Touch during mother-infant interactions: Influences of maternal unavailability and risk status

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ABSTRACT

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Mother-infant interactions are fundamental to infant social-emotional development. Touch is an influential channel through which mothers and their infants convey emotion and affection and establish a strong connection. In a series of two studies, the types of maternal touch and the functions of mutual touch during mother-infant interactions were investigated. Further, touch in at-risk populations (e.g., depressed mothers, VLBW/preterm infants) and the relationship between the quality of the dyadic relationship and touch were examined in order to elucidate the association between relationship indicators on tactile communication.

Study 1 examined maternal touching in 41 mothers with and without depressive symptomatology. Mothers and their 4-month-old infants participated in the Still-Face (maternal emotional unavailability) and the Separation (maternal physical unavailability) procedures. The types of mother touch were coded using the Caregiver-Infant Touch Scale (CITS; Jean, Stack, & Fogel, 2009; Stack, 2010; Stack, LePage, Hains, & Muir, 1996). Study 2 examined the communicative functions of mutual touching during the Still-Face procedure between mothers and their 5½-month-old full-term (n = 40) and very low-birthweight/preterm (VLBW/preterm; n = 40) infants. The functions of mutual touch were coded using the Functions of Mutual Touch Scale (FMTS; Mantis, Burnside, & Stack, 2012) and the quality of the mother-infant relationship (emotional availability) was coded using an adapted version of the Emotional Availability Scales Coding Guidelines

(EA Scales; Biringen, Robinson, & Emde, 1988, 1998), an observational and relational measure designed to rate dimensions of maternal emotional availability and child behavior.

Results from Study 1 indicated that mothers with higher levels of depressive symptoms engaged in less touching following the perturbation in the Still-Face procedure, whereas mothers with lower levels of depressive symptoms maintained stable levels of touching across both interaction periods. Mothers with higher levels of depressive symptoms displayed less playful/stimulating types of touching. Results from Study 2 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. Higher levels of maternal sensitivity and regulatory mutual touch were associated for full-term infant-mother dyads, while lower levels of maternal sensitivity were associated with unbalanced mutual touch for VLBW/preterm infant-mother dyads.

Together, the findings provide insight into how both mothers and infants participate in shaping and co-regulating their interactions through the use of touch. By identifying the patterns of maternal touch and the functions of mutual touch present during different contexts in both typically developing and at-risk dyads, we are able to identify disrupted patterns of communication. Ultimately, findings have direct implications for parenting practices and for the design of preventative intervention programs of early touch stimulation for at-risk infants and their parents.

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I am grateful for my dearest family and friends who have always been there for me no matter where I am. Thank you for all of the love, support, patience, and encouragement you have sent my way. A special mention to my mom and mom-in-law, who are beyond incredible grandmothers to my children. Thank you for being so present in their lives and for showering them with so much love and fun, which eased my mind while I was away working.

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Contributions of Authors

This dissertation consists of two manuscripts:

Study 1 (*see Chapter 2*)

Mantis, I., Mercuri, M., Stack, D. M, & Field, T. M. (2019). Depressed and non-depressed mothers' touching during social interactions with their infants. [Part of a special issue on *Social touch: A new vista for developmental cognitive neuroscience*.] *Developmental Cognitive Neuroscience*, *25*, 57-65. https:/doi.org/10.1016/j.dcn.2018.01.005.

Study 2 (*see Chapter 4*)

Mantis, I., & Stack, D. M. (2018). The functions of mutual touch in full-term and very low-birth weight/preterm infant-mother dyads: Associations with infant affect and emotional availability during face-to-face interactions. [Part of a special issue on *Expanding Perception: The Role of Touch in Comparative Psychology*]. *International Journal of Comparative Psychology, 31,* https://scholarship.org/uc/item/62x2k310

I with my supervisor am responsible for the conceptualization of the research presented in this dissertation, including the two specific studies. The data used in Study 1 was collected by Dr. Tiffany Field's research staff at the Touch Research Institute (University of Miami School of Medicine). The data used in Study 2 was collected by research staff in Dr. Stack's Infant and Child Studies Laboratory (Concordia University). Behavioral observational coding for both studies was carried out by me in Dr. Stack's research laboratory. Following the reliability and observational coding, I entered all the data into SPSS. With guidance and feedback from my supervisor, Dr. Stack, at every step I chose the research questions, hypotheses and analyses plan, and conducted all the statistical analyses, interpreted the results and wrote the present dissertation in all of its sections. Dr. Stack provided guidance, revisions, and feedback throughout every step of my dissertation.

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Chapter 1: General Introduction

Early parent-infant interactions are central to infants' social, emotional, and communicative development. It is within the context of the mother-infant relationship that infants first experience a reciprocal social exchange, learn to regulate their emotions, and to communicate effectively (Stack, 2010). During early mother-infant interactions, non-verbal communication is paramount given that infants are largely prelinguistic during the first year of life (Barnett, 2005). Nonetheless, historically past studies investigating social interactions during early development (e.g., first year of life) have primarily focused on the examination of the distal behavioral indices of gaze and affect, while neglecting to investigate the specific contribution of contact behaviors such as touch during these interactions (Jean, Stack, & Arnold, 2014). Yet, caregivers commonly employ touch during the majority of their everyday interactions with their infants (Aznar & Tenenbaum, 2016), along with their vocal and facial expressions (Cascio, Moore, & McGlone, 2019; Stack, 2010). Evidence of the increasing interest in touch has led to a growth in studies on touch in recent years (e.g., Botero, 2018; Cascio et al., 2019; Field, 2019; Gallace & Spence, 2016; Gliga, Farroni, & Cascio, 2019; Hertenstein, 2010; Mantis, Mercuri, Stack, & Field, 2019; Mantis & Stack, 2018; Mercuri et al., 2019; Stack, 2010; Stack & Jean, 2011; Tuulari et al., 2019).

Touch carries important implications for infant growth and development. Because of the early functionality of the tactile system, touch is one of the first sensations experienced by infants (Cascio et al., 2019; Montagu, 1986; Stack, 2010). Tactile information is transmitted through the skin, which is the largest sensory organ (Field, 2010). Its positive influence begins even before the infant is born as it is the first sensory

stimulation experienced by the foetus; as early as 6-weeks gestation (Gallace & Spence, 2016; Fearon, Hains, Muir, & Kisilevsky, 2002). As the first sense to develop, infants and young children are dependent on touch for learning about their world. During the first year of life, everything goes in the infant's mouth and is learned through the mouth's touching (orally; oral haptics). Young children subsequently explore the physical world by touch and haptics and learn about the many facets it can convey (e.g., elasticity, resilience, shape, sharpness, softness, temperature, and texture); and about safety and self-preservation (e.g., how to avoid frostbite, hot stoves, dangerous substances; Field, 2010).

Touch is the most basic mammalian behavior. From the moment an infant is born, mammalian mothers engage in species-specific maternal behaviors. Importantly, these maternal postpartum behaviors consist primarily of close physical proximity and touch (Feldman, 2011). Maternal touch patterns are one of the most evolutionarily conserved behaviors where a clear consistency has been documented in the genetic, neuroendocrine, and brain circuitry between humans and other mammals (Feldman, 2011; McGlone, Cerritelli, Walker, & Esteves, 2017). This consistency has led to significant advancements in research on animal models, particularly in understanding the biological underpinnings of early touch and contact and their effect on shaping an infant's capacity for social affiliation throughout life (Feldman, 2011).

Important physiological effects of touch have been well documented in the animal literature. Empirical investigations examining the stress-reducing effects of touch have been confirmed in rodent studies where licking and grooming of rat pups by their mothers were found to permanently change how the rat, as an adult, responded to stressful events

(Champagne & Meaney, 2007; Menard, Champagne, & Meaney, 2004). Furthermore, results from animal studies clearly show that tactile interactions during the neonatal period impact the expression of adult behavior by altering sensitivity to neuropeptides (e.g., oxytocin and arginine vasopressin; Hammock, 2015). In turn, this influences the expression of behaviors such as affiliation, aggression, socio-sexual behavior, parental behavior, and responses to stress (Cushing & Kramer, 2005; Hellstrom, Dhir, Diorio, & Meaney, 2012). Close physical proximity between newborn infants and caregivers results in improved growth and development as measured by a wide range of physiological, behavioral and neuropsychological indices (Harlow & Harlow, 1962b; Hofer, 1994; Kuhn & Schanberg, 1998; Pawling, Cannon, McGlone, & Walker, 2017). Earlier research demonstrated that rat pups that have undergone maternal separation, experience negative bio-behavioral responses, such as decreased body temperature and heart rate, an increase in the release of stress hormone corticosterone, and a decline in a hormone that regulates growth and differentiation (Schanberg & Field, 1988). Moreover, several research teams (Kuhn, Pauk, & Schanberg, 1990; Suchecki, Rosenfeld, & Levine, 1993; van Oers, de Kloet, Whelan, & Levine, 1998) have shown that even in the absence of maternal licking and grooming, these effects can be mimicked by stroking with a soft brush, further highlighting the significance and magnitude of tactile stimulation.

Touch is also critical for social attachment, a topic first addressed in the classical work of Harlow and Zimmermann (1958) and Harlow and Harlow (1962a) on nonhuman primates, who found that the absence of comforting touch led to long lasting psychological stress in monkeys. Infant rhesus monkeys spent more time climbing and clinging onto a cloth than a wire surrogate mother, even when being fed only by the wire

surrogate. These findings contradicted previous assumptions that attachment was derived from a reduction in the hunger drive (Harlow, 1959) and implied that bodily contact is more important in the formation of the mother-infant bond because it provides warmth, comfort, and security. Hofer (1975) studied the effects of maternal separation on mother rats and their rat pups and found that the separation experience led to a state of increased excitability for the rat pups, who ultimately died. Findings showed that following birth is a crucial time where rat pups need their mothers' thermal and tactile stimulation to prevent them from becoming hyperexcitable. Although Hofer (1975) tried to create substitute mother rats by covering a heater with fur, the rat pups could not return to a normal state. Further, Suomi (1997) suggested that tactile stimulation is a core component of rhesus monkeys' social activities (e.g., grooming and play). These aforementioned studies underscore the vital role of touch in normative animal development and in the emergence of social attachment.

In humans, benefits of maternal touch for infants' cognitive, neurological, and social-emotional development have been documented throughout infancy. Immediately after the birth of a human infant, mothers begin to engage in typical maternal behaviors including holding the infant in a cradling position, gazing at the infant's face and body, expressing positive affect, emitting "motherese" (high-pitched vocalizations), and providing affectionate touch. Feldman (2011) described the combination of these behaviors as the "maternal postpartum repertoire". Affectionate touch has been described as the human analogue to the "licking-and-grooming" behaviors of rat mothers and is the most prevalent active behavior in the maternal constellation. This behavior often co-occurs with social gaze, and together, they establish the basis for interpersonal mutuality

between mother and infant in the first days after birth (Feldman, 2011). Immediately after birth, both mothers and fathers have been found to display a range of touching behaviors toward their infants, including stroking and caressing, massaging or rubbing, holding, and kissing, as well as static touch (Mercuri et al., 2019). Mothers often use such forms of affectionate touch in concordance with the infant's social signals and adapt the provision of maternal behavior to the newborn's limited moments of attention (Feldman, 2011).

In highly social species, across the lifespan, touch plays a key role in the formation and maintenance of relationships (Pawling et al., 2017). Tactile interactions between a human infant and a caregiver are rewarding, buffer physiological and psychological responses to stress and ultimately enhance well-being (Gallace & Spence, 2010; Hofer, 1994; Walker & McGlone, 2013). Parental touch is a key regulator of an infant's physiological and behavioral arousal (Hofer, 1994). Although still in its early stage, significant advancements have contributed to our understanding of tactile stimulation as an integral component of the mother-infant communicative system (Stack, 2010; Stack & Jean, 2011). In particular, touch has been shown to be an influential channel through which mothers and their infants convey emotion and affection, and establish a strong connection (Barnett, 2005; Hertenstein, 2002; Jean et al., 2014; Stack & Jean, 2011). During the first year of life, touch serves as one of the primary means of non-verbal communication through which both partners communicate with each other (Hertenstein, 2002; Stack & Jean, 2011). Specifically, maternal touch has been found to occur between 55% and 99% of the total interaction time between a mother and her infant (Field, 1984; Jean et al., 2009; Stack & Muir, 1990). The duration of maternal touch as well as its qualitative components such as types, functions, and intensity have been linked

to an enhanced quality of face-to-face mother-infant interactions (e.g., Feldman, Singer, & Zagoory, 2010) and to infants' later attachment (Ainsworth, Blehar, Waters, & Wall, 1978). While a number of procedures and paradigms have been used to study touch and interactions, one popular means through which infants' sensitivity to changes in maternal behaviors during face-to-face social exchanges has been studied is through the Still-Face (SF) procedure (Stack & Jean, 2011, Stack & Muir, 1990, 1992; Tronick, Als, Adamson, Wise, & Brazelton, 1978).

The Still-Face Procedure and Mother-Infant Interactions

The SF procedure is widely used as a means to investigate infants' self-regulating, affective, and communicative abilities (Mesman, van Ijzendoorn, & Bakermans-Kranenburg, 2009) and mothers' sensitivity and responsiveness (Conradt & Ablow, 2010; Lowe et al., 2012), among other domains of interest. The SF procedure involves normal face-to-face interaction periods separated by a period where mothers are instructed to continue to gaze at their infants while maintaining an expressionless (still-face) face and refraining from touching their infants or vocalizing. The SF period provides conflicting information to infants because their mothers' body postures and gaze invite social interaction, whereas their mothers' unresponsive face rejects it (Stack & Muir, 1990). Mothers are thus emotionally unavailable during the SF period, providing the opportunity to study infants' self-regulatory skills when mothers are not available as external sources of stimulation and arousal modulation (Tronick et al., 1978). This SF period can be challenging for infants given that they must cope with the sudden loss of their mothers' availability and responsiveness, modulate their own emerging negative emotions, while at

the same time attempt to reengage their caregiver into mutual regulation (Manian & Bornstein, 2009).

Results from numerous studies suggest that infants react to maternal unavailability experienced during the SF period by displaying a typical SF signature effect: during the SF period, infants spend less time gazing and smiling at their mothers, and they exhibit increased fretting and neutral affect (Adamson & Frick, 2003; Ekas, Haltigan, & Messinger, 2013; Mesman et al., 2009). Since maternal regulatory support is absent during the SF period, infants must rely on their own coping mechanisms. As such, an increase in infants' self-regulatory behaviors, such as gaze away and self-touch have been documented (Ellsworth, Muir, & Hains, 1993; Moszkowski & Stack, 2007; Jean & Stack, 2012). Following the SF period and the resumption of normal mother-infant interaction, a carry-over effect has been demonstrated (Cohn, 2003). Specifically, in the reunion period, infants continue to exhibit negative affect while displaying an increase in smiling and gazing at their mothers, thus displaying both avoidant and approach behaviors (Cohn, 2003; Weinberg & Tronick, 1996). The robust findings from studies with the SF procedure suggest that infants' reactions to the SF are caused by a violation of infants' expectancies about maternal social behavior and that infants are sensitive to changes in their mothers' communicative behaviors (i.e., maternal unavailability during the SF period; e.g., Mammen et al., 2016; Mantis, Stack, Ng, Serbin, & Schwartzman, 2014; Montirosso, Cozzi, Tronick, & Borgatti, 2012). Over time, infants develop expectancies of their mothers' social behaviors and assume that mothers will respect the social rules governing reciprocal social interactions (Mesman et al., 2009). This

disruption of the normal interactive cycle between mothers and their infants is considered mildly distressing or challenging to infants.

Face-to-face interactions between caregivers and infants are believed to form a mutually regulated system that is bidirectional in nature (Tronick, 1989). Dynamic systems theory (Fogel, 1993; Fogel & Garvey, 2007) posits that both mothers and infants are responsive to the communicative signals of their social partners, and based upon these signals, adjust their behavior and affective displays accordingly (Cohn & Tronick, 1987). Although the sequence of events characterizing interaction periods between mothers and their infants is primarily framed by mothers, it nonetheless remains highly dependent on infants' behaviors. Throughout the interaction, infants often cycle in and out by shifting their gaze towards and away from their mothers, while mothers continue to gaze at their infants for long periods (Fogel, 2009; Hsu & Fogel, 2003). Mothers then exhibit positive facial expressions in response to their infants focusing attention on them. Before six months of age, this change in mothers' facial expressions is generally followed by positive affect in infants. As infants continue to develop over time, their positive affect becomes less and less dependent on their mothers' displays and they begin to initiate these displays on their own, thereby demonstrating increased sophistication in their communicative abilities (Fogel & Garvey, 2007).

Along similar lines, the Mutual Regulation Model (Gianino & Tronick, 1988) stipulates that periods of synchronized engagement are a mutual goal of mothers and infants during their interactions (Tronick, 2011; Tronick, Als, & Brazelton, 1977). Mothers structure their behaviors in accordance with those of their infants' (Kaye, 1982). Through their affective displays, infants may communicate their needs and desires, and in

response mothers adjust their behavior accordingly (Tronick, 2011). By sensitively responding to their infants' bids, mothers are reinforcing infants' sense of efficacy and their emerging self-regulating abilities.

Although dyads aim to partake in synchronous and coordinated interactions, dyadic interactions are often asynchronous and uncoordinated. During periods of desynchronized interaction, mothers and infants work together to repair the interactive sequence (Gianino & Tronick, 1988). Successful attempts at repairing the interaction promotes growth, adaptability, and self-consciousness in the infant and is an indicator of the quality of the mother-infant relationship (Tronick & Beeghly, 2011). If a mother's behavior shows strong intent for interaction, it attracts the infants' attention and initiates mutual exchange, response, and participation (Chung, Wan, Kuo, Lin, & Liu, 2018). In such cases, infants actively contribute to social engagements and learn from these to anticipate social responses. Thus, mother–child interactions are a shared, reciprocal experience within the dyads, whereby the experience of each has an impact on the experience of the other as noted above. Effective mother–child interactions require that both send clear cues and respond to each other, thus facilitating the development of an interactive environment that continues the interaction (Trevarthen & Aitken, 2001; White, Simon, & Bryan, 2012). The mother and infant learn to adapt, modify, and change their behaviors in response to the other in every interaction process (Chung et al., 2018).

The Quality of the Mother-Infant Relationship

A greater understanding of the interactive processes occurring between mothers and infants during interactions can be ascertained based on the quality of the mother-infant relationship. Emotional availability, as measured by the Emotional

Availability Scales (EA Scales; Biringen, Derscheid, Vliegen, Closson, & Easterbrooks, 2014), is a relationship construct that reflects the degree to which each interactive partner expresses emotion during interactions and is attuned to the affective displays of the other partner (Biringen, 2012; Biringen et al., 2014; Easterbrooks & Biringen, 2009). During normal interactions, mother and infant vary in the levels of emotional availability displayed (Bigelow & Power, 2016). Sensitivity and responsiveness have been isolated as important emotional availability characteristics that affect the behavior of both interactive partners (Bigelow & Power, 2016; Bornstein, Suwalsky, & Breakstone, 2012; Smith et al., 1996). These characteristics, in addition to maternal structuring, intrusiveness and hostility, as well as child responsiveness and involvement, reflect the overall quality of the mother-infant relationship (Biringen et al., 2014). By considering the behavior of both interactive partners when investigating the level of emotional availability in dyadic interactions, important information regarding bidirectional influences in the mother-infant relationship are obtained. Research has revealed that typically developing and at-risk dyads can be distinguished based on their level of emotional availability during interactions, as will be discussed in the forthcoming sections.

Consequential risk factors for the development of a healthy mother-infant relationship have been reported in at least two at-risk groups. These groups include premature birth and maternal postpartum depression (PPD), each of which occurs in approximately 10-15% of the population in industrial societies (Centers for Disease Control and Prevention, 2019a, 2019b; March of Dimes, 2019). In both groups, mothers have difficulty touching or making contact and connecting with their infants (Feldman, 2011).

Premature Birth

Preterm infants can be regarded as a specific group for whom the course of parenting might be different. Preterm birth remains a major health concern as an estimated 15 million infants are born prematurely each year, half a million being in the United States (World Health Organization, 2018) and more than twenty-five thousand in Canada (Shah et al., 2018; Statistics Canada, 2020). The World Health Organization defines preterm birth as a birth occurring before 37 completed weeks of gestation. Preterm neonates, born prior to 37 weeks of gestation, differ from full-term neonates according to the degree of brain maturation, which is related to the gestational age in weeks at birth (Mento & Bisiachi, 2012). Infants born very preterm and/or with a very low birth weight (VLBW; less than 1500 g) are considered at even greater risk for adverse and multiple short and long term developmental and behavioral outcomes (Delonis, Beeghly, & Irwin, 2017; Scott, Winchester, & Sullivan, 2018; Tessier & Nadeau, 2007; Zelkowitz, 2017). Improvements in medical technology and neonatal care have led to a growing number of children born very premature and/or VLBW (Stack, Matte-Gagné, & Dickson, 2019; te Pas, 2017). Preterm birth has also been described as stressful and emotionally demanding for parents (Kersting et al., 2004). Following the birth, responding sensitively to a medically fragile preterm infant can be challenging as their cues are more difficult to detect and understand (Eckerman, Hsu, Molitor, Leung, & Goldstein, 1999). Therefore, a preterm birth can have a negative impact on maternal responsiveness and maternal attachment (Zelkowitz, Bardin, & Papageorgiou, 2007).

Typical fetal development occurs under specific sensory conditions that facilitate neurological development and maturation. Premature birth interrupts these physiological

processes, with the neonatal intensive care unit (NICU) environment imposing artificial conditions on the developing premature infant (Montirosso, Del Prete, Bellù, Tronick, & Borgatti, 2012; Peng et al., 2009; Provenzi et al., 2017). In the NICU, a premature newborn is both under- and over- stimulated wherein sub-optimal conditions during a critical period of brain development may result in atypical developmental trajectories (Als et al., 2004; Carbajal et al., 2008; Sansavini et al., 2011). It has been suggested that very preterm infants are exposed to a double-risk condition for social-emotional development, encompassing both difficulties in social-emotional stress response and exposure to less-than-optimal maternal bonding (Provenzi et al., 2017). Moreover, prematurity places surviving infants at increased risk for social-emotional, language, and cognitive and motor developmental delays (Boyle et al., 2012; Breeman, Jaekel, Baumann, Bartmann, & Wolke, 2016; Brydges et al., 2018; Ruth, Roos, Hildes-Ripstein, & Brownell, 2012; Scott et al., 2018; Williams et al., 2013; Zimmerman, 2018). Later on, premature infants tend to experience difficulties in mathematics, reading, spelling, attention and behavioral problems (e.g., Breeman et al., 2016; Scott et al., 2018) and deficits in executive functions (Brydges et al., 2018), which persist throughout childhood (Chan, Leong, Malouf, & Quigley, 2016). Social interaction is especially important in optimizing the aforementioned negative outcomes (Forcada-Guex, Pierrehumbert, Borghini, Moessinger, & Muller-Nix, 2006). Given that parents and caregivers are central socializing agents they play a pivotal role in impacting these skills with their child (Stack et al., 2019).

For most infants, interaction with their mothers is the foundation that builds their capacity for displaying clear behavioral cues and responding during social interactions

(White-Traut et al., 2013). While premature infants have a high need for positive interactions, establishing positive interaction patterns is challenging for both infants and their mothers because of the infants' biological immaturity. From an early age, preterm infants present as more demanding and qualitatively different social partners than full-term infants (e.g., Eckerman et al., 1999; Evans, Boyd, Colditz, Sanders, & Whittingham, 2017). During interactions with their mothers, they are less alert and less socially responsive than full-term infants. In addition, preterm infants express their needs using ambiguous behavioral cues, vocalize less, and display more negative affect and gaze aversion (Jean & Stack, 2012; Provenzi et al., 2017). Furthermore, preterm infants are described as easily excitable, and more irritable and disorganized than full-term infants, suggesting poor emotion and behavior regulation strategies (Feldman, 2009; Korja et al., 2008; Poehlmann et al., 2011). Overall, interaction between a preterm infant and their mother has been shown to be influenced by the infant's lower self-regulation capacities, the infant's physical condition, the amount of physical closeness, as well as by maternal stress and anxiety.

The lack of emotional and physical closeness between mothers and preterm infants, together with maternal emotional distress, can negatively affect the mother-infant relationship and result in adverse outcomes for infants' socioemotional development (Montirosso, Tronick, & Borgatti, 2017). Given that preterm birth is assumed itself to be a risk-factor for normative development of the mother-infant relationship (Korja et al., 2008), it has long lasting implications for the quality of mother-child interactions (Forcada-Guex, Borghini, Pierrehumbert, Ansermet, & Muller-Nix, 2011; Poehlmann et al., 2011). During face-to-face interactions, mothers of preterm infants have often been

described to be more active and controlling in interaction situations, leading to maternal intrusiveness and lower sensitivity compared to mothers of full-term infants. At the same time, these mothers report experiencing more psychological distress than mothers of full-term infants (Ahlund, Clarke, Hill, & Thalange, 2009; Feldman & Eidelman, 2007) which in turn impedes their abilities to sensitively detect changes in their infants' behavior and emotional expressions (Feldman, 2007). Interactions between mothers and their preterm infants are typically characterized by less mutually synchronous and co-regulated exchanges (Feldman, 2007). As such, the development of sensitive, co-regulated, and contingent interactions that are characteristic of normative mother-infant interactions are often hindered in preterm dyads. Thus, they are poor social partners, and often demonstrate fewer relationship building behaviors, including co-regulation (Doiron & Stack, 2017), making it potentially more difficult for mothers to optimally engage with their infants.

Prematurity involves a disruption to the physical contact between mother and child during the child's postnatal hospitalization. This break in contact typically results in lower levels of maternal affectionate touch and, at times, in increases in maternal instrumental, functional, and intrusive touch, even after physical contact is resumed (Feldman, 2004). Reduced maternal touch, particularly in combination with the preterm infant's already compromised physiology, may place these infants at marked developmental risk. Results from several studies highlight the centrality of maternal touch for the premature infant's optimal growth (e.g., Feldman & Eidelman, 2007; Maitre et al., 2017; Schneider, Charpak, Ruiz-Peláez, & Tessier, 2012; Vittner et al., 2019). Furthermore, numerous studies have demonstrated that one way in which mothers can

counteract the negative effect of prematurity is through the use of touch. For example, from the time preterm infants are born, extra skin-to-skin contact and massage have been found to have beneficial effects on the physiology, development, and behavior of premature infants (see Field, 2011; Vickers, Ohlsson, Lacy, & Horsley, 2004).

In a study by Feldman and Eidelman (2007), touch patterns between parents and their premature infants were observed. Results showed that mothers and fathers of premature infants (both in the neonatal period and at 3 months of age) provided less affectionate touch to their infants than parents of full-term infants (Feldman & Eidelman, 2007). However, mothers of preterm infants varied in their ability to engage in affectionate touch. Specifically, mothers who resolved the trauma of premature birth (i.e., were able to discuss the experience with openness, coherence, and richness; to utilize the assistance of the nursing staff during the hospitalization period; and to form specific plans for themselves and the infants after discharge) displayed more affectionate touch during interactions with their infants prior to discharge. As a result, their infants were found to be more socially alert and less withdrawn (Keren, Feldman, Eidelman, Sirota, & Lester, 2003). Moreover, a mother's use of affectionate touch has been found to increase security of attachment among preterm infants and reduce their likelihood of developing emotional and behavioral problems as toddlers (Feldman, 2010; Weiss, Wilson, Hertenstein, & Campos, 2000; Weiss, Wilson, St. John-Seed, & Paul, 2001).

Touch interventions for premature infants, in particular massage therapy and skin-to-skin contact ("kangaroo mother care"), are standard practice in many countries and have been shown to improve the infant's state regulation and neuro-maturation, decrease hospitalization stay, and accelerate motor development (Field, 2014; Field, Hernandez-

Reif, Feijo, & Freedman, 2006; Moore, Bergman, Anderson, & Medley, 2016). In a randomized control study of preterm massage, three groups were included: infants massaged by their mothers, infants massaged by trained nurses, and controls matched for demographic and medical conditions. While both massage groups showed a quicker weight gain (Ferber et al., 2002), mothers who massaged their own infants were more sensitive and provided more affectionate touch, and their infants showed higher social engagement during interactions at 3 months (Ferber & Feldman, 2005). Mothers providing massage therapy to their infants have reported an increased ability to read their infants' signals, to provide appropriate stimulation, and an overall feeling of empowerment as a parent (Bigelow et al., 2010; Neu, 1999). In another study by Maitre and colleagues (2017) it was found that when premature infants were given more "supportive touch" experiences (including skin-to-skin care and breastfeeding), their brains responded more strongly to light touch. Moreover, kangaroo mother care has been found to have lasting psychosocial effects including reduced stress, enhancement of mother-infant bonding, and positive effects on the family environment and the infant's cognitive development (Charpak, Ruiz, & Kangaroo Mother Care Team, 2007; Schneider et al., 2012; Tessier et al., 2009).

Maternal Postpartum Depression

The postpartum period brings both physiological and psychological transitions that predispose many women to depressive symptoms within 12 months of giving birth (Bigelow, Power, MacLellan-Peters, Alex, & McDonald, 2012). Postpartum depressive symptoms can involve experiences of mental confusion, sadness, anxiety, fear, compulsive thinking, and feelings of inadequacy (Bigelow et al., 2012). Postpartum

depression (PPD) has been associated with reduced quality of mother-child interaction and impaired cognitive, social, and emotional development in their offspring (Granat, Gadassi, Gilboa-Schechtman, & Feldman, 2017; Myers & Johns, 2018; Netsi et al., 2018; Sinclair & Murray, 1998; Weissman, 2018). Although PPD does not preclude maternal-infant physical contact, depressed mothers appear to avoid physical proximity and provide minimal levels of affectionate touch (Feldman, 2011). Maternal depression has been shown to be a significant risk factor for the infant's development and the quality of the mother-infant relationship (Korja et al., 2008). Depressed mothers have been reported to be more negative and less sensitive during their interactions with their infants, showing more flat and tense expressions than nondepressed mothers (Murray, Fiori-Cowley, Hooper, & Cooper, 1996). In addition, infants of depressed mothers have been characterized as showing more anger and less affective sharing in free-play situations with their mothers and to be more insecurely attached to their mothers as compared to infants of nondepressed mothers (Korja et al., 2008). Results from studies have also shown that children whose mothers have experienced depression during the infant's first year have more behavioral problems at 18 months and lower cognitive performance at 4 years (Korja et al., 2008).

Despite the important role that touch plays in the context of mother-infant relationships and its frequent occurrence during even brief mother-infant interactions, most researchers studying mother-infant face-to-face interactions have neglected to fully investigate the touching behaviors in at-risk groups. Yet it is not merely the presence of maternal touch that is beneficial to infants' wellbeing, but rather, the particular type of touch displayed (Jean et al., 2014; Mantis et al., 2019; Mercuri et al., 2019). Systematic

investigations of the quality of maternal touch have documented the use of different types of touch by mothers such as nurturing, affectionate, holding, caregiving, poking, stroking, and proprioceptive stimulation (e.g., Jean et al., 2009; Weiss & Neimann, 2011). In order for mothers to recognize the appropriate type of touch to engage in with their infants, they must be attentive to their infants' changing needs. As such, a mother's ability to engage her infant and respond to her infant's needs is essential for the development of a positive mother-infant relationship (Pearson et al., 2012).

Maternal depression is known to affect maternal engagement during early social exchanges and has been shown to have a negative impact on these early interactions with their infants as well as their development (Jung, Short, Letourneau, & Andrews, 2007; Turney, 2011). As a result, the development of a positive mother-infant relationship, as well as the socio-emotional health of the infant, may be at risk for infants of depressed mothers because maternal depression is associated with reduced maternal sensitivity and responsiveness (Field et al., 2007; Jung et al., 2007; Pearson et al., 2012). Yet, despite the important and frequent role of touch during mother-infant face-to-face interactions, most investigations have neglected to fully investigate how the touching behaviors of depressed mothers may differ from that of non-depressed mothers.

The few studies that have investigated the association between depression and maternal touching behaviors have primarily examined depressed mothers' displays of negative touching behaviors, without systematically investigating the full range of diverse types of touch (Field, 2010; Field, Diego, & Hernandez-Reif, 2006; Lovejoy, Graczyk, O'Hare, & Neuman, 2000; Turney, 2011). Touching behaviors of depressed mothers are often described as intrusive, forced, and over-stimulating (Ferber, Feldman,

& Makhoul, 2008; Jung et al., 2007) while at other times described as under-stimulating, withdrawn, or disengaging (Malphurs, Raag, Field, Pickens, & Peláez-Nogeuras, 1996). As such, past studies have differentiated the touching behaviors of depressed mothers from that of non-depressed mothers to some extent, however, such investigations have primarily focused on the more negative constructs (e.g., Field, 2010). In addition, the touching behaviors of depressed mothers remain ambiguous as it is still unclear exactly what types of touch are being used (i.e., poking, pushing, grasping) and how these might change as a function of the interaction period (i.e., before or after a perturbation period) of interaction. Thus, investigating how depressive symptoms influence the display of different types of touch, including a range of positive touching behaviors (Ferber et al., 2008; Field, 2010) is warranted.

The way that depressed and non-depressed mothers interact with their infants, be it positive or negative, is important to infants' development. Children of depressed mothers are more likely to have impaired social, behavioral, and cognitive sequelae throughout the life course (Jung et al., 2007; Milgrom, Westley, & Gemmill, 2004). Considering the prominent role of touch in mother-infant interactions, touch is one important channel through which these disadvantages may be transferred. Investigating how depressive symptoms may influence maternal touching behaviors during face-to-face mother-infant interactions is imperative to advancing our understanding of the roles that touch serves during early social interactions.

Rationale for the Present Studies and Guiding Theories

Mother-infant interactions form a mutually regulated bidirectional system (Tronick, 1989). Periods of synchronized engagement are a mutual goal during

interactions. Thus, not only are mothers and infants responsive to each other's behaviors and affective displays, but they both actively contribute to shaping their interactions (Gianino & Tronick, 1988). Nonetheless, most research on touch has focused on examining the important communicative role of *maternal* touch *or* of *infant* touch from a unidirectional perspective. As such, the investigation of *mutual* touch, whereby *both* mothers and children are active agents in shaping their interactions, has been overlooked. In addition, only one form of maternal unavailability (i.e., emotional through the use of a face-to-face SF procedure) is typically examined in studies on touch and this within a *normative* population, where dyads at-risk (e.g., infants born premature, depressed mothers) are relatively understudied. Taken together, given that VLBW/PT infants have fragile nervous systems which can be easily over-stimulated, mothers' sensitivity to their infants' cues and accordingly adjusting the qualities of their tactile behaviors may have vital implications for infants' social-emotional development and well-being (Weiss & Goebel, 2003). Similarly, mothers with postpartum depressive symptoms often show disturbances in their interactions with their infants as they tend to be less sensitive and responsive to their infants, less engaged, more irritable, less playful, and show less emotion and warmth (Field, 2010). What remains unknown is how the qualitative characteristics of touch, such as the types and functions, used by mothers of VLBW/PT infants and mothers with depressive symptomatology vary with changes in maternal availability.

Theoretical models of development characterize mother-infant interactions as bidirectional and transactional in nature. The concept of bidirectionality posits that both mothers and infants affect each other and interactions are viewed as having mutual and

reciprocal influences (Kuczynski, 2003; Kuczynski & De Mol, 2015). Perceiving interactions as circular is consistent with Bronfenbrenner's ecological model (1979, 1986, 1995), which stipulates that nested systems influence child development (Rosa & Tudge, 2013; Tudge, Mokrova, Hatfield, & Karnik, 2009; Tudge et al., 2016). Similarly, the transactional model of development specifies that change in an individual occurs within the larger system and that multiple sources of influence affect developmental outcomes (Sameroff, 2009). In line with these views, dynamic systems theory underscores that it is not the mother or the infant alone, but rather the relationship between the two that contributes to the development of infants' communicative abilities in the first year of life (Hsu & Fogel, 2001). Communication between mothers and infants is a continuous and reciprocal process whereby interactive partners modify their behaviors at various times through their interactions, contributing to the creation of a shared dialogue (Hsu & Fogel, 2001). Working to achieve their mutual goal of coordinated states of interactions, mothers and infants jointly regulate their interactions by modifying their affective states according to changes in their social partner's behavior (Tronick, 2007). According to the mutual regulation model, mismatches between interactive partners occur and through the process of repairing these mismatches, the development of infants' sense of self-efficacy and trust in their social partners occurs. Both dynamics systems theory and the mutual regulation model framed the present dissertation.

The Present Studies

Few studies have investigated the types of maternal touch and the functions of mutual touch during mother-infant interactions in at-risk dyads. A more direct and systematic study of such types of touch during interaction periods with changes in

maternal availability is warranted in order to contribute to our understanding of the role(s) of touch in early mother-infant social interactions. Further, it is important to study touch in at-risk populations (e.g., depressed mothers, VLBW/preterm infants), especially those exhibiting repeated and prolonged periods of emotional unavailability, and to examine the impact of the quality of the dyadic relationship on touch in order to elucidate the effects of positive and less adaptive or negative relationship indicators on tactile communication. The series of two studies as part of the present dissertation were designed to contribute to the literature by systematically investigating the role of touch and risk status during early mother-infant face-to-face interactions with two different forms of unavailability.[1]

Study 1 was designed to investigate how depressive symptomatology may influence mothers' displays of specific touching behaviors following different forms of maternal unavailability (e.g., emotional unavailability through use of a still-face; physical unavailability through brief separation). The specific objectives were to document: (1) whether and how the different types of touch employed by mothers varied across the SF and Separation procedures, and (2) how these were associated with maternal depression status. By examining more specific rather than general differences in maternal touch according to maternal depressive symptomatology, results from this study were

[1] Worth noting is that mothers were the participants in the present studies. For at risk-children, an essential protective factor is a positive parent-child relationship, often with the child's mother (Barbot, Crossman, Hunter, Grigorenko, & Luthar, 2014; Luthar, 2006). While father-child relationships are also clearly important and fathers play an important role in infants' socio-emotional development, historically and to date most of the research has focused on mothers (Feldman, 2003; Feldman, Gordon, Schneiderman, Weisman, & Zagoory-Sharon, 2010). Although the literature on father-infant interactions is expanding, the research investigating father touch is still scant (Aznar & Tenenbaum, 2016; Baber, 2016; Chen et al., 2017; Kim, Kim, & Cho, 2016; Mercuri et al., 2019).

anticipated to contribute to our understanding of how depressive symptoms experienced by mothers may alter the typical course of mother-infant interactions, which may contribute to the design of preventative interventions of early touch stimulation for at-risk infants.

Building on this research, Study 2 was designed to investigate the communicative functions of mutual touch during early mother-infant social exchanges in a different at-risk group (i.e., VLBW/preterm infants) and to examine their relation to infant affect. 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 EA Scales).

Overall, it was anticipated that the findings would provide insight into how both mothers and infants participate in shaping and co-regulating their interactions through the use of touch and deepen our knowledge regarding infants' socio-emotional development. Furthermore, by identifying the patterns of maternal touch and the functions of mutual touch present during different contexts in both typically developing and at-risk dyads, we may ultimately be able to identify disrupted patterns of communication. Thus, early communicative differences may be recognized, and this may lead to a means of identifying early patterns of communication impairments.

Chapter 2: Dissertation Study 1

Depressed and Non-Depressed Mothers' Touching during Social Interactions with their Infants

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Abstract

Touch is a critical channel of communication used by mothers to communicate and interact with their infants and to contribute to their infants' socio-emotional development. The present study examined maternal touching in 41 mothers with and without depressive symptomatology. Mothers and their 4-month-old infants participated in the Still-Face (maternal emotional unavailability) and Separation (maternal physical unavailability) procedures. Maternal touching behaviors were video-recorded and coded using the Caregiver Infant Touch Scale (CITS). Results indicated that mothers with higher levels of depressive symptoms engaged in less touching following the perturbation in the Still-Face procedure, whereas mothers with lower levels of depressive symptoms maintained stable levels of touching across both interaction periods. Mothers with higher levels of depressive symptoms displayed less playful/stimulating types of touching. Taken together, these results underscore the importance of touch and suggest key differences in touching behaviour between dyads with maternal depressive symptomatology and those without.

1. Introduction

Touch is a critical channel for communication and regulation, and an essential component of the mother-infant relationship (Jean et al., 2014; Stack, 2010; Stack and Jean, 2011). The significance of touch is reflected in its prominent presence throughout mother-infant interactions, occurring between 55% and 99% of the time (Field, 1984; Jean et al., 2009). During these interactions, infants use touch to explore objects, others, and themselves, while mothers use touch to engage and play with their infants, maintain infants' attention, demonstrate affection, and reduce infant distress (Jean and Stack, 2009; Stack, 2010; Striano and Bushnell, 2005). Its significance is also reflected in infants' physiological development, as the skin is the largest and earliest sense organ to develop (Field, 2010; Montagu, 1986).

Touch is a primary component of infants' neurobiological development, as it is beneficial to both human and non-human brain growth and development (Baldini et al., 2013; McGlone et al., 2017). The stress-reducing effects of touch have been confirmed in animal studies with rodent and rat pups demonstrating that levels of affiliative and nurturing touch between mothers and their offspring can positively influence the development and expression of social behaviour in adulthood (Champagne and Meaney, 2007; Hellstrom et al., 2012; Meredith, 2015). Moreover, in human infants, as in rodents, parental touch has been shown to decrease stress activated cortisol production, impacting both short and long term memory function (Miles et al., 2006). Furthermore, it has been shown that high self-reported levels of maternal stroking were associated with reduced negative impact of maternal depression on both physiological and behavioural indices of emotional reactivity in the infant (Sharp et al., 2012). Therefore, studies examining

human mother-infant behaviour provide evidence that certain types of touch have similar beneficial neurodevelopmental effects to those reported in animal studies (McGlone et al., 2017).

Through investigation of the multimodal properties of the human somatosensory system, two dimensions of touch have been underscored: discriminative (sensory) and emotional (affective). An important aspect of the tactile experience is the existence of separate neural mechanisms underlying sensory and affective touch in the human body (Gordon et al., 2013; McGlone et al., 2014). A-beta afferent fibers have been found to be responsible for transmitting the discriminative (sensory) aspect of touch (Kandel et al., 2013), whereas C-Tactile (CT) afferents in the skin are thought to be responsible for the emotional (affective) and rewarding properties of touch (Olausson et al., 2010). Recent brain imaging studies demonstrate that these latter CT pleasant-responding touch fibers project into areas of the brain. Taken together, touch is inherently multi-dimensional given the communicative, affectionate, and regulatory roles it plays in infants' behaviour and in the development of emotion expression and emotional competence (Ferber et al., 2008; Jean et al., 2014).

One avenue to study affective or social touching is during face-to face mother-infant interactions, as in the Still-Face (Tronick et al., 1978) and Separation procedures (Field et al., 1986). During the Still-Face procedure, mothers display emotional unavailability by assuming a neutral, unresponsive "still face" while continuing to gaze at their infant without touching or vocalizing. During the Separation procedure, mothers are briefly separated from and physically unavailable to their infants (i.e., infants can neither see nor hear their mothers). In comparing infants' behaviours during these procedures,

findings have revealed greater infant gaze aversion, crying, motor activity and distress brow during maternal emotional (still-face) versus physical (separation) unavailability (Field et al., 1986). Thus, infants are especially responsive and sensitive to changes in maternal affective availability (Jean and Stack, 2012; Moszkowski and Stack, 2007; Stack and LePage, 1996).

Infants' sensitivity to changes in maternal availability highlights the risk of disadvantaged socio-emotional development among infants of depressed mothers (Gordon and Feldman, 2015). Maternal depression is associated with reduced maternal sensitivity and responsiveness (Field et al., 2007; Jung et al., 2007; Pearson et al., 2012). Depressed mothers have been found to be more irritable and less engaged when interacting with their 3-month-olds (Lovejoy et al., 2000). Compared to non-depressed mothers, they tend to display less visual and vocal communication, including less smiling and talking, when interacting with their infants (Field, 2010; Field et al., 2006). It has been suggested that early interaction patterns developed between depressed mothers and their infants can persist even after depressive symptoms subside (Weinberg and Tronick, 1998), leading to the transfer of disadvantage beginning in infancy (Turney, 2011). Considering the prominent role of touch in mother-infant interactions, touch is one important mechanism through which disadvantage may be transferred (Milgrom et al., 2004). Therefore, it is imperative to investigate how depressive symptoms influence maternal touching behaviours during mother-infant interactions.

Although depressed mother-infant dyads represent an important vulnerable at-risk group where reduced touching is expected (Feldman, 2011; Field, 2014), researchers have neglected to fully investigate how the touching behaviours of mothers with higher

levels of depressive symptoms may differ from those with lower levels (Moszkowski et al., 2009). Of the few studies that have investigated the association between depression and maternal touch, the focus has primarily been on negative touching behaviours (Ferber et al., 2008; Field, 2010), including intrusive, over stimulating touch, and withdrawn, under-stimulating touch (Field, 2010; Jung et al., 2007; Lovejoy et al., 2000; Malphurs et al., 1996). The touching behaviours of mothers with higher levels of depressive symptoms remain ambiguous, as the range and types of touch used and how they might change according to the period and type of interaction are unclear. Thus, researchers have yet to differentiate how depressive symptoms influence the display of specific types of touch, including a range of positive touching behaviours.

The present study was designed to examine how depressive symptomatology is associated with mothers' displays of touching behaviours during face-to-face interactions with their infants, with varying levels of maternal availability. The frequency and duration of the specific type of maternal touching behaviours were assessed. Mothers were classified into two groups: high versus low levels of depressive symptomatology. The objectives were to document whether and how the different types of touch employed by mothers varied across the Still-Face and Separation procedures and how these were associated with maternal depression status. It was hypothesized that mothers with lower levels of depressive symptoms would engage in more playful/stimulating types of touch (i.e., touching behaviours that were playful and engaging) compared to mothers with higher levels of depressive symptomatology, who were expected to engage in less playful/stimulating types of touch. In addition, mothers with higher levels of depressive symptomatology were expected to touch their infants less, overall. Because the still-face

period can be mildly distressing for infants, it was hypothesized that all mothers would engage in more playful/stimulating types of touch and would touch their infants for a longer length of time following the still-face period compared to before the still-face period. With regards to the Separation procedure, mothers with higher levels of depressive symptoms were expected to engage in more affectionate/nurturing types of touch (i.e., touching behaviours that are less stimulating and slower paced), while mothers with lower levels of depressive symptoms were expected to engage in more playful/stimulating types of touch across interaction periods. By examining specific rather than general differences in maternal touch according to maternal depressive symptomatology, results were anticipated to contribute to our understanding of how depressive symptoms experienced by mothers may alter the normal course of mother-infant interactions.

2. Method

2.1. Participants

Forty-six mothers and their 4-month-old infants participated in this study. Participants were recruited prenatally through ultrasound clinics at the University of Miami School of Medicine in Miami, Florida, USA. Five additional dyads were excluded from the study due to: mothers not following instructions (n = 4), or excessive infant fussiness or crying following the first procedure (n = 1). Of the 41 remaining dyads, 20 of the infants were male and 21 were female. Based on questionnaire measures (see Measures section), 13 mothers were classified as mothers with high levels of depressive symptomatology, whereas the remaining 28 mothers were classified as having low levels of depressive symptomatology. Mothers' ages ranged from 18 to 41 years (M = 24.88, SD = 5.97) and

their infants' ages averaged 17 weeks (*SD* = 1.33). Mothers were of lower socioeconomic status with a mean level of education being high school completion and they varied in terms of ethnicity: 46% Hispanic, 46% African American and 8% Caucasian.

2.2. Measures

2.2.1. Center For Epidemiological Studies Depression Scale (Radloff, 1977)

Mothers completed this reliable and valid self-report questionnaire, which measures the number of depressive symptoms (such as depressed mood, feelings of worthlessness, helplessness, etc.) experienced by caregivers over the past week. This measure has been found to have a very high internal consistency in other samples (α = 0.80 to 0.90) and has proven to be a valid measure of depressive symptomatology. The scale consists of 20 items, which are rated on a scale ranging from "rarely" to "most of the time." Higher scores on this measure indicate higher levels of depressive symptoms. In the present study, maternal depression was classified according to a clinical cut-off score of 16 or greater (consistent with Field et al., 2007, and Moszkowski et al., 2009), in accordance with the CES-D guidelines (Lewinsohn et al., 1997).

2.3. Apparatus

A video camera was used to record each interaction period of the two procedures. Videotapes were later digitized and transferred onto a computer. The video records were then reviewed for behavioural coding using Mangold INTERACT 9.0, a professional software system for behavioural research that allows for the qualitative and quantitative analysis of multimedia data.

2.4. Procedure

2.4.1. Data collection

All sessions took place in the laboratory at the Touch Research Institute at the University of Miami School of Medicine (USA). Infants were securely fastened in an infant seat on a table, facing their mother at eye-level, with a distance of approximately 46 cm between them. Two cameras were positioned on a tripod and angled in such a way to be in the periphery of the dyads' fields of vision.

Mothers first completed a demographic questionnaire and the CES-D. Dyads then participated in six face-to-face interaction periods, three of which comprised the Still-Face procedure (Tronick et al., 1978) and the other three comprised the Separation procedure (Field et al., 1986). The Still-Face and Separation procedures were counterbalanced across infants to control for order and state effects. Further, a 3-min interval separated the Separation and Still-Face procedures to give the infants a break from sitting in the infant seat and to provide more separation between the two conditions to potentially lessen any order effects. The Still-Face procedure consists of three face-to-face interaction periods (normal, still-face, and reunion-normal) between the mother and her infant. During the two normal periods, mothers were instructed to play with their infant as they normally would at home. During the still-face period, mothers were instructed to gaze at their infant with a still, neutral facial expression, and refrain from vocalizing to and touching their infant. That is, mothers were unresponsive and emotionally unavailable to their infants. The Separation procedure comprised two normal periods separated by the separation period, whereby mothers were instructed to be physically unavailable to their infants by going behind a curtain and being out of their

infants' view. Infants could neither see nor hear their mothers during the Separation period. All periods were 90 s in duration and the experimenter knocked on the one-way mirror to mark the beginning and end of each period.

2.4.2. Observational coding

Following the testing sessions, behavioural coding was carried out in the Infant and Child Studies Laboratory (Concordia University, Montreal, Canada). Maternal compliance with instructions was verified prior to coding by previewing the video records and observing maternal behaviour during the normal and perturbed interaction periods. Maternal touching behaviours were coded second-by-second by two of the authors who were blind to mothers' scores on the CES-D, i.e., as to whether mothers were classified as having high or low levels of depressive symptomatology.

2.4.2.1. Maternal touching behaviours. The Caregiver-Infant Touch Scale (CITS; Stack, 2010; Stack and Jean, 2011; Stack et al., 1996), a reliable and systematic coding system, was used to code maternal touch. The CITS is a measure of the qualitative (and quantitative) changes in tactile stimulation produced by caregivers when interacting with their infants. It consists of 8 categories of touch: (1) static touch, (2) stroke/caress/rub/massage, (3) pat/tap, (4) squeeze/pinch/grasp, (5) tickle/finger walk/prod/poke/push, (6) shake/wiggle, (7) pull/lift/ extension/clap, and (8) instrumental/utilitarian (i.e., wiping the infant's mouth or nose, adjusting the infants' posture or clothing, etc.). To establish inter-rater reliability, a trained second coder double coded 30% of randomly chosen video records of mother-infant interactions and a very high inter-rater reliability between coders was determined for touch overall (k =

0.90) and for each of the 8 types of touch individually (k = 0.80 to 0.93; kappa; Cohen, 1960).

The coded categories of touch were later clustered in terms of affectionate/nurturing and playful/stimulating touch. These two clusters were created using a systematic step-by-step process based on observations of mother-infant face-to-face interactions, previous coding systems developed in our research laboratory, and a factor analysis, all in conjunction with prior relevant literature. Previous investigations (e.g., Moszkowski and Stack, 2007; Moszkowski et al., 2009) have utilized affectionate/nurturing and playful/stimulating categorizations of infant touch, and have yielded meaningful findings. Previous research has suggested that maternal types of touch such as stroking, massaging, and other gentle movements (including static touch which has been shown to be soothing) have been found to relax infants to reduce the level of negative infant affect (Moreno et al., 2006; Pelaez- Nogueras et al., 1997). Similarly, in our study, the affectionate/nurturing touch cluster includes the types of touch that would be calming or soothing to the infant (static touch, stroke/caress/rub/massage, and pat/tap). On the other hand, playful or stimulating touch, such as tickling, lifting, and rhythmic touch, has been found to reinforce infants' social behaviours, such as eye contact and positive affect (Lowe et al., 2016; Moreno et al., 2006; Pelaez-Nogueras et al., 1997; Pelaez-Nogueras et al., 1996; Stack and LePage, 1996). In our study, the playful/stimulating touch cluster included the types of touch that were more playful and engaging such as squeeze/pinch/grasp, tickle/fingerwalk/poke/prod/push, shake/wiggle, and pull/lift/extension/clap.

In addition, a principal component factor analysis was used to identify patterns of relationships among our set of variables (i.e., 8 types of touch). The factor matrix (with a varimax rotation) revealed two factors. The first factor had a rotated Eigenvalue of 2.0 while the second factor had a rotated Eigenvalue of 1.7. The loadings of each of these factors were interpreted using a cut-off of 0.40. The pull, squeeze, shake, and tickle types of touch loaded onto factor 1 (labelled the playful/stimulating types of touch cluster), whereas the Static, Stroke, and Pat types of touch loaded onto factor 2 (labelled the affectionate/nurturing types of touch cluster). Given how it is categorized in previous literature and given that the instrumental/utilitarian type of touch did not load onto either of the two factors, this type of touch was not categorized into either of two clusters.

3. Results

3.1. Statistical analyses

Data screening procedures were undertaken to evaluate the data and to ensure that the assumptions of ANOVAs were met within the current sample. The data was normally distributed and did not reveal any outliers, skewness, or kurtosis, thus no transformations were necessary. Pearson correlations were then conducted to examine the association between mothers' scores on the CES-D and the type of maternal touch displayed. The type of maternal touch displayed included the 8 categories of touch coded using the CITS. The playful/stimulating types of touch cluster, affectionate/nurturing types of touch cluster, and total touch (i.e., all 8 types of touch combined) were also analyzed. All the types of maternal touch displayed were assessed both in terms of frequency and duration. In addition, difference scores were computed using the total touch variables to

represent the change in maternal touch from the normal to the reunion-normal period, in both the Still-Face and Separation procedures. Pearson correlations were conducted to assess the relation between these difference scores and the CES-D scores.

A series of mixed analyses of variance (ANOVA) were then conducted in order to examine group differences in maternal touching behaviours across periods of the Still-Face and Separation procedures. Interaction period (before still-face/separation period, after still-face/separation period) was entered as the within subjects variable. Maternal depression (i.e., high versus low levels of maternal depressive symptomatology) was entered as a between-subjects factor to assess for group differences. Procedure (i.e., Still-Face or Separation) was entered as a between-subjects factor for the types of touch analyses due to missing data for one of the procedures for 12 participants (n = 5 mother-infant dyads participated in the Still-Face procedure only; n = 7 mother-infant dyads participated in the Separation procedure only). For those dyads that participated in both procedures (n = 29), only data from the first procedure in which they participated was included in order to rule out order and fatigue effects (n = 15 for dyads who participated in the Still-Face procedure first; n = 14 for dyads who participated in the Separation procedure first). The number of dyads who participated in the Still-Face procedure (n = 20) was roughly equal to the number of dyads who participated in the Separation procedure (n = 21). The dependent measure was maternal touch. Each of the 8 types of touch represents different levels of the dependent variable of the total duration or frequency of touch. Following analyses investigating group differences among the 8 individual types of touch, clusters of touch (i.e., the playful/stimulating touch cluster; affectionate/nurturing touch cluster), and total touch were analyzed. Of note, the

frequency and duration of touch were examined through separate ANOVAs. For all of the ANOVA analyses, statistically significant main effects and interactions were followed up with post hoc tests to isolate the source of the significance. Bonferroni corrections were performed to reduce the occurrence of Type 1 errors. Only significant findings are reported in the text. For all significant ANOVAs, eta squared (η^2) is reported as a measure of effect size. The mean and standard error for each type of touch are presented in Tables 1 and 2.

3.2. CES-D scores and demographic variables

Mothers' scores on the CES-D ranged overall from 0 to 31 (M = 12.27, SD = 7.60), with the highest possible score on this measure being 60. As aforementioned, mothers in the current sample were classified as depressed according to a cut-off score of 16 on the CES-D. For those mothers in the depressed group, CES-D scores averaged at a score of 21.30 (SD = 3.92). For those mothers in the non-depressed group, CES-D scores averaged at a score of 8.07 (SD = 4.60). Correlations were computed to assess the relation between CES-D scores and demographic variables (maternal age, ethnicity, SES, and maternal education). CES-D scores were negatively correlated with maternal age, r = −0.38, p = 0.05, but were not correlated with any of the other demographic variables.

3.3. Correlations

CES-D scores were negatively correlated with the frequency and duration of playful/stimulating touch during the reunion-normal period, r = −0.32, p = 0.01 and r = −0.33, p = 0.05, respectively, combined across the Still-Face and Separation procedures. CES-D scores were negatively correlated with both frequency and duration of total touch in the reunion-normal period across both procedures, r = −0.39, p = 0.05. Furthermore,

CES-D scores were positively correlated with the difference score computed using frequency of total touch, $r = 0.53$, $p = 0.002$, in that more depressive symptoms were positively correlated with more of a change (i.e., less frequent touch) in the frequency of total touch from the normal to the reunion-normal period in the Still-Face procedure.

3.4. Analyses of variance

3.4.1. Frequency and duration of individual types of maternal touch

A 2 (group) x 2 (procedure) x 2 (interaction period) mixed-subjects ANOVA was conducted with group and procedure as the between subjects factors and interaction period as the within subjects factor.

A statistically significant main effect of period was found, $F(1,39) = 0.6$, $p = < 0.05$, $\eta^2 = 0.170$; $F(1, 39) = 5.9$, $p = 0.019$, $\eta^2 = 0.139$, (frequency and duration, respectively). Post hoc comparisons revealed that collapsed across group and procedure, mothers more frequently used and spent more time engaged in the "tickle/fingerwalk/prod/poke/push" type of touch during the normal period as compared to the reunion-normal period.

A statistically significant group by procedure interaction was found, $F(1, 39) = 11.9$, $p = 0.001$, $\eta^2 = 0.245$ (frequency). Post hoc comparisons revealed that mothers with lower levels of depressive symptomatology touched their infants using squeezing/pinching/grasping types of touch more frequently compared to mothers with higher levels of depressive symptomatology. A main effect of procedure was also found, $F(1, 39)=6.82$, $p = 0.013$, $\eta^2 = 0.156$ (duration). Post hoc analyses revealed that mothers engaged in more "squeeze/pinch/grasp" touch in the Separation procedure as compared to the Still-Face procedure.

A statistically significant period by procedure interaction was found, $F(1, 39) = 4.26$, $p = 0.046$, $\eta^2 = 0.103$ (frequency). Post hoc analyses indicated that mothers touched their infants more frequently using "shaking/wiggling" types of touch in the normal period of the Still-Face procedure than they did during the normal period of the Separation procedure. Regarding the reunion-normal period, mothers touched their infants more frequently using "shaking/wiggling" types of touch in the Separation procedure as compared to the reunion-normal period of the Still-Face procedure. Analyses further indicated that mothers touched their infants more frequently using "shaking/wiggling" types of touch in the normal period of the Still-Face procedure than they did during the normal period of the Separation procedure. Regarding the reunion-normal period, mothers touched their infants more frequently using "shaking/wiggling" types of touch in the Separation procedure as compared to the reunion-normal period of the Still-Face procedure.

3.4.2. Clusters of touch

The playful/stimulating types of touch (squeeze/pinch/grasp, tickle/fingerwalk/poke/prod/push, shake/wiggle, pull/lift/extension/clap) were subsequently classified into the "playful/stimulating" type of touch cluster, while the affectionate/nurturing types of touch (static touch, stroke/caress/rub/massage, and pat/tap) were classified into the "affectionate/nurturing" type of touch cluster.

A 2 (group) x 2 (procedure) x 2 (interaction period) mixed-subjects ANOVA was conducted with group and procedures as the between subjects factors and interaction period as the within subjects factor. Results revealed a statistically significant three-way interaction between group, period, and procedure, $F(1, 39) = 4.49$, $p = 0.041$, $\eta^2 = 0.108$;

$F(1, 39) = 6.26$, $p = 0.017$, $\eta^2 = 0.145$, (frequency and duration, respectively; see Fig. 1 for frequency). Post hoc analyses revealed that mothers with higher levels of depressive symptomatology touched their infants less frequently using playful/stimulating types of touch and engaged in less total playful/stimulating touch in the reunion-normal period of the Still-Face procedure as compared to mothers with lower levels of depressive symptomatology, while no such differences were found during the normal period of the Still-Face procedure. Results also indicated that mothers with higher levels of depressive symptomatology touched their infants less frequently using playful/stimulating types of touch in the normal and the reunion-normal periods of the Separation procedure as compared to mothers with lower levels of depressive symptomatology. None of the post hoc analyses revealed any statistically significant findings for either the frequency or duration of the affectionate/nurturing types of touch cluster.

3.4.3. Total touch

The total amount of maternal touch was obtained by summing up all 8 types of touch in order to form one total touch category. A 2 (group) x 2 (period) x 2 (interaction period) mixed-subjects ANOVA found a statistically significant main effect of group, $F(1, 39) = 6.8$, $p = 0.013$, $\eta^2 = 0.156$, $F(1, 39) = 5.7$, $p = 0.023$, $\eta^2 = 0.133$, (frequency and duration, respectively). Post hoc analyses revealed that mothers with lower levels of depressive symptomatology touched their infants more frequently and spent significantly more time touching them compared to mothers with higher levels of depressive symptomatology. A period by group interaction was found, $F(1, 39) = 1.05$, $p = 0.05$, $\eta^2 = 0.003$ (frequency). Specifically, mothers with lower levels of depressive symptomatology touched their infants more frequently in both the normal and reunion-

normal periods as compared to mothers with higher levels of depressive symptomatology. Similarly, a period by group interaction was found, $F(1, 39) = 5.67$, $p = 0.02$, $\eta^2 = 0.133$ (duration). Post hoc analyses revealed that mothers with higher levels of depressive symptoms engaged in significantly less total touch in the reunion-normal period of the Still-Face procedure as compared to the normal period. Mothers with lower levels of depressive symptoms engaged in similar levels of total touch across both the normal and reunion- normal periods of the Still-Face procedure.

4. Discussion

In the present study, we examined how depressive symptomatology is associated with mothers' displays of specific touching behaviours when engaging in face-to-face interactions with their infants, with varying levels of maternal availability. CES-D scores were for the most part negatively correlated with playful/stimulating touch during the interactive periods of the Still-Face and Separation procedures. That is in line with our expectations, mothers with higher levels of depressive symptoms spent less time and engaged in significantly fewer playful/ stimulating types of touch during the reunion period of the Still-Face procedure, and during both the normal and reunion-normal periods of the Separation procedure. Playful/stimulating touch included those types of touch that while mostly playful and interactive in nature, also involve more effort on behalf of the mother. This result is consistent with the limited past findings showing that depressed mothers are less engaged when interacting with their infants (Lovejoy et al., 2000) and that depressed mothers use fewer interactive behaviours (Field et al., 2007).

Results also revealed which specific playful/stimulating touching behaviours mothers with lower versus higher levels of depressive symptoms tend to engage in during

interaction periods. Mothers with lower levels of depressive symptoms spent significantly more time "squeezing/pinching/grasping" their infants. Previous literature similarly describes non-depressed mothers as being quite playful and playful/stimulating during interactions with their infants (Field et al., 2007). During the normal period of our study, mothers in both groups used playful/stimulating touch at the same frequency. This suggests that the touching behaviours of depressed mothers are not necessarily always over-stimulating or intrusive as previously suggested (Ferber et al., 2008; Jung et al., 2007). If these mothers were indeed over-stimulating in their use of touch, they would be expected to use it more frequently than mothers with lower levels of depressive symptoms.

Moreover, as hypothesized, the differences between mothers with lower versus higher depressive symptoms in the amount of playful/stimulating touch engaged in seemed to have varied as a function of which period they were interacting in, as differences between groups were strongest in the reunion-normal period of the Still-Face procedure. During the reunion-normal period, however, mothers with higher depressive symptoms displayed a significant decrease in the use of playful/stimulating touch and total touch, whereas mothers with lower levels of depressive symptoms maintained high levels in both the normal and reunion-normal periods.

Such group differences may be partly explained by maternal sensitivity, a mother's ability to be aware of her infant and respond to her infant's needs (Pearson et al., 2012). The still-face effect has been reliably documented in the literature, as infants display increased levels of neutral to negative affect and decreased levels of vocalizing, smiling, and gazing at their mothers' faces. This suggests that infants are responsive to

variations in maternal emotional availability as they regulate their affect through changes in their behaviour. One possible explanation as to why mothers with higher levels of depressive symptoms did not increase or at least maintain high levels of total touch across periods could be that these mothers are less responsive to their infants' needs (Bigelow and Power, 2014). Previous literature suggests that depressed mothers show less maternal responsiveness during mother- infant interactions (Gergely and Watson, 1999) and are less responsive to their infants' cues (Righetti-Veltema et al., 2002), as depressed individuals tend to be more focused on their own internal affective states (Hagen, 1999). Alternatively, Cohn et al. (1990) argue that depressed mothers are no less responsive to their infants but rather, differ in their level of affective expressions, as demonstrated by lower levels of affective expression. In our study, one of several explanations for the fewer maternal touching behaviours displayed by mothers with higher levels of depressive symptoms during the reunion-normal period of the Still-Face procedure may have been a manifestation of these lower levels of affective expression. However, another explanation may be related to maternal responsiveness and differences in infants' responses during the still-face period. It is argued that maternal behaviours and the affective quality of these behaviours are contingent on the infant's behaviour (Cohn et al., 1990). According to Field et al. (2007), infants of depressed mothers show fewer distress behaviours during the still-face period compared to infants of non-depressed mothers. Specifically, infants of depressed mothers have been found to manifest less motor activity, gaze aversion, and crying (Field et al., 2007; Stanley et al., 2004). Given that the still-face is thought to simulate a depressive state, these findings suggest that infants of depressed mothers are more accustomed to their mothers appearing depressed and may

have habituated to a "still face" and emotional unavailability (Field, 2005; Mesman et al., 2009). Moreover, the still-face is likely to violate the expectations of infants of non-depressed mothers (Field et al., 2007) and they may be alarmed when their mothers become suddenly unresponsive during a typical interactive situation (Field et al., 2007). If infants of mothers with lower levels of depressive symptoms are more distressed by the still-face, this may explain why mothers with lower levels of depressive symptoms maintained high levels of touch in the reunion-normal period of the Still-Face procedure. The negative affect potentially experienced by infants of mothers with lower levels of depressive symptoms during the still-face is thought to carry over into the reunion-normal period, and their mothers are likely to maintain high levels of playful/stimulating touch in order to reinstate the initial positive interaction that occurred in the normal period (Cohn, 2003; Field et al., 2007; Weinberg and Tronick, 1996).

These conceivable group differences in infant responsiveness, as well as in maternal responsiveness, may explain why mothers with higher levels of depressive symptoms did not maintain their high levels of total touch across periods. However, such potential differences in infant or maternal responsiveness may not fully explain why mothers with higher depressive symptoms significantly decreased their displays of total touch in the reunion-normal period in the Still-Face procedure. According to Pearlstein et al. (2009), fatigue and loss of energy are observed in mothers with postpartum depression and maternal depression. Consequently, mothers with higher levels of depressive symptomatology may have been less able to sustain high levels of touch across periods. In addition, transitioning between states of being fully engaged with their infants during the normal period, to being disengaged and unexpressive during the still-face, and then

being asked to interact with their infants again in the reunion-normal period may have been especially difficult for mothers with higher levels of depressive symptoms. In the present study, mothers with higher levels of depressive symptoms appear to have engaged in less playful/stimulating touching with their infants throughout the course of the Still-Face procedure, resulting in decreased touch in the reunion-normal period. Moreover, previous research has revealed greater infant gaze aversion, crying, motor activity and distress brow during maternal emotional unavailability versus physical unavailability. Thus, the reduced touching in the reunion normal period during the Separation procedure may not have been the case as infants experience emotional unavailability as more difficult. Thus, mothers are likely less required to engage in various touching behaviours in order to help their child recover from the separation period.

While our results are compelling and offer insight into different touching patterns in mothers with depression, the mechanisms underlying these results are important to uncover. All the touching behaviours on the part of the mothers took place on the hairy skin of their infants where it is argued the slow-conducting, low-threshold C afferent fibers are innervated, by for example gentle stroking of the skin (McGlone et al., 2014). It is these C-fibers, responsive to low force dynamic touch, that are contended to be implicated in the affective and rewarding properties of touch that occurs during social interactions (Field, 2014; McGlone et al., 2014).

Behavioural studies have consistently revealed the skin as a social organ (Field, 2014; Morrison et al., 2010). Yet, the neurobiological mechanisms underlying the social and affective properties of touch are lacking (McGlone et al., 2014). With recent exciting

research advancements in the neurosciences, the links between touching patterns and the brain regions responsible for social and affective touch are becoming clearer (Field, 2014). Integrating findings from both fields of research will allow us to make important discoveries about touch and how it relates to the brain systems through which it operates.

Along with a number of important contributions, there are some limitations to the present study. First, we had a rather small sample size, however this is consistent with other infant studies that integrate vulnerable groups more difficult to recruit. Second, other maternal behaviours apart from touch were not assessed. Thus, it is not possible to state whether mothers with higher levels of depressive symptoms showed a decrease in all behaviours during the reunion-normal period. Nonetheless, in addition to displaying less touch, depressed mothers have been shown to display less elaborate facial expressions and child directed speech when interacting with their infants (Field et al., 2009). Third, our study was limited with respect to the infants' responses to the still-face. Since mother-infant interactions are reciprocal social exchanges, and changes in maternal touching behaviours are closely tied to infants' affect and behaviour, it would be beneficial for future researchers to assess simultaneous changes in mothers and their infants.

These limitations notwithstanding, findings from the current study contribute to our understanding of how depressive symptoms can alter the normal course of mother-infant interactions and provide further support for the contention that different forms of touch may communicate different meanings. Our findings demonstrate that mothers with higher levels of depressive symptoms do show positive touching behaviours that resemble those of mothers with lower levels of depressive symptoms (i.e., they engage in

playful/stimulating types of touch throughout their interactions, albeit not as frequently), highlighting that interactions between mothers with higher levels of depressive symptoms and their infants can also be positive. What is potentially concerning is that mothers with more depressive symptoms do not appear to maintain such positive touching behaviours as they may only be able to sustain these behaviours for limited lengths of time; or they may not be entirely attuned to their infants' needs, which may subsequently interfere with the quality of these mother-infant interactions.

Considered within a social neuroscience framework, touch is an essential channel for social information. Such information conveys features of individuals or their interactions that have possible bearing on future interactions, and associated mental and emotional states (Morrison et al., 2010). Given that the quality of mother-infant interactions tends to vary according to the mother's emotional state (Herrera et al., 2004), the findings from our study support the assertion that infants of depressed mothers may be at a developmental disadvantage. It has been noted that improving maternal depression does not necessarily improve mother-infant interactions (Cooper and Murray, 1997). Rather, direct attempts to improve the quality of mother-infant interactions in depressed dyads have been more successful in this regard (Onozawa et al., 2001). Specifically, teaching depressed mothers to be more aware of infant cues and how to respond positively to such cues, as well as teaching depressed mothers how to massage their infants have been shown to be effective treatments for improving mother-infant interactions in depressed mothers (Field et al., 2010; Jung et al., 2007). These discoveries and our results have direct implications for the design of parenting-touch programs and preventative intervention programs of early touch stimulation for at-risk infants (Field,

2014; Mantis et al., 2014). Due to the impact depressive symptoms are likely to have on maternal touching behaviours, mother-infant interactions, and consequently, the mother-infant relationship in the next generation, our study underscores the importance of continuing to further investigate depressive symptoms in relation to touch and its impact via affective skin-brain pathways.

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Table 1

Means and standard errors for the frequencies and durations of maternal touching during the normal and reunion-normal periods of the Still-Face procedure.

	Duration of touch				Frequency of touch			
	Depressed		Non-Depressed		Depressed		Non-Depressed	
Individual/Clusters of Touch	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Squeeze/Pinch/ Grasp								
Normal Period	5.19	5.08	10.74	3.32	2.33	1.46	4.29	0.96
Reunion Period	1.63	5.38	16.65	3.52	1.33	1.06	5.50	0.70
Pull/Lift/Extension/Clap								
Normal Period	5.37	4.87	12.17	3.19	1.67	0.89	2.43	0.58
Reunion Period	7.02	3.31	10.64	2.17	1.50	0.98	2.36	0.64
Shake/Wiggle								
Normal Period	14.93	4.69	8.23	3.07	3.50	1.24	3.0	0.81
Reunion Period	4.65	4.01	11.26	2.63	1.00	1.16	3.21	0.76
Tickle/Fingerwalk/Prod/Poke/Push								
Normal Period	17.83	4.80	12.46	3.15	4.83	1.74	4.43	1.41
Reunion Period	7.49	4.16	12.40	2.73	1.67	1.30	3.43	0.85
Playful/Stimulating Types of Touch								
Normal Period	43.32	10.20	43.59	6.68	12.33	3.52	14.14	2.31
Reunion Period	20.79	8.63	50.95	5.65	5.50	3.05	14.50	1.97
Stroke/Caress/Rub/Massage								
Normal Period	3.90	4.51	8.14	2.95	1.67	0.91	2.07	0.59
Reunion Period	4.18	2.77	7.31	1.81	1.83	0.84	1.71	0.55
Static								
Normal Period	1.22	4.10	4.57	2.68	0.50	0.75	1.50	0.49
Reunion Period	3.29	2.66	4.05	1.74	0.83	0.47	0.64	0.31
Pat/Tap								
Normal Period	0.64	0.84	0.95	0.55	0.50	0.27	0.43	0.18
Reunion Period	0.55	1.97	0.50	1.29	0.50	0.36	0.21	0.23
Instrumental/Utilitarian								
Normal Period	6.48	4.67	8.70	3.06	3.00	0.87	2.14	1.04
Reunion Period	9.80	4.77	6.00	3.12	1.83	0.93	2.36	1.03
Affectionate/Nurturing Types of Touch								
Normal Period	12.24	7.12	22.37	4.66	5.17	1.58	6.14	1.04
Reunion Period	17.82	6.87	17.86	4.50	5.00	1.57	4.93	1.03
Total Touch								
Normal Period	55.55	10.31	65.96	6.75	14.00	4.13	17.57	2.71
Reunion Period	38.60	10.53	68.81	6.89	10.50	3.51	19.43	2.23

Table 2

Means and standard errors for the frequencies and durations of maternal touching during the normal and reunion-normal periods of the Separation procedure.

	Duration of touch				Frequency of touch			
	Depressed		Non-Depressed		Depressed		Non-Depressed	
Individual/Clusters of Touch	*M*	*SE*	*M*	*SE*	*M*	*SE*	*M*	*SE*
Squeeze/Pinch/ Grasp								
Normal Period	15.89	4.70	20.08	3.32	3.71	1.35	6.86	0.96
Reunion Period	16.34	4.98	19.73	3.52	3.43	0.98	5.86	0.70
Pull/Lift/Extension/Clap								
Normal Period	1.48	4.50	7.06	3.19	0.43	0.82	1.57	0.58
Reunion Period	4.20	3.06	4.60	2.17	1.14	0.90	1.86	0.64
Shake/Wiggle								
Normal Period	8.62	4.35	8.05	3.07	1.57	1.14	2.50	0.81
Reunion Period	9.90	3.72	9.68	2.63	3.00	1.08	3.00	0.76
Tickle/Fingerwalk/Prod/Poke/Push								
Normal Period	7.67	4.45	10.19	3.15	1.71	1.61	4.36	1.14
Reunion Period	5.14	3.85	3.37	2.73	1.14	1.20	2.0	0.85
Playful/Stimulating Types of Touch								
Normal Period	33.66	9.44	45.39	6.68	7.43	3.27	15.29	2.31
Reunion Period	35.58	7.99	37.38	5.65	8.71	2.82	12.71	2.00
Stroke/Caress/Rub/Massage								
Normal Period	4.83	4.17	5.47	2.95	1.00	0.84	1.79	0.59
Reunion Period	1.62	2.56	8.46	1.81	1.43	0.78	2.43	0.55
Static								
Normal Period	6.34	3.79	7.34	2.68	1.43	0.70	1.43	0.49
Reunion Period	5.60	2.46	1.96	1.74	1.14	0.44	.79	0.31
Pat/Tap								
Normal Period	0.00	0.78	1.43	0.55	0.00	0.25	0.29	0.18
Reunion Period	0.86	1.82	2.73	1.29	0.29	0.33	0.71	0.23
Instrumental/Utilitarian Cluster								
Normal Period	10.59	4.32	12.79	3.06	2.29	0.81	2.50	0.57
Reunion Period	8.86	4.42	19.62	3.12	1.83	0.86	2.35	0.61
Affectionate/Nurturing Types of Touch								
Normal Period	21.75	6.59	27.04	4.66	4.71	1.47	6.00	1.04
Reunion Period	16.94	6.36	32.76	4.50	6.00	1.46	8.21	1.03
Total Touch								
Normal Period	55.41	9.55	72.42	6.75	7.71	3.83	17.14	2.71
Reunion Period	52.52	9.75	70.12	6.89	14.71	3.25	20.93	2.30

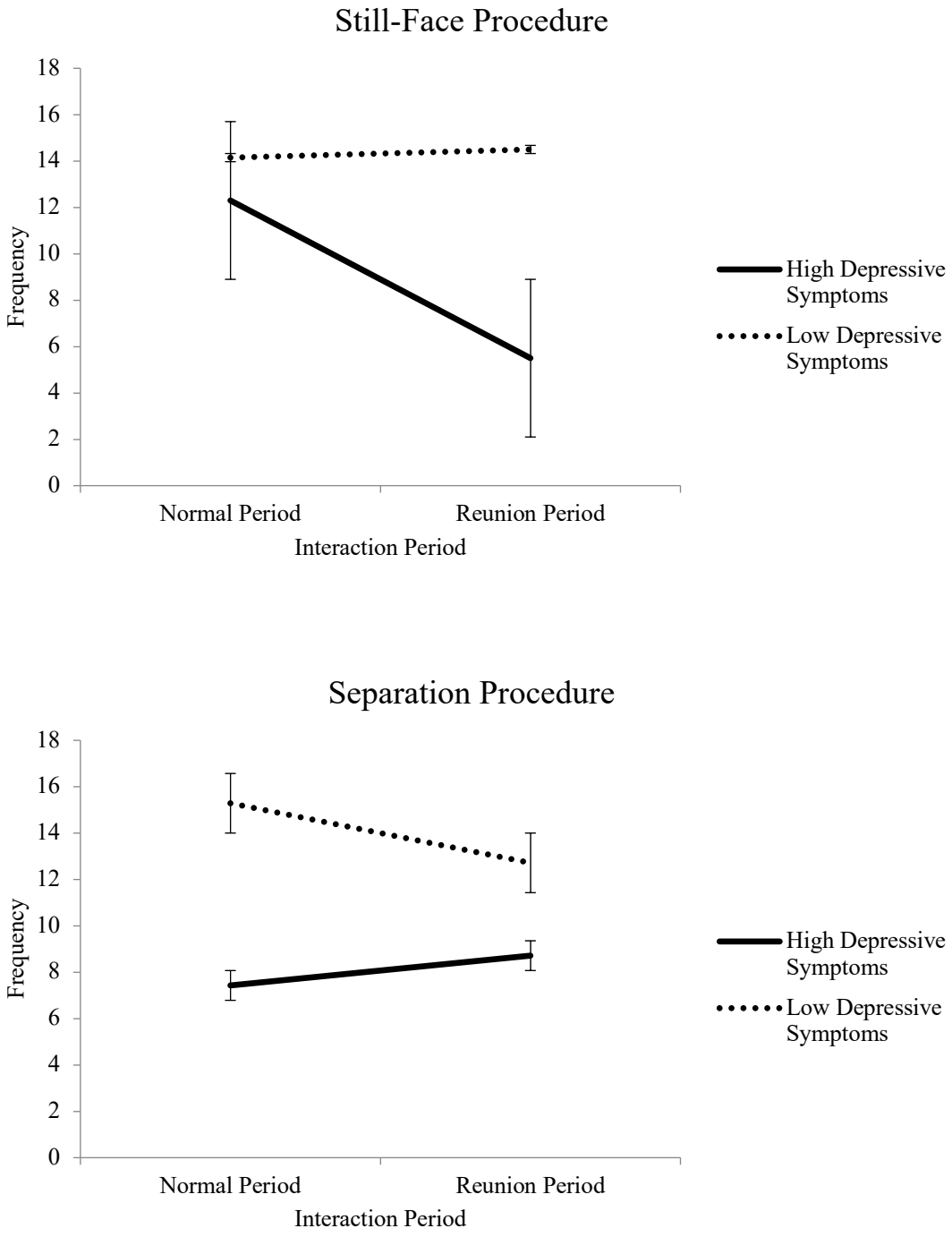

Fig. 1. Frequency of Playful/Stimulating Touch as a function of group, period, and procedure.

Chapter 3: Transition Statement Between Study 1 and Study 2

In Study 1 we examined how depressive symptomatology is associated with mothers' displays of specific touching behaviors when engaged in face-to-face interactions with their infants, with varying levels of maternal availability. The findings from Study 1 contribute to our understanding of how depressive symptoms can alter the normal course of mother-infant interactions and provide further support for the contention that different forms of maternal touch may communicate different meanings. Study 2 builds on the first study by examining the important communicative role of touch from a bidirectional process and in a different at-risk group.

Mother-infant interactions form a mutually regulated bidirectional system (Tronick, 1989). Periods of synchronized engagement are a mutual goal during interactions. Thus, not only are mothers and infants responsive to each other's behaviors and affective displays, but they both actively contribute to shaping their interactions (Gianino & Tronick, 1988). Nonetheless, much of the research on touch to date has focused primarily on the communicative role of *maternal* touch *or* of *infant* touch from a unidirectional perspective. As such, the investigation of *mutual* touch, whereby both mothers and children are active agents in shaping their interactions, has been overlooked.

In a prior study, we examined mutual touch during mother-infant face-to-face interactions. Results revealed that mutual touch is prevalent, occurring 37% of the time during the normal periods of the Still-Face (Mantis et al., 2014). Despite its implications for bidirectional touch, Mantis and colleagues (2014) did not examine the *functions* of mutual touch. Given that communication between a mother and her infant is dynamic, it varies as a function of the nature of the interaction (Tronick et al., 1978; Fogel & Garvey, 2007). Therefore, Study 2

built on Study 1 in examining the quality of the touch, in this case the functions of mutual touch, as opposed to only focusing on its mere presence or absence. Study 2 was designed to determine what communicative functions (e.g., playful, regulatory) mutual touch serves in order to obtain a better understanding of this dynamic interaction. Further, this study examined how the functions 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.

Further, patterns of communication are likely to differ in various at-risk groups (e.g., VLBW/preterm infants) and investigations regarding the differences in the communicative patterns between at-risk infants are warranted. Consequently, Study 2 added to the findings of Study 1 by documenting normative or typical mutual touching in a sample of 5½-month-old full-term and a sample of healthy VLBW/preterm infants. This step was essential in order to appreciate the roles played by touch for infants whose socio-emotional development may not be at risk. Knowledge of typical patterns of maternal touch has the potential to assist in early identification of problematic patterns in dyads for whom early touch intervention programs may be beneficial.

Moreover, in Study 1, the quality of the mother-infant relationship on touching behaviors was not considered. The examination of the quality of the relationship and its association to mutual touch is particularly important since both partners are sensitive to each other's behaviors during interactions (Cohn & Tronick, 1989) and bidirectional influences impact on regulatory processes within the dyad (Fogel & Garvey, 2007). Thus, in Study 2, we also examined the relationship between the functions of mutual touch and the dimensions of the quality of the

mother-infant relationship; and investigated how the functions of mutual touch are integrated with other modalities of infant communication.

Chapter 4: Dissertation Study 2

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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Abstract

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.

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).

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 κ = .89, for regulatory mutual touch, κ = 1.00, and for passive, guided, and attention-centered mutual touch, κ = .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 κ = .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 were 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.

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.

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.

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) x 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, $F(1, 78) = 13.67$, $p < .001$, $\eta_p^2 = .15$.

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.

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 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 caregivers, 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, & Zupancicm, 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 (Pougnet, 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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Table 1

Demographic and Medical Information

	Full-Term (*n* = 40)		**VLBW/Preterm (*n* = 40)**	
	M	*SD*	*M*	*SD*
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**	9.25	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

** $p < .001$.

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 ten represents the best possible condition.

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	**Normal**		**Reunion**	
Group	**Full-Term**	**VLBW/Preterm**	**Full-Term**	**VLBW/Preterm**
Overall Touch	97.58	95.01	97.68	100.01
	(17.87)	(18.23)	(16.23)	(16.29)
Function of Mutual Touch				
Playful	46.47	24.09	58.93	36.15
	(5.1)	(3.51)	(5.15)	(4.28)
Regulatory	7.55	2.38	12.81	0.75
	(2.40)	(1.02)	(2.77)	(.31)
Passive	13.2	10.95	7.93	8.18
	(2.33)	(2.27)	(2.57)	(1.67)
Attention-Centered	15.99	19.18	8.22	21.99
	(2.96)	(3.78)	(2.29)	(3.78)
Unbalanced	5.33	23.1	5.33	20.73
	(1.96)	(4.26)	(1.96)	(3.63)
Guided	9.04	15.31	4.35	12.21
	(3.12)	(3.99)	(1.49)	(2.62)

Note. Numbers in parentheses are standard errors.

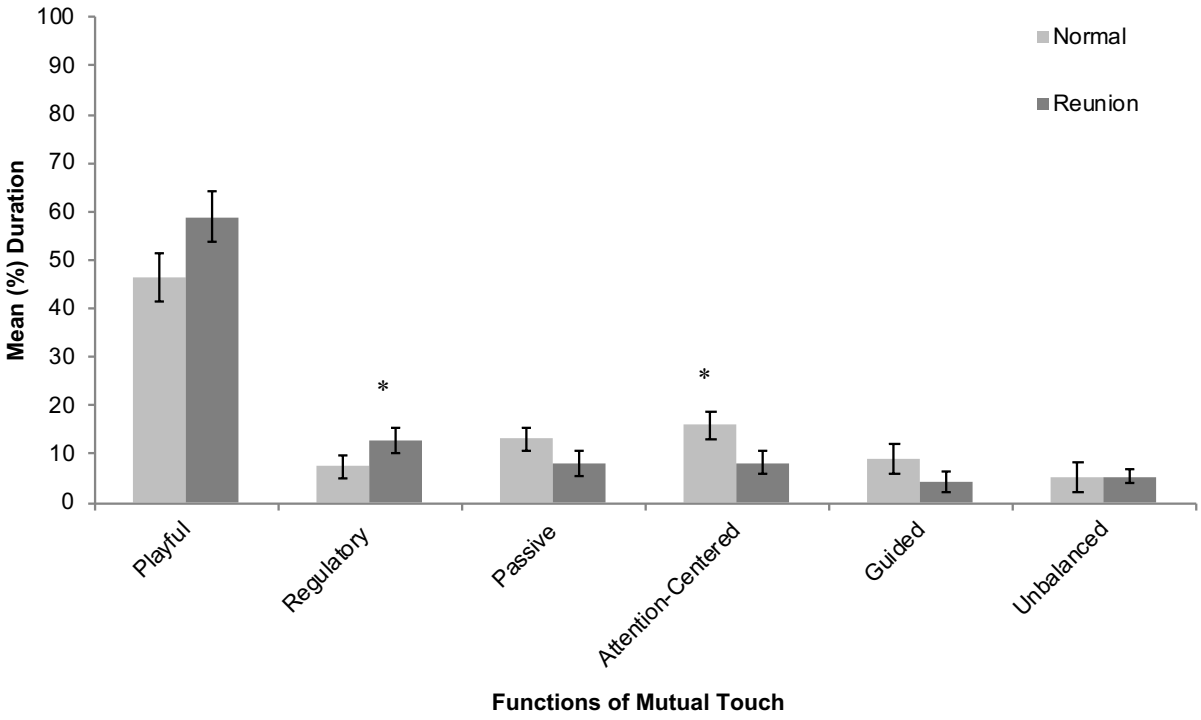

Figure 1. The mean durations for the six functions of mutual touch as a percentage of the total duration of mutual touch for the normal and reunion periods for the full-term infant-mother dyads. * $p < 0.05$.

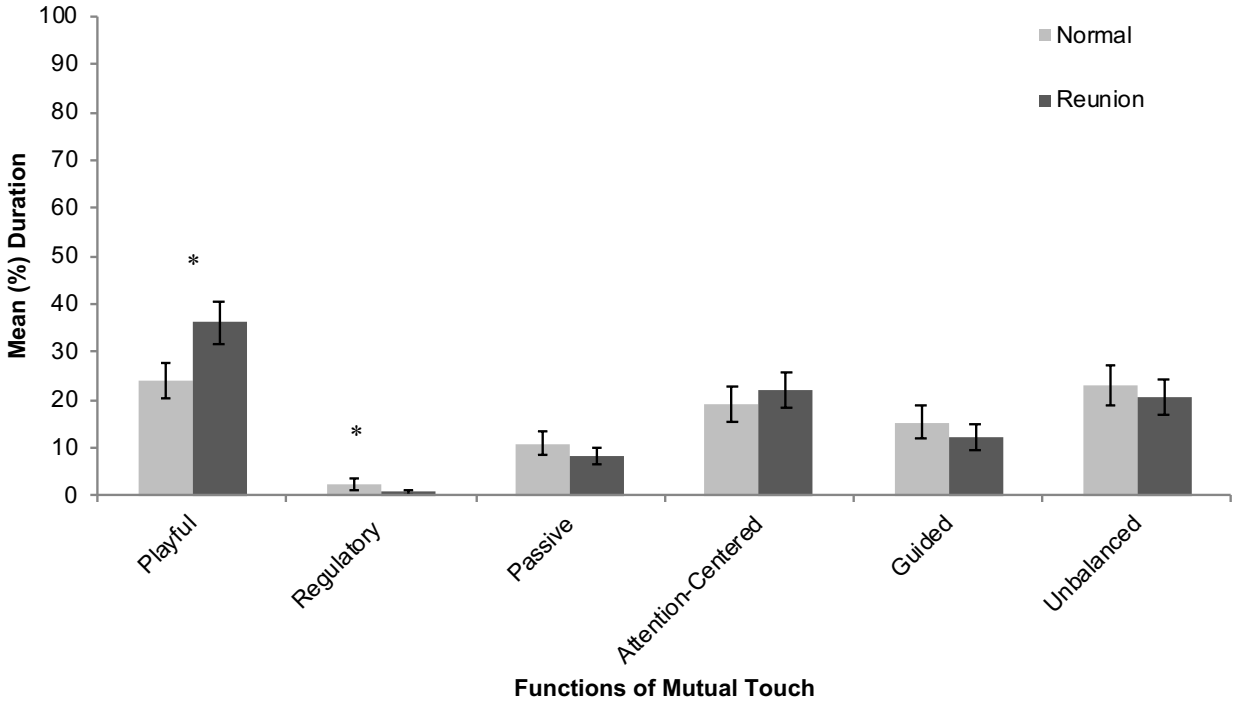

Figure 2. The mean durations for the six functions of mutual touch as a percentage of the total duration of mutual touch for the normal and reunion periods for the VLBW/preterm infant-mother dyads. * $p < 0.05$.

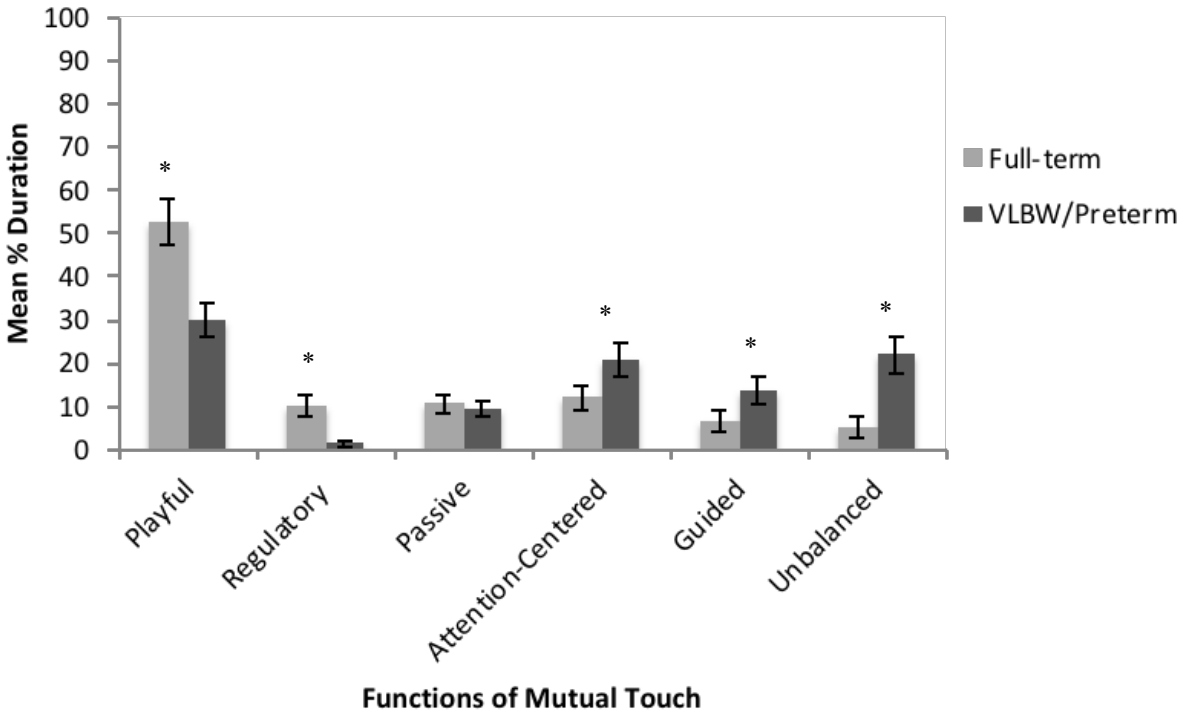

Figure 3. The mean durations for the six functions of mutual touch as a percentage of the total duration of mutual touch collapsed across the interaction periods of the Still-Face Procedure. * $p < 0.001$.

Chapter 5: General Discussion

The present dissertation comprised a series of two studies designed to investigate the types of maternal touch and the functions of mutual touch during early mother-infant interactions. The studies that make up the dissertation fill an important void in the literature by examining various forms of touch in normative and at-risk populations and the association of the quality of the dyadic relationship and touch in order to elucidate the effects of relationship indicators on tactile communication.

Study 1 examined the effects of different types of maternal unavailability (i.e., emotional, physical) on maternal touching behaviors. Moreover, this examination was uniquely carried out using an at-risk sample of depressed and non-depressed mothers and their infants. Findings revealed that depressed mothers are less engaged when interacting with their infants and that depressed mothers use fewer interactive types of touch (i.e., playful/stimulating touch). Another key finding from Study 1 was that the types and amount of maternal touch vary across interaction periods. Specifically, depressed mothers showed a decrease in the use of playful/stimulating types of touch and in their overall amount of touch between the first (normal period) and second (reunion period following the SF period) periods of the SF procedure. Non-depressed mothers however, maintained high levels in both the normal and reunion-normal periods. These findings contribute to our understanding of how depressive symptoms can alter the normal course of mother-infant interactions and provide further support for the contention that different types of touch may communicate different meanings.

Study 2 supported the findings from Study 1 whereby maternal touching behaviors are influenced by maternal unavailability and risk status. Building on Study 1, Study 2 examined the important communicative role of touch from a bidirectional process and in a different at-risk

group. This study adds to the existing literature by simultaneously examining both maternal and infant touch (i.e., mutual touch) and by taking into account infants' behavior, as opposed to studying unidirectional touch or touch in isolation. Touch occurs within a dynamic bidirectional system between infants and caregivers. That is, it is impossible to touch without being touched at the same time (Montagu, 1986). Therefore, it is essential to investigate the bidirectional influence of touch and how the functions of mutual touch relate to infants' affect, and in return, how infants' affect relates to the functions of mutual touch. In addition, although the positive influence of touch has been well documented for preterm infants (e.g., Field, 2011) most investigations have focused on the impact of touch for medically fragile preterm infants or have focused on the neonatal period (e.g., infants born premature with or without medical conditions). Consequently, results from Study 2 add to the existing findings by documenting touching in a sample of 5 ½-month-old full-term infants and a sample of healthy VLBW/preterm infants. Study 2 made its own independent contribution by investigating what communicative functions (e.g., playful, regulatory) mutual touch serves in order to obtain a better understanding of this dynamic interaction, in both full-term and VLBW/preterm infants. The findings revealed that full-term infant-mother dyads spent more time engaged in playful and regulatory mutual touch compared to VLBW/preterm infant-mother dyads who spent more time engaged in attention-centered, unbalanced, and guided mutual touch. Infant affect was found to co-occur with specific functions of mutual touch, suggesting that infants are trying to communicate with their mothers in more than one way potentially to increase the salience of a message. How the quality of the mother-infant relationship influenced the functions of mutual touch was also examined and demonstrated that lower levels of maternal sensitivity were associated with unbalanced mutual touch for VLBW/preterm dyads compared to full-term infants.

Together, the findings from the current studies underscore the importance of touch during mother-infant interactions; thereby supporting the cumulating evidence that touch is an important channel of communication between members of the dyad (e.g., Stack & Jean, 2011; Mantis et al., 2019; Mantis & Stack, 2018; Mercuri et al., 2019). Further, through both of the current studies, key differences in which various types/functions of maternal/mutual touching behaviors are organized with infants' affect and relationship dimensions across normative and at-risk infant-mother dyads were outlined. In both studies, the results illustrate the dyadic nature of mother-infant interactions and the dynamic aspects of touch, ultimately offering support for the importance of including touch education in parenting programs and preventative intervention programs of early touch stimulation in at-risk groups.

Prior research has neglected to investigate maternal touch in mothers with higher levels of depressive symptomatology as compared to those with lower levels. Study 1 of this dissertation took an important step in differentiating how depressive symptoms influence the display of specific types of touch, including a range of positive touching behaviors. Further, it is important to note that the touching behaviors of depressed mothers remain ambiguous as previous studies have not investigated the range and types of touch used and specifically, how they may change according to the period or types of interaction. Findings revealed important differences in maternal touch following differing periods of unavailability, as the effects of brief periods of emotional versus physical unavailability were each examined.

Moreover, the findings advance the literature on the SF procedure by understanding the important contributions of maternal touch: the unique experimental designs of the studies provided insight into the types of maternal touch and the functions that mutual touch serve when other forms of communication are unavailable. Variations in the types of touch and the amounts

of touch being provided following a perturbation period in both studies provides evidence that the perturbation caused by maternal unavailability negatively influenced touch in the proceeding periods. Findings from Study 2 also indicated that the qualitative properties of mutual touch, in this case the functions, were affected by the SF period. Consequently, the importance of examining the quality of touch as opposed to only focusing on its mere presence or absence is underscored. Although a limited number of prior studies have documented variations in the types of touch used by mothers, the current findings contribute new insights into the important of measuring types and functions of maternal and mutual touch across different interaction periods and procedures.

Results from the present study also extend scientific knowledge through the examination of the relationship between affect (fretting and smiling) and mutual touch. Infant smiling was found to significantly co-occur with playful forms of touch for both full-term and VLBW/preterm infants, while fretting co-occurred with unbalanced mutual touch for VLBW/preterm infants. The co-occurrence of infant affect with specific functions of mutual touch corroborated existing literature and suggests that infants are trying to communicate with their mothers in more than one way. Despite taking an important step in demonstrating an association between affect and touch, more research is needed to elucidate how and when infant self-regulatory strategies are used in combination with touch through sequential analyses, as discussed below.

The importance of touch throughout mother-infant interactions was further clarified and enriched by results from the current dissertation. Thus far, the few studies investigating maternal touch have focused on high-risk dyads (i.e., preterm infants, infants of depressed or anxious mothers, medically fragile infants) while neglecting to study typically developing infants (Stack

& Jean, 2011). In addition, although the positive influence of maternal touch has been documented for preterm infants (Field, 2011; Vickers et al., 2004) most investigations have focused on the impact of prematurity complicated by medical issues. Consequently, Study 2 adds to the findings of Study 1 by documenting typical mutual touching in a sample of 5½-month-old full-term infants and mutual touching in a sample of VLBW/preterm infants whose medical histories were not compromised outside of being born early and at very low birth weight. In this way, the prematurity and low birth weight are not complicated by additional medical issues. This step was essential in order to appreciate the roles played by touch for infants whose socio-emotional development may be at lower risk (Stack & Jean, 2011). Knowledge of typical patterns of maternal touch has the potential to assist in early identification of problematic patterns in dyads for whom early touch intervention programs may be beneficial.

Theoretical Implications

Findings from the present studies confirm and expand upon theory and research in the area of infant-mother interactions, infants' reactions to the SF and SP periods (i.e., emotional/physical availability), and the influence of risk status on touch. In particular, by demonstrating that mothers and infants are communicating through touch during their early social interactions strengthens the view that both members are active participants during their early social exchanges. Moreover, by highlighting their active involvement in social exchanges, the current research supports a dynamic systems perspective of interactions where each interactive partner is believed to exert an influence over the behavior of the other (Fogel, 1993; Hsu & Fogel, 2001). Specifically, mothers and infants are responsive to each other's ongoing changes in behavior and affective displays, and both actively contribute to shaping their interactions. Through this process, infants learn the rules of social engagement and

communication (Kaye & Fogel, 1980). Consistent with this theory, synchronized engagement was found to be a mutual goal as mothers and infants were found to adjust their affect and touching in accordance with their interactive partners' affect and touching.

The transactional model posits that while mother-infant interactions can be a context for fostering healthy development they can also be a context through which risk can be transmitted (Sameroff, 2009). In turn, co-regulation may be impaired, particularly in dyads at-risk leading to maladaptive development, behavioral problems, and poor socio-emotional competence (Crockenberg & Leerkes, 2005). Nonverbal behavior is of importance as the sequelae associated with preterm birth have been found to affect infants' abilities to engage in sustained social interactions and provide clear nonverbal signals to their caregivers (Crnic, Ragozin, Greenberg, Robinson, & Basham, 1983). Findings from this dissertation are in line with the transactional model (Sameroff, 2009; Sameroff & Chandler, 1975) underscoring how mothers' risk status (e.g., depression) and infants' risk status (e.g., birth status) can support, or undermine, the touching behaviors during early social exchanges and the quality of mother-infant interactions.

Future Directions and Limitations

Our findings underline the importance of including a bidirectional focus, when examining mother-infant interactions, both in research and clinical practice. Specifically, in investigating mutual touch in full-term and VLBW/preterm infant-mother dyads, the results contribute to a greater understanding of how both mother and their infants participate in shaping and co-regulating their interactions through touch and affect. In order to further unravel the bidirectional contribution during interactions, future work should examine the sequencing of infant touch in relation to specific maternal behaviors (e.g., affect, gaze, touch). Time window sequential analyses allow for taking advantage of the sequential information in the micro-coding of the

temporal relationships between maternal and infant behaviors (Egmose, 2017). By examining what infant behaviors precede or follow particular types of mother touch and what non-touch behaviors follow particular functions of mutual touch, sequential analyses may help to clarify the impact of touching behaviors on their partners during social interactions, underscoring the communicative role of touch. Further, this approach would help disentangle the roles of maternal touch in infants' self-regulation. Investigating sequential ordering of behaviors is important for research on interactions in general, but is likely an especially useful tool for investigating mothers' and infants' affect and touch under more naturalistic settings as they could provide an empirical assessment of the extent to which a mother's behavior at any point is a function of the preceding behavior of her infant and vice versa.

While the results from this dissertation make important contributions, at the same time, several limitations should be acknowledged. The VLBW/preterm group was gathered using strict exclusionary criteria so as to only include medically healthy preterm infants. This allowed for a more accurate comparison between touch/emotional availability and birth status, however, it may underestimate the disparities between full-term and preterm infants in the general population. Many VLBW/preterm infants experience a number of medical problems that were not accounted for in this study and could potentially contribute to the mother-infant interactions. In future studies of preterm infants and their families, it would be important to assess various risk factors contributing to the development of preterm infants. In a study by Korja and colleagues (2008), it is suggested that preterm infants are not automatically at a higher risk for mother-infant interaction problems. Rather, they stipulate that there are additional risk factors within the heterogenic population of preterm infants. More studies are needed to identify these specific risk groups to be able to plan the optimally targeted prevention programs.

Without taking away from the important contributions of the present dissertation in providing a significant step forward toward elucidating the different types of maternal touch and the functions of mutual touch and their relation to risk, it is nonetheless important to recognize that it was not possible to determine with absolute certainty what functions mothers' touch was serving at every point in time as mothers' intentions were not directly assessed. Nevertheless, our findings are based on a well operationalized and systematic coding system aimed at capturing maternal touch and the functions of mutual touch. In order to clarify this issue, future work could directly assess mothers' intention while using a specific type or function of touch. For example, mothers might be asked to clarify the reasons that propelled them to use a specific function at a given time while either watching a video record of their interaction or stopping them intermittently while the interaction is occurring. Alternatively, similar to the work by Stack and colleagues (1992, 1996, 1998), specific instructions might be given to mothers at the beginning of each interaction period to elicit a specific function of touch (e.g., get your infants excited and stimulated).

Further, the interaction setting was controlled in that infants were placed in an infant chair, consequently limiting their range of movement as opposed to less structured interactions, where mother and infant are not restricted in their physical distance. Nonetheless, a face-to-face format allows for rich observations during a short period of time by helping to keep the dyad focused on the interaction. In interactions with little physical distance we might expect that various forms of touch, such as holding and stroking the infant, might occur more naturally in non-restricted interactions where mothers and infants can interact in close proximity. Therefore, findings from the present dissertation could be strengthened with future research observing maternal and mutual touch across other interactive contexts (such as feeding and floor play).

Given the difficulties associated with at-risk groups, there is a heightened importance for examining mother-preterm infant interactions during such interactive contexts to obtain a complete picture of the overall quality of their developing interaction patterns.

Another limitation was that there was only one cross-sectional screening of the maternal depression in Study 1. Serial assessments of depressive symptoms would have brought more information about the role of the duration or the timing of depressive features in the mother-infant relationship. It would also be interesting to include assessments of depression before and during pregnancy to study the specific role of postnatal depressive symptoms as distinguished from chronic depression. A study by Korja and colleagues (2008) found that maternal depressive symptoms were associated with mothers' interactive behavior with their preterm infants, suggesting that maternal depression may be one of the factors adding to the vulnerability of preterm infants. In clinical practice, it would be important to identify those mothers of preterm infants who suffer from depression and need specific support. In addition, screening of maternal depressive symptoms should be included in the clinical practice of preterm neonatal and infant follow up. Further, given that previous research has demonstrated that the quality of maternal touch changes across infants' age (Jean et al., 2009; Stack, 2010), a longitudinal investigation of how maternal and mutual touching episodes evolve and change across various age-periods (i.e., throughout early infancy, toddlerhood and preschool for example) is vital to better understanding its role in early mother-infant interactions. Longitudinal studies are also needed to study the impact of maternal depression on touch and how this evolves with infants' age and development, and with their growing self-regulatory abilities. Additionally, up until recently (e.g., Mercuri et al., 2019), most studies have neglected to study paternal touch. Yet, fathers are also an integral part of families and important partners in the development of children's emotion regulation

(Pougnet, Serbin, Stack, & Schwartzman, 2011). It may be that touching surfaces differently and serves different functions during father-infant interactions. Finally, there would be much value in investigating contextual factors such as SES and perceived maternal distress (Jean & Stack, 2009) to determine its impact on maternal tactile behaviors.

Applied and Clinical Implications

Results from the dissertation studies have a number of more applied implications that were alluded to earlier. Findings from Study 1 contribute to our understanding of how depressive symptoms can alter the normal course of mother-infant interactions and provide further support for the contention that different forms of touch may communicate different meanings. The findings from our study support the assertion that infants of depressed mothers may be hindered developmentally. Findings of this kind can inform NICU interventions and more generally, clinical work with at-risk dyads. Direct attempts to improve the quality of the mother-infant interactions in depressed dyads are important (Onozawa, Glover, Adams, Modi, & Kumar, 2001). For example, teaching depressed mothers to be more aware of infant cues and how to respond positively to such cues. Moreover, given that maternal touch is compromised in at-risk groups, interventions utilizing touch could help improve infant outcomes. Mothers can be taught the importance of touch, positive touch patterns (static, calming touch) but also the capacity to sustain positive touch and to rapidly repair negative touch patterns or disruptive communications. Mothers can be taught increased capacity to reciprocate infant gaze through heightened contingent touch responsivity, and with much more positive touch, in the very next second.

A unique contribution made by Study 2 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 infant-mother dyads as compared to full-term infant-mother dyads. 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. Other research has found that mothers of very preterm infants face some difficulties in developing an affectionate bond during the immediate postnatal period, with limited capacity to moderate the pattern of difficulties in socio-emotional stress regulation of their infant (Provenzi et al., 2017).

Supporting mothers, particularly those at-risk (e.g., mothers of premature infants, mothers with elevated symptoms of depression and/or anxiety, mothers with stress and lacking social support) during the difficult immediate postnatal period is crucial. Our findings help inform the development of preventative interventions and parenting programs with early touch stimulation. The nature of maternal touch that was uncovered in the present dissertation may be utilized to help with the screening for mothers that appear to use touch ineffectively. Specifically, mothers who demonstrate few nurturing, soothing, or affectionate touching behaviors, or those who demonstrate inappropriate or inadequate touching (i.e., intrusive or over-stimulating kinds of touch) would benefit from early touch intervention programs. Such interventions and programs should draw parents' attention to the age of the infant, the context of the interaction, and the various functions of particular types of touch.

Behavioral and developmental interventions are necessary to address the unique behaviors of premature infants and interactive capacities of the mother-infant dyad. To date, many interventions have addressed the needs of premature infants and mothers separately (White-Traut et al., 2013). Interventions for premature infants have largely concentrated on

improving the development of the infant's nervous system and have had positive outcomes including better neurobehavioral functioning; increased alertness, and increased arousal (Lekskulchai & Cole, 2001; White-Traut et al., 2002). Interventions for mothers of premature infants have focused on reducing maternal distress and improving maternal sensitivity to their premature infant, resulting in reduced maternal anxiety and improved mother-infant interactions (Feeley et al., 2011; Kaaresen, Rønning, Ulvund, & Dahl, 2006). Other interventions have been directed to mothers of premature infants with the aim of improving their capacity to recognize and respond to their infant's unique behavioral cues, resulting in improved sensitivity and responsiveness among mothers (Ravn et al., 2011; Schroeder & Pridham, 2006).

Despite a number of promising NICU interventions, there is no consensus on which interventions are of greatest benefit (Symington & Pinelli, 2006). NICU intervention studies often lack randomization and blind assessments (Hussey-Gardner & Famuyide, 2009), and many interventions commence after the period of isolated confinement, depriving the infant of critical maternal involvement during the first weeks of life (Beebe et al., 2018). In addition, NICUs often do not have embedded protocols of developmental care interventions in their everyday care of preterm infants and their mothers. Recent research suggests that some infants' mothers need to be empowered and supported in their sense of being at ease and competent with their infant during their motherhood transition during their NICU stay (Provenzi et al., 2017). Furthermore, research points to the need of a more uniform adoption of developmental care practices and their inclusion in NICU protocols of care (Westrup, 2007). The early establishment of a healthy relationship should be taken into account from a preventative perspective even in the general population. Healthcare professionals are encouraged to support dyadic intervention whereby

strategies for mother-infant closeness and sensitivity are discussed and mothers are taught to better understand their infants' signals of distress (Kaaresen et al., 2006).

A key question that warrants future research is the long-term impact of such interventions on parent-infant interaction and the child's social, language cognitive and motor development. While the long-term benefits of positive mother-infant interaction are well established (White-Traut et al., 2013), additional work is needed to establish the role of intervention in fostering positive interactions that support both mothers (with and without depressive symptomatology) and their typically developing or preterm infants.

Conclusions

Infants develop essential social and emotional skills within the context of an interactive relationship with their mothers. The quality of mother-infant interactions varies according to a mother's emotional state and therefore, the findings of the current studies support the contention that infants born premature and infants of depressed mothers may be at a developmental disadvantage. These studies make a unique contribution in revealing the adverse influence of risk on touching behaviors. Both maternal depression and prematurity with very low birth weight appeared to have an adverse impact on maternal and mutual touching behaviors during face-to-face mother-infant interactions. Our results convey important implications for early care practices (with early touch stimulation for at-risk children) and the design of medically and clinically oriented parenting programs.

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Appendix A

Maternal Consent Form: Study 1

Informed Consent
Preventing Depression in Infants

We are doing a study on how being depressed may affect your baby, the ways to reduce depression in mothers, and how to prevent it in infants. During your pregnancy, after your baby is born and during your baby's first two years of life, we will interview you and test your baby. The tests are strictly for our study and will be confidential.

During Pregnancy

If you agree to be in the study, between your 3rd and 9th month of pregnancy you will be asked to complete questions on alcohol and smoking and your general health during pregnancy. In addition, we will ask you some questions regarding your feelings of depression, anxiety, stress, anger, daily hassles and your attitudes and knowledge about being pregnant and raising children. These will take between 1-2 hours to complete. We will ask for a urine sample to look at different hormones. You will be asked if we can observe two of your ultrasounds and/or if you are interested in having your significant other or family member learn a pregnancy massage and provide twice weekly 20-minute massages during pregnancy. The massage may be a moderate or light pressure or you may be in a group that receives no massage. If you are in a massage group, and if you prefer, massage therapists can conduct your massages at the U.M. Touch Research Institutes. Ultrasound sessions will take place in the prenatal clinic during your second and third trimesters of pregnancy and will last approximately 25-50 minutes. In order to record how your baby moves inside you. Head, foot or hand massage at the ultrasound clinic will last 3 to 5 minutes and we will watch your baby for 4 minutes during the ultrasound to see how he/she moves.

After you give birth

Shortly after birth, a psychologist will test your baby's alertness, behaviour and physical activity and we will ask you how you feel. We will also videotape your baby and record the baby's heart rate. Heart rate will be recorded at the same time we collect brain wave information through electrodes (little round stickers) placed on your baby's chest. We will take recordings of you and your baby's brain waves to see if they are affected by your moods. For the brain wave test we will place a few sensors on your baby's head and a cap on your head. We will also place 3 sensors on your chest area, arm, or neck to record heart rate. This will not cause any discomfort. There are no risks to these procedures. These recording only take a few minutes. We will also record you and your baby during a feeding, ask you questions about breast feeding and we will ask for a sample of you and your baby's urine. This visit will take approximately 2-2½ hours. We may also show you how to massage your baby and ask you to do a bedtime massage every night.

During the first 6 months

Once a month, for the first 6-months of your baby's life, we will ask you to come back to our video lab where we will videotape you while you and your baby play together for about 5 minutes. One video camera will be focused on your baby's face and record your baby's expressions and another will be focused on your face and record your expressions. We will also videotape your baby's responses to a Raggedy Ann doll's face (at the 4-month visit), to another baby's face and your baby's own face in a mirror (at 5 months), and to an object (e.g., a star versus a round-shaped object at 6 months). We will erase the videotapes after we finish analyzing them. We will ask for another urine sample from you and your baby at one of these visits and ask you some questions about stress. When your baby is 6 months we will give him/her a developmental test and a physical examination.

We will pay $20.00 for each visit. If we find any medical problems we will refer you to a doctor, your records and results will be given a number instead of your name and will be kept confidential to the extent permitted by law. If you decide to take part in the study with your baby, we will ask you for permission to review your medical records at delivery and your baby's medical records at birth. The results of this study will be reported as group results to protect your identity. Your records may also be bound by the same provisions of confidentiality. The Department of Health and Human Services (DHHS) may review these research records.

Your participation is voluntary and if you do not want to be in the study, you can leave at any time and it will not hurt your treatment. Feel free to ask questions at any time. For questions regarding this study contact Dr. Tiffany Field at 305-243-6781. You will receive a copy of this consent form for your records. If you have any questions about your rights as a research subject you may contact Maria Arnold, IRB Director, University of Miami at 305-243-3195.

_____ _____

Signature of Mother Date

Appendix B

Brief Coding Criteria for the Caregiver-Infant Touch Scale (CITS)

Brief coding criteria for the Caregiver-Infant Touch Scale (CITS; Jean et al., 2009; Stack, 2010)

Touching behaviour	Brief description
Static	Touch without movement
Stroke/Caress/Rub/Massage	Lateral soft and gentle movements or rubbing motion involving strong back and fourth or circular movements
Pat/Tap	Quick up and down motions using either palm or fingertips
Squeeze/Pinch/Grasp	Taking hold of infant's body or limb, or part of infant's body or limb, using a firmer hold or grip
Tickle/Finger Walk/Prod/Poke/Push	Usually involves bent finger(s) and often repetitive small movements
Shake/Wiggle	Moving part of the infant in short quick motions from side-to-side or up and down
Pull/Lift/Extension/Clap	Stretching or raising infant's limb away from infant's body
Other	Any other type of touch that cannot be classified in any of the other 7 categories. Includes kissing, blowing, and rocking, adjusting infants' clothing or posture, or wiping infants' mouth or nose

Appendix C

Maternal Consent Form: Study 2

Consent Form
Mother-Infant Interactions

This study is designed to look at infants' responses during social interaction and to study the different types of interaction used by caregivers and their role in social exchange.

I understand that my baby and I will participate in a study lasting approximately 60 minutes. In the first part, my baby will be seated in an infant seat directly facing me. The procedure will consist of several interaction periods, each lasting two to three minutes in length, during which time I will be asked to interact in different ways with my baby. During some periods I will be asked to interact with my baby as I normally do, while in others I will be asked to pose a neutral, still facial expression and remain silent for a brief period. There will be brief breaks separating the interaction periods. In the second part, my baby and I will be asked to play with my baby as I normally would at home. Under no circumstances will any manipulation be harmful to my baby. Finally, I will be asked to complete several brief questionnaires.

The entire session will be videotaped so that at a later point my baby's responses may be scored. However, these recordings are kept in the strictest of confidence and are not shown to others without my permission.

I understand that my participation in this study is totally voluntary. I know that I may withdraw at any time and for any reason. I also understand that I may request that the videotape recording of my baby be erased. In the event that the results of the study are published, my name and the name of my baby will be kept confidential. I am also aware that I may be asked to participate again when my baby is 12 and 18 months of age.

In the event that I have any unanswered concerns or complaints about this study, I may express these to Dr. Dale Stack (848-2424, ext. 2255) or Dr. Alex Schwartzman (848-2424 ext. 2251) of the Psychology Department at Concordia University. In addition, the patient representative of the Jewish General Hospital is Mrs. Laurie Berlin (340-8222, ext. 5833). She can be contacted should you have any questions regarding your rights as a research volunteer.

Thank you for your cooperation.

I, _____, do hereby give my consent for my baby _____ to participate in a study conducted by Dr. Dale Stack at Concordia University, and with the cooperation of the Jewish General Hospital. A copy of this consent form has been given to me.

Parent's signature on behalf of child: _____ Date:_____
Parent's signature:_____ Date:_____
Witness:_____ Date:_____

Appendix D

Inclusion and Exclusion Criteria for the VLBW/preterm Infants

Inclusion and Exclusion Criteria for the VLBW/preterm Infants

Inclusion Criteria	Exclusion Criteria
Aged between 26 and 33 weeks	Infants who were diagnosed with a major congenital abnormality or major congenital defects
Birth weight of 800 to 1500 g	Infants who suffered a Grade IV (or III) intra-ventricular hemorrhage or other major medical complications, illnesses or syndromes, such as hydrocephalus, severe neurological impairment, or those with hearing loss, retinopathy
Within 2 standard deviations on age in weeks, birth weight and head circumference	Infants who had a prolonged hospitalization since the neonatal period; if re-hospitalized must have been for short periods
Must have been living with their biological mother	Infants who had multiple hospitalizations since the neonatal period
Mothers must have spoken English or French	Infants who were diagnosed with a congenital abnormality
	Mothers at psychosocial risk due to a history of inadequate prenatal care, drug abuse, mental illness, etc.

Appendix E

Brief Coding Criteria for the Functions of Mother-Infant Mutual Touch Scale (FMTS)

Brief coding criteria for the Functions of Mutual Touch Scale (FMTS; Mantis et al., 2018)

Touching behaviour	Brief description
Playful	Both members of the dyad engaged in an agreeable and enthusiastic mutual touch
Regulatory	Both members of the dyad engaged in a calm and soothing-centered mutual touch
Passive	Both members of the dyad engaged in a resting/accepting touch
Attention-Centered	One member of the dyad seeking the other member's attention in the context of mutual touch
Guided	One member of the dyad guides the exploratory touch of the other member in the context of mutual touch
Unbalanced	One member of the dyad is engaged in mutual touch that is not in synchrony with the other member of the dyad

Appendix F

Brief Operational Definitions for the Emotional Availability Scales

Operational Definitions for Emotional Availability Scales (Biringen & Easterbrooks, 2012; Biringen et al., 2014).

Category	Brief Definitions	Scale Range
	Maternal Dimensions	
Maternal Sensitivity	A more sensitive parent will be attuned to the child's ability to regulate emotional and physiological states, and provide stimulation or soothing as needed	1 = Highly insensitive 5 = Optimally sensitive 9 = Highly sensitive
Maternal Structuring	This scale directly assesses the degree to which the mother structures her child's play, follows the child's lead, and sets limits	1 = No structuring 5 = Optimal structuring 7 = Overly high structuring
Maternal Hostility	This scale assesses the presence and degree of overt and covert hostile behaviour expressed during the interaction with the child	1 = Not hostile 3 = Markedly covertly hostile 5 = Markedly overtly hostile
Child Dimensions		
Child Responsiveness	The child's responsiveness to the mother reflects two aspects of the child's behaviour: a) willingness to engage with the mother and follow her bids; b) clear pleasure within the interaction with the mother	1 = Unresponsive 5 = Moderately responsive 7 = Highly responsive