



The Functions of Mutual Touch in Full-Term and Very Low-Birthweight/Preterm Infant-Mother Dyads: Associations with Infant Affect and Emotional Availability During Face-to-Face Interactions

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The purpose of the present study was to investigate the communicative functions of mutual touch during mother-infant interactions and their relation with infants' affect and the quality of the mother-infant relationship. The two normal periods of the Still-Face procedure were examined for mothers and their 5½-month-old full-term ($n = 40$) and very low-birthweight/preterm (VLBW/preterm; $n = 40$) infants. The Functions of Mother-Infant Mutual Touch Scale was used to code the function of each mutual touch. Results indicated that full-term infant-mother dyads spent significantly more time engaged in playful and regulatory mutual touch compared to VLBW/preterm infant-mother dyads who spent significantly more time engaged in attention-centered, unbalanced, and guided mutual touch. Infant smiling was found to significantly co-occur with playful mutual touch for both the full-term and VLBW/preterm infants, while fretting co-occurred with unbalanced mutual touch for VLBW/preterm infants. Higher levels of maternal sensitivity and regulatory mutual touch were associated for full-term dyads, while lower levels of maternal sensitivity were associated with unbalanced mutual touch for VLBW/preterm dyads. Results from this study enable a more comprehensive understanding of the functions of mutual touching, and suggest differences in which mutual touching behaviors are organized with infants' affect and relationship dimensions between mothers and their infants.

Keywords: mother-infant interactions, touch, VLBW/preterm infants, relationship, still-face procedure

During social interactions, touch is an influential channel through which mothers and their infants convey emotion and affection and establish a strong connection (Hertenstein, 2002; Stack, 2010; Stack & Jean, 2011). However, much of the research that has examined touch during mother-infant face-to-face interactions has focused on *maternal* tactile behaviors (Beebe, 2006; Jean & Stack, 2009; Stack, 2010). Yet, touch is also an important modality of communication for infants (Moszkowski & Stack, 2007; Moszkowski, Stack, & Chiarella, 2009). Infants are active and competent participants during their early social encounters (e.g., Adamson & Frick, 2003; Cohn, 2003), and mother-infant interactions are a two-way processes involving influences from both interactive partners.

Face-to-face mother-infant exchanges are important interactive contexts during which detailed investigations of touch can be examined. The Still-Face (SF; Tronick, Als, Adamson, Wise, & Brazelton, 1978) paradigm is one type of face-to-face mother-infant interaction procedure that has been commonly employed as a perturbed context in which interactions among mothers and their infants, and their communicative and regulatory behaviors, have been explored (e.g., Adamson & Frick, 2003; Gusella, Muir, & Tronick, 1988; Mesman, van Ijzendoorn, & Bakermans-Kranenburg, 2009). The SF procedure is a structured face-to-face interaction that consists of two normal interaction periods during which mothers are instructed to interact with their infants as they normally would, separated by another period (i.e., the SF period) in which mothers are instructed to stare blankly at their infants while maintaining a neutral facial expression and providing neither

vocal nor tactile stimulation (e.g., Mantis, Stack, Ng, Serbin, & Schwartzman, 2014; Mastergeorge, Paschall, Loeb, & Dixon, 2014; Moszkowski & Stack, 2007, Stack & Muir, 1992; Tronick et al., 1978). The SF period is a time during which mothers appear emotionally unavailable, despite being physically present (Mantis, Mercuri, Stack, & Field, 2018; Stack, 2010).

Earlier studies with the SF procedure indicated that touch can serve several functions during face-to-face interactions. For example, Jean and Stack (2009) devised the Functions of Touch Scale (FTS) in order to examine changes in maternal functions of touch in the context of the SF procedure. Results demonstrated that specific functions of maternal touch varied according to the interaction period; mothers' touch during the period before the SF was more attention getting, while mothers used more nurturing types of touch during the period after the SF. Subsequently, Moszkowski et al. (2009) developed the Functions of Infant Touch Scale (FITS) to investigate the communicative functions of *infant* touch. During the SF period, infants were found to use more regulatory and exploratory functions of touch, but more calming and reactive touch during the two normal periods, underscoring that infants use touch to express and regulate their emotions and to respond to changes in their mothers' behaviors (Moszkowski et al., 2009). Taken together, these findings demonstrated how maternal (and infant) touch is purposeful and serves a range of diverse functions (Ferber, Feldman, & Makhoul, 2008; Jean & Stack, 2009), and underscored how it relates to changes in infants' behavior. Of note, these researchers addressed functions of unidirectional touch. In contrast, in the context of touching behavior, Mantis and colleagues (2014) differentiated between touch coming from one member of the mother-infant dyad and touching from both members simultaneously (i.e., mutual touch). Mutual touch was found to be prevalent during face-to-face interactions, but it remains unknown what functions mutual touch may serve and how these different functions may be used during early mother-infant social exchanges. Thus, a more direct and systematic study of the communicative functions of these mutual touch bouts during mother-infant interactions with changes in maternal availability is warranted so as to contribute to our understanding of the role of mutual touch in early social interactions and to better understand when and how members of a dyad communicate bidirectionally through touch. Further, it has been suggested that co-occurring behaviors serve to enhance the communicative messages infants convey (Jean, Stack, & Arnold, 2014; Moszkowski et al., 2009; Weinberg & Tronick, 1994). Because touch does not naturally occur in isolation, it is critical to examine the interplay between touch and other communicative behaviors. Thus, a part of the current study was designed to examine how the functions of mutual touch co-occur with infants' affect (i.e., smiling and fretting) using the SF paradigm, which controls for maternal affect. In doing so, the messages being conveyed would be clarified with implications for the functions that mutual touch serves during face-to-face interactions.

According to the mutual regulation model (Beebe et al., 2010; Hofer, 1994; Tronick & Weinberg, 1997) and the dynamic systems perspective (Fogel, 1993; Fogel & Garvey, 2007; Hsu & Fogel, 2001), mothers and their infants are constantly influencing each other during face-to-face interactions. By the age of 3-4 months, mothers and infants participate in an interactive "dance", whereby they mutually interact by means of touching, gazing, gesturing, affective displays, and vocalizations and verbalizations (Beebe et al., 2010; Feldman, 2007; Hall et al., 2015; Stern, 1985). Even young infants have rudimentary intentions and motivating emotions and are able to react to the meanings of others' intentions and emotions (Lavelli & Fogel, 2005; Reddy, 2008; Trevarthen, Aitken, Vendekerckhove, Delafield-Butt, & Nagy, 2006; Tronick & Beeghly, 2011). Thus, it is not the mother or the infant alone, but the relationship between the two that contributes to the development of infants' communicative abilities during the first year of life. Working to achieve their mutual goal of coordinated states of interaction, mothers and infants jointly regulate their interactions by modifying their affective states according to changes in their social partner's behavior (Fogel, 1993; Gianino & Tronick, 1988, Tronick & Beeghly, 2011). Thus, both mothers and infants modify their behaviors at various times through their interactions, contributing to the creation of a shared dialogue. Examining touch through a

bidirectional process would add to our understanding of the communicative properties underlying nonverbal communication during mother-infant interactions.

Despite an abundance of studies involving interactions of mothers and their infants, research on touch is sparse, particularly with at-risk dyads (i.e., infants born prematurely at very low birthweight). In the present study, infants born full-term and prematurely at very low birthweight were examined. Preterm birth itself is assumed to be a risk factor for normal development of the mother-infant relationship as several factors may alter infants' abilities to process and/or reciprocate tactile-gestural stimulation in the same way as full-term birth weight infants. Specifically, interactions between a preterm infant and their mother have been shown to be influenced by the infant's physical condition and the amount of physical closeness (i.e., early separation and decreased parental touch and contact) during postnatal care in the neonatal intensive care unit (NICU; Field, Diego, & Hernandez-Reif, 2010). Furthermore, preterm infant-mother interactions have been shown to be influenced by maternal stress and anxiety as a result of the infant's medical condition (Amankwaa, Pickler, & Boonmee, 2007; Evans, Boyd, Colditz, Sanders, & Whittingham, 2016; Korja et al., 2008). Even in the absence of significant clinical and/or medical conditions, early repeated stress exposure in the NICU (i.e., painful stimuli, disruption of sleep, excessive noise and light levels, and frequent handling associated with medical or nursing procedures; Peng et al., 2009) may contribute to infants' socioemotional difficulties later in life (Aita, Johnston, Goulet, Oberlander, & Snider, 2013; Brummelte et al., 2011). Further, preterm infants have less well developed self-regulatory strategies than full-term infants (Jean et al., 2014), as infants born prematurely demonstrate greater reactivity and sensitivity to distress and have lower thresholds for displaying reactions to negative stimuli (Als, 1995; Feldman, 2009; Field, 1982; Korja et al., 2008; Lester, Boukydis, & LaGasse, 1996). Preterm infants are less inclined to make eye contact with their mothers (Harel, Gordon, Geva, & Feldman, 2011), vocalize less (Salerni, Suttora, & D'Odorico, 2007), smile less, display more negative affect (De Schuymer, De Groote, Striano, Stahl, & Roeyers, 2011), and express their needs using ambiguous behavioral cues (Feldman & Eidelman, 2007; Olafsen et al., 2012).

It has been suggested that very preterm infants (i.e., gestational age < 32 weeks and/or birth weight < 1,500 g) are exposed to a double-risk condition for social-emotional development, encompassing both difficulties in social-emotional stress response and exposure to a less-than-optimal maternal bonding (Provenzi et al., 2017). The lack of emotional and physical closeness between parents and preterm infants, together with parents' emotional distress, can negatively affect the parent-infant relationship and result in adverse outcomes for infants' socioemotional development (Montirosso, Tronick, & Borgatti, 2017). Because preterm infants are at higher risk of social-emotional, language, mental, and motor development delays, social interaction is especially important in optimizing these outcomes (White-Traut et al., 2013). Though premature infants have a high need for positive interactions, establishing positive interaction patterns is challenging for preterm infant-mother dyads (White-Traut et al., 2013).

Investigations of interaction patterns have documented differences in the communicative styles between preterm infant-mother dyads and full-term infant-mother dyads during the first year of life (Doiron & Stack, 2017; Jean & Stack, 2012; White-Traut et al., 2013). From an early age, preterm infants present as more challenging and qualitatively different social partners than full-term infants. The quality of the dyadic interaction has been described as less optimal, as interactions in preterm infant-mother dyads are typically characterized by less mutually synchronous and coregulated exchanges (Feldman & Eidelman, 2007). Given that preterm infants place different demands on their caregivers, the development of sensitive and coregulated interactions that are typical in infant-mother dyads and characterized by an intimate interchange is often hindered in preterm infant-mother interactions (Feldman, 2007). While the significance of touch for VLBW/preterm infants' cognitive and physical development has been established and comprehensively

investigated (Field, 2011; Vickers, Ohlsson, Lacy, & Horsley, 2004), the impact of touch on the quality of dyadic exchanges is still warranted. Touch may be serving different needs or be especially important in preterm infant-mother dyads and may be used in different ways compared to full-term dyads.

The relationship between the quality of dyadic exchanges and maternal and infant tactile behaviors has been underscored in several studies, wherein touch has been found to be an essential component of mother-infant exchanges (Field, 2010; Jean & Stack, 2009; Moszkowski et al., 2009). Nonetheless, the examination of the communicative properties of touch through a bidirectional process has yet to be examined. Mothers and infants are responsive to each other's behaviors and affective displays and both actively contribute to shaping their interactions. Examining touch as a dynamically-changing cocreated aspect of communication is a key phenomenon to study. Investigating mutual touch in both typically developing and at-risk dyads would allow for a more comprehensive understanding of the ways through which mothers and infants influence one another in a synergistic setting and co-construct their interactions. Furthermore, the examination of the quality of the relationship and its influence on mutual touch is particularly important because both partners are sensitive to each other's behaviors during interactions (Cohn & Tronick, 1989; DiCorcia & Tronick, 2011), and bidirectional influences impact regulatory processes in the dyad (DiCorcia & Tronick, 2011; Fogel, 1992).

The present study was designed to examine the functions of mutual touch and to achieve a more comprehensive understanding of the communicative roles of touch during early mother-infant social exchanges. Infants were classified into two groups: full-term or VLBW/preterm. The objectives were to examine (1) how the functions of mutual touch change in different interactive periods (i.e., whether the various functions of mutual touch differ in duration before and after a period during which the mother is less emotionally available to her infant; the SF period) and how these functions differ between full-term and VLBW/preterm infant-mother dyads, (2) how the functions of mutual touch are integrated with other modalities of infant communication (e.g., affect), and (3) the relationship between the functions of mutual touch and dimensions of the quality of the mother-infant relationship (i.e., measured via the Emotional Availability Scales; EA Scales; Biringen, Derscheid, Vliegen, Closson, & Easterbrooks, 2014; Biringen, Robinson, & Emde, 1988).

Method

Participants

The final sample consisted of two groups of 5½-month-old full-term ($n = 40$) and VLBW/preterm ($n = 40$) infants and their mothers. Demographic and medical information can be found in Table 1. All infants were recruited from the same hospital and neighborhoods in order to control for socioeconomic status (SES) and ethnic background. In addition, the VLBW/preterm and full-term dyads were matched on infant sex, maternal age, and maternal education (years of education were matched within 5 years). Maternal education was controlled for in the statistical analyses due to the broad time frame for matching and because maternal education is known to be a protective factor against risk (Serbin et al., 1998; Stack et al., 2012).

Table 1
Demographic and Medical Information

	Full-Term (<i>n</i> = 40)		VLBW/Preterm (<i>n</i> = 40)	
	<i>M</i>	<i>SD</i>	<i>M</i>	<i>SD</i>
Maternal age of birth (years)	30.62	5.13	32.86	5.68
Maternal education at birth**	14.75	1.92	13.12	2.11
Infant birth weight (g)**	3476	395	1092	237
Infants weeks of gestation**	39.74	1.08	28.51	2.29
1 min APGAR**	8.56	1.08	6.29	2.12
5 min APGAR**	8.25	0.60	8.00	1.38
Length of hospital stay (days)**	3.75	3.81	63.25	28.77
Infant length at birth (cm) **	50.58	4.81	37.40	3.68
Infant head circumference (cm)**	34.94	1.57	26.60	2.27
Infant weight at 5 ½ months (g)	6800	0.89	6750	1.04
Infant height at 5 ½ months (cm)	64.18	4.41	62.65	3.54

Note: The APGAR score is a scoring system used to assess newborns one minute and five minutes after birth. It is a measure of the physical condition of the newborn infant obtained by adding points for heart rate, respiratory effort, muscle tone, response to stimulation, and skin coloration. A score of 10 represents the best possible condition. * $p < 0.01$. ** $p < 0.001$.

Full-term infants. Subsequent to ethics approval, mothers and their infants were recruited from birth records from a major community hospital in the Montreal (Quebec, Canada) area. Following a letter outlining the general research, mothers were contacted by telephone and asked to voluntarily participate. Participants consisted of 48 mothers and their healthy, full-term infants born between 37 and 41 weeks gestation, and weighing more than 2,750 g (6 lb) at birth. Eight dyads were excluded from the current study based on various exclusion criteria: if the infant-mother dyad did not engage in mutual touch in both normal periods of the SF procedure ($n = 2$), if mothers did not follow instructions ($n = 1$), if the infant's gaze was obstructed ($n = 2$), if dyads took a break between the SF and reunion periods ($n = 2$), and if there was excessive infant crying ($n = 1$; no fretting lasting more than 20 s was permitted). The final sample consisted of 40 infants (20 males, 20 females). The mean age of infants at the time of the study was 5 months and 12 days ($SD = 6.70$). The mean age of mothers was 30.6 years (range = 21 – 41 years, $SD = 5.13$) and 91% of the infants were from Caucasian families.

Very low-birthweight (VLBW)/preterm infants. Subsequent to ethics approval and in collaboration with the chief neonatologist, VLBW/preterm infants were prescreened for medical status variables by the nurse in charge of the follow-up clinic of the same major community teaching hospital during their 3-4 month clinic visit. Caregivers of infants who met inclusion criteria were provided with a letter outlining the general description of the study and, if interested, were contacted by telephone for participation. The VLBW/preterm group consisted of 63 mothers and their infants with gestational ages ranging from 26 to 32 weeks and birthweights between 800 and 1,500 g (approximately 1 lb, 12 oz to 3 lb, 5 oz). Additional selection criteria limited the study population to healthy infants who were living with their biological mothers and excluded infants who suffered from any serious medical problems (e.g., infants diagnosed with a congenital abnormality or major congenital defects; infants who suffered GRADE IV [or III] intraventricular hemorrhage or other major medical complications, illnesses, or syndromes, such as hydrocephalus, severe neurological impairment, or those with hearing loss, retinopathy). Further exclusion criteria included infants who had had a prolonged hospitalization since the neonatal period, and mothers at psychosocial risk due to a history of inadequate prenatal care, drug abuse, and mental illness. Thus, our VLBW/preterm sample was composed of healthy infants who met rigorous inclusion/exclusion health criteria. Corrected age (i.e., postnatal age minus the number of weeks the infant was premature) was used to correct for prematurity in order for testing and developmental evaluations to be most accurate for a child's specific age. Twenty-three infant-mother dyads were excluded from the current group due to the infant-mother dyad not engaging in mutual touch in both normal periods of the Still-Face procedure ($n = 2$), mothers' failure to follow instructions ($n = 9$), procedural error ($n = 6$), and the SF period being repeated more than once due to infants'

fussiness ($n = 6$). The final sample consisted of 40 infants (18 males, 22 females). The mean age of infants at the time of the study was 5 months and 14 days ($SD = 8.21$). The mean age of mothers was 33.15 years (range = 21 – 44 years, $SD = 5.57$).

Apparatus

All sessions took place at the participants' homes and were video-recorded for subsequent coding purposes. Testing was carried out in a spacious and well-lit room, and outside distractions were minimized (e.g., televisions and radios were turned off, siblings or pets remained outside of the room). Infants were securely fastened in an infant seat placed on a table without toys or pacifiers. Mothers and infants were seated facing each other at eye-level, with a distance of approximately 70 cm between them. A stopwatch was used to time the duration of each period. A Sony video camera was positioned on a tripod in order to simultaneously capture a full view of the infant's face and body and their mother's hands. To capture the mother's face, the set-up included a mirror that was strategically placed at an angle beside the infant seat on the table.

Procedure

During the home visit, mothers received detailed information on the study, and were given a consent form to read and sign. Before beginning the study, mothers were reminded that they could withdraw from the study at any given moment and for any reason. Each dyad participated in the face-to-face SF procedure (Tronick et al., 1978), which consisted of three 2-min face-to-face interaction periods (normal, SF, and reunion) between the mother and her infant. Each of these periods was separated by a transition period of 20 to 30 s, during which mothers received instructions for the subsequent period. During this transition period, the dyads were free to interact with one another. During the first and third (i.e., reunion) normal periods, mothers were instructed to play with their infant as they normally would at home. During the second period, the SF, mothers were instructed to gaze at their infant with a still, neutral facial expression, and refrain from speaking to and touching their infant. That is, mothers were unresponsive and emotionally unavailable to their infants. If infants fretted for 20 s ($n = 7$), the session was interrupted. At the end of the testing session, mothers were asked to complete a demographic questionnaire and answer some questions in relation to their infants' developmental and medical histories. Mothers were thanked for their participation and given an "Infant Scientist Award" for their infant, as a symbol of appreciation for their participation in the study.

Measures and Observational Coding

Following the testing sessions, behavioral coding was carried out in the research laboratory using Mangold INTERACT 9, a software tool that is designed to facilitate observational coding (Mangold, 2010). Maternal compliance with instructions was verified prior to coding by previewing the video records and observing maternal behavior during the normal and SF interaction periods. Each function of mutual touch behavior was mutually exclusive and each second of the interaction was assigned a function of mutual touch code (i.e., behaviors were coded for 1-s intervals). The summed percent duration of each dependent measure (function of touch) was defined as the duration of time in seconds that a touch occurred out of the total time of the period (120 s) computed as a percentage (multiplied by 100). This was calculated for each of the two periods. Infants' affect, which included smiling and fretting during mutual touch bouts, was also coded.

A trained second coder coded 30% of the videotapes, which were randomly selected, to calculate a measure of inter-rater reliability. Thus, kappa (κ) was used as a measure of agreement between the two coders relative to the onset and offset times for each measure. Kappa is corrected for chance, which would equate to a $\kappa = 0$, and is scaled from -1 to +1, where a value of +1 equals perfect agreement between the two coders (Fleiss & Cohen, 1973).

Functions of mutual touch. The Functions of Mother-Infant Mutual Touch Scale (FMTS) (Mantis, Burnside, & Stack, 2013) was used to measure the communicative functions of mutual touch in the normal and the reunion periods of the SF procedure. This coding system was developed in order to categorize functions of touch that would apply to mutual touch. The coding method and mutual touch definitions were adapted from the Co-Touch Scale (Mantis et al., 2014). The FMTS was based in part on the FTS (Jean & Stack, 2009), which had an inter-rater reliability value of $\kappa > .90$, and the FITS, which had an inter-rater reliability value of $\kappa = .80$ (Moszkowski et al., 2009). Overall, six functions of mutual touch were coded: playful, regulatory, passive, attention-centered, guided, and unbalanced. A *playful* mutual touch was defined as both members of the dyad engaged in an agreeable and enthusiastic mutual touch, such as when both members hold hands while swaying them. A *regulatory* mutual touch was defined as both members of the dyad engaged in a calm and soothing-centered mutual touch wherein the potential aim of this touch may be to regulate emotion. An example of a regulatory touch is when both members' hands are intertwined in a calm and soothing manner. A *passive* mutual touch was defined as both members of the dyad engaged in a resting/accepting touch, such as when both members hold one another's hands

and are resting. *Attention-centered* mutual touch was defined as one member of the dyad seeking the other member's attention in the context of mutual touch. An example of an attention-centered mutual touch is when one member taps the other member's palm of the hand while already engaged in mutual touch; thus, the hands of both members are touching simultaneously. *Guided* mutual touch was defined as when one member of the dyad guides the exploratory touch of the other member in the context of mutual touch. An example of a guided mutual touch is when the mother lays the palms of her hands in front of her infant while the infant explores her fingers. *Unbalanced* mutual touch was defined as when one member of the dyad is engaged in mutual touch that is not in synchrony with the other member of the dyad. Typically, one member of the dyad attempts to control the interaction while the other member is more resistant to engage in the same function of mutual touch. For example, the mother tickles her infant while the infant pushes her hands away. The measure of inter-rater reliability for all the functions of mutual touch was $\kappa = .87$, and all individual functions showed very good to excellent reliability. The inter-rater reliability coefficients for playful mutual touch was $\kappa = .89$, for regulatory mutual touch, $\kappa = 1.00$, and for passive, guided, and attention-centered mutual touch, $\kappa = .78$ each.

Infants' affect. Infants' smiling and fretting were coded frame by frame. Infants' smiling was operationally defined as an upturned mouth (either open or closed). Fretting was coded when the infant was crying or when his/her mouth was turned down or curled. These infant affective behaviors have been reliably measured and coded in a number of studies (e.g., Jean & Stack, 2009; Moszkowski et al., 2009). Kappa coefficients were calculated for infants' affect and were found to be higher than $\kappa = .90$.

Emotional availability. The quality of the dyadic interactions (i.e., emotional availability) was coded using the Emotional Availability Scales (EA Scales; Biringen, Robinson, & Emde, 1988, 1993, 1998). Emotional availability is a relational measure reflecting dimensions related to the quality of the relationship and the ability of mothers and infants to effectively regulate their interactions (Biringen et al., 2014; Din, Riddell, & Gordner, 2008; Garvin, Tarullo, Van Ryzin, & Gunnar, 2012; Kaplan, Evans, & Monk, 2008; Mantis et al., 2014; Stack et al., 2012). Because they are relational scales, the behavior of both mothers and infants is considered for each rating, and, as such, scores could only be assigned during the normal periods when mothers were available and interacting. This version of the EA Scales is composed of four dimensions (maternal sensitivity, nonhostility, structuring, and child responsiveness). One maternal (i.e., sensitivity) and one infant (i.e., responsiveness) EA characteristic were selected as predictors to determine their impact on the functions of mutual touch. Maternal sensitivity was selected given that research has isolated sensitivity as an important component of maternal emotional availability that affects dyadic behavior (Kaye & Fogel, 1980; Little & Carter, 2005). Previous research has suggested that infants who are less responsive may have more difficulty expressing themselves and, thus, appear unengaged during interactions with their caregivers (Doiron & Stack, 2017). As such, infant responsiveness was also a predictor in order to better investigate its relationship with the various functions of mutual touch. Maternal sensitivity refers to the mother's responsiveness to the infant's needs, based on the infant's emotional cues. Infant responsiveness refers to the infant's active engagement and positive response to interactions with the mother (Biringen et al., 1993, 1998; Carter, Little, & Garrity-Rokous, 1998). One global rating was made on each scale for each normal interaction period. Since the EA Scales were originally designed for toddlers and children, an adapted version of the EA Scales was used to code the interactions between young infants and their mothers in the present study (Carter et al., 1998; Little & Carter, 2005). The EA Scales were coded by a research associate in our laboratory who was trained on the scales. Thirty percent of the sample was double coded by a trained second coder. Intraclass reliability coefficients revealed highly satisfactory levels for all EA Scales ($r = .82$ – $.99$). Previous studies have shown the EA Scales to be both reliable and valid measures of mother-child interactions (e.g., Biringen et al., 2014; Bornstein, Suwalsky, & Breakstone, 2012; Stack et al., 2012).

Results

The data was screened to determine whether the assumptions underlying repeated-measures analyses of variance (ANOVA) had been met. Prior to conducting statistical analyses, all data were double-checked by the first author and an undergraduate honors student in order to assure that there were no errors in initial data entry. Following confirmation of the data's integrity, descriptive statistics were used to assess the normality of the distribution, skewness, and kurtosis for each variable, and to identify outliers. The distributions of playful, regulatory, passive, and attention-centered functions of mutual touch were normally distributed. However, for the full-term group only, guided mutual touch was not normally distributed in the normal period and unbalanced mutual touch was not normally distributed in both periods, with skewness values exceeding 3 and kurtosis values exceeding 10. No transformations were performed because these two functions of mutual touch had very low frequencies; unbalanced mutual touch was not expected to be normally distributed in the full-term group due to the nature of this type of touch. All statistical tests were tests of a priori hypotheses and were conducted using the Statistical Package for the Social Sciences for Macintosh (SPSS, version 18.0).

Objective 1: Investigating the Influence of Infants' Birth Status on the Functions of Mutual Touch

Mutual touch occurred for a total of 44.3 s (37.0%) in the normal period and 42.7 s (36.1%) in the reunion period in the full-term infant-mother group. The average length of a mutual touch bout was 13.17 s in the normal period and 12.92 s in the reunion period. In the VLBW/preterm infant-mother group, mutual touch occurred for a total of 65.2 s (54.31%) in the normal period and for a total of 52.2 s (44.33%) in the reunion period. The average length of a mutual touch bout was 15.17 s in the normal period and 16.92 s in the reunion period. The mean durations of the six functions of mutual touch as a percentage of the total duration of mutual touch for each period and group are listed in Table 2.

Table 2

Mean Durations for the Six Functions of Mutual Touch as a Percentage of the Total Duration of Mutual Touch for Each Period for Full-Term and Very-Low-Birthweight/Preterm Infant-Mother Dyads

Period Group	Normal		Reunion	
	Full-Term	VLBW/Preterm	Full-Term	VLBW/Preterm
Overall Touch	97.58 (17.87)	95.01 (18.23)	97.68 (16.23)	100.01 (16.29)
Function of Mutual Touch				
Playful	46.47 (5.10)	24.09 (3.51)	58.93 (5.15)	36.15 (4.28)
Regulatory	7.55 (2.40)	2.38 (1.02)	12.81 (2.77)	0.75 (0.31)
Passive	13.20 (2.33)	10.95 (2.27)	7.93 (2.57)	8.18 (1.67)
Attention-Centered	15.99 (2.96)	19.18 (3.78)	8.22 (2.29)	21.99 (3.78)
Unbalanced	5.33 (1.96)	23.10 (4.26)	5.33 (1.96)	20.73 (3.63)
Guided	9.04 (3.12)	15.31 (3.99)	4.35 (1.49)	12.21 (2.62)

Note. Numbers in parentheses are standard errors.

A series of mixed ANOVA were conducted in order to examine within- and between-group differences in the functions of mother-infant mutual touch across the normal and reunion periods of the SF procedure. For all the analyses, significant main effects were followed with post hoc *t* tests, and when ANOVAs revealed significant interactions, Bonferroni pairwise comparisons were used to isolate the source of the significance. Results were considered statistically significant at a critical alpha level of .05 and partial eta-squared values (η_p^2) are reported as a measure of effect size (Kline, 2004; Olejnik & Algina, 2003). Finally, to examine the association between mutual touch and the quality of the mother-infant relationship as measured by the EA Scales, hierarchical regressions were conducted for the full-term and VLBW/preterm dyads.

Full-term infant-mother dyads. A one-way ANOVA was conducted with interaction period as the within-subjects factor. A statistically significant main effect of period was found, $F(1, 38) = 2.09, p = 0.04, \eta_p^2 = .08$. Post hoc analyses revealed that when comparing the mean percent duration of the six functions of mutual touch across the normal periods of the SF procedure, only two functions had statistically significant differences. There was a statistically significant increase in regulatory mutual touch from the normal period ($M = 7.55, SE = 2.40$) to the reunion period ($M = 12.81, SE = 2.77$). In contrast, there was a statistically

significant decrease in attention-centered mutual touch from the normal period ($M = 15.99, SE = 2.96$) to the reunion period ($M = 8.22, SE = 2.29$). The mean percent durations for each communicative function of mutual touch for both periods are presented in Figure 1.

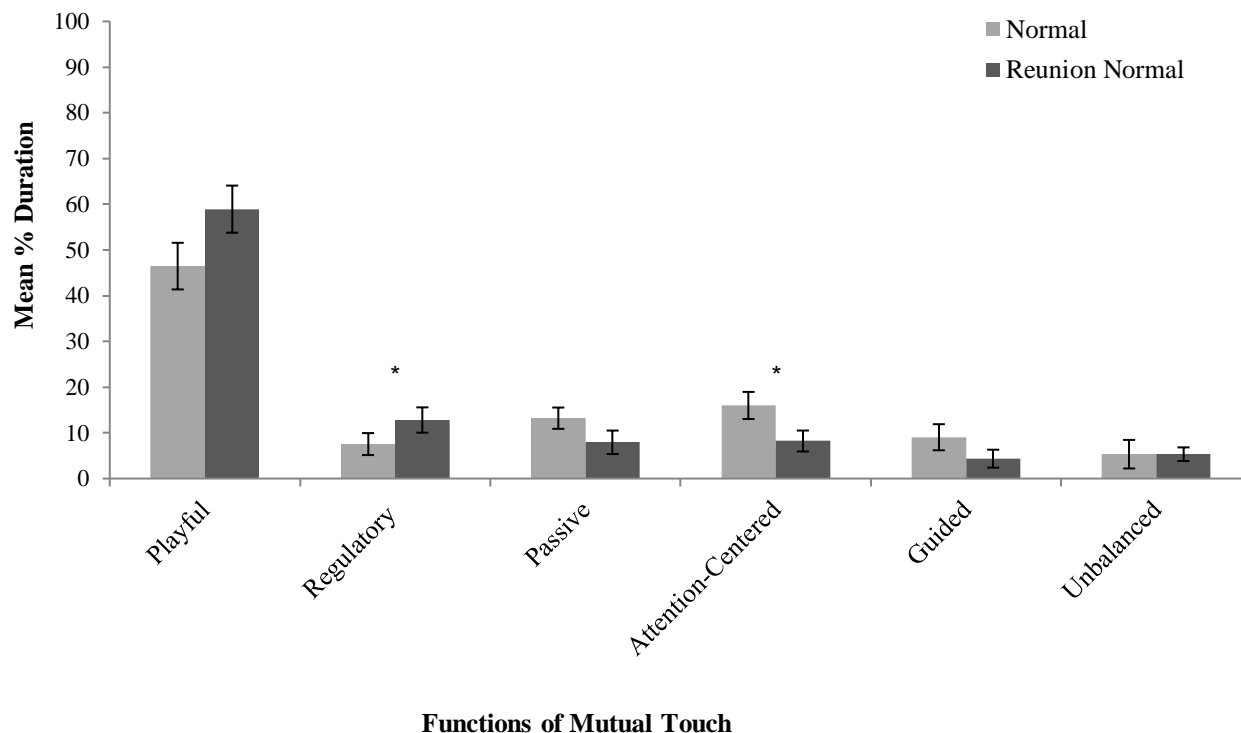


Figure 1. The mean durations for the six functions of mutual touch. Numbers represent a percentage of the total duration of mutual touch for the normal and reunion periods for the full-term infant-mother dyads. * $p < 0.05$.

Preterm infant-mother dyads. A one-way ANOVA was conducted with interaction period as the within-subjects factor. A statistically significant main effect of period was found, $F(1, 38) = 2.08, p = 0.05, \eta_p^2 = .23$. Post hoc analyses revealed that when comparing the mean percent duration of the six functions of mutual touch across the normal periods of the SF procedure, two functions had statistically significant differences. There was a statistically significant decrease in regulatory mutual touch from the normal period ($M = 2.38, SE = 1.02$) to the reunion period ($M = 0.75, SE = 0.31$). In contrast, there was a statistically significant increase in playful mutual touch from the normal period ($M = 24.09, SD = 3.51$) to the reunion period ($M = 36.15, SD = 4.28$). The mean percent durations for each communicative function of mutual touch for both periods are presented in Figure 2.

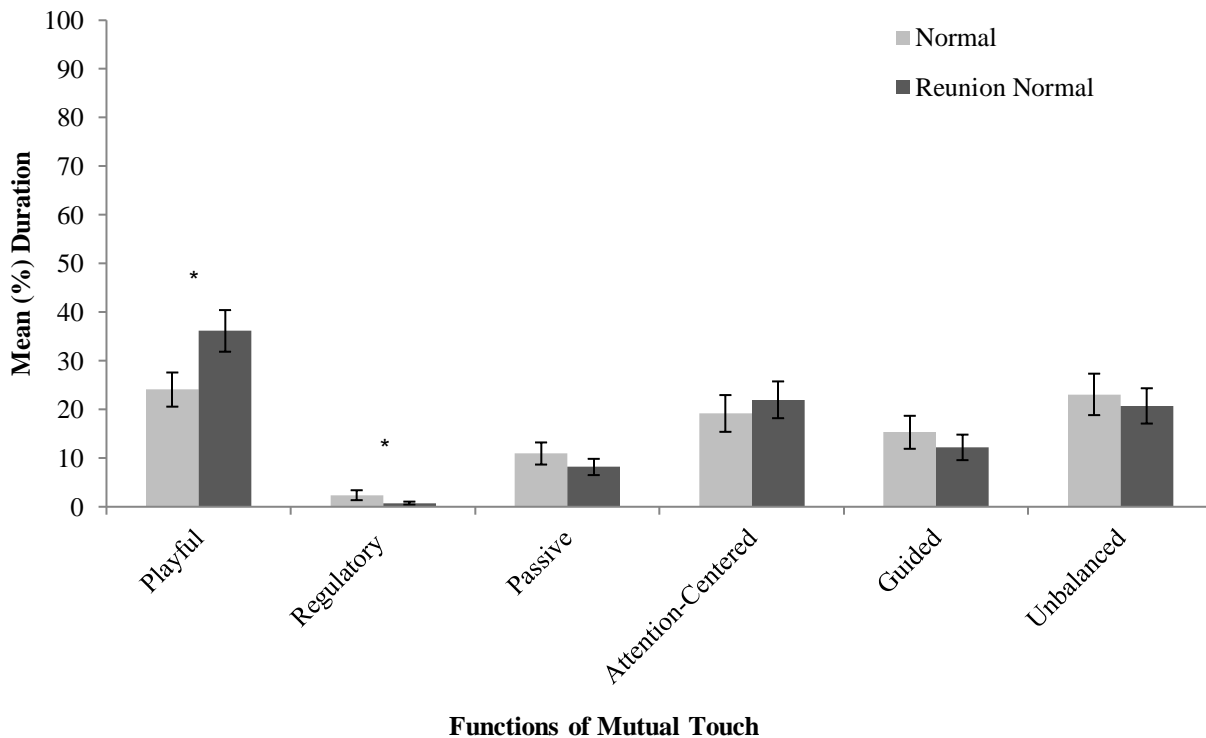


Figure 2. The mean durations for the six functions of mutual touch. Numbers represent a percentage of the total duration of mutual touch for the normal and reunion periods for the VLBW/preterm infant-mother dyads. * $p < 0.05$.

The functions of mutual touch across interaction periods and birth status. To examine whether the percent duration of the functions of mutual touch (as a percentage of the total duration of mutual touch) varied between the two periods of the interaction and between the full-term and VLBW/preterm birth status risk groups, a 2 (Group: full-term, VLBW/preterm) \times 2 (Interaction Period: normal, reunion) repeated-measures ANOVA was conducted. Group was entered as a between-subjects factor and interaction period was entered as the within-subjects factor. The dependent variable was the percent duration of the functions of mutual touch. Each of the six functions of mutual touch represents different levels of the dependent variable of the total percent duration of mutual touch.

A statistically significant main effect of functions of mutual touch was found, $F(1, 78) = 48.57, p < 0.001, \eta_p^2 = .39$. Post hoc comparisons revealed that, collapsed across group and period, mothers and their infants spent more time engaged in playful mutual touch ($M = 82.53, SE = 5.40$) compared to all the other functions of mutual touch. Collapsed across group and period, mothers and their infants spent significantly less time engaged in regulatory mutual touch ($M = 11.63, SE = 2.48$) as compared to attention-centered ($M = 32.80, SE = 3.79$) and unbalanced ($M = 27.45, SE = 4.03$) mutual touch. No significant main effect of period was found and no significant three-way interaction between period, functions of mutual touch, and group was found.

In order to examine whether there were any significant group differences among the total functions of mutual touch, the interaction periods were collapsed. The total amount of each function of mutual touch was obtained by computing the mean durations of mutual touch that had occurred in the normal and reunion periods of the SF procedure. A statistically significant group by functions of mutual touch interaction was found, $F(1, 78) = 13.67, p < 0.001, \eta_p^2 = .15$. Post hoc comparisons revealed that, collapsed across periods, full-term infant-mother dyads spent significantly more time engaged in playful ($M = 52.70, SE = 5.13$) and regulatory ($M = 10.18, SE = 2.56$) mutual touch as compared to VLBW/preterm infant-mother dyads ($M = 30.12, SE = 3.89$; $M = 1.57, SE = 0.67$, respectively; see Figure 3). VLBW/preterm infant-mother dyads spent significantly more time engaged in attention-centered ($M = 20.59, SE = 3.78$), unbalanced ($M = 21.92, SE = 3.95$), and guided ($M = 13.76, SE = 3.01$) mutual touch compared to full-term infant-mother dyads.

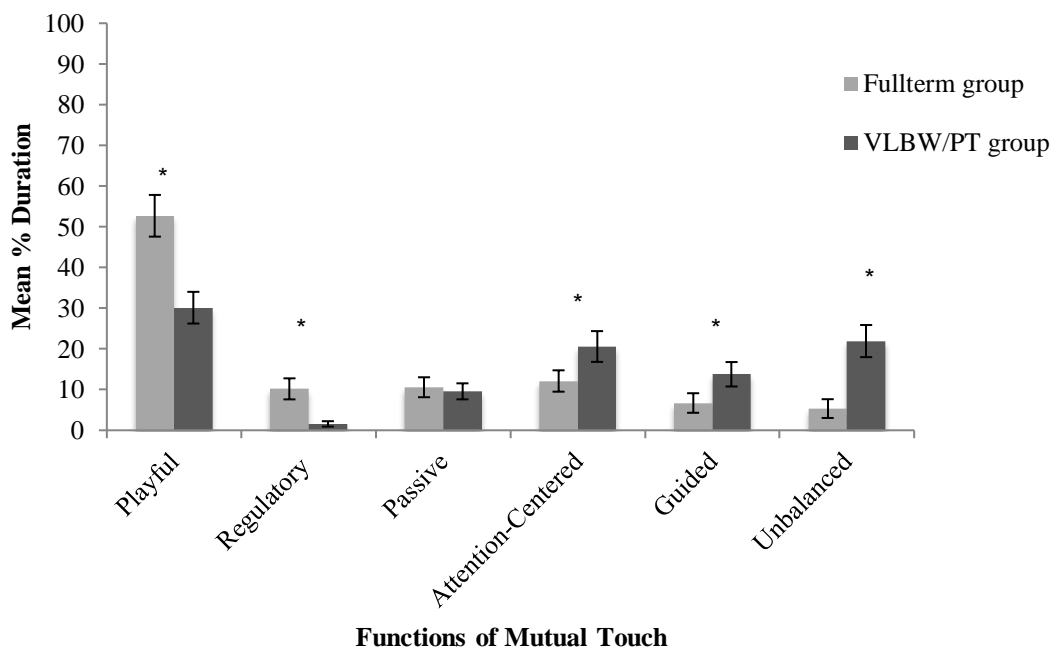


Figure 3. The mean durations for the six functions of mutual touch. Numbers represent a percentage of the total duration of mutual touch collapsed across the interaction periods of the Still-Face Procedure. * $p < 0.001$.

Given that mutual touch and its functions may have been distributed differently within each of the normal periods, a more precise and accurate representation of its occurrence was warranted in order to observe whether there were differences that were not being detected by use of an average mutual touch score for the entire period. In order to obtain such a representation of mutual touch during the periods of the SF procedure, 30-s segments were compared. That is, several repeated-measures ANOVAs were conducted for each group to evaluate (1) the first 30 s of the normal period with the first 30 s of the reunion-normal period, (2) the last 30 s of the normal period with the last 30 s of the reunion-normal period, and (3) the last 30 s of the normal

period with the first 30 s of the reunion-normal period. No statistically significant differences in the functions of mutual touch were found.

Objective 2: Examining Infants' Affect During Mutual Touch Across Periods

Infants' affect (smiling and fretting) during mutual touch was coded for full-term and VLBW/preterm infant-mother dyads. The average duration of infants' smiling during mutual touch bouts was 15.77 s for full-term infants and 10.40 s for VLBW/preterm infants. The mean percent durations of smiling were calculated for each normal period of the SF procedure. The mean duration of smiling during mutual touch as a percentage out of the total duration of smiling was 39.02% for full-term infants, while it was 28.21% for VLBW/preterm infants.

The average duration of fretting was computed including the infants who did not engage in fretting. The average duration of fretting during mutual touch was 0.69 s for full-term infants and 0.76 s for VLBW/preterm infants. The mean duration of fretting during mutual touch as a percentage of the total duration of fretting was 6.31% for full-term infants, and 6.11% for VLBW/preterm infants.

Following descriptive statistics, analyses were conducted to determine significantly co-occurring pairs between the functions of mutual touch and infants' affect (smiling and fretting) across interaction periods and groups. Wilcoxon signed-ranks tests were conducted to identify significantly co-occurring behavioral pairs (e.g., function of mutual touch – smiling; function of mutual touch – fretting) that occurred to a degree significantly greater than expected by chance (Fogel & Hannan, 1985; Jean et al., 2014; Legerstee, Corter, & Kienapple, 1990, Moszkowski et al., 2009). Specifically, to determine which behavior pairs were significant across each interaction period, the degree to which particular behavior pairs were observed to occur (i.e., observed/actual co-occurrence values) was compared with the expected degree to which these two behaviors were expected to co-occur based on chance alone (i.e., expected co-occurrence values). Expected co-occurrence values were determined by calculating the joint probability of the two behavior categories of interest (i.e., multiplying the proportional session durations of the two behaviors). The actual and expected co-occurrence values were then compared using Wilcoxon signed-ranks tests and behavior pairs were considered to be significantly co-occurring if the actual co-occurrence values were significantly greater than the expected co-occurrence values. The co-occurrence analyses between infants' affect and playful mutual touch indicated that in the normal period, playful mutual touch significantly co-occurred with smiling for both full-term and VLBW/preterm infant-mother dyads. For the reunion period, playful mutual touch significantly co-occurred with smiling only for the full-term infant-mother dyads. Finally, unbalanced mutual touch significantly co-occurred with fretting only for VLBW/preterm mother infant dyads in the reunion period.

Objective 3: Associations Between the Functions of Mutual Touch and Dimensions of the EA Scales

To address the third objective, hierarchical regressions were conducted in order to investigate whether the specific EA dimensions were associated with particular functions of mutual touch across periods. Predictor variables were two of the emotional availability dimensions (e.g., maternal sensitivity and child responsiveness) to determine their impact on the functions of mutual touch. The outcome variables were the regulatory, playful, and unbalanced functions of mutual touch given the significant differences observed between full-term and VLBW/preterm dyads. In all regressions, maternal education was entered in the first

step as a control variable. Intercorrelations were conducted to ensure that the variables employed in the regressions were not highly correlated with each other (Tabachnick & Fidell, 2001).

Full-term infant-mother dyads. In the regression examining the function of regulatory mutual touch, maternal sensitivity emerged as a significant predictor, $B = 0.02$, 95% CI [.002, .041], $b = 0.34$, $t = 2.21$, $p < 0.05$. Higher levels of maternal sensitivity were associated with dyads that engaged in more mutual regulatory touch during their interactions.

In the regression examining the function of playful mutual touch, child responsiveness emerged as a significant predictor, $B = 0.02$, 95% CI [0.004, 0.04], $b = 0.38$, $t = 2.46$, $p < 0.01$. Higher levels of child responsiveness during their interactions with their mothers were associated with dyads that engaged in more playful mutual touch during their interactions.

VLBW/preterm infant-mother dyads. In the regression examining the function of unbalanced mutual touch, maternal sensitivity emerged as a significant predictor, $B = -0.366$, 95% CI [0.11, 0.63], $b = -0.43$, $t = 2.87$, $p < 0.01$. Lower levels of maternal sensitivity were associated with dyads that engaged in more unbalanced mutual touch during their interactions with their preterm infants.

In the regression examining the function of playful mutual touch, child responsiveness emerged as a significant predictor, $B = 0.03$, 95% CI [0.01, 0.05], $b = 0.44$, $t = 2.97$, $p < 0.01$. Higher levels of child responsiveness during their interactions with their mothers were associated with dyads that engaged in more playful mutual touch during their interactions.

Discussion

The present study was designed to examine the functions of mutual touch during face-to-face interactions between mothers and their 5½-month-old full-term and VLBW/preterm infants in order to achieve a deeper and more comprehensive understanding of the communicative roles of touch during early mother-infant social exchanges. Our findings underscore the importance of the functions of mutual touch and suggest key differences in which mutual touching behaviors are organized with infants' affect and relationship dimensions between full-term and VLBW/preterm infant-mother dyads.

The total percent duration of mutual touch in the normal period of the SF procedure did not differ from the total percent duration of mutual touch in the reunion period for full-term dyads, whereas the total percent duration of mutual touch decreased in the reunion period for VLBW/preterm dyads (Mantis et al., 2014). The finding that infant-mother dyads engaged in mutual touch for over one third of the face-to-face interactions suggests that it is an important mode of communication. However, little is known about what functions mutual touch serves and how the functions are used during early mother-infant social exchanges.

The first objective was to investigate how the functions of mutual touch change in different interactive periods (i.e., whether the various functions of mutual touch differed in duration before or after a period where the mother is less emotionally available to her infant) and how these functions are influenced by infants' birth status (i.e., born full-term or VLBW/preterm). In line with expectations, mothers and their full-term infants appeared to engage in more regulatory mutual touch following a perturbation period. Regulatory mutual touch occurred for about 7% of total mutual touch in the normal period and increased to about 13% in the reunion-normal period, almost doubling. This result suggests that the dyad was compensating for the period when the

mother was less emotionally available, engaging in more calm and soothing-centered regulatory mutual touch in the reunion-normal period. This is consistent with past findings in which mothers seem to use more nurturing types of touch in the reunion-normal period, following the period when mothers are less emotionally available to the infant (Jean & Stack, 2009). However, mothers and their full-term infants did not engage in significantly more playful mutual touch following a perturbation period as was expected. Although there was an increase from the normal to the reunion period, the increase was not statistically significant, likely due to the variability observed in playful mutual touch. Studies with infants often have a large amount of variability due to the nature of individual differences in infant behavior and communication (Fogel, 1988; Mantis et al., 2014). Higher levels of variability for playful mutual touch also suggest that there might be subcategories of playful mutual touch (e.g., playful light versus playful active) that could warrant further investigation.

Results also revealed that attention-centered mutual touch appeared to decrease from the normal period for mothers and their full-term infants. That is, the dyad used more attention-centered mutual touch when the face-to-face interaction began than in the reunion-normal period of the SF procedure. Jean and Stack (2009) also found a decrease in maternal attention-getting touch from the normal to the reunion-normal period of the SF procedure. Thus, it seems that attention types of mutual touch are more prevalent in the beginning of these face-to-face interactions, whether they originate from the mother or in the context of mutual touch. This finding should be replicated as this may be attributed to the novelty of the task and testing situation in the first interaction period, or it may be that following a perturbation period (i.e., SF period), attention types of mutual touch do not take precedence.

In examining group differences, results revealed that mothers and their VLBW/preterm infants spent significantly more time engaged in unbalanced mutual touch as compared to full-term infant-mother dyads. During bouts of unbalanced mutual touch, members of the dyad are not engaged in synchronous touch and, typically, one member of the dyad attempts to control the interaction while the other member is more resistant to engage in the same function of mutual touch. Group differences in unbalanced mutual touch may be partly explained by preterm infants' displays of various behaviors that have been reliably documented in previous literature. Specifically, preterm infants have been found to be less alert, have lower capacities for self-regulation, be hypersensitive to stimulation, be less oriented toward their mother's face, and have facial expressions of emotions that are less clear-cut (Bozzette, 2007; Hall et al., 2015). These infant behaviors could make it more difficult for mothers to interpret their preterm infants' signals, regulate their arousal, and socially engage their infant (Goldberg & DiVitto, 2002). Therefore, mothers of preterm infants have to work harder to initiate and maintain positive interactions with their infants, as they receive ambiguous behavioral cues that are difficult to interpret (Feldman & Eidelman, 2007; Olafsen et al., 2012) as compared to mothers of full-term infants. Further, in examining differences in coregulation between full-term and VLBW/preterm infant-mother dyads, Doiron and Stack's (2017) results suggested that VLBW/preterm infant-mother dyads are less able to regulate their emotional outbursts and adhere more to the turn-taking nature of communication.

The second objective was to investigate how the functions of mutual touch are integrated with other modalities of infant communication (e.g., affect). It was hypothesized that smiling would co-occur with the playful function of mutual touch for infant-mother dyads in both groups. Smiling and playful mutual touch were found to significantly co-occur for both full-term and VLBW/preterm infants. Researchers have previously established that infants smile more in the first normal period of the SF procedure (e.g., Mesman et al., 2009; Tronick et al., 1978). Other researchers observed that infant playful touch and mother playful touch are prevalent in both the normal periods of the SF procedure (Jean & Stack, 2009; Moszkowski et al., 2009).

Results also revealed that unbalanced mutual touch in the reunion period co-occurred with fretting in VLBW/preterm infant-mother dyads. This is in line with expectations, as VLBW/preterm infants have more difficulty regulating their emotions following a perturbation period than do full-term infants. It was hypothesized that fretting would co-occur with the regulatory function of mutual touch for dyads in both groups. Contrary to our hypothesis, regulatory mutual touch did not co-occur with infants' fretting in either group. Given the low levels of fretting observed across period, this result is not surprising. In addition, this finding is consistent with Crockenberg and Leerkes (2004) result, in which maternal tactile soothing behavior did not co-occur with an increase in infants' distress. In previous research, soothing types of touch co-occurred with neutral, rather than negative, infant affect in the reunion-normal period (Moszkowski et al., 2009). Nevertheless, the SF effect can involve increased negative affect in the reunion-normal period. It may be that infants engage in soothing types of touch once they have already begun to self-regulate to prevent negative affect (i.e., fretting). In the dynamic context of mutual touch, the infant may be fretting during unbalanced mutual touch to increase the likelihood that their mother will engage in coregulation by means of another function of touch in order to change the infant's negative affect. That is, the co-occurrence of infant affect with specific functions of mutual touch suggests that the infants are trying to communicate with their mothers in more than one way to increase the salience of a message.

It has been suggested that when infants express themselves through more than one communicative modality, the probability that the mother responds to the message will increase (Weinberg & Tronick, 1994). Results from the present study suggest that the mother and the infant behave in a dynamic and simultaneous manner. Dyads continue to coregulate in order to achieve a coordinated state of interaction, whereby both members adjust their behavior based on the cues of their partners. In this study, the normal periods of the SF procedure evoked playful interaction, as per the large percentage of playful mutual touch and co-occurrence of playful mutual touch and smiling. Although fretting did not significantly co-occur with regulatory mutual touch, it did significantly co-occur with unbalanced mutual touch for VLBW/preterm infant-mother dyads, suggesting that there was an attempt to increase the saliency of the message to the mother in order to promote the dyad's coregulation.

By considering the behavior of both interactive partners when investigating the level of emotional availability (i.e., dimensions of the quality of the mother-child relationship) in dyadic interactions, important information regarding bidirectional influences in the mother-infant relationship can be gleaned. Thus, the third objective of our study was to examine the relationship between the functions of mutual touch and the quality of the mother-infant relationship. As expected, mothers who had higher levels of sensitivity engaged in more regulatory mutual touch during their interactions with their full-term infants; however, no association was found between maternal sensitivity and regulatory mutual touch for mothers of VLBW/preterm infants. From an early age, preterm infants present as more challenging and qualitatively different social partners than full-term infants. Premature infants have been described as more passive, less alert, and less responsive in interaction than full-term infants (Gatta et al., 2017), while mothers of infants born prematurely have been described as more active and controlling in the interaction situation, leading to higher intrusiveness and lower sensitivity compared to mothers of full-term infants (Korja et al., 2008). At the same time, these mothers report experiencing more psychological distress than mothers of full-term infants (Åhlund, Clarke, Hill, & Thalange, 2009; Feldman & Eidelman, 2007), which in turn impedes their abilities to sensitively detect change in their infants' behavior and emotional expression (Feldman, 2007). However, for both full-term and VLBW/preterm mother-infant dyads, an association was found between child responsiveness and playful mutual touch. That is, full-term and VLBW/preterm infants who showed higher levels of responsiveness were part of dyads that engaged in more playful mutual touch during their interactions. Moreover, results also revealed that mothers of VLBW/preterm infants who showed lower levels of maternal sensitivity engaged in more unbalanced mutual

touch during their interactions. This is in line with expectations given that preterm infants place different demands on their caregiver, and, thus, the development of sensitive and coregulated interactions that are typical in infant-mother dyads are hindered in preterm mother-infant interactions.

Although the results from our study make some important contributions that are discussed below, there are a few limitations. First, even though interactions were filmed in the participants' homes, the ecological validity is somewhat limited. Specifically, the interaction setting was controlled in that infants were constrained to the infant seat, consequently limiting their range of movement (so as to keep the interaction in a face-to-face format). It may have been that infants wanted to touch their mothers but could not in some instances. Nonetheless, this context allows for rich observations during a short period of time by helping to keep the dyad focused on the interaction. Second, only 4 min of interactions were coded per mother-infant dyad. Given that 4 min is relatively short in duration, it may not be truly representative of the daily interactions between mothers and their infants. However, face-to-face interactions in the lap and on the floor also have these limitations, and most of the studies to date have consistently used the SF procedure. Furthermore, 2-min interaction periods are consistent with the majority of face-to-face interaction studies, while some have used shorter (60-90 s) or longer (3 min) periods. Third, the VLBW/preterm sample was gathered using strict exclusionary criteria so as to only include medically healthy infants (aside from their birth status as VLBW/preterm). Although this criterion allows for greater confidence in differences in functions of mutual touch being associated with birth status, it may be an underestimation of the differences between VLBW/preterm infants and full-term infants in the general population. Many VLBW/preterm infants experience a number of other medical problems (McCormick, Litt, Smith, & Zupancic, 2011), which were not accounted for in this study and could potentially contribute to the literature on mother-infant interactions. Finally, the small sample size of the current study limits the generalizability of our findings and, as such, future studies are warranted to replicate our findings.

Despite the limitations, this study was the first to examine the functions of mutual touch in full-term and VLBW/preterm infant-mother dyads and as a function of the quality of the mother-infant relationship (i.e., using the EA Scales). By documenting the functions of mutual touch, and demonstrating how the functions vary across interaction periods and across birth status risk groups, the current study took an important step in demonstrating how mothers and infants use touch simultaneously to fulfill a mutual goal of coordinated states of interaction. The present study also demonstrated how both mothers and infants can jointly regulate their interactions according to changes in their social partner's behavior and while infants modify their affective states. Moreover, previous research has found that preterm infants have difficulty regulating their behavioral states and have limited capacities for coping with stress (Montirosso, Borgatti, Trojan, Zanini, & Tronick, 2010). The results from our study suggest that these factors likely affect the dyadic coordination of the interactions, and mother-infant synchrony as VLBW/preterm infant-mother dyads were found to engage in significantly more unbalanced mutual touch during the SF procedure as compared to full-term infants. Thus, results demonstrate how important it is to evaluate the functions of mutual touch in preterm infants as well, as touch may be serving different needs or be especially important in preterm infant-mother dyads.

Another unique contribution made by the current research was its examination of how indicators of quality of the relationship impacted the functions of infant-mother mutual touch. Our findings demonstrated that lower levels of maternal sensitivity were associated with unbalanced mutual touch for VLBW/preterm dyads as compared to full-term infants. Our findings are in line with previous research suggesting that several factors associated with prematurity may increase the risk for aberrant development of the mother-infant relationship as they are likely to affect the quality and coordination of the interaction.

Several potential avenues for future research are nonetheless warranted in order to increase our understanding of bidirectional communication. Because previous research has demonstrated that the quality of maternal touch changes across infants' age (Arnold, 2003; Jean, Stack, & Fogel, 2009), a longitudinal investigation of how the functions of mutual touch evolve and change across age periods is vital to better understanding its role in early mother-infant interactions. Moreover, there would be much value in investigating infants' reactions to the SF as well as maternal distress displayed or felt during the SF interaction and its association with mutual touch (Jean & Stack, 2009). Investigating infants' and mothers' level of distress could shed light on its impact on their subsequent regulatory and tactile behaviors. Furthermore, to date, most studies have neglected paternal touch. Fathers are sensitive and important partners in the development of children's emotion regulation and control (Pouget, Serbin, Stack, & Schwartzman, 2011). It may be that mutual touching surfaces differently and serves different functions during father-infant interactions.

Maternal touch patterns are among the most evolutionarily conserved behaviors and, as such, there is marked consistency in the genetic, neuroendocrine, and brain circuitry between humans and other mammals (Feldman, 2011). The role of maternal touch between humans and other mammals renders research in animal models particularly useful for understanding the biological underpinnings of early touch and contact and their effect on shaping the infant's capacity for social affiliation and stress modulation throughout life (Feldman, 2011). Indeed, it is well established that tactile stimulation is also of central importance for nonhuman species. Several animal studies have underscored the importance of parental care and parent-infant interactions and provide evidence for the importance of tactile stimulation (Hellstrom, Dhir, Diorio, & Meaney, 2012; McGlone, Cerritelli, Walker, & Esteves, 2017; Meredith, 2015; Stack, 2010). Just as in humans, animal and rodent studies have found that maternal separation can have adverse effects and negative sequelae; however, touch and contact (i.e., handling) can alter the negative effects during periods of maternal separation and positively impact emotion regulatory abilities (Kuhn, Pauk, & Schanberg, 1990; Suchecki, Rosenfeld, & Levine, 1993; van Oers, de Kloet, Whelan, & Levine, 1998). Results from primate and rodent models have implicated physical contact and touch (tactile stimulation) as significant concomitants of an infant's ability to regulate its own response to stress, and maternal behavior and proximity are considered the most important regulatory factors (Champagne & Meaney, 2007; Menard, Champagne, & Meaney, 2004). In primates, because of secondary altriciality, mothers play a fundamental role in helping infants learn how to self-regulate their emotional states (Botero, 2014). Moreover, studies have shown that gentle stroking touch in humans has similar beneficial neurodevelopmental effects to those reports from licking and grooming in rodents (McGlone, Wessberg, & Olausson, 2014). Mutual touch likely surfaces differently and serves different functions in nonhuman interactions; thus, there are several avenues for future research that are warranted in order to increase our understanding of bidirectional communication.

In conclusion, while further work is required to gain a more complete understanding of the role of mutual touch in mother-infant interactions (humans and nonhumans), the present study was the first to investigate the functions of mutual touch in early mother-infant social interactions in full-term and VLBW/preterm infant-mother dyads. Results from our study provide support for evidence that infant-mother dyads communicate bidirectionally and that they adapt to a perturbed moment by altering the functions of their bidirectional communication. Secondly, because these alterations in touching behavior were observed following the SF period, this provides additional support for touch as a salient mode of communication between mothers and their infants. Thirdly, by knowing what functions of mutual touch are present between mothers and infants during the SF procedure, we can ultimately compare functions of mutual touch in other at-risk groups. At-risk groups may include medically at-risk infants and high-risk infants, such as infants with depressed mothers or mothers with psychosocial difficulties (Mantis et al., 2018).

Results from our study have important implications and set the stage for continued research on mutual touch. Our findings support existing evidence that touch is integral to mother-infant interactions and emphasize the dynamic and communicative quality of mutual touch. Together, the results contribute to a greater understanding of how mothers *and* their infants participate in shaping and coregulating their interactions through the use of touch. By identifying the patterns of the functions of mutual touch present during the SF procedure in typically-developing infants, we may ultimately be able to identify when a disrupted pattern of mutual touch occurs and what it means taking into consideration both the mother and the infant. It has been suggested that when atypical forms of meaning-making persist during infant-mother interactions, they can distort how infants master age-appropriate developmental tasks, such as developing self-regulation, forming attachments with caregivers, or establishing autonomy (Tronick & Beeghly, 2011). Understanding meaning-making during early interactions is fundamental and needed for a clearer understanding of how development can become derailed and generate infant mental health problems (Cicchetti & Barnett, 1991; Hill-Soderlund & Braungart-Rieker, 2008; Sroufe, 2009; Tronick & Beeghly, 2011). Thus, early communicative differences may be spotted across a number of modalities and may lead to ways of identifying early communication impairments that may hinder infants' socioemotional development. Ultimately, findings could have implications for the design of preventive interventions and programs of early touch stimulation for at-risk infants.

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