate bidirectionality in parent-child interactions in prior research (e.g., Atkinson et al., 2013; Barry & Kochanska, 2010). However, to our knowledge, it has yet to be applied to mother-infant dyads during the SFP. The APIM is a promising tool for studying bidirectionality in mother-infant affective exchanges during the SFP because it allows researchers to study the unique influence that each member of a dyad has on their own behavior assessed at a later time point (*actor effects*), as well as the unique influence that each member has on the other member (*partner effects*), both concurrently and over time (Cook & Kenny, 2005; *See* Fig. 1). In the current study, bidirectional effects in mother-infant affective exchanges are defined as partner effects.

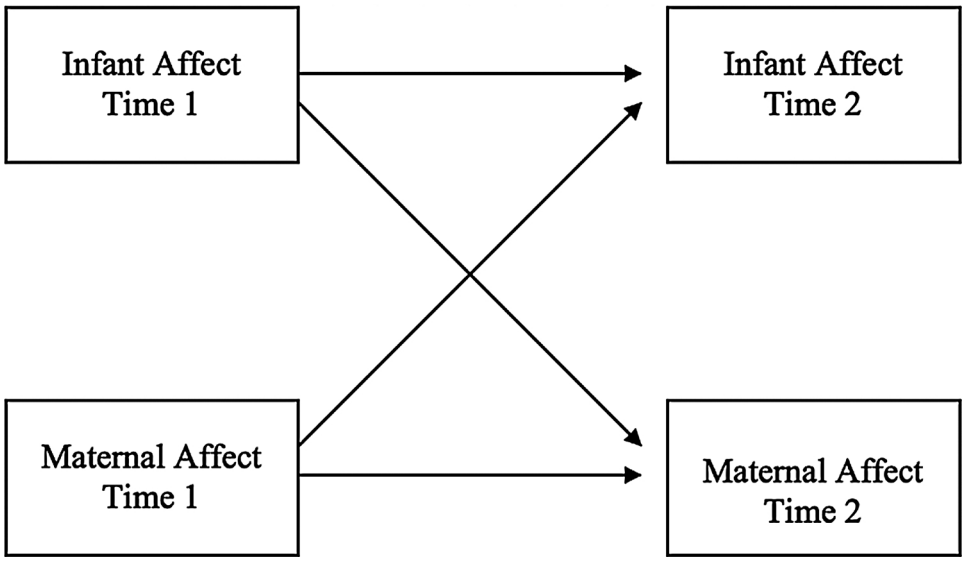

Fig. 1. Theoretical model of the APIM. Actor effects are denoted by straight lines, while partner effects are diagonal lines.

1.1. Dyadic nature of parent-infant interactions

The current study is guided by the Mutual Regulation Model, which describes the parent-infant relationship as a dynamic affective communication system comprised of both members of the dyad and their interchanges (Tronick & Beeghly, 2011; Tronick, 1989). According to this perspective, relationships are developed and co-regulated by both parent and infant (Beeghly & Tronick, 2011), and the responses of each member of the dyad to the other over time are crucial in building successful social interactions, as experienced by both members of the dyad.

This approach is consistent with broader transactional models of development (Sameroff & Mackenzie, 2003), which focus on how infant and caregiver alter each other both at the same moment in time, and over time in an ongoing manner. This perspective is also consistent with, but not identical to, Trevarthen's (1993) psychobiological Theory of Innate Intersubjectivity, or readiness for intersubjectivity, including its construct "intra-subjective coherence." This theory argues that infants are born with characteristics and intentions of the self that influence the consistency of their own behavior over time and contribute to how infants and caregivers perceive and respond to each other's behavior (Kokkinaki & Vasdekis, 2015; Trevarthen, 1993, 2011). It accounts for the process within which innate thoughts, motives, and emotions are exchanged between infants and their caregivers (Trevarthen, 1997, 1998, 2005). Over time, this intrinsic motivation for infants to acquire and sustain relationships then affects the intra-subjective coherence, or emotional equilibrium, of the infant himself (Trevarthen, 1997). The interplay between the self-awareness of the infant and the bids that he puts forth to others, begins to build relationships between the infant and those around him. Importantly, the Theory of Innate Intersubjectivity emphasizes the agency of the infant himself, even from birth (Trevarthen, 2011). As this agency and self-awareness mature, relationships with significant caregivers grow stronger.

The Mutual Regulation Model, Theory of Innate Intersubjectivity, and other transactional approaches posit that early relationships between infants and their parents emerge gradually over time and are influenced by the dynamic interplay of both parental and infant characteristics and behaviors; therefore, parent-infant interactions are best conceptualized within a dyadic framework (Mastergeorge, Paschall, Loeb, & Dixon, 2014). During early social interactions, it is quite common for dyadic mismatches in level of engagement, excitement, anger, or attention to occur (Feldman, 2007). The constant shifts in attention, behavior, and affect between mother and infant over time can initiate different dyadic configurations of affect (Tronick, 2007). For example, a dyad may exhibit a positive affective match when both mother and infant look at each other and display positive affect at the same time. However, this dyadic match in shared positive engagement is unlikely to last. Given infants' immature self-regulatory skills, infants are likely to become dysregulated and gaze away from the mother. At this point, if the mother is still exhibiting positive affect, the dyad experiences an affective mismatch. If the mother pauses and waits for the infant to recover before attempting to re-engage the infant in social interaction, the dyad is likely to repair the mismatch and re-establish a positive interaction.

According to the Mutual Regulation Model, affective mismatches are repaired through the mutual participation of both members of the dyad. If a particular dyad is able to repair interactive mismatches in a timely manner, they are likely to experience positive mutually regulated interaction processes later on, and such dyads' interactions become more regulated and synchronous over time (Tronick, 2007). In turn, engaging in well-regulated parent-child interactions is linked to the establishment positive parent-child relationships and more mature infant self-regulatory skills (Feldman, 2003; Tronick & Beeghly, 2011; Tronick, 1989). If persistent, less positive parent-infant interactions may lead to the establishment of insecure attachment relationships (Beebe et al., 2010), and other less optimal child outcomes, particularly poorer social-emotional adjustment (Beeghly & Tronick, 2011; Feldman, 2003, 2007).

One aspect of the literature on parent-infant interactive processes that needs further study is the role of actor and partner effects in early parent-infant interactions; i.e., the extent to which each member of the dyad exhibits stability in their own behavior over time (actor effects) and how each member's behavior alters the behavior of the other member over time (partner effects). Studies of parent-infant interactive processes rarely evaluate actor effects, and rarely control for them when studying partner effects, which may obscure our understanding of the directionality of effects in parent-child interactions. Given infants' immaturity, caregiver regulatory support is thought to be critical in supporting infants' ability to engage the world of people and objects in a positive manner (Calkins & Hill, 2007; Tronick & Beeghly, 2011; Tronick, 1989). Accordingly, one might hypothesize that parental behavior may be more influential than infant behavior in determining the quality of subsequent infant affective responses over time, particularly when dyadic interactions are assessed during early infancy. On the other hand, individual differences in infant vulnerability (e.g., those associated with male sex, difficult temperament, or preterm birth) may cause infants to become dysregulated during social interactions than less vulnerable or less reactive infants, and more difficult to soothe, leading to stronger infant effects on dyadic social interaction processes.

The direction of effects observed may also vary depending on the valence of the particular affect under study (i.e., negative or positive affect). The affect displayed by both members of the dyad, mother and infant, has been shown to change the quality of interaction. In line with the Mutual Regulation Model, interactions that are mutually regulated in an effective manner are associated with higher levels of positive affect in both partners at subsequent time points (Lindsey, Cremeens, Colwell, & Caldera, 2009; MacLean et al., 2014; Tronick, 2007). In contrast, infant negative affect can influence maternal behavior in a variety of ways and is associated with lower levels of maternal sensitivity during interactions (Haltigan, Leerkes, Supple, & Calkins, 2014; Rosenblum, McDonough, Muzik, Miller, & Sameroff, 2002). In turn, maternal negativity, including harsh and insensitive child-directed behavior, predicts infant negative affect and disengagement, and if persistent, a variety of long-term negative outcomes, including externalizing behaviors and psychopathology (Barker, Oliver, Viding, Salekin, & Maughan, 2011; Wagner, Mills-Koonce, Propper et al., 2016; Wagner, Mills-Koonce, Willoughby et al., 2016)

1.2. Still-Face Paradigm (SFP)

The current study utilizes the SFP to evaluate actor and partner (or bidirectional) effects in mother-infant affective processes during social interaction. The SFP is a widely used social interaction task designed to evaluate infant reactivity and mother-infant interactive processes before and after a social stressor: a maternal still-face (Tronick et al., 1978). The traditional SFP comprises three successive 2-minute episodes. The first is a baseline mother-infant social play episode during which the dyad interacts as they normally would. This is followed by a maternal still-face perturbation, during which the mother assumes a still (poker) face and continues to look at the infant while refraining from talking to or touching the infant. Finally, there is a reunion play episode, during which the dyad resumes their normal social interaction. The SFP still-face and reunion episodes are emotionally and physiologically stressful, as evidenced by increased skin conductance level and heart rate in response to the still face that are seen among infants whose mothers are considered higher risk (Adamson & Frick, 2003; Camfferman, 2013**).** Additionally, infant and maternal characteristics predict individual differences in infants' and parents' responses (Braungart-Rieker, Garwood, Powers, & Notaro, 1998). For example, both infant temperament and maternal sensitivity are associated with variations in infants' affective displays during the SFP (Braungart-Rieker et al., 1998; Lowe et al., 2012; Yoo & Reeb-Sutherland, 2013).

During the reunion episode, parent-infant interaction resumes, and infants typically exhibit a carryover of negative affect from the still-face episode, but also show a rebound in positive affect and social engagement (Weinberg & Tronick, 1996). This suggests that "making up" during the reunion episode is stressful for both infants and parents. Notably, the still-face and reunion effects are observed across a wide variety of infant ages and are robust across a variety of different methodologies, such as length of the still-face episode, and the directions given to the adult for their behavior between segments. However, evidence for the carryover of negative affect into reunion is mixed (Adamson & Frick, 2003; Mesman et al., 2009).

Although there has been much research evaluating mother-infant interaction during the SFP, much of the research has focused solely on infant behavior within episodes, as opposed to changes that may occur across episodes (Mesman, Linting, Joosen, Bakermans-Kranenburg, & van IJzendoorn, 2013). The current study extends this literature by analyzing both mother and infant partner and actor effects across the two interaction episodes of the SFP (baseline play and reunion).

1.3. The Actor-Partner Interdependence Model (APIM; Cook & Kenny, 2005)

For several decades, researchers have investigated the SFP using a variety of statistical methodology. For example, many studies have utilized repeated measures analysis of variance to elucidate behavioral changes across SFP episodes (Braungart-Rieker et al., 1998; Camfferman, 2013). Handal et al. (2017) utilized the Friedman test to analyze differences in affect across five episodes of an extended ("double") SFP. Lowe et al. (2012) used paired *t*-tests to analyze the difference between infant affect scores and maternal interaction style during the SFP. Additionally, sophisticated models have been utilized to tease apart more complex interactions that take place during the paradigm. MacLean et al. (2014) used multilevel modeling to elucidate the relationship between mother-infant synchrony and infant affect during the SFP. Chow, Haltigan, and Messinger (2010) utilized mixed effects bivariate autoregressive models to better understand self-regulation and interactive dynamics during the SFP between infants who had a sibling on the autism spectrum and their parents.

Although much research using a variety of methodology has been conducted on the SFP, no study, to our knowledge, has yet used the Actor-Partner Interdependence Model (APIM) to analyze affective exchanges between infants and their mothers during the SFP. The APIM is a relatively new statistical method used to measure dyadic interactive processes. In contrast to simple bivariate correlations, it controls for all the pathways in the model (actor and partner effects, as well as any covariates) at the same time. In the current study, partner effects in the APIM are defined as a measure of bidirectionality; i.e., the impact of the infant's affect at time one (e.g., baseline play episode of the SFP) on mother's affect at time two (e.g., reunion episode of the SFP) can be measured and, conversely, the impact of the mother's affect at time one on the infants affect at time two can be measured (for a theoretical model, see Fig. 1). Essentially, the APIM is able to take into account each member's interdependence on the other member (Garcia, Kenny, & Ledermann, 2015).

Although the APIM is increasingly used to assess theoretically meaningful dyadic interaction patterns in adult and adolescent populations, especially among social psychologists (Fitzpatrick, Gareau, Lafontaine, & Gaudreau, 2016; Markey & Markey, 2011), it has been used less often to study parent-child interactions (Fitzpatrick et al., 2016). To address this gap in the literature, we utilized the APIM and structural equation modeling (SEM) to evaluate mother-infant affective processes during the SFP. The APIM is particularly valuable as it can shed light on the influences that each member of the mother-infant dyad have on themselves across episodes of the SFP (actor effects), which are rarely studied or controlled for in mother-infant interaction research, as well as the influences each member has on the other member (partner effects, or bidirectionality), both within and across episodes of the SFP, within a single model.

Studies that evaluate mother-infant processes using dyadic approaches other than the APIM are relatively rare. The majority of studies take a static approach, such as combining the behavioral scores of both members of a dyad into a single score (Cook & Kenny, 2005). This obscures assessment of the intricate nature of dyadic processes. For example, if one member of the dyad is engaged and positive, and the other member is unengaged or negative, a combined dyadic score would balance out these differences and fail to provide information about actor and partner effects. Using the APIM to evaluate mother-infant bidirectional affective exchanges (partner effects) during the SFP, while controlling for actor affects, promises to shed further light on the nature of mother-infant interactive processes before and after a social stressor.

1.4. The role of infant and maternal characteristics

The broader literature on mother-infant interaction suggests that infant and maternal characteristics, such as infant sex and maternal education, are linked to variations in infant and maternal affect expressivity and other interactive behavior. Because these variables could alter the nature of actor and partner effects observed in the SFP, they were statistically controlled in the current study. For instance, male sex is associated with poorer biobehavioral regulation during early childhood (Ahl, Fausto-Sterling, Garcia-Coll, & Seifer, 2013; Eiden et al., 2015; Fausto-Sterling, Crews, Sung, Garcia-Coll, & Seifer, 2015). Meta-analyses suggest that these emotion differences may be biological and that young boys show less inhibitory control and attention focusing and more arousal than girls (Else-Quest, Hyde, Goldsmith, & Van Hulle, 2006). Further, infant girls show greater responsiveness to social stimuli, including human faces (Connellan, Baron-Cohen, Wheelwright, Batki & Ahluwaia, 2000) and better discrimination of emotional expressions (McClure, 2000). Certainly, a mother's own socialization about gender and emotions impacts how she attends to and responds differently to the varying temperamental characteristics and emotional expression of a male versus female infant (Brody & Hall, 2008).

Sex differences are less often reported in the SFP literature, and findings among the few studies who report them are inconsistent. For example, Weinberg and colleagues report that male infants have greater difficulty than female infants in regulating their negative emotions during each episode of the SFP (Weinberg et al., 1999). In contrast, Carter, Mayes, and Pajer (1990) report that infant girls exhibit stronger negative reactions to the SFP than infant boys. Still other studies report no significant main effects of sex on infant behavior during the SFP (Lowe, Handmaker, & Aragon, 2006; Weinberg, Olson, Beeghly, & Tronick, 2006; Yirmiya et al., 2006). In a large meta-analytic review of the SFP literature, sex differences in infant behavior were not robust (Mesman et al., 2009). Studies evaluating sex differences in mother-infant interaction using dyadic analytic models such as the APIM have not yet been conducted, to the authors' knowledge. It is therefore important to consider the contribution of infant sex to observed effects. Here, we include infant sex as a control variable (predictor) of mother-infant affective processes during the SFP.

Maternal education is also associated with maternal and infant affective behavior in the broader literature. For instance, higher maternal education is robustly linked to more maternal positive affect and greater sensitivity (e.g., Joosen, Mesman, Bakermans-Kranenburg, & van IJzendoorn, 2012), which in turn is linked to more frequent displays of maternal and infant positive affect, and to less frequent displays of maternal and infant negative affect during social interaction (Beebe et al., 2016; Windhorst et al., 2015). Additionally, higher levels of maternal education are related to higher levels of maternal verbal and physical responsiveness to infants (Richman, Miller, & LeVine, 1992).

However, as is the case for infant sex, few studies have evaluated the role of maternal education on maternal and infant affective processes during the SFP, and the findings of those that have are mixed. In several studies by Tamis-LeMonda et al., maternal education was associated with higher levels of maternal sensitivity (Tamis-LeMonda, Shannon, Cabrera, & Lamb, 2004; Tamis-LeMonda, Briggs, McClowry, & Snow, 2009), which in turn was related to more infant positive affect during the SFP (Mesman et al., 2009). Similarly, in a more highly educated sample, mothers with higher education exhibited more positive affect in each episode of the SFP (MacLean et al., 2014). In many other SFP studies, effects of maternal education are not reported. For example, Pelaez-Nogueras, Field, Hossain, and Pickens (1996) studied a group of demographically high-risk infants and their mothers during the SFP, however, their findings focused strictly on maternal depression and its effect on infant reactions to the SFP rather than maternal education. In another study, Lowe et al. (2016) analyzed maternal education in the context of a cross-cultural examination of touch during the SFP. Although significant effects of education were observed on the amount and type of touch used by mothers during the SFP, the authors did not report overall education effects.

Despite the inconsistent findings for infant sex and maternal education in the SFP literature, we included both as covariates in the APIM model in the current study. This was done in light of the robust effects for each variable reported in the broader literature and because these variables have not to our knowledge been evaluated in the scant APIM literature on early mother-infant interactions.

1.5. The current study

The goal of the current study was to evaluate bidirectionality (partner effects) and actor effects in mother-infant affective processes during the SFP in an understudied, mostly low-income urban sample at 7 months postpartum. After conducting preliminary descriptive statistics and bivariate correlations among the study variables, we assessed actor and partner/bidirectional effects in maternal and infant positive and negative affect observed during the baseline and reunion episodes of the SFP using a dyad-level analytic approach (the APIM and structural equation modeling), controlling for infant sex and maternal education. Separate APIM analyses were conducted for positive and negative affect.

First, we examined potential actor effects for maternal and infant positive affect over time. Specifically, we evaluated whether each person's positive affect observed during the baseline play episode of the SFP contributed unique variance in predicting their own positive affect during the reunion episode of the SFP, controlling for partner effects, infant sex, and maternal education. Second, we examined potential partner (bidirectional) effects for maternal and infant positive affect across the two interaction episodes of the SFP. Specifically, we evaluated whether mothers' or infants' positive affect during the baseline episode of the SFP exerted a stronger effect on the other partner's positive affect during the reunion episode, controlling for actor baseline effects, infant sex, and maternal education.

These analyses were repeated for negative affect in a separate APIM analysis. Fig. 1 displays the theoretical model that these analyses were based upon.

Based on the Mutual Regulation Model and other transactional theoretical perspectives, we expected to find significant actor and

partner effects for both mothers' and infants' positive and negative affective displays from the baseline play to the reunion episodes of the SFP. Regarding actor effects, we hypothesized that each partner's affect (both positive and negative) observed during the baseline episode of the SFP would predict their own affect observed during the reunion episode, which would indicate cross-episode intraindividual stability. Regarding partner/bidirectional effects, we expected that each partner's affectivity (both positive and negative) observed during the baseline episode of the SFP would influence the other partner's affectivity observed during the reunion episodes, and that the magnitude of these partner/bidirectional effects for mothers and infants would be relatively equal.

2. Methods

2.1. Participants

Analyses in the present study were based on data collected for 111 mother-infant dyads (60.4% male infants) who were videotaped during the SFP at 7 months postpartum, as part of a larger ongoing longitudinal study. The goal of the larger study was to investigate the association between characteristics of fetal brain development, as assessed using functional magnetic resonance imaging (fMRI), and postpartum infant and maternal outcomes (blinded for review). Mothers were recruited during the last trimester of their pregnancy and participated in fMRI studies of fetal brain development. After the delivery of the infant, infants' newborn neurobehavior was evaluated during a home visit. At 7-, 36-, and 56- months postpartum, mother-child dyads participated in a lab visit during which their interactive behavior was videotaped, and children's developmental skills were assessed. Mothers also participated in telephone calls between lab visits to update demographics and provide information about the child's behavior.

Analyses in the current study utilized demographic data collected during pregnancy and interaction data collected at the 7-month laboratory visit. Seven months is an important developmental time period for studying mother-child interaction because infants at this age are experiencing the emergence of new skills regarding mobility (i.e., crawling), improved communication (i.e., gestures, facial expressions, and vocalizations), and increased understanding of the world around them (Mayo Clinic, 2017). These emerging skills provide new opportunities and challenges for mother-infant interactions and are foundational to longer-term child outcomes (Brazelton, 1994).

Descriptive statistics for the sample's characteristics are reported in Table 1. Mothers varied in level of completed education, age at the time of the child's birth, and marital status (about half were single parents). Families also varied in total annual income, but most were from low-income backgrounds (about half had an annual income of $20,000 or less, which falls at or below the federal poverty line for most families in this sample). About three-fourths of the mothers self-reported their race/ethnicity as African American.

All research was conducted in accordance with APA ethical standards for the treatment of both mothers and infants in our study and the study was approved by the university's Institutional Review Board (university blinded for review). All mothers provided

Table 1
Sample Characteristics (N = 111).

	n (%) or M(SD) Min-Max
Maternal Education	
GED/High School Diploma or less	42 (37.8%)
Some College	44 (39.6%)
2 year College Degree	4 (3.6%)
4 year College Degree	5 (4.5%)
Master's Degree	2 (1.8%)
Doctorate	2 (1.8%)
Chose Not to Respond	4 (3.6%)
Maternal Race/Ethnicity	
African American	82 (73.9%)
Caucasian	9 (8.1%)
Other	5 (4.5%)
Chose Not to Respond	15 (13.5%)
Marital Status	
Single	57 (51.4%)
Married/Partnered	52 (46.8%)
Widowed	1 (0.9%)
Chose Not to Respond	1 (0.9%)
Household Annual Income	
Less than $20,000	55 (49.6 %)
$20,000 to $40,000	26 (23.4%)
$45,000 +	16 (14.4%)
Chose Not to Respond	14 (12.6%)
Maternal Age at Child's Birth	
	25.96 (4.69)18.71-40.33

written consent to participate in the study.

2.2. Procedures at the 7-month laboratory visit

All procedures at the 7-month laboratory visit took place in a carpeted playroom at a large university. The playroom was equipped with a one-way mirror. Prior to the onset of the laboratory protocols, a trained research assistant described the study procedures to the mother and administered informed consent. Dyads were then videotaped during the SFP, following the procedures described below. After the SFP observation was completed, infants' current developmental skills were assessed using the Bayley Scales of Infant Development-Third Edition (Bayley, 2006) by a trained research assistant while the mothers completed questionnaires pertaining to the larger study. To thank them for their time, mothers were given a gift card or monetary compensation. Mother-infant dyads were also provided with free round-trip transportation to the laboratory at the university or were reimbursed for gas expenses if they chose to drive themselves.

2.3. Still-Face Paradigm (SFP, Tronick et al., 1978)

The SFP is a widely used observational task designed to evaluate parent-infant interactive processes before and after exposure to a social stressor (maternal still-face). During the SFP, infants were placed into a feeding seat, and mothers were asked to sit in a chair directly facing their infant. During the first (baseline) play episode of the SFP, mothers were asked to play with their infant in a normal manner for two minutes without using toys or pacifiers. Immediately following the baseline play episode, a 2-minute still-face episode took place. During the still-face episode, mothers were asked to look down briefly, and then look at the infant while holding a still or poker face (a face that is completely neutral) and to refrain from smiling, vocalizing, or touching the infant. If mothers felt they were going to break the still-face (i.e., smile or laugh), they were asked to look at the infant's forehead or just above the infant's head. After the still-face episode, mothers were asked to look down briefly, then to resume normal play with their infant for two minutes (reunion episode). Mother-infant dyads were videotaped during each episode of the SFP using two digital cameras (one focused on the mother, one focused on the infant). The two images were combined into a single video record for scoring purposes.

If infants became highly distressed during the SFP, episodes were shortened or terminated. In the larger study, seven SFP episodes were shortened due to infant distress (four by the examiners, and three by the mothers). Analyses in the present study were based on SFP data collected for the 111 dyads who completed the baseline, still-face, and reunion episodes of the SFP.

2.4. Coding of mother-infant interaction during the SFP

The APIM requires that a single code for maternal and for infant behavior is used at each time point (baseline play and reunion episodes). Therefore, in order to analyze actor and partner effects in the current study, we used global ratings of mothers' and infants' positive affect and negative affect scored in each interaction episode of the SFP.

In the larger project, coders masked to background variables independently rated multiple dimensions of infant, maternal, and dyadic behavior from videotapes in each episode of the SFP using a reliable scoring system developed for the Maternal Anxiety during the Childbearing Years (MACY) study (MACY Infant-Parent Coding System, MIPCS; Earls, Muzik, & Beeghly, 2009). This coding scheme includes 14 maternal, 10 infant, and 4 dyadic rating Likert scales, each of which ranged from 1 to 5. Half-point scores (e.g., 2.5) were scored when observed behaviors fell between two scale points. Evidence for the high validity and reliability of the MIPCS for scoring mother-infant interactive behavior during the SFP and other interactive contexts is reported elsewhere (e.g., Martinez-Torteya et al., 2014; Morelan et al., 2016).

In the present study, we utilized four MIPCS rating scales assessing maternal and infant positive and negative affect scales. These scales are described in detail, below.

2.4.1. Maternal positive and negative affect scales

Maternal positive affect was coded during the baseline and reunion episodes of the SFP using a 5-point Likert scale, with 1 denoting "no positive affect" and 5 denoting "much enthusiasm/joy." Middle scores signified a moderate range of positive affect. Positive affect was defined using both facial affect and behavior indicators, including positive facial expressions (e.g., smiles), positive vocal tones (e.g., vocal warmth and enthusiasm), and behavioral indicators, such as joyful clapping or excited body movements.

Ratings were assigned based on the frequency, duration, and intensity of positive affect displayed. For instance, a score of 2 indicated the mother displayed mildly positive facial expressions, vocal tones, and/or remarks at least half the time (one minute or longer), with no display of more intense or clear-cut affect. A score of 3 required that the mother additionally display more intense positive affect (e.g., open-mouthed smiles, vocal enthusiasm, or laughter) for a duration of between one second and one minute (less than half of the time). A score of 4 was given when mothers displayed clear-cut and intense positive affect more than half the time (between one minute and two minutes), whereas a score of 5 when a mother displayed clear-cut and intense positive affect all or nearly all of the time.

Maternal negative affect was also coded during the baseline and reunion episodes of the SFP using a 5-point Likert scale, with 1 denoting "no negative affect" and 5 denoting "many instances of moderate to high negative affect for much of the episode." Middle scores signified a moderate range of negative affect. Negative affect included both negative facial expressions (e.g., sad or flat affect) and behavioral indicators (e.g., negative or monotonic vocal tone or other behaviors). Flat affect was defined as neutral or flat facial expressions, a monotone voice, expressionless gazing away from the child, in the absence of positive affect, and was considered to be

a milder indicator of negative affect. Sadness was considered to be a more clear-cut indicator of negative affect and was defined as sad or wistful facial expressions or verbalizations.

As was the case for positive affect, ratings for negative affect were assigned based on the frequency, duration, and intensity of affect displayed. For instance, a score of 2 indicated the presence of some maternal flat affect (i.e., the mother appears slightly flat very briefly), whereas a score of 3 denoted a longer duration of flat affect which may be mixed with more clear-cut negative emotion, such as sadness (less than one minute). A score of 4 indicated that the mother displayed negative affect for more than one minute, whereas a score of 5 indicated that the mother consistently displayed negative affect throughout the observation.

2.4.2. Infant positive and negative affect scales

Infant positive affect was coded during the baseline and reunion episodes of the SFP using a 5-point Likert rating scale, with 1 denoting "no positive affect" and 5 denoting a high level of intense positive affect. For an infant to get a 1, he or she must exhibit no positive affect for the entire time. For an infant to get a 5, he or she must exhibit intense positive affect for all or most of the time. Middle scores signified a moderate amount of positive affect. As with the maternal positive affect scale, infant positive affect was defined using both facial expressions (e.g., smiling) and behavioral indicators (e.g., joyful vocal tones, enthusiasm, excited movements).

Indicators of positive affect range from subtle to explicit, and from mild to very intense. The frequency, duration, and intensity of negative affect are also considered. Subtle positive affect includes brief smiles, positive vocal tones, and face-brightening. More intense indicators of positive affect include clear-cut smiles of longer duration, laughter, marked interest, and clear excitement or enthusiasm. Very high (joyful) positive affect includes squeals of pleasure and excited gestures such as reaching or clapping. A score of 2 denoted that the infant displayed a few indicators of mild or subtle positive affect or one brief instance of more intense or enthusiastic positive affect (e.g., a clear-cut smile). A score of 3 indicated that the infant exhibited subtle positive affect for about half of the time (one minute) and/or showed more intense or enthusiastic positive affect occasionally. A score of 4 denoted that the infant displayed positive affect for more than half the time (over one minute) and/or showed more frequent and intense enthusiastic positive affect than in 3.

Infant negative affect was scored during the baseline and reunion episodes of the SFP using a 5-point Likert scale, where 1 denoted "no negative affect" and 5 denoted "intense negative affect occurring all or most of the time". Middle scores signified moderate amounts of negative affect. Indicators of infant negative affect can range from subtle to clear-cut, and from mild to intense. Subtle indicators of negative affect include brief facial expressions of anger or sadness (e.g., pouts) and/or brief, mild negative vocalizations such as fussing or whining. Clear-cut indices of negative affect include more prolonged facial expressions of anger or sadness, full-blown crying, screaming, or angry behaviors such as hitting or kicking the parent or chair.

The frequency, duration, and intensity of negative affect are also considered. For instance, a score of 2 denoted that the infant displayed some subtle indicators of negative affect or one moderate or prolonged instance of subtle negative affect, whereas a score of 3 denoted that the infant exhibited subtle or moderate negative affect about half the time (one minute) or displayed more intense indicators of negative affect occasionally. A score of 4 denoted that the infant displayed a combination of more frequent negative affect of moderate intensity (over one minute) with the addition of a few instances of high intensity negative affect.

2.4.3. Inter-rater reliability

A team of coders blinded to background variables was trained to independently evaluate and score these qualitative dimensions of the mother-child interaction using the MIPCS. Coders were required to achieve an initial reliability of .80 or higher on each scale in the scoring system prior to being allowed to code for the project. Once initial reliability was achieved, intercoder reliability was subsequently assessed on an ongoing basis on every fifth videotape (20% of the sample) to ensure fidelity to scoring rules and to minimize coder drift. In addition, meetings were held to discuss difficult cases between coders and resolve disagreements. Intercoder reliability was assessed using intraclass correlation coefficients (ICC).

Intercoder reliability was calculated using intraclass correlations (ICCs). ICCs for maternal and infant positive and negative affect during baseline and reunion episodes of the SFP ranged from .82 to .98, indicating very good to excellent reliability. During baseline play, ICCs were .82 for maternal positive affect, .98 for maternal negative affect, .87 for infant positive affect, and .85 for infant negative affect. Similarly, during the reunion episode, ICCs were .83 for maternal positive affect, and .85 for maternal negative affect, .95 for infant positive affect, and .95 for infant negative affect.

3. Results

3.1. Descriptive statistics and preliminary analyses

Means, standard deviations, and minimum and maximum scores for the infant and maternal affect ratings in the baseline and reunion episodes of the SFP are presented in Table 2. To illustrate the distribution of maternal and infant ratings at each scale point in each episode, frequency statistics for each coded variable in each episode of the SFP are presented in Table 3.

With a few exceptions, dyads in the current sample exhibited the full range of scale points for both positive and negative affect (1–5). However, as is relatively common in SFP research (DiCorcia, Snidman, Sravish, & Tronick, 2016; Moore et al., 2009), there was some restriction in the range of scores at the higher end of the positive and negative affect scales for both mothers and infants, although specific findings varied in the baseline vs. the reunion episodes. This restriction was especially evident for mothers' display of negative affect at the higher end of the scale (see Table 3).

Table 2
Descriptive Statistics for Infant and Maternal Affect Ratings during the Still-Face Paradigm (N = 111).

	M	SD	Min-Max
Infant Affect Ratings			
Positive Affect: Baseline	2.45	.90	1.00-5.00
Negative Affect: Baseline	1.73	1.04	1.00-5.00
Positive Affect: Still-Face	1.40	.55	1.00-3.00
Negative Affect: Still-Face	2.27	1.38	1.00-5.00
Positive Affect: Reunion	2.22	.92	1.00-4.50
Negative Affect: Reunion	2.29	1.33	1.00-5.00
Maternal Affect Ratings			
Positive Affect: Baseline	2.64	.77	1.00-5.00
Negative Affect: Baseline	1.20	.49	1.00-4.00
Positive Affect: Reunion	2.42	.79	1.00-4.50
Negative Affect: Reunion	1.23	.51	1.00-4.00

Table 3
Frequency Statistics Describing the Distribution of Infant and Maternal Affect Ratings during the Still-Face Paradigm (N = 111).

	1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0
Infant Affect Ratings									
Positive Affect: Baseline	11	12	25	25	22	5	7	2	2
Negative Affect: Baseline	61	8	14	9	9	2	5	0	3
Positive Affect: Reunion	22	10	29	20	16	3	8	2	0
Negative Affect: Reunion	40	8	16	9	10	8	7	2	10
Maternal Affect Ratings									
Positive Affect: Baseline	1	11	26	24	34	3	8	3	1
Negative Affect: Baseline	87	13	6	2	2	0	1	0	0
Positive Affect: Reunion	7	14	29	24	23	8	3	3	0
Negative Affect: Reunion	84	13	8	3	2	0	1	0	0

Bivariate correlations among the maternal and infant affect variables and the two *a priori* control variables (infant sex and maternal education) were also conducted for descriptive purposes, prior to conducting the APIM. These results are presented in Table 4. Maternal and infant positive and negative affect during the baseline play and reunion episodes of the SFP were significantly correlated in expected ways. Infant baseline positive affect was positively correlated with infant reunion positive affect and maternal baseline and reunion positive affect. Infant baseline positive affect was negatively correlated with infant baseline and reunion negative affect and maternal baseline and reunion negative affect. Infant baseline negative affect was positively correlated with infant reunion negative affect and maternal baseline and reunion negative affect. Infant baseline negative affect was negatively correlated with infant baseline and reunion positive affect and maternal baseline and reunion positive affect. Maternal baseline positive affect was positively correlated with maternal reunion positive affect and negatively correlated with maternal baseline and reunion

Table 4
Correlations among Infant and Maternal Interaction Variables (N = 111).

	1	2	3	4	5	6	7	8	9	10
Infant Interactive Behavior										
1. Baseline Positive Affect	1	−.38**	.56**	−.22*	.54**	−.32**	.40**	−.31**	.06	−.21*
2. Baseline Negative Affect		1	−.47***	.70***	−.29**	.20*	−.39***	.22*	−.18	.05
3. Reunion Positive Affect			1	−.51***	.47***	−.24*	.52***	−.28**	.09	−.15
4. Reunion Negative Affect				1	−.18	.18	−.39***	.18	.10	−.04
Maternal Interactive Behavior										
5. Baseline Positive Affect					1	−.38***	.57***	−.33***	.16	.13
6. Baseline Negative Affect						1	−.19*	.56***	−.08	.04
7. Reunion Positive Affect							1	−.33***	.11	−.07
8. Reunion Negative Affect								1	−.17	.13
Control Variables									1	−.02
9. Maternal Education										1
10. Infant Sex										

Note.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

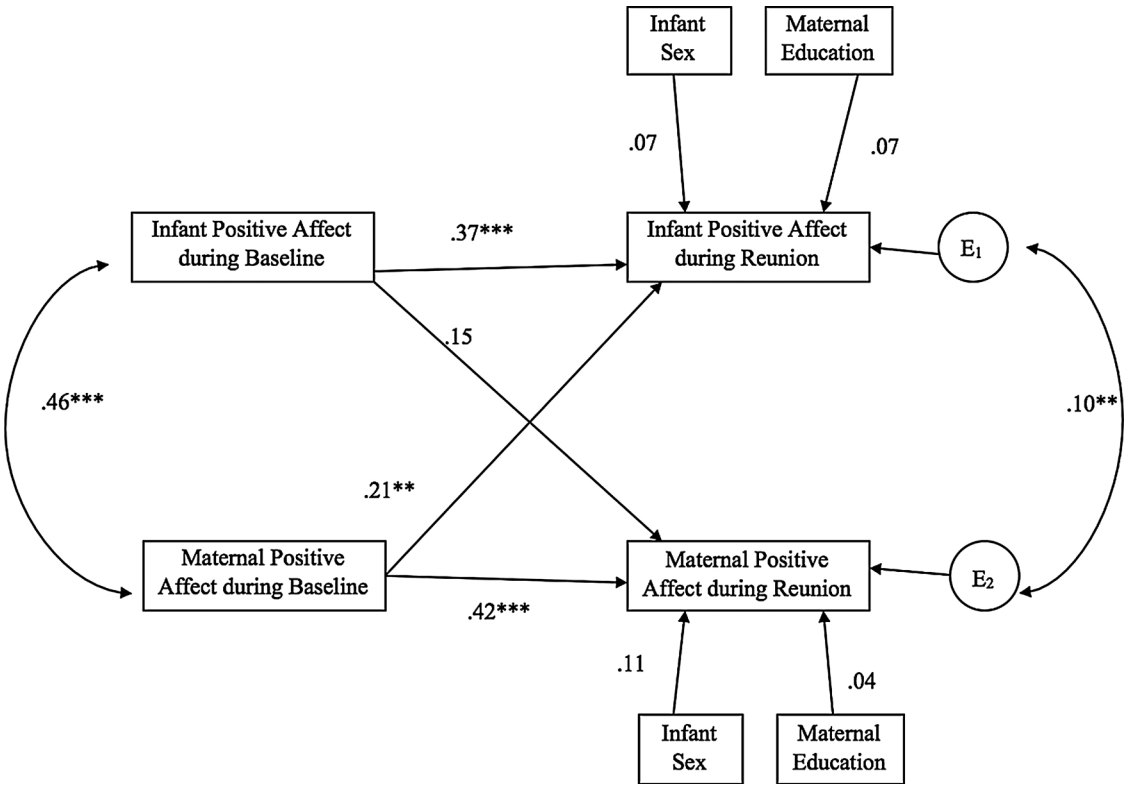

Fig. 2. APIM for positive affect. Significant actor effects are seen for both infant and mother. The only significant partner effect is for maternal positive affect during baseline to infant positive affect during reunion. Actor effects are straight lines and partner effects are diagonal lines. Curved lines indicate the correlations between infant and maternal positive affect during the baseline and the errors relating to infant and maternal positive affect during the reunion (respectively).

negative affect.

Regarding the two control variables (infant sex and maternal education), infant girls exhibited more positive affect than infant boys in the baseline episode of the SFP but not in reunion episode, as seen by the significant negative correlation between infant sex and positive affect in the baseline episode but no significant correlation in the reunion episode (see Table 4). Contrary to our expectations based on findings from prior studies, maternal education was not significantly correlated with any of the maternal or infant affective variables. Both infant sex and maternal education were retained as control variables in the APIM analyses, based on theoretical considerations and findings in the broader literature.

3.2. APIM results

The APIM was carried out using structural equation modeling, controlling for infant sex and maternal education, to evaluate actor and partner effects for maternal and infant positive and negative affect during the SFP. Positive and negative affect were evaluated in separate APIM analyses. Results for maternal and infant positive affectivity are presented first, followed by results for maternal and infant negativity.

3.2.1. APIM results for positive affect

A basic APIM was created to understand the actor and partner influences for maternal and infant positive affect from baseline to reunion. That is, we evaluated how mothers' positive affect at baseline influences her own positive affect at reunion (actor effect) and how her positive affect at baseline predicts her infant's positive affect at reunion (partner effect). In contrast to the results from the simple bivariate correlations, the APIM controls for all the pathways in the model (actor and partner effects, any covariates) at the same time. Infant sex and maternal education were added as control variables. Model fit was determined to be sufficient (χ_2 = 5.52, RMSEA = .06, CFI = .99). Results are presented in Fig. 2.

There were significant actor effects for both mother (p < .001) and infant (p < .001). Specifically, how positive mothers were during the baseline episode of the SFP directly predicted how positive mothers were during the reunion episode, following the stress of the maternal still-face. Similarly, how positive infants were during the baseline episode of the SFP directly predicted how positive infants were during the reunion episode.

There was one significant partner effect for positive affect for the pathway from maternal positive affect in the baseline episode to

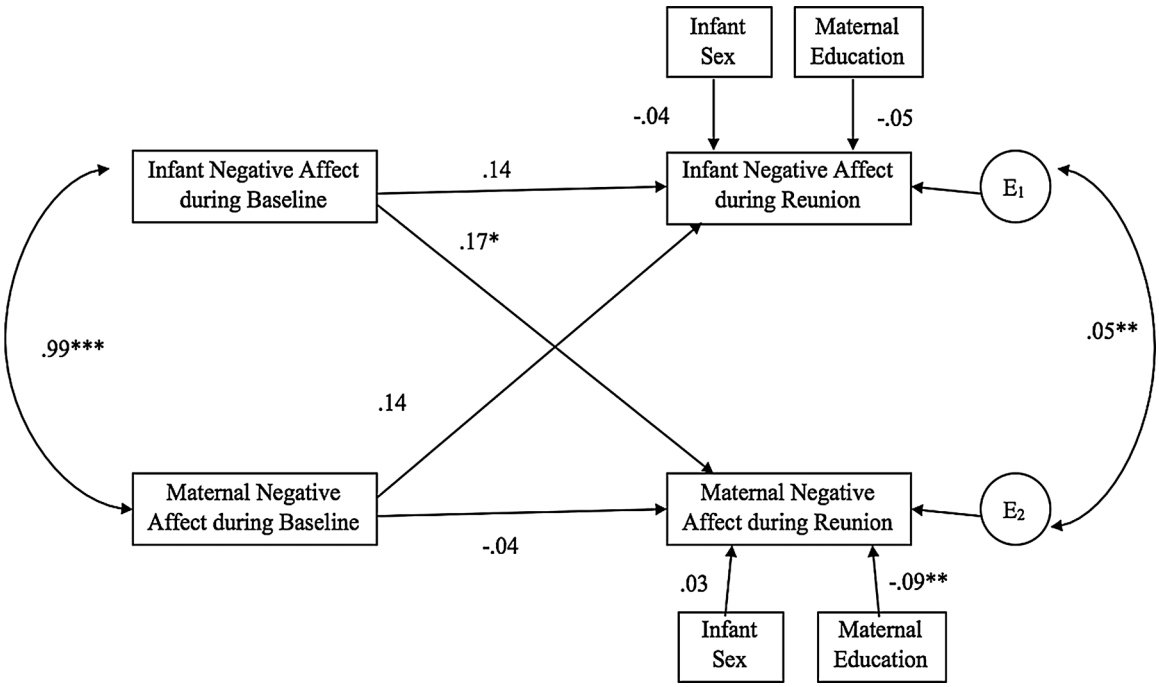

Fig. 3. APIM for negative affect. The partner effect from infant negative affect during baseline to maternal negative affect during reunion is the only significant effect. Actor effects are straight lines and partner effects are diagonal lines. Curved lines indicate the correlations between infant and maternal negative affect during the baseline and the errors relating to infant and maternal negative affect during the reunion (respectively).

infant positive affect in the reunion episode ($p < .01$). This finding indicates that how positive mothers were during the baseline episode of the SFP directly predicted how positive their infants were during the reunion episode, controlling for actor effects and the covariates. Neither infant sex nor maternal education were significant predictors in the APIM for positive affect.

3.2.2. APIM results for negative affect

A separate basic APIM was created to evaluate actor and partner effects for maternal and infant negative affect during the baseline and reunion episodes of the SFP. Infant sex and maternal education were included as control variables. Model fit for negative affect was determined to be sufficient, albeit somewhat less fitting than the model for positive affect ($\chi_2 = 5.97$, RMSEA = .07, CFI = .94). Results are presented in Fig. 3.

In contrast to the bivariate correlational results, no significant actor effects were observed for either maternal or infant negative affect. Thus, how negative mothers were during the baseline episode did not predict how negative they were during the reunion episode. Similarly, how negative infants were during the baseline episode did not predict how negative they were during the reunion episode.

There was one significant partner effect for negative affect, for the pathway from infant affect during baseline to maternal affect during the reunion ($p < .05$). This finding indicates that how negative infants were during the baseline episode directly predicted how negative their mothers were during the reunion episode.

Infant sex was not a significant predictor of maternal or infant affect in the APIM for negative affect. However, maternal education was a significant predictor in the APIM for maternal negative affect. Specifically, mothers who had more education were less likely to display negative affect during the reunion episode than mothers with less education.

4. Discussion

Guided by the Mutual Regulation Model and other transactional models of development (Sameroff & Mackenzie, 2003; Trevarthen, 1993; Tronick & Beeghly, 2011; Tronick, 1989), the goal of this study was to investigate maternal and infant contributions to maternal and infant displays of positive and negative affect during the SFP at 7 months postpartum, in an understudied low-income urban sample of mother-infant dyads. To our knowledge, this is the first study to use the APIM to investigate partner/bidirectional effects in dyadic affective interactions during the SFP. The APIM is a valuable tool for this purpose because it permits the evaluation of the unique contribution of each member of the dyad to their own behavior over time (i.e., actor effects from baseline to reunion), as well as to the behavior of the other partner during dyadic interaction (partner effects). Additionally, evaluation of the current low-income urban sample was particularly important, as dyads in this marginalized group are at higher risk for parenting problems and negative child outcomes than dyads from higher socioeconomic backgrounds (Evans et al., 2008). Moreover, dyads from low-income backgrounds are much less likely to be involved in research for a multitude of purposes (including difficulty in

recruiting participants and high attrition rates). Results from the present study help fill an important research gap by augmenting our understanding of early bidirectional processes in the affective displays of mothers and their infants during the SFP in a low-income urban sample.

4.1. Correlational results

Most of the maternal and infant affect variables within and across episodes were significantly correlated with each other in expected ways, suggesting a strong potential for finding significant actor and partner effects in the APIM analyses.

Infant sex was significantly correlated only with infant positive affect during the baseline (but not the reunion) episode of the SFP. That is, infant girls were more positive during the baseline mother-infant episode than were infant boys. Of note, the magnitude of this correlation (-.21) was relatively small, suggesting that the effect of infant sex may be more apparent during the less challenging baseline play episode. The effect of infant sex on infant positive affect may have been obscured in the more challenging reunion episode, which follows exposure to the maternal still-face.

The correlational results for infant sex are both consistent and inconsistent with those from prior studies. Many prior studies report no significant effects of infant sex on infants' behavior during the SFP (Lowe et al., 2006; Mesman et al., 2009; Weinberg et al., 2006; Yirmiya et al., 2006). However, it is important to note that many studies report sex effects only for infants' behavior during or following exposure to the maternal still-face, not during baseline play. Our findings contrast with those of Weinberg et al. (1999), who report no significant sex differences for infant affect during baseline play, but that male infants had more difficulty regulating negative emotions following the still-face episode female infants. Our findings are also inconsistent with those of Carter et al. (1990), who report that infant girls exhibit stronger negative reactions to the SFP than infant boys.

Contrary to our expectations, maternal education was not significantly associated with any maternal or infant affective variable in the bivariate correlations. This finding was unexpected because findings from previous studies suggest that higher maternal education is linked to higher infant positive affect across all episodes of the SFP (MacLean et al., 2014). In other studies by Tamis-LeMonda et al., higher maternal education is associated with higher levels of maternal sensitivity (Tamis-LeMonda et al., 2004, 2009), which in turn is linked to more infant positive affect during the SFP (Mesman et al., 2009).

4.2. APIM results

Results of the APIM evaluating positive affect reveal significant actor effects for both mother and infant. These findings indicate that how positive one member of the dyad was during the baseline episode of the SFP predicted how positive that same member of the dyad was in the reunion episode, regardless of the level of positivity displayed by the other person. This finding suggests that both mothers and infants exhibit relative stability in the level of their own positive affect before and after exposure to a social stressor (maternal still-face). The stability of infant's positive behavior provides further evidence for the construct of intra-subjective coherence, or the emotional equilibrium that is hypothesized to be innately present in infants (Kokkinaki, 2003; Trevarthen, 1997). This finding suggests that infants remain stable in their behaviors across contexts, based on this innate motive. This finding may also reflect stable individual temperament or personality characteristics. For instance, the relative stability in infants' positive affect across episodes may reflect individual differences in infant surgency (Braungart-Rieker et al., 1998).

Similarly, stability for maternal positive affect from the baseline play to the reunion episode of the SFP may reflect individual differences in maternal personality characteristics. For example, if mothers have a persistently optimistic view of the world, they may exhibit positive affect consistently before and after a stressful event, even after controlling for the infant's level of positivity. The significant actor effects observed for both mothers and infants may also reflect the quality of the dyadic relationship. If a mother consistently displays a positive coping style when confronted with stressors, she could be teaching her child to approach difficulties in this same adaptive way (Kagan, 1983; Silk, Shaw, Skuban, Oland, & Kovacs, 2006).

Contrary to expectations, there was only one significant partner/bidirectional effect in the APIM for positive affect. This partner effect was significant for the pathway from maternal positive affect in the baseline play episode to infant positive affect in the reunion episode. This effect indicates that mothers who are more positive with their infant during baseline episode of the SFP have infants who are positive during the reunion episode, following exposure to a social stressor. This finding is consistent with findings reported in other studies regarding the correlations of maternal positivity with infant behavior during the SFP (Kogan & Carter, 1996; Mesman et al., 2009) and with the tenets of the Mutual Regulation Model (Tronick & Beeghly, 2011; Tronick, 1989). The Mutual Regulation Model posits that a child's ability to regulate emotions is directly impacted by their caregiver's ability to teach her self-regulation skills (Tronick, 1989). Although further research is needed, this finding may suggest that, compared to less positive mothers, mothers who are more positive with their children during normal social interactions are more likely to have children who are better able to cope with stressful situations. This finding also complements previous research by Tarabulsy et al. (2003), who found that higher levels of maternal sensitivity during the baseline episode of the SFP predicted lower levels of infant negative affect during the still-face episode and by Haley and Stansbury (2003), who found that higher levels of maternal sensitivity during the baseline episode predicted faster re-engagement and less negative affect during the reunion episode.

Notably, the reverse partner effect for was not observed in the APIM model for positive affect. That is, infants' level of positive affect during the baseline episode did not predict mothers' level of positive affect during the reunion. This finding suggests that mothers may have a more powerful influence on their baby's emerging emotion regulation than immature infants have on their mothers, at least during infancy. An alternative explanation for this finding is that infants could be modeling their mother's positive engagement during baseline play, resulting in better infant coping following the still-face (Kagan, 1983; Silk et al., 2006). The latter

idea is consistent with behavioral theories that posit that children learn how to regulate emotions by watching the regulatory approaches of their parents (Compas et al., 2014; Rutherford, Wallace, Laurent, & Mayes, 2015).

These findings also suggest that infants' level of positive affect displayed after exposure to a stressful situation is dependent on both infant and maternal behaviors in prior settings, whereas mothers' level of positive affect with their infant after a stressful situation is mostly dependent on their own positivity with the infant in normal interactive contexts. This finding is consistent with a theory proposed by Field and colleagues regarding the still-face effect (Field, 1994; Stoller & Field, 1982), which states that parents play a more important role than infants in helping infants regulate their emotional states and to repair dyadic mismatches and restore synchronous interactions with their infants. Without this external regulatory support from parents, immature infants are likely to become increasingly dysregulated (Field, 1994). According to the Mutual Regulation Model, infants' positive emotion regulation skills develop during parent-infant interactions. These skills are important to study because they are thought to be foundational in supporting infants' positive developmental outcomes in other domains and may help prevent the emergence of later behavior problems (Tronick & Beeghly, 2011).

The APIM results for negative affect in the current study show a different pattern of findings to those observed for positive affect. In contrast to the bivariate correlational findings, there were no significant actor effects for either mother or infant negative affect from the baseline to the reunion episode of the SFP. These null findings indicate that the level of negative affect of each partner at baseline does not predict that same individual's level of negative affect during the reunion episode, when controlling for partner effects and the covariates. This finding may suggest that negativity is a less stable feature of interactive behavior than positivity following exposure to a social stressor in the SFP, at least for the mothers and infants in the current sample.

However, one significant partner/bidirectional effect was observed in the APIM model of negative affect, for the pathway from infant negative affect during baseline to maternal negative affect during reunion. This finding suggests that mothers' own negativity is more affected by their infant's prior displays of negative affect than by their own negativity. Perhaps it is more difficult for a mother to respond sensitively to her infant if the infant is distressed (Leerkes, 2010). Crying is typically reported to be a highly aversive stimulus to adults, which can heighten maternal stress and undermine sensitivity (Haltigan et al., 2014; Leerkes, 2010). Increasing levels of stress, especially **in** a low-income population that reportedly experiences higher levels of stress than higher income populations (Evans et al., 2008) may have made it more difficult for mothers to respond to their infants positively in the reunion episode.

In the current study, there also was no significant partner/bidirectional effect for the pathway from maternal negative affect during baseline to infant negative affect during reunion. This null finding suggests that mothers' level of negative affect with their infant during baseline play did not predict their infant's level of negative affect during the more challenging reunion episode. Although the explanation for this null finding is not known, it is possible that mothers may have been able to mask their negative affect during the relatively brief SFP conducted in a lab setting with developmental experts. On average, mothers in the current sample did not exhibit a sustained level of high negative affect in the SFP. Other studies have also reported relatively low levels of negative affect exhibited by mothers at six months of age in a variety of interactive contexts including the SFP (Martinez-Torteya et al., 2014; Morelan et al., 2016). Evaluation of mother-infant interactions in home settings will be important in future research.

4.3. Effects of infant and maternal characteristics

Mixed findings were also observed for the two control variables (infant sex and maternal education) evaluated in the present study. Despite the significant correlation of infant sex with increased infant positive affect during baseline play in the bivariate correlations, there were no significant effects of infant sex on any maternal or infant affective variables, in either APIM model. The sex of the infant did not help to predict the infant's response to the SFP (actor effects) or the mother's response to the SFP (partner effects). These findings add to the literature suggesting that the sex of the infant does not impact their reaction to the SFP (Lowe et al., 2006; Weinberg et al., 2006; Yirmiya et al., 2006).

In contrast, although maternal education was not significantly associated with any infant or maternal affective variables in the bivariate correlations, it did play an important role in the multivariate APIM model for negative affectivity. Specifically, mothers who with more education were less likely to display negative affect during the reunion episode of the SFP. Because maternal education is often robustly correlated with income (Evans et al., 2008), perhaps mothers with higher levels of education in the current sample were less stressed and better able to regulate their negative emotions, particularly when observed during a relatively brief structured lab paradigm. Mothers with higher levels of education might have different styles of parenting and emotion socialization than mothers with lower education and may understand that soothing their child should be done with positive affect, rather than negative (Asscher, Hermanns, & Dekovic, 2008; Gershoff, Lansford, Sexton, Kean, & Sameroff, 2012; Nicholson, Anderson, Fox, & Brenner, 2002).

In summary, the APIM results provide evidence for significant actor and partner/bidirectional effects during mother-infant interactions in the SFP, after controlling for infant sex and maternal education. However, specific findings vary depending on the valence of the affect (positive or negative) under study. Significant actor effects were observed for both maternal and infant positive affect, but not for negative affect. These findings show that the positive affectivity of each member of the dyad contributes unique variance to each individual's own level of positive affect observed at a later time point, following exposure to a social stressor. This suggests that positivity may be a relatively stable dimension of interactive behavior over time. Significant partner effects were also observed for both positive and negative affect. In the APIM model for positive affect, higher maternal positive affect in the baseline episode predicted higher infant positive affect in the reunion episode. The reverse direction was observed in the APIM model for negative affect: Higher infant negative affect in the baseline episode of the SFP predicted higher maternal negative affect during

reunion.

Taken together, the significant actor and partner effects provide partial support for the Mutual Regulation Model and the significant actor effects provide partial support for the Theory of Innate Intersubjectivity. Consistent with findings by Mastergeorge et al. (2014) and others, our results suggest that, rather than a uni-directional influence from mother to infant, both members of the dyad have a significant effect on the other's partner's subsequent affective behavior, even after controlling for all other effects. These results provide some support for a bidirectional pattern of influence between mother and infant that affects the behavior of both members of the dyad over time. Notably, affect for mother and infant were coded independently of one another, rather than in relation to each other, which makes a stronger case for this argument. On the other hand, global ratings made in a 2-minute interval rather than microanalytic codes made in real-time were utilized in the analyses. Findings from previous studies have confirmed that global, macro coding systems find similar results in the still-face literature as do micro-level coding schemes (Mesman et al., 2013). Interestingly, as was the case for actor effects, specific results for partner effects in the current study varied, depending on the valence of affect under study.

4.4. Implications

This study sheds important light on relationships between infants and their mothers in a mostly low-income sample. Actor effects for positive affect were shown for both mother and infant. This provides evidence for the stability of individual behavior across interactive contexts; if one displays more positive behavior during non-stressful times, they are more likely to also display positive behavior during times of recovery from stress. Clinical mental health professionals can encourage their adult clients to increase levels of positivity during daily life, which may then extend to more positive outlooks after stress. Positivity training has been shown to increase positivity which, based on the results of this study, might be a promising method to help with coping after a stressor (Becker et al., 2016).

It is relevant in this vein that partner effects for mothers' positive affect during baseline play to the infant's positive affect at reunion were significant. This demonstrates that the positivity that a mother exhibits *before* a social stressor impacts the infant's capacity to regulate negative emotions after a stressor. Perhaps infants rely on the adult's past emotions in order to regulate their current emotions (Mesman et al., 2013). This knowledge can be particularly helpful in parenting, especially with parents at higher risk of developing maladaptive relationships with their infants. Instructors can teach parents about how their positivity may affect their infant's ability to recover after stressful situations. Parents can practice techniques to increase their positive affect when interacting with their infants. This could have an impact on their infant's ability to recover from stress in the future.

It also is notable that there was no significant partner effect for mothers' negative affect during the baseline play episode to the infant's negativity during the reunion. This may reflect mothers' greater capacity to cope with the stresses of the SFP, which is highlighted in mothers' relative lack of sustained negativity observed during the SFP in general. Mental health or parenting instructors should support ways higher-risk mothers can regulate maternal negativity when confronted with infant distress.

4.5. Limitations

As is the case for all research, the current study has several limitations which should be considered when evaluating the results. Although the multivariate APIM has several advantages, including its versatility and ability to delineate specific individual contributions to the study of dyadic interactions, the APIM was designed to investigate mother-infant interactive processes using the same variable for each member of the dyad (in this case, maternal and infant positive and negative affect). This restriction limits our understanding of how maternal or infant affectivity is related to other behavioral variables (e.g., maternal sensitivity or child responsivity). Additionally, the APIM cannot accommodate smaller, micro-analytic codes that may explain moment-to-moment intricacies in dyadic interactions.

Using a global rating coding scheme, although a common practice in still-face research (Mesman et al., 2013), has limitations as well. These ratings take into account three dimensions of the interaction: frequency, duration, and intensity of behavior. Although the coding scheme is reliable and valid, there could be unique cases in which maternal or infant behavior in the current sample varied in ways not fully captured by the score. Global ratings may have limited our ability to understand second-by-second variations in mother-infant affective exchanges during early social interaction. Even with these limitations, the APIM is nevertheless valuable because it can tease apart how the affective displays of both mother and infant assessed at time one (baseline play episode of the SFP) may impact the affective displays of both mother and infant at time 2 (reunion episode), and thus its unique benefits seem to outweigh its limitations.

Also, sample size and power considerations constrained our ability to evaluate multiple variables in a single model (e.g., both positive and negative affect) or take into account possible other control variables (e.g., infant temperament). In future studies with larger samples, it may be helpful to control for both infant positive and negative affectivity during the still-face perturbation, or both infant and maternal levels of positive or negative affect at baseline in the opposite models (i.e., control for infant and maternal positive affect in the model in which negative affect was being explored and vice versa). Perhaps one type of affect (i.e., positivity) has an opposite effect on the other (i.e., negativity), and considering both in the same model could have resulted in more nuanced findings. Also, it might be the case that maternal positivity during the baseline has an effect on infant negativity during the reunion, or so on. These variables are worth investigating simultaneously in future studies with larger samples.

Another limitation is that, although maternal and infant affect scores were normally distributed and virtually all five rating scale points were represented in the sample (see Tables 2 and 3), relatively few participants received the highest scale points for either

positive or negative affect. High sustained levels of maternal negative affect were particularly rare in our sample. This range restriction may have limited our power to find significant mother-to-infant bidirectional effects for negative affect. Other researchers also report a low incidence of maternal negative affect during mother-infant interaction paradigms such as the SFP (DiCorcia et al., 2016; Moore et al., 2009). The relatively low prevalence of maternal negative affect in the present study may indicate that the mothers in our sample have lower negative affectivity than expected, or that they were able to dampen their negative affect during a relatively brief observational paradigm in a lab setting.

Finally, the current study was cross-sectional in design and utilized a single observation of mother-infant interaction during a lab visit. These issues preclude our ability to make causal interpretations of the findings and limits our ability to generalize effects over time or to other contexts. Evaluating a mostly low-income sample of mother-infant dyads, while understudied, also limits our ability to generalize findings to other populations.

4.6. Future directions

In future studies of mother-infant affective exchanges during the SFP, investigators should use cross-lagged models in larger longitudinal samples using structural equation modeling, to investigate questions of how both positive and negative affect of mother and infant work together in the same model. Although this was not possible with the APIM, this approach warrants further attention. Additional topics of interest for future cross-lagged models include how infant responsivity/compliance to the mother during baseline and reunion play are associated with maternal engagement or sensitivity to the infant during baseline and reunion, and how each are linked to dyadic ratings of affectivity. This would help clarify our understanding the complex relationship between mothers and their infants during dynamic social interactions. This approach could also help expand the Mutual Regulation Model and other transactional theoretical perspectives, because how responsive infants are during normative (baseline) interactions could influence mothers' positive engagement with their infants during the reunion episode. Conversely, how sensitively engaged mothers are with their infants before a stressful situation could affect how well their infants cope following exposure to the stressful situation. Dyadic codes could better capture the relationship of the dyad as a whole, which could further elucidate how the SFP effects interaction between mothers and their infants.

Evaluation of maternal psychosocial characteristics as potential moderators or mediators is also an important topic for future research. Maternal personality, depressive symptoms, social support, or mindfulness (e.g., reflective functioning capacity, Slade, Sadler, and Mayes (2005), Smaling et al. (2016) may all contribute to both mothers' and infants' affective exchanges during the SFP (Field et al., 2007; Forbes, Cohn, Allen, & Lewinsohn, 2004; Weinberg et al., 2006).

In addition, investigators in future research should evaluate bidirectional effects in mother-infant affect exchanges in more naturalistic settings (e.g., home or daycare settings), in addition to lab settings, and utilize longer observation times. These methodological alternatives may increase the generalizability of findings, as well as the probability of observing mother-to-infant bidirectional effects for negative affect during mother-child interactions.

Moreover, researchers should investigate longitudinal associations between mother-infant affective exchanges during the SFP in infancy and the dyadic affective relationship at later ages, as well as children's behavioral and developmental outcomes. Evaluation of potential moderators (e.g., infant temperament, maternal personality, or infant sex) could also shed further light on this area of research. The results of such future studies are likely to contribute significantly to our knowledge about how maternal, infant, and broader contextual factors contribute to the nature of dyadic mother-infant affective processes during the SFP.

5. Conclusion

Consistent with the tenets of the Mutual Regulation Model, the APIM results from this study provide further evidence that both members of a dyad contribute to mother-infant affective processes during the SFP. Although both mothers and infants exhibit relative stability in the level of their positive affect from baseline to reunion, as seen in significant actor effects, the positive affective displays of mothers may play a greater role in regulating their infants' affect following exposure to a social stressor than the other way around, at least at 7 months postpartum. Conversely, greater infant negativity during baseline interactions predicts greater maternal negativity during the reunion following a social stressor. These partner effects are consistent with bidirectional models of early mother-infant interactions.

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References

Adamson, L. B., & Frick, J. E. (2003). The still face: A history of a shared experimental paradigm. *Infancy, 4*(4), 451–473. https://doi.org/10.1207/S15327078IN0404_01.

Ahl, R. E., Fausto-Sterling, A., Garcia-Coll, C., & Seifer, R. (2013). Gender and discipline in 5-12-month-old infants: A longitudinal study. *Infant Behavior & Development, 36*(2), 199–209. https://doi.org/10.1016/j.infbeh.2013.01.005.

Asscher, J. J., Hermanns, J. M. A., & Dekovic, M. (2008). Effectiveness of the home-start parenting support program: Behavioral outcomes for parents and children. *Infant Mental Health Journal, 29*, 95–113. https://doi.org/10.1002/imhj.20171.

Atkinson, L., Gonzalez, A., Kashy, D. A., Basile, V. S., Masellis, M., Pareira, J., ... Levitan, R. (2013). Maternal sensitivity and infant and mother adrenocortical function across challenges. *Psychoneuroendocrinology, 38*(12), 2943–2951. https://doi.org/10.1016/j.psyneuen.2013.08.001.

Barker, E. D., Oliver, B. R., Viding, E., Salekin, R. T., & Maughan, B. (2011). The impact of prenatal maternal risk, fearless temperament and early parenting on adolescent callous unemotional traits: A 14-year longitudinal investigation. *Journal of Child Psychology and Psychiatry, 52*, 878–888. https://doi.org/10.1111/j.1469-7610.2011.02397.x.

Barry, R. A., & Kochanska, G. (2010). A longitudinal investigation of the affective environment in families with young children: From infancy to early school age. *Emotion, 10*(2), 237–249. https://doi.org/10.1037/a0018485.

Bayley, N. (2006). *Bayley scales of infant and toddler development, third edition. Administration manual.* San Antonio, TX: Harcourt.

Becker, E. S., Ferentzi, H., Ferrari, G., Mobius, M., Brugman, S., Custers, J., ... Rinck, M. (2016). Always approach the bright side of life: A general positivity training reduces stress reactions in vulnerable individuals. *Cognitive Therapy and Research, 40*(1), 57–71. https://doi.org/10.1007/s10608-015-9716-2.

Beebe, B., Jaffe, J., Markese, S., Buck, K., Chen, H., Cohen, P., ... Feldstein, S. (2010). The origins of 12-month attachment: A microanalysis of 4-month mother-infant interaction. *Attachment & Human Development, 12*(1–2), 3–141. https://doi.org/10.1080/14616730903338985.

Beebe, B., Messinger, D., Bahrick, L. E., Margolis, A., Buck, K. A., & Chen, H. (2016). A systems view of mother-infant face-to-face communication. *Developmental Psychology, 52*(4), 556–571. https://doi.org/10.1037/a0040085.

Beeghly, M., & Tronick, E. (2011). Early resilience in the context of parent-infant relationships: A social developmental perspective. *Current Problems in Pediatric and Adolescent Health Care, 41*, 197–201. https://doi.org/10.1016/j.cppeds.2011.02.005.

Bell, R. Q. (1968). A reinterpretation of the direction of effects in studies of socialization. *American Psychological Association, 75*(2), 81–95. https://doi.org/10.1037/h0025583.

Bradley, R. H., & Corwyn, R. F. (2003). Socioeconomic status and child development. *Annual Review of Psychology, 53*, 371–399. https://doi.org/10.1146/annurev.psych.53.100901.135233.

Braungart-Rieker, J. M., Garwood, M. M., Powers, B. P., & Notaro, P. C. (1998). Infant affect and affect regulation during the still-face paradigm with mothers and fathers: The role of infant characteristics and parental sensitivity. *Developmental Psychology, 34*, 1428–1437. https://doi.org/10.1037/0012-1649.34.6.1428.

Brazelton, T. B. (1994). Touchpoints: Opportunities for preventing problems in the parent-child relationship. *Acta Paediatrica, 83*, 35–39. https://doi.org/10.1111/j.1651-2227.1994.tb13212.x.

Brody, L. R., & Hall, J. A. (2008). In: Handbook of emotions. In M. Lewis (Ed.). *Publisher* (pp. 395–408). The Guilford Press.

Calkins, S. D., & Hill, A. (2007). Caregiver influences on emerging emotion regulation: Biological and environmental transactions in early development. In J. J. Gross (Ed.). *The handbook of emotion regulation* (pp. 229–248). New York, NY: Guilford Press.

Camfferman, R. (2013). *Emotion regulation of 6-months old infants during the Still-Face Paradigm: (the) effect(s) on the autonomic nervous system*(unpublished master's thesis).

Carter, A. S., Mayes, L. C., & Pajer, K. A. (1990). The role of dyadic affect in play and infant sex in predicting infant response to the still-face situation. *Child Development, 61*, 764–773. https://doi.org/10.1111/j.1467-8624.1990.tb02819.x.

Chow, S.-M., Haltigan, J. D., & Messinger, D. S. (2010). Dynamic infant-parent affect coupling during the face-to-face/still-face. *Emotion, 10*(1), 101–114. https://doi.org/10.1037/a0017824.

Compas, B. E., Jaser, S. S., Dunbar, J. P., Watson, K. H., Bettis, A. H., Gruhn, M. A., ... Williams, E. K. (2014). Coping and emotion regulation from childhood to early adulthood: Points of convergence and divergence. *Australian Journal of Psychology, 66*(2), 71–81. https://doi.org/10.1111/ajpy.12043.

Connellan, J., Baron-Cohen, S., Wheelwright, S., Batki, A., & Ahluwalia, J. (2000). Sex differences in human neonatal social perception. *Infant Behavior and Development, 23*(1), 113–118. https://doi.org/10.1016/S0163-6383(00)00032-1.

Cook, W. L., & Kenny, D. A. (2005). The actor-partner interdependence model: A model of bidirectional effects in developmental studies. *International Journal of Behavioral Development, 29*, 101–109. https://doi.org/10.1080/01650250444000405.

DiCorcia, J. A., Snidman, N., Sravish, A. V., & Tronick, E. (2016). Evaluating the nature of the Still-Face Effect in the double Face-to-Face Still-Face Paradigm using different comparison groups. *Infancy, 21*(3), 332–352. https://doi.org/10.1111/infa.12123.

Earls, L., Muzik, M., & Beeghly, M. (2009). *Maternal and infant behavior coding manual.* Unpublished manuscript.

Eiden, R. D., Molnar, D. S., Granger, D. A., Colder, C. R., Schuetze, P., & Huestis, M. A. (2015). Prenatal tobacco exposure and infant stress reactivity: Role of child sex and maternal behavior. *Developmental Psychobiology, 57*(2), 212–225. https://doi.org/10.1002/dev.21284.

Else-Quest, N. M., Hyde, J. S., Goldsmith, H. H., & Van Hulle, C. A. (2006). Gender differences in temperament: A meta-analysis. *Psychological Bulletin, 132*(1), 33–72. https://doi.org/10.1037/0033-2909.132.1.33.

Evans, G. W., Boxhill, L., & Pinkava, M. (2008). Poverty and maternal responsiveness: The role of maternal stress and social resources. *International Journal of Behavioral Development, 32*(3), 232–237. https://doi.org/10.1177/0165025408089272.

Fausto-Sterling, A., Crews, D., Sung, J., Garcia-Coll, C., & Seifer, R. (2015). Multimodal sex-related differences in infant and in infant-directed maternal behaviors during months three through twelve of development. *Developmental Psychology, 51*(10), 1351–1366. https://doi.org/10.1037/dev0000033.

Feldman, R. (2003). Infant-mother and infant-father synchrony: The coregulation of positive arousal. *Infant Mental Health Journal, 24*(1), 1–23. https://doi.org/10.1002/imhj.10041.

Feldman, R. (2007). Parent-infant synchrony. *Current Directions in Psychological Science, 16*(6), 340–345. https://doi.org/10.1111/j.1467-8721.2007.00532.x.

Field, T. (1994). The effects of mother's physical and emotional unavailability on emotion regulation. *Monographs of the Society for Research in Child Development, 59*, 208–227. https://doi.org/10.1111/j.1540-5834.1994.tb01286.x.

Field, T., Hernandez-Reif, M., Diego, M., Feijo, L., Vera, Y., Gil, K., ... Sanders, C. (2007). Still-face and separation effects on depressed mother-infant interactions. *Infant Mental Health Journal, 28*(3), 314–323. https://doi.org/10.1002/imhj.20138.

Fitzpatrick, J., Gareau, A., Lafontaine, M.-F., & Gaudreau, P. (2016). How to use the Actor-Partner Interdependence Model (APIM) to estimate different dyadic patterns in MPLUS: A step-by-step tutorial. *The Quantitative Methods for Psychology, 12*(1), 74–86. https://doi.org/10.20982/tqmp.12.1.p074.

Fogel, A. (1993). *Developing through relationships.* Chicago: The University of Chicago Press.

Forbes, E. E., Cohn, J. F., Allen, N. B., & Lewinsohn, P. M. (2004). Infant affect during parent-infant interaction at 3 and 6 months: Differences between mothers and fathers and influence of parent history of depression. *Infancy, 5*, 61–84. https://doi.org/10.1207/s15327078in0501_3.

Garcia, R. L., Kenny, D. A., & Ledermann, T. (2015). Moderation in the actor-partner interdependence model. *Journal of the International Association for Relationship Research, 22*, 8–29. https://doi.org/10.1111/pere.12060.

Gershoff, E. T., Lansford, J. E., Sexton, H. R., Kean, P., & Sameroff, A. J. (2012). Longitudinal links between spanking and children's externalizing behaviors in a national sample of White, Black, Hispanic, and Asian American families. *Child Development, 83*, 838–843. https://doi.org/10.1111/j.1467-8624.2011.01732.x.

Grusec, J. E., & Hastings, P. D. (Eds.). (2007). *Handbook of socialization: Theory and research.* New York: Guilford Press.

Haley, D. W., & Stansbury, K. (2003). Infant stress and parent responsiveness: Regulation of physiology and behavior during still-face and reunion. *Child Development, 74*(5), 1534–1546. https://doi.org/10.1111/1467-8624.00621.

Haltigan, J. D., Leerkes, E. M., Supple, A. J., & Calkins, S. D. (2014). Infant negative affect and maternal interactive behavior during the Still-Face procedure: The moderating role of adult attachment states of mind. *Attachment & Human Development, 16*(2), 149–173. https://doi.org/10.1080/14616734.2013.863734.

Handal, A. J., Saavedra, L. G., Schrader, R., Aragon, C. L., Paez, M., & Lowe, J. R. (2017). Assessment of maternal-infant interaction: Application of the Still Face Paradigm in a rural population of working women in Ecuador. *Maternal and Child Health Journal, 21*, 458–466. https://doi.org/10.1007/s10995-016-2123-9.

Joosen, K. J., Mesman, J., Bakermans-Kranenburg, M. J., & van IJzendoorn, M. H. (2012). Maternal sensitivity to infants in various settings predicts harsh discipline in toddlerhood. *Attachment & Human Development, 14*(2), 101–117. https://doi.org/10.1080/14616734.2012.661217.

Kagan, J. (1983). *Stress and coping in early development.* Johns Hopkins University Press191–216.

Kogan, N., & Carter, A. S. (1996). Mother-infant reengagement following the still-face: The role of maternal emotional availability in infant affect regulation. *Infant Behavior & Development, 19*, 359–370. https://doi.org/10.1016/S0163-6383(96)90034-X.

Kokkinaki, T. (2003). A longitudinal, naturalistic, and cross-cultural study on emotions in early infant-parent imitative interactions. *British Psychological Society, 21*(2), 243–258. https://doi.org/10.1348/026151003765264066.

Kokkinaki, T., & Vasdekis, V. G. S. (2015). Comparing emotional coordination in early spontaneous mother-infant and father-infant interactions. *The European Journal of Developmental Psychology, 12*(1), 69–84. https://doi.org/10.1080/17405629.2014.950220.

Kuczynski, L. (2003). *Handbook of dynamics in parent-child relations.* Sage.

Leerkes, E. L. (2010). Predictors of maternal sensitivity to infant distress. *Parenting, Science and Practice, 10*, 219–239. https://doi.org/10.1080/15295190903290840.

Lindsey, E. W., Cremeens, P. R., Colwell, M. J., & Caldera, Y. M. (2009). The structure of parent-child dyadic synchrony in toddlerhood and children's communication competence and self-control. *Social Development, 18*(2), 375–396. https://doi.org/10.1111/j.1467-9507.2008.00489.x.

Lowe, J., Handmaker, N., & Aragon, C. (2006). Impact of mother interactive style on infant affect among babies exposed to alcohol in utero. *Infant Mental Health Journal, 27*(4), 371–382. https://doi.org/10.1002/imhj.20098.

Lowe, J. R., MacLean, P. C., Duncan, A. F., Aragon, C., Schrader, R. M., Caprihan, A., ... Phillips, J. P. (2012). Association of maternal interaction with emotional regulation in 4- and 9- month infants during the Still Face Paradigm. *Infant Behavior & Development, 35*, 295–302. https://doi.org/10.1016/j.infbeh.2011.12.002.

Lowe, J. R., Coulombe, P., Moss, N. C., Pieger, R. E., Aragon, C., Maclean, P. C., ... Handal, A. J. (2016). Maternal touch and infant affect in the Still Face Paradigm: A cross-cultural examination. *Infant Behavior and Development, 44*, 110–120. https://doi.org/10.1016/j.infbeh.2016.06.009.

MacLean, P. C., Rynes, K. N., Aragon, C., Caprihan, A., Philips, J. P., & Lowe, J. R. (2014). Mother-infant mutual eye gaze supports emotion regulation in infancy during the Still-Face paradigm. *Infant Behavior & Development, 37*(4), 512–522. https://doi.org/10.1016/j.infbeh.2014.06.008.

Markey, C., & Markey, P. (2011). Romantic partners, weight status, and weight concerns. *Journal of Health Psychology, 16*(2), 217–225. https://doi.org/10.1177/1359105310376360.

Martinez-Torteya, C., Dayton, C. J., Beeghly, M., Seng, J., McGinnis, E., Broderick, A., ... Muzik, M. (2014). Maternal parenting predicts infant biobehavioral regulation among women with a history of childhood maltreatment. *Development and Psychopathology, 26*, 379–392. https://doi.org/10.1017/S0954579414000017.

Mastergeorge, A. M., Paschall, K., Loeb, S. R., & Dixon, A. (2014). The Still-Face Paradigm and bidirectionality: Associations with maternal sensitivity, self-esteem and infant emotional reactivity. *Infant Behavior & Development, 37*, 387–397. https://doi.org/10.1016/j.infbeh.2014.05.006.

Mayo Clinic (2017). *Infant development: Milestones from 7 to 9 months* (2017, June 28) Retrieved fromhttps://www.mayoclinic.org/healthy-lifestyle/infant-and-toddler-health/in-depth/infant-development/art-20047086.

McClure, E. B. (2000). A meta-analytic review of sex differences in facial expression processing and their development in infants, children, and adolescents. *Psychological Bulletin, 126*(3), 424–453. https://doi.org/10.1037/0033-2909.126.3.424.

McLoyd, V. C. (1998). Changing demographics in the American population: Implications for research on minority children and adolescents. *Studying Minority Adolescents: Conceptual, Methodological, and Theoretical Issues,* 3–28.

Mesman, J., Linting, M., Joosen, K. J., Bakermans-Kranenburg, M. J., & van IJzendoorn (2013). Robust patterns and individual variations: Stability and predictors of infant behavior in the still-face paradigm. *Infant Behavior & Development, 36*, 587–598. https://doi.org/10.1016/j.infbeh.2013.06.004.

Mesman, J., van IJzendoorn, M. H., & Bakermans-Kranenburg, M. J. (2009). The many faces of the Still-Face Paradigm: A review and meta-analysis. *Developmental Review, 29*(2), 120–162. https://doi.org/10.1016/j.dr.2009.02.001.

Moore, G. A., Calkins, S. D., Hill-Soderlund, A. L., Mills-Koonce, W. R., Propper, C. B., & Cox, M. J. (2009). Mother-infant vagal regulation in the Face-to-Face Still-Face Paradigm is moderated by maternal sensitivity. *Child Development, 80*, 209–223. https://doi.org/10.1111/j.1467-8624.2008.01255.x.

Morelan, D., Menke, R. A., Rosenblum, K. L., Beeghly, M., & Muzik, M. (2016). Understanding bidirectional mother-infant affective displays across contexts: Effects of maternal maltreatment history, depression, and PTSD. *Psychopathology, 49*(4), https://doi.org/10.1159/000448376.

Murray, L., & Trevarthen, T. (1986). The infant's role in mother-infant communications. *Journal of Child Language, 13*(1), 15–29. https://doi.org/10.1017/S0305000900000271.

Nicholson, B., Anderson, M., Fox, R., & Brenner, V. (2002). One family at a time: A prevention program for at-risk parents. *Journal of Counseling & Development, 80*, 362–371. https://doi.org/10.1002/j.1556-6678.2002.tb00201.x.

Pelaez-Nogueras, M., Field, T., Hossain, Z., & Pickens, J. (1996). Depressed mothers' touching increases infants' positive affect and attention in Still Face interactions. *Child Development, 67*(4), 1780–1792. https://doi.org/10.2307/1131731.

Richman, A. L., Miller, P. M., & LeVine, R. A. (1992). Cultural and educational variations in maternal responsiveness. *Developmental Psychology, 28*(4), 614–621.

Rosenblum, K. L., McDonough, S., Muzik, M., Miller, A., & Sameroff, A. (2002). Maternal representations of the infant: Associations with infant response to the Still Face. *Child Development, 73*(4), 999–1015. https://doi.org/10.1111/1467-8624.00453.

Rutherford, H. J. V., Wallace, N. S., Laurent, H. K., & Mayes, L. C. (2015). Emotion regulation in parenthood. *Developmental Review, 36*, 1–14. https://doi.org/10.1016/j.dr.2014.12.008.

Sameroff, A. (2010). A unified theory of development: A dialectic integration of nature and nurture. *Child Development, 81*(1), 6–22. https://doi.org/10.1111/j.1467-8624.2009.01378.x.

Sameroff, A. J., & Chandler, M. J. (1975). Reproductive risk and the continuum of caretaking casualty. In F. D. Horowitz, M. Hetherington, S. Scarr-Salapatek, & G. Siegel (Vol. Eds.), *Review of child development research: Vol. 4*, (pp. 187–244). Chicago: University of Chicago Press.

Sameroff, A. J., & Mackenzie, M. J. (2003). Research strategies for capturing transactional models of development: The limits of the possible. *Development and Psychopathology, 15*, 613–640 10.1017.S0954579403000312.

Silk, J. S., Shaw, D. S., Skuban, E. M., Oland, A. A., & Kovacs, M. (2006). Emotion regulation strategies in offspring of childhood-onset depressed mothers. *Journal of Child Psychology and Psychiatry, 47*(1), 69–78. https://doi.org/10.1111/j.1469-7610.2005.01440.x.

Slade, A., Sadler, L. S., & Mayes, L. C. (2005). Minding the baby: Enhancing parental reflective functioning in a nursing/mental health home visiting program. In L. J. Berlin, Y. Ziv, L. Amaya-Jackson, & M. T. Greenberg (Eds.). *Enhancing early attachments: Theory, research, intervention, and policy* (pp. 152–177). New York: Guilford Press.

Smaling, H. J. A., Huijbregts, S. C. J., Suurland, J., van der Heijden, K. B., Mesman, J., van Goozen, S. H. M., ... Swaab, H. (2016). Prenatal reflective functioning and accumulated risk as predictors of maternal interactive behavior during free play, the Still-Face Paradigm, and two teaching tasks. *Infancy, 21*(6), 766–784. https://doi.org/10.1111/infa.12137.

Stern, D. N., Hofer, L., Haft, W., & Dore, J. (1985). Affect attunement: The sharing of feeling states between mother and infant by means of inter-modal fluency. *Social Perception in Infants,* 249–268.

Stoller, S. A., & Field, T. (1982). Alteration of mother and infant behavior and heart rate during a still-face perturbation of face-to-face interaction. *Emotion and Early Interaction,* 57–82.

Tamis-LeMonda, C. S., Shannon, J. D., Cabrera, N. J., & Lamb, M. E. (2004). Fathers and mothers at play with their 2- and 3-year olds: Contributions to language and cognitive development. *Child Development, 75*(6), 1806–1820. https://doi.org/10.1111/j.1467-8624.2004.00818.x.

Tamis-LeMonda, C. S., Briggs, R. D., McClowry, S. G., & Snow, D. L. (2009). Maternal control and sensitivity, child gender, and maternal education in relation to children's behavioral outcomes in African American families. *Journal of Applied Developmental Psychology, 30*(3), 321–331. https://doi.org/10.1016/j.appdev.2008.12.018.

Tarabulsy, G. M., Provost, M. A., Deslandes, J., St-Laurent, D., Moss, E., Lemelin, J.-P., ... Dassylva, J.-F. (2003). Individual differences in infant still-face response at 6 months. *Infant Behavior & Development, 26*, 421–438. https://doi.org/10.1016/S0163-6383(03)00039-0.

Trevarthen, C. (1993). The function of emotions in early infant communicating. In U. Neisser (Ed.). *The perceived self: Ecological and interpersonal sources of self-knowledge* (pp. 48–81). London, England: Routledge.
Trevarthen, C. (1997). The nature of motives for human consciousness. *Psychology: The Journal of the Hellenic Psychological Society, 4*, 187–221.
Trevarthen, C. (1998). The concept and foundations of infant intersubjectivity. In S. Braten (Ed.). *Intersubjective communication and emotion in early ontogeny* (pp. 15–46). Cambridge: Cambridge University Press.
Trevarthen, C. (2011). What is it like to be a person who knows nothing? Defining the active intersubjective mind of a newborn human being. *Infant and Child Development, 20*, 119–135. https://doi.org/10.1002/icd.689.
Tronick, E. Z. (1989). Emotions and emotional communications in infants. *The American Psychologist, 44*(2), 112–119.
Tronick, E. Z. (2007). Depressed mothers and infants: The failure to form dyadic states of consciousness. In E. Z. Tronick (Ed.). *The neurobehavioral and social-emotional developments of infants and children* (pp. 274–304). New York: Norton & Company.
Tronick, E. Z., Als, H., Adamson, L., Wise, S., & Brazelton, T. B. (1978). The infant's response to entrapment between contradictory messages in face-to-face interaction. *Pediatrics, 62*(3), 403.
Tronick, E. Z., & Beeghly, M. (2011). Infants' meaning-making and the development of mental health problems. *American Psychology, 6*, 107–119. https://doi.org/10.1037/a0021631.
Tronick, E. Z., & Cohn, J. F. (1989). Infant-mother face-to-face interaction: Age and gender differences in coordination and the occurrence of miscoordination. *Child Development, 60*(1), 85–92. https://doi.org/10.2307/1131074.
Wagner, N. J., Mills-Koonce, W. R., Propper, C. B., Willoughby, M. T., Rehder, P. D., Moore, G. A., ... Cox, M. J. (2016). Associations between infant behaviors during the Face-To-Face Still-Face Paradigm and oppositional defiant and callous-unemotional behaviors in early childhood. *Journal of Abnormal Child Psychology, 44*(8), 1439–1453. https://doi.org/10.1007/s10802-016-0141-0.
Wagner, N. J., Mills-Koonce, W. R., Willoughby, M. T., Zvara, B., Cox, M. J., & The Family Life Project Key Investigators (2016). Parenting and children's representations of family predict disruptive and callous-unemotional behaviors. *Developmental Psychology, 44*(8), 1439–1453. https://doi.org/10.1007/s10802-016-0141-0.
Weinberg, M. K., Olson, K. L., Beeghly, M., & Tronick, E. Z. (2006). Making up is hard to do, especially for mothers with high levels of depressive symptoms and their infant sons. *Journal of Child Psychology and Psychiatry, 47*, 670–683. https://doi.org/10.1111/j.1469-7610.2005.01545.x.
Weinberg, M. K., Tronick, E. Z., Cohn, J. F., & Olson, K. L. (1999). Gender differences in emotional expressivity and self-regulation during early infancy. *Developmental Psychology, 35*, 175–188. https://doi.org/10.1037/0012-1649.35.1.175.
Weinberg, M. K., & Tronick, E. Z. (1996). Infant affective reactions to the resumption of maternal interaction after the Still-Face. *Child Development, 67*(3), 905–914. https://doi.org/10.1111/j.1467-8624.1996.tb01772.x.
Windhorst, D. A., Mileva-Seitz, V. R., Linting, M., Hofman, A., Jaddoe, V. W. V., Verhulst, F. C., ... Bakermans-Kranenburg, M. J. (2015). Differential susceptibility in a developmental perspective: DRD4 and maternal sensitivity predicting externalizing behavior GxE effects of DRD4 and sensitivity over time. *Developmental Psychobiology, 57*, 35–49. https://doi.org/10.1002/dev.21257.
Yirmiya, N., Gamliel, I., Pilowsky, T., Feldman, R., Baron-Cohen, S., & Sigman, M. (2006). The development of siblings of children with autism at 4 and 14 months: Social engagement, communication, and cognition. *Journal of Child Psychology and Psychiatry, 47*(5), 511–523. https://doi.org/10.1111/j.1469-7610.2005.01528.
Yogman, M. W. (1982). Development of the father-infant relationship. In H. E. Fitzgerald, B. M. Lester, & M. W. Yogman (Eds.). *Theory and research in behavioral pediatrics*. Boston, MA: Springer.
Yoo, K., & Reeb-Sutherland, B. C. (2013). Effects of negative temperament on 5-month-old infants' behavior during the still-face paradigm. *Infant Behavior & Development, 36*(3), 344–348. https://doi.org/10.1016/j.infbeh.2013.03.002.