

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 behaviours 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 period 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

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involved in processing emotion and wellbeing (McGlone et al., 2017). 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 ($\alpha = 0.80$ 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; Peláez-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 (Low et al., 2016; Moreno et al., 2006; Peláez-Nogueras et al., 1997; Peláez-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

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.

Individual/Clusters of Touch	Duration of touch				Frequency of touch			
	Depressed		Non-Depressed		Depressed		Non-Depressed	
	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>
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 Cluster								
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
Affectionate/nurturing Types of Touch Cluster								
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
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
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

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.

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.

Individual/Clusters of Touch	Duration of touch				Frequency of touch			
	Depressed		Non-Depressed		Depressed		Non-Depressed	
	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>	<i>M</i>	<i>SE</i>
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 Cluster								
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	0.79	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
Affectionate/nurturing Types of Touch Cluster								
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
Instrumental/Utilitarian								
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
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

3.4. Analyses of variance

3.4.1. Frequency and duration of individual types of maternal touch

A 2 (group) × 2 (procedure) × 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) × 2 (procedure) × 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. Results revealed a statistically significant three-way interaction

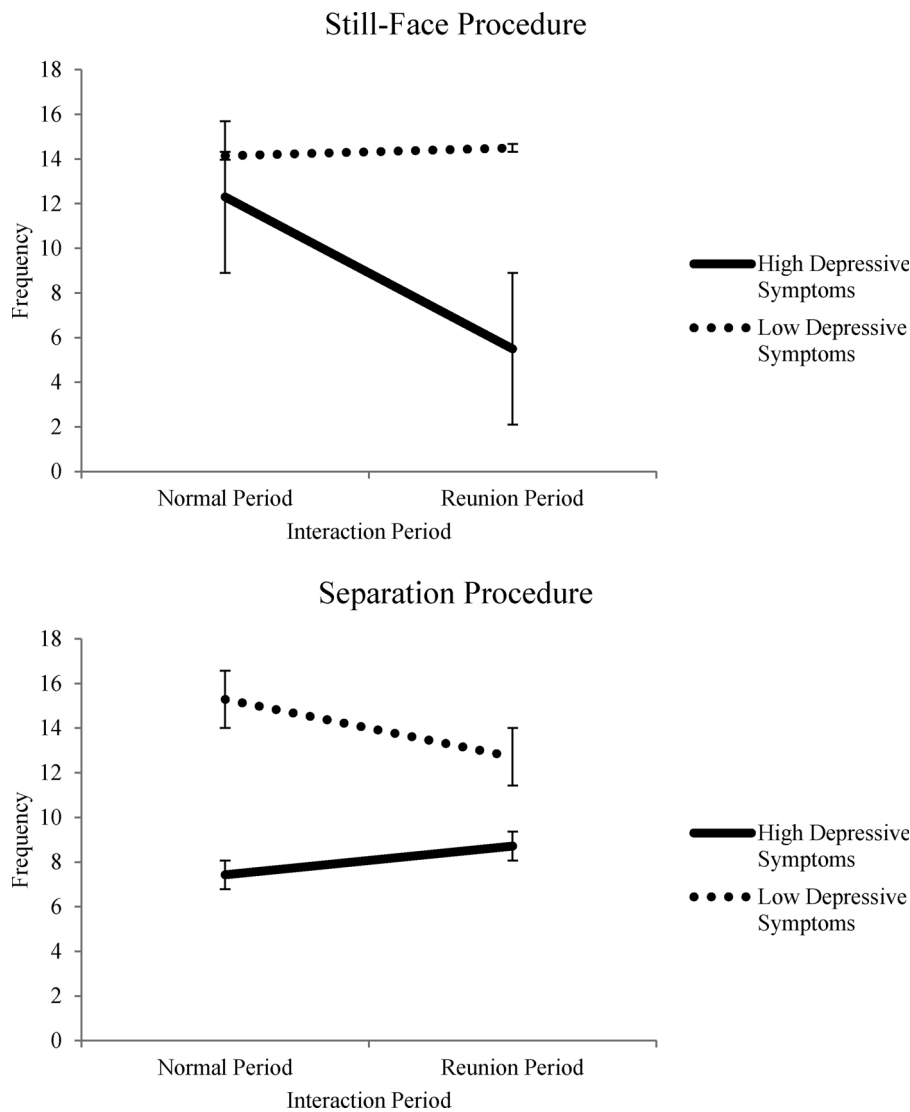


Fig. 1. Frequency of Playful/Stimulating Touch as a function of group, period, and procedure.

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) \times 2 (period) by 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 unresponsive 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.

Conflict of Interest

None.

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