Early Tactile Experience of Low Birth Weight Children: Links to Later Mental Health and Social Adaptation

Sandra J. Weiss a,*, Peggy Wilson b, Mary St. Jonn Seed c and Steven M. Paul d

a Department of Community Health Systems, School of Nursing, University of California, San Francisco, CA, USA
b San Francisco General Hospital, San Francisco, CA, USA
c School of Nursing, University of San Francisco, San Francisco, CA, USA
d School of Nursing, University of California, San Francisco, CA, USA

The purpose of this study was twofold: to determine (1) the degree to which specific qualities of maternal touch may contribute to the low birth weight infant’s emotional and behavioural problems as well as social adaptation, and (2) the relationship between maternal touch and a mother’s other caregiving behaviour. The sample included 114 socioculturally diverse infants and their mothers who were videotaped during an infant feeding when the baby was 3 months old. This videotape was analysed to assess dimensions of mother–infant interaction, including maternal touch. Data on perinatal risk and the mother’s acceptance versus rejection of the infant were also acquired. Social adaptation and emotional/behavioural problems were measured when the child was 2 years of age.

Hierarchical regression analyses indicated that maternal touch accounted for 15% of the variance in the likelihood of a child having emotional/behavioural problems at age 2. Children who received more nurturing touch had significantly fewer internalizing problems (such as depression) while children receiving both more frequent touch and harsh touch had more externalizing problems (such as aggressive behaviour). Infants who were less responsive to their caregivers were especially at risk of developing aggressive/destructive behaviour as a result of frequent touch. But less responsive infants also appeared to benefit most from greater use of diverse types of maternal touch, accounting for 6% of the variance in superior adaptive behaviour at age 2. Nurturing touch was the only quality that showed even a modest relationship to other caregiving behaviour, suggesting

* Correspondence to: Department of Community Health Systems, Box 0608, School of Nursing, University of California, San Francisco, CA 94143, USA. E-mail: sandra.weiss@nursing.ucsf.edu

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that touch may play a distinct role in the infant’s psychosocial development. Copyright © 2001 John Wiley & Sons, Ltd.

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The growing evidence of social and emotional problems for low birth weight children cannot be dismissed. Studies suggest that emotional immaturity, poor social competence and both internalizing and externalizing psychiatric disorders hamper low birth weight children (Breslau et al., 1988). Early behaviour problems, in turn, predict their later social and emotional functioning (Velez et al., 1989), especially conduct disorders and delinquency (Brooks-Gunn and Bensich, 1997). The prevalence of moderate to severe behaviour problems ranges from 10 to 16% for low birth weight infants (McCormick et al., 1990), increasing to 15–25% for babies less than 1500 g (Hay et al., 1992; Bennett, 1997).

Various characteristics of the infant have been found to affect the likelihood of problems developing, such as smaller birth weight, more perinatal complications and male gender (Bennett, 1988; Breslau et al., 1988; Pharaoh et al., 1994; Brooks-Gunn et al., 1997). But these characteristics interact dynamically with the environment from the first days of the baby’s life. During the first few months, the basic structure and functions of the brain are shaped (Sylva, 1997), particularly by sensory experience from social interaction (Harris, 1998). It is the resulting patterns of neuronal connectivity and neurochemical organization that create internal representations which will guide an infant’s future emotional and behavioural potential (Thoenen, 1995; Shore, 1997).

THE TACTILE ENVIRONMENT AS A FOUNDATION FOR PSYCHOSOCIAL DEVELOPMENT

Many features of the infant’s environment help to shape neurobehavioural development; however, tactile experience may play an early and significant role. Receptors and neural pathways associated with touch are the first to develop in infancy and the baby’s primary stimulation is through the touch received in care (Turkewitz and Kenny, 1982; Myslivecek, 1991). As a result, touch is central to development of the brain’s ‘hardwiring’ during this initial period. Evidence from animal models indicates that the nature of early tactile experience can indeed affect the size of the brain’s cortex as well as the numbers and patterns of connections between nerve cells in the brain (Greenough, 1990; Nudo et al., 1996). To a great extent, the brain of the newborn develops through sensory and motor stimulation acquired from body contact with the mother (Larsson, 1994).

However, because of their fragile or underdeveloped nervous systems, low birth weight infants have a diminished ability to regulate their responses to tactile stimulation during the first few months of life (Als et al., 1986; Gunnar et al., 1987; Harrison et al., 1990). They may also be especially vulnerable to touch because of their history of invasive and painful medical procedures which can distort their somatosensory perception and increase the potential for touch to be aversive (DeMaio-Feldman, 1994). But, despite the unique challenges faced by these infants in regard to touch, nothing is known of the longer term consequences of parental touch patterns for the eventual mental health or social adaptation of low birth weight infants. A goal of this study was to better
understand the effects of various qualities of touch on these infants by building upon what is known about touch from research using other human and animal models.

**Frequency of Touch**

Research using animal models has identified numerous dysfunctions resulting from the absence or infrequency of physical contact during infancy, including repetitive, stereotyped rocking or head banging, unusual posturing, self-clinging and self-touching, withdrawal and fear of exploration, depressive affect, anxious behaviour, and failure to participate in normal social relationships such as mutual grooming (Harlow, 1958; Suomi, 1986, 1990).

These studies parallel the findings of human research which show that rejection of physical contact by attachment figures can lead to angry, aggressive behaviour by the child as well as abnormal stereotypies such as hair pulling and hand flapping (Main and Stattman, 1981). Blunted affect has also been noted as a key feature in physically neglected infants (Schore, 1998) as well as infants diagnosed with ‘failure-to-thrive’ (Spitz, 1945). Studies of children with ‘failure-to-thrive’ describe patterns of less overall touch from their mothers (especially holding, kissing and caressing) as well as evidence of mothers obstructing the child’s physical access to them and verbal reprimands to the child not to touch them (Pollitt et al., 1975; Polan and Ward, 1994). The discovery of a gene that is triggered by touch (Schanberg, 1995) may ultimately help to explain these findings regarding failure to thrive. In addition, data from a recent randomized trial indicate that human neonates cry immediately when not in skin-to-skin contact with the mother (Christensson et al., 1995). The investigators conducting that research suggest that the ‘distress call’ of neonates may be a genetically encoded reaction to separation which attests to the infant’s biological need for close physical contact with the mother.

Beyond these studies of touch deprivation, animal research has provided evidence that greater tactile stimulation in early life may ‘program’ a more effective regulation of the stress response in later life. Rats whose mothers lick and groom them more frequently as pups show reduced hormonal reactivity to acute stress, increased receptor mechanisms for the detection and uptake of stress hormones, and faster recovery from stressors when they become adults (Liu et al., 1997; Francis et al., 1999). In contrast to other rats, those who receive more licking and grooming as pups also exhibit behavior indicating less anxiety later in life (e.g. more open field exploration) and more brain receptors for the uptake of chemicals that reduce anxiety (Sapolsky, 1997). These findings suggest an important link between early tactile experience and one’s subsequent emotional response to the stress encountered in life.

**Complexity/Diversity of Touch**

A predominant feature of tactile deprivation is the lack of enrichment that such a condition provides to the developing child. Animal models have proferred growing support for the hypothesis that more complex, varied or diverse tactile environments enhance brain development, producing (a) greater numbers of neuronal connections for animals reared in enriched environments (Greenough et al., 1985) and (b) increased numbers of genes and neurons responsible for learning and memory function (Anokhin et al., 1991; Kempermann et al., 1997). Tactile enrichment, in contrast to deprivation, has apparent implications for improving the cognitive, emotional and behavioural repertoires available to the child for dealing with the challenges of life.
Nurturing Touch

Research constructs a picture of the special importance of caressing and comforting skin contact between parent and child in fostering a sense of being valued that influences profoundly the child’s emotional and social development (Walsh, 1991). Tender, gentle holding and touching have been identified as central to a child’s secure attachment and emotional security (Ainsworth et al., 1978; Anisfeld et al., 1990; Kaitz et al., 1992), serving as the primary means through which support and tenderness are communicated prelinguistically. In particular, caressing and close holding seem to indicate special nurturance and intimacy (Kaitz et al., 1995). In addition to the emotional security fostered by nurturing touch, it has been proposed that an infant’s later ability to feel and express empathy and caring toward others depends, to a great extent, on that infant’s earliest tactile experience and whether s/he was touched in a caring way (Ziajka, 1981; Perry et al., 1995).

Primate studies provide evidence that nurturant physical caregiving by monkey mothers can be the crucial factor in infant development of emotional security and social competence, especially in more temperamentally vulnerable infants (Suomi, 1990, 1997). When these infants do not have nurturant mothers, they develop numerous behavioural problems, and lack the skills to succeed or be accepted in the primate social world.

Harsh Touch

There is a growing literature indicating high rates of mental health morbidity for children experiencing early physical abuse (Kolko, 1992) and physical punishment (Straus and Gelles, 1990). Even as infants, these children begin to show substantial negative affect and minimal positive affect (Schore, 1998), becoming physically aggressive to their peers and caregivers as they develop (Main and George, 1985). Ultimately, physical maltreatment increases the child’s risk for full blown neuropsychiatric syndromes, especially depression, aggressive and destructive behaviour, and self-destructive disorders (Kaufman, 1991; Green, 1998). Although it is difficult to separate out the specific effects of strictly physical abuse versus its concomitant emotional abuse, research suggests that punitive forms of touch may actually alter the neural structure and neurochemical circuits of the corticolimbic system, the system responsible for processing socioemotional experience (Perry and Pollard, 1998; Schore, 1998).

Touch: Autonomous Entity or Caregiving Marker?

In nearly all of the research cited above, it is difficult to separate out the discrete effects of touch from overarching attitudes or styles present in the caregiving environment which may be affecting the infant’s development. Touch may reflect a marker of the larger caregiving approach, just as variables such as amount of maternal vocalization, eye contact or smiling may serve as indicators of the caregiver’s attentiveness, warmth or sensitivity toward the child. For instance, greater use of tender, affectionate touch has been long considered an attribute of maternal sensitivity (Ainsworth et al., 1978).

Yet, there are important distinctions in the various facets of caregiving behaviour. While many aspects of maternal behaviour may be associated with more optimal outcomes, these behaviours are not necessarily interdependent nor redundant. Seifer and Schiller (1995) have provided evidence of such a distinction between maternal warmth and sensitivity; a mother may have one
attribute without possessing the other. Similarly, caregivers can show overall warmth and concern while using qualities of touch that may have potentially aversive or negative effects on the child (Harrison et al., 1990; Weiss, 1993). Research has also shown that people can communicate different content simultaneously through different sensory modalities (Ekman et al., 1988; Sanders and Dadds, 1992; Mestel, 1996). An obvious example is someone smiling while using critical or hostile words. Montague (1986) has noted that, in public situations, people often use touch in ways that either (a) contradict their words or facial expression, or (b) communicate something unrelated to other sensory channels. For instance, a mother may use harsh touch to restrain and control her ebullient child while concealing her irritation from others via a pleasant voice and positive facial affect. Such observations raise important questions about the relationship of touch to the more general caregiving behaviour of the mother. Yet there is little knowledge to date regarding how these systems function in relation to one another.

RESEARCH AIMS

There were two major aims of this study. The first was to determine the contribution of frequent, diverse, nurturing and harsh properties of maternal touch to the psychosocial development of low birth weight infants at 2 years of age. We hypothesized that these properties would contribute significantly to the variance in emotional and behavioural problems for infants as well as to their social adaptation. However, we predicted that their effects would depend, to some extent, upon their interaction with the particular biological makeup and interactive capacity of the infant. Perinatal risk status, birth weight and gender were selected as salient biological variables which could moderate the effects of maternal touch. Infant responsiveness and clarity of cues were included as two additional moderating variables.

The second research aim was to examine the relationship between properties of maternal touch and the overarching nature of the mother’s caregiving behaviour with the low birth weight child. We hypothesized that greater use of nurturing touch would be positively related to more general maternal warmth, responsiveness to the child’s distress, and more socioemotional growth fostering behaviour. In contrast, a mother’s use of harsh touch would be related to more rejection of the infant, less responsiveness to distress and less socioemotional growth fostering. We also hypothesized that greater diversity in maternal touch would be related positively to more cognitive growth-fostering behaviour by the mother and greater sensitivity to the infant’s cues. Lastly, we predicted that frequency of touch would have no relationship to a mother’s caregiving behaviour because the qualitative characteristics of touch, rather than its simple amount, would be more likely to reflect the mother’s overarching caregiving approach.

METHODS

Sample

The sample included 114 infants and their mothers who were recruited into the study during the infant’s first 2 weeks of life and followed through their second
birthday. This convenience sample was ethnically diverse, including 46% Caucasian, 28% Hispanic, 19% African–American, and 7% Asian or Native American babies. Their weight ranged from 570 to 2500 g with a mean birth weight of 1487 g (S.D. = 547). Ninety-four percent of the babies had a gestational age of less than 37 weeks, with a sample mean of 32 weeks. Forty-four percent of the babies were girls and 56% were boys, with 22% known to have been drug exposed in utero. Mothers had a mean age of 29 years (S.D. = 7), ranging from 16 to 44. They averaged 12.5 years of education (S.D. = 4), with a spread from 1 to 20 years. Eighty-one percent of the mothers lived with their partner, but not necessarily a spouse. Forty-five percent of the mothers were living below the poverty level. Sixty-one percent were employed at least part time, with 29% being the sole support for their family.

**Procedures**

Families were recruited from the neonatal intensive care units of three major teaching hospitals. Once an informed consent was acquired, the mother was given a demographic questionnaire regarding both herself and her baby to complete. When the baby was 1 month old, a research assistant (RA) with clinical expertise in care of neonates reviewed the medical charts of mother and infant to identify the presence or absence of specific perinatal risk factors that constituted the Parmelee Perinatal Complications Scale. When the baby was 3 months of age, a RA who was a clinical nurse specialist made a home visit to videotape the mother and infant during a typical feeding. Mothers fed the infant in their normal feeding mode, either breast (31%) or bottle (69%). The video camera was set up and turned on as soon as the RA arrived in order to allow time for the mother to adjust to its presence. The camera was then left focused on the mother and infant while the baby was being fed. The videotape of the feeding was analysed at a later time using the Tactile Interaction Index (to measure the mother’s use of touch) and the NCAST feeding scales (to measure the infant’s interactive capacity and the mother’s caregiving style). Mothers also completed the Parental Acceptance–Rejection Questionnaire at the 3-month visit to measure their warmth versus rejection of the infant. Near the infant’s second birthday (corrected for gestational age), an appointment was set to interview the mother regarding her child’s social adaptation, using the Vineland Adaptive Behaviour Scales. She was also asked to complete Achenbach’s Child Behaviour Checklist/2-3 at this time, describing any emotional or behavioural problems she observed for her child. Because this study represented only one aspect of a larger programme of research, RAs were in quarterly contact through telephone calls or visits with the families between the 3-month and 2-year home visits.

**Measures**

**Perinatal Risk Status**

Risk status was determined by the Perinatal Complications Scale, developed by Parmelee (Parmelee et al., 1976; Littman and Parmelee, 1978). The measure assesses maternal obstetrical history, pregnancy events, perinatal measures of the infant (e.g. gestational age and apgar), and hazardous postnatal events such as need for ventilatory assistance, metabolic abnormality, or surgery. A summary score is based on the number of risk factors incurred by a mother–infant pair, with higher scores indicating greater risk. Risk data were acquired primarily from chart review during the first month postnatal, with supplemental input from the infant’s primary nurse. Reliability and validity have been
demonstrated for the scale (Francis et al., 1987; Scott et al., 1997). Although it was developed in the 1970s, the scale’s categories are still highly salient and broad enough for classification of the most contemporary of medical complications.

**Infant–Mother Interaction**

The NCAST Feeding Scale (Barnard et al., 1989) was used to measure the nature of the videotaped maternal–child interaction: both an infant’s interactive capacity with the mother and the mother’s caregiving behaviour toward the child. We coded the two infant subscales (clarity of cues and responsiveness to the mother) and the four maternal subscales (sensitivity to cues, responsiveness to distress, socioemotional growth fostering, and cognitive growth fostering). The NCAST measure has established normative data and has shown internal consistency and test-retest reliability as well as construct, concurrent and predictive validity (Sumner and Spietz, 1994). The subscales each consist of binary items which are summed; larger scores indicate more of the particular behaviour in question.

An expert coder was trained and certified as reliable in use of the NCAST Scales by the University of Washington NCAST office (i.e. met their criterion of at least 85% reliability on a series of standardized observational tests). This individual completed the coding for all infants based upon review of the entire videotape of their feeding situation with the mother. The coder was blind to any other information about the mother–infant pairs.

**Maternal Acceptance–Rejection**

A mother’s acceptance versus rejection of her infant was measured using the Parental Acceptance–Rejection Questionnaire (Rohner, 1991). This measure is a self-report tool regarding the mother’s specific behaviour toward the infant. Sixty items provide a total composite score for degree of acceptance versus rejection on bipolar ends of a continuum where more overall rejection yields a higher score. There are four subscales contributing to the total rejection score: lack of warmth/affection, aggression/hostility, neglect/indifference and undifferentiated rejection. A subscale score for overall warmth can also be determined. Each item is on a four point scale from almost never true to almost always true.

The reliability of the measure has been demonstrated (Rohner, 1991; McGuire and Earls, 1993), with the internal consistency of the total scale having an alpha of 0.91. Subscales range from 0.86–0.95. Content, concurrent, convergent and discriminant validity have also been established (Holden and Edwards, 1989; Rohner, 1991; Myers et al., 1992; Gorman et al., 1993). Response bias and social desirability have been tested with no evidence of their effects. The measure shows substantial cross-cultural validity and utility.

**Maternal Touch**

The specific properties used by mothers in their touching of infants were measured with the Tactile Interaction Index (Weiss, 1990, 1992). The Index (TII) includes both a series of training videotapes differentiating various properties of touch as well as a coding system to analyse these properties within a specified interaction. The coding system has indices measuring the intensity, location, action and frequency of a touch. It was created specifically for microanalysis of videotaped or filmed interaction.

The intensity index allows for coding of touch as strong, moderate or light based on the degree of pressure to the skin. Each mother received an initial raw score for the number of times she used each type of intensity in her touching and then a percentage score for the degree to which she used each of the three intensities during the feeding situation.
The location index specifies 19 different areas of the infant’s body that could be touched. Each touch that occurs is coded as to which body area the mother touches. From initial raw scores regarding the number of times each area was touched, a percentage score was developed, to identify the extent to which a variety of different body areas were touched, that is, the percentage of different areas a mother touched from among the 19 possible.

The action index identifies 28 different gestures or movements that can be used in touching (e.g. grab, push, rub, squeeze). From the raw data regarding specific tactile gestures, three percentage scores were developed. The first score rated each mother on the degree to which she used nurturing actions (e.g. stroking, kissing) and the second score identified the degree of harsh actions (e.g. pinching, slapping). A third score was computed regarding the variety of actions used (i.e. the number of different actions from among the 28 possible).

The fourth index identified the frequency of a mother’s touching, being the actual number of times a mother touched her baby. This was the only score that was not a percentage score.

From these TII data, four final scores were used to test the hypotheses of this study: (1) nurturing touch, (2) harsh touch, (3) frequent touch, and (4) complex/diverse touch. The first three scores came directly from the original index scores just described. Diversity (complexity) of touch was operationally defined by summing scores for (a) the extent of body areas touched and (b) the variety of actions used in touching.

The content, construct and predictive validity, as well as internal consistency, interrater reliability and test–retest stability of the TII have been established previously (Weiss, 1990, 1992). Data from the sample of mothers in the study reported here have provided further evidence of the measure’s validity and reliability.

A standardized 5-min segment of the infant feeding situation was used for analysis of each mother’s touch. The initial few minutes of the feeding were not used in order to allow mothers to adjust comfortably to their normal feeding routine. Two subsequent minutes were then coded during active feeding of the baby. Three additional minutes near the end of the feeding were also coded, when mothers were concluding the feeding, burping the baby, and engaging in other interaction with the infant unrelated to the feeding per se. While standardizing the times of the feeding limited some of the variance in overall frequency of touch, it was necessary in light of a number of factors, including the length of some feeds, periods where the baby was sleeping with no interaction taking place, and the time-intensive nature of the tactile coding process. Yet the natural, spontaneous quality of the feeding was preserved by standardizing what was coded rather than rigidly structuring the feeding situation itself.

A trained RA who analyzed the touch reviewed the 5-min feeding tapes four separate times, coding each of the original indices separately (i.e. intensity, action, location and frequency of touch). She was reliable at the 0.92 level or above for each index with another expert coder. This RA had no other contact with the families participating in the study, nor any access to information about them.

Adaptive Social Behaviour
The Vineland Adaptive Behaviour Scales were employed as a measure of adaptive social behaviour (Sparrow et al., 1984). The items in the measure are each on a three-point scale and are divided into three separate domains: communication, daily living skills, and socialization. There is also a motor skills
domain which was not used in this study. We used the combined adaptive behaviour composite of the three social adaptation subscales as the major dependent variable in this research. A child’s placement on the items was based upon interview with the mother when her child was 2 years of age. Split-half, test–retest and interrater reliability have been established for the measure as well as concurrent and predictive validity (Poth and Barnett, 1988; Middleton et al., 1990; Raggio and Massingale, 1990; Atkinson et al., 1992).

Because we were dependent upon maternal report of the infant’s adaptive behaviour, we looked for evidence within our own database to support the validity of the Vineland scores. Cognitive ability has been clearly linked to social adaptation in previous research (e.g. Liaw and Brooks-Gunn, 1994; Harris, 1998) so we compared the infants’ adaptation scores with scores from a measure of the infant’s cognitive ability (the Mullen Scales of Early Learning) which we had acquired as part of a separate study in the larger research programme. These cognitive tests were administered by a developmental psychologist when the infant was 2 years of age. The correlation between the Vineland composite score for social adaptation and the sum score for the infant’s cognitive status was $r = 0.61 \ (p < 0.000)$. The most directly linked variables within the Vineland and the Mullen Scales are the measure of ‘language expression’ in the Mullen and the subscale for ‘communication skills’ in the Vineland. This correlation was $r = 0.68 \ (p < 0.000)$, providing support for the validity of the mother’s report about her infant’s adaptive behaviour.

**Emotional and Behavioural Problems**

The Child Behaviour Checklist (CBC) for 2–3 year olds was used to assess the degree of behavioural and emotional problems manifested by children at 2 years of age (Achenbach, 1992). This questionnaire consists of 99 items describing potential problems that a child might experience, each on a three-point scale. The checklist provides a total problem score, scores for externalizing and internalizing problem behaviours and six scales indicating specific syndromes, each with standardized comparison scores for a normative sample. Syndrome scores include social withdrawal, anxiety/depression, sleep disorders, somatic problems, aggression, and destructive behaviour. The total score as well as scores for externalizing and internalizing disorders were used as the primary indices to determine emotional and behavioural problems because the reliability of these scores is the most robust and least subject to measurement error. Syndrome scores were examined only to understand some specific features of the overall results.

Because of the early age of our infants, we were dependent upon maternal report as the basis of a child’s problem assessment. However, for a small subsample of our families in whom fathers were also willing to complete the CBC for their infant ($n = 20$), we found a reliability of $r = 0.71 \ (p < 0.01)$ between our mothers’ and fathers’ total problem scores. This level of agreement is actually better than the average parental agreement for 2-year olds noted by Achenbach (1992) of $r = 0.63$.

The questionnaire has been tested and normed with a broad cross section of SES and cultural groups as well as children with varying degrees of perinatal risk. Its reliability and validity have been documented in numerous studies (Crawford and Lee, 1991; Achenbach, 1992; Spiker et al., 1992; Leadbeater and Bishop, 1994), including internal consistency, stability, and discriminant and predictive validity. In order to feel more confident about the validity of our mothers’ descriptions of their children’s emotional and behavioural problems,
we correlated the infants’ total problem scores on the CBC with their scores for security of attachment from another study within our larger programme of research. Security of attachment has been linked to fewer behavioural problems in children (e.g. Carlson and Sroufe, 1995; Greenberg, 1999). Our data indicate a significant negative correlation between the degree of attachment security for our sample of infants (measured in the home by trained observers using Waters and Deane’s Attachment Q-Set) and the infants’ total number of emotional and behavioural problems \( r = -0.23, p < 0.02 \). This evidence of construct validity augmented our confidence in the mother’s evaluation of her child’s emotional and behavioural problems.

Data Analysis

Data analysis for Aim # 1 involved two phases. First, separate multiple regressions were performed for each of the touch variables to determine their individual contributions to adaptive social behaviour and to emotional/behavioural problems. This phase allowed for determination of their main effects as well as any potential impact of their interactions with infant characteristics. Total scores for adaptive behaviour and for behavioural problems served as the two dependent variables. Separate hierarchical regression equations were computed for each touch variable with each dependent variable. At the first step, three variables reflecting the infant’s biological makeup were entered (gender, birth weight, perinatal risk status). At the second step, two variables indicative of infant interactive capacity were entered (clarity of cues and responsiveness). At the third step, the score for one of the touch variables was entered. Five interaction terms were entered at the fourth step, representing the interactions of all variables in steps 1 and 2 with the particular touch variable entered in Step 3. All touch variables and interaction terms that were significant at \( p < 0.05 \) or better were then reserved for further examination in the second phase of data analysis.

In the second phase, hierarchical multiple regression procedures were again employed, with separate equations for each of the outcome variables and entry of the same moderating variables at steps 1 and 2 to control for their effects. However, in this phase, any touch variable and any interactions which had shown a significant relationship to the particular outcome variable in phase 1 were all entered, respectively, at steps 3 and 4.

Only nine of the mothers used any harsh touch so there was not adequate power to perform regressions for that touch variable. However, two other procedures were used to determine whether a potential relationship existed between harsh touch and the outcome variables. First, Pearson correlations were computed to examine the degree of the relationship between harsh touch and the outcome variables. Secondly, \( t \)-tests were employed to compare both the adaptive behaviour and problem scores of infants whose mothers used any harsh touch \( (n = 9) \) with those infants whose mothers used a substantial amount of nurturing touch, that is, at least 75% of their total touching \( (n = 12) \).

To test Aim # 2, Pearson correlation coefficients were computed to examine the relationships between properties of maternal touch and the six characteristics of a mother’s more general caregiving (sensitivity to cues, responsiveness to distress, socioemotional and cognitive growth fostering, warmth and rejection). Because of the small number of mothers using harsh touch, for this variable, we used \( t \)-tests to compare the caregiving behaviour of mothers who used any harsh touch with the group of mothers who used substantial amounts of nurturing touch.

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RESULTS

Maternal Touch Descriptors

Within the standardized feeding period, mothers touched their babies an average of 213 times (S.D. = 109), ranging from 41 to 714 touches. Most maternal touching was of the infant’s trunk ($M = 72\%$, S.D. = 0.16), especially the back. Patting was the most common of the 26 gestures used. The particular properties of touch they used varied substantially across mothers. However, as an average, approximately half of a mother’s touch was nurturing ($47\%$), with a range from 0 to 91\%. Complex/diverse touch constituted an average of 32\% across mothers, with a range from 27 to 66\%. For the nine mothers who used any harsh touch, their mean for its use was 2\% of their total touch, with a range from 1 to 19\%.

Maternal age, income and years of education had no relationship to the frequency or diversity of maternal touch. However, a mother’s use of nurturing touch was positively associated with more adequate financial income ($r = 0.19$, $p < 0.04$), older age ($r = 0.25$, $p < 0.004$) and years of education ($r = 0.34$, $p < 0.000$). Once we controlled for these socioeconomic variables, we found no differences across ethnic groups in their patterns of touch. Although the difference in adjusted means was not significant, it is interesting to note that African–American mothers touched their infants the most frequently ($M = 226$ times). Hispanic mothers were in the middle of the spectrum with a mean of 207 and Caucasian mothers touched the least frequently ($M = 199$). Other ethnicities were not included in this analysis because of their small subsample size.

The Contribution of Touch to Psychosocial Development

Tables 1 and 2 present the regression results for the first aim. These tables reflect the empirical models generated through the two-phase process of analysis described earlier.

Adaptive Social Behaviour

As shown in step 1 of Table 1, the infant’s biological characteristics accounted for 33\% of the variance in adaptive behaviour. If we look at the squared
Table 2. Summary of hierarchical regression analysis for variables predicting emotional and behavioural problems (N = 75)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Beta at final step</th>
<th>Squared semi-parital at step entered</th>
<th>R² change</th>
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<td>Step 1</td>
<td></td>
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<tr>
<td>Gender</td>
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<td>0.05*</td>
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<td>Risk</td>
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</tr>
<tr>
<td>Step 2</td>
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<td></td>
<td>0.00</td>
</tr>
<tr>
<td>Clarity of cues</td>
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<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Responsiveness</td>
<td>0.63</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Step 3</td>
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<td>0.09*</td>
</tr>
<tr>
<td>Nurturing touch</td>
<td>-0.24*</td>
<td>0.05*</td>
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<tr>
<td>Frequent touch</td>
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<tr>
<td>Step 4</td>
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<td>Responsiveness × Frequency</td>
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<td>0.06*</td>
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</tbody>
</table>

Total model: R² = 0.21, F₈,₆₈ = 2.20, p < 0.04.
* p < 0.05.

semi-partial coefficient for gender (i.e. the correlation between gender and social adaptation when all other predictors have been partialed out), we can see that it had the greatest unique effect, with girls being more adaptive than boys. Perinatal risk also contributed significantly, with less risk predicting better social adaptation. As noted in steps 2 and 3, infant interactive capacity at 3 months of age and maternal touch for infants as a whole made no significant contributions to social adaptation. However, the interaction between infant responsiveness and a mother’s diverse touch (step 4) did account for a significant proportion of the variance in the infant’s adaptive behaviour. In other words, the effect of touch depended on the infant’s level of responsiveness. Diverse touching was linked to better adaptive outcomes for less responsive infants, but it appeared to have no effect on more responsive infants. Examination of the correlation matrices for infants who were less responsive (i.e. below the sample mean for responsiveness) showed that the most significant correlation with diverse touch was for the adaptive subdomain of ‘daily living skills’ (r = 0.47, p < 0.007). This score reflects a child’s personal living habits and task performance; for example, the ability to feed oneself with a spoon without spilling, use the toilet or potty-chair, and put away possessions when asked. The total model accounted for 43% of the variance in a child’s adaptive behaviour (F₇, ₇₃ = 7.97, p < 0.0001).

Emotional/Behavioural Problems
In contrast to their substantial effect on adaptive social behaviour, step 1 of Table 2 indicates that an infant’s biological characteristics accounted for only 6% of the variance in his/her later development of emotional and behavioural problems. This effect was due primarily to gender differences, with boys having significantly more problems than girls. The infant’s interactive capacity (step 2) accounted for none of the variance. But, at step 3, maternal touch accounted for 9% of the variance, with nurturing touch and frequent touch both making a contribution. Infants whose mothers used more nurturing touch were reported to have fewer problems, especially fewer internalizing problems such as depression and anxiety. However, frequent touch showed a positive relationship to
development of emotional and behavioural problems. In addition to its main effect for the entire sample, its interaction with infant responsiveness (step 4) contributed another 6% to the model. The relationship between frequent touch and emotional/behavioural problems depended to a significant extent on the level of an infant’s responsiveness. Correlation matrices indicated that frequent touch was linked most significantly to externalizing disorders such as aggression and destructive behaviour, especially for infants who were below the mean for responsiveness. The total model contributed to 21% of the variance in a child’s emotional/behavioural problems ($F_{6,86} = 2.20, p < 0.04$).

**Harsh Touch and Psychosocial Outcomes**

Correlation coefficients for the small sample of mothers ($n = 9$) who used harsh touch did show a relationship between the degree to which they slapped, pinched or hit the child and their child’s psychosocial development. The greater a mother’s use of harsh touch during the feeding, the more emotional/behavioural problems were reported for her child ($r = 0.66, p < 0.05$), especially internalizing problems of depression, anxiety and withdrawal ($r = 0.72, p < 0.03$). $t$-Tests comparing children whose mothers used harsh touch with a group of children whose mothers were high in use of nurturing touch ($n = 12$) did not show any significant differences, although children receiving harsh touch had a higher mean for their problem scores ($M = 40.3$) than children receiving nurturing touch ($M = 33.5$).

Correlations of harsh touch with a child’s total score for adaptive social behaviour showed a trend toward a negative relationship, specifically for ‘daily living skills’ ($r = -0.58, p < 0.09$). The more mothers used harsh touch, the lower was their child’s score for adaptive social behaviour. Comparison of infants receiving harsh versus nurturing touch indicated that children receiving harsh touch were less adaptive ($M = 269$) than were children receiving high degrees of nurturing touch ($M = 286$). But, like the correlation coefficient, this difference was only a trend ($t = 1.99, p < 0.07$).

**Caregiving Behaviour and Maternal Touch**

Results of the correlation matrix related to the second aim are shown in Table 3. For the full sample of infants, there were no significant relationships between any measure of caregiving behaviour and the properties of frequent, diverse or nurturing touch, not even a trend. Because our regression models pointed to significant interaction effects between infant responsiveness and maternal touch, we also computed correlations between touch and caregiving behaviour separately for the less responsive and more responsive infants. For the group of more responsive infants, nurturing touch was associated significantly with a mother’s warmth toward the infant ($r = 0.25, p < 0.02$). However, these variables were unrelated for less responsive infants. Results of the $t$-test comparing mothers who used harsh touch ($n = 9$) with those using high amounts of nurturing touch ($n = 12$) identified one trend toward a difference in caregiving behaviour between these groups. But it did not support our hypothesis. Mothers who used some harsh touch during the feeding actually had slightly higher scores for their socioemotional growth fostering behaviour with the infant ($M = 12.50$) than did the mothers who used high amounts of nurturing touch ($M = 11.42$), $t = 1.94$ (df = 18), $p < 0.06$. While these two groups were independent samples (i.e. none of the mothers using harsh touch also used nurturing touch more than 75% of their total touch), we found that
Table 3. Pearson correlations for the relationship between qualities of maternal touch and maternal caregiving behaviour ($N = 114$)

<table>
<thead>
<tr>
<th>Caregiving behaviour</th>
<th>Frequency of touch</th>
<th>Nurturing touch</th>
<th>Diversity of touch</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitivity</td>
<td>0.13</td>
<td>0.01</td>
<td>0.05</td>
</tr>
<tr>
<td>Responsiveness</td>
<td>-0.03</td>
<td>0.07</td>
<td>0.02</td>
</tr>
<tr>
<td>Socioemotional growth-fostering</td>
<td>0.12</td>
<td>0.08</td>
<td>0.06</td>
</tr>
<tr>
<td>Cognitive growth-fostering</td>
<td>0.03</td>
<td>-0.01</td>
<td>-0.04</td>
</tr>
<tr>
<td>Warmth</td>
<td>0.02</td>
<td>0.12</td>
<td>0.02</td>
</tr>
<tr>
<td>Rejection</td>
<td>0.04</td>
<td>-0.03</td>
<td>0.00</td>
</tr>
</tbody>
</table>

No coefficients are significant at $p < 0.05$.

there was a positive correlation between a mother’s use of harsh touch and her use of nurturing touch ($r = 0.61$). Because of the small sample size, this coefficient did not reach a level of significance; however, it indicated that mothers who used harsh touch were also using nurturing touch with their infants.

This finding led us to question whether a mother’s lack of any nurturing touch could be more of a marker for her overall warmth versus rejection or her socioemotional behaviour than the use of harsh touch per se. Indeed, this analysis showed that mothers who used absolutely no nurturing touch during the feeding ($n = 18$) had significantly lower scores for socioemotional growth fostering ($M = 10.7$) than mothers who used at least some nurturing touch ($M = 11.9$), $t = 2.73$ (df = 26), $p < 0.01$. In addition, the mothers who used some nurturing touch ($n = 96$) were higher in their scores for warmth toward the infant ($M = 65.2$) than mothers who used no nurturing touch at all ($M = 62.9$), $t = 2.43$ (df = 112), $p < 0.01$. No other differences between these groups were found in their caregiving behaviour.

DISCUSSION

The results of this study do indicate a potential link between the maternal touch received by low birth weight infants during their early months of life and their later psychosocial development. Our findings suggest that touch may play more of a role in the development of emotional and behavioural problems than in the evolution of adaptive social behaviour for low birth weight children. The nurturing quality of touch seems particularly important in the prevention of later problems for all low birth weight children. In contrast, frequent touching appears to place infants at risk for increased problems. This negative relationship between frequent touch and emotional/behavioural problems was strongest for infants who were less socially responsive in their early months of life. At the same time, complex maternal touch seemed to facilitate superior adaptive social behaviour for these less responsive infants. The very modest and/or nonexistent relationships between specific properties of maternal touch and a mother’s other caregiving behaviour suggest that the contribution of touch to the infant’s psychosocial development may be a distinct part of the mother’s constellation of caregiving rather than simply a marker of her overarching style.
Nurturing Touch as an Enhancement to Self-Regulation

Children of mothers who used more nurturing touch had significantly fewer emotional and behavioural problems at 2 years of age, especially fewer internalizing problems such as depression and anxiety. In contrast, children of mothers who showed evidence of any harsh touch during the feeding exhibited more problems. Lastly, there was a trend toward better adaptive ‘daily living skills’ for children receiving high amounts of nurturing touch than for children receiving any form of harsh touch. It is important to note, however, that the small size of the subsample using harsh touch limits generalizability of their data.

Our findings implicate nurturing touch as a protective factor for the child, potentially because of its contribution to the infant’s development of self-regulatory skills. There is growing interest in the idea that many of the social and emotional problems plaguing the low birth weight child are the result of deficits in self-regulation of affect and behaviour. Self-regulation develops in a sophisticated progression throughout childhood, but its early foundations appear to stem from internalization of the felt experience of maternal regulation of the infant’s emotional reactivity (Perry et al., 1995; Schore, 1998). Hofer (1987, 1993) argues that normal, maternal tactile stimulation constitutes an early stage in development of psychological self-regulation, the absence of which may have profound repercussions for internal regulatory development later in life. For instance, the child may incur later regulatory failures in behavioural control or emotional stability, manifested in outcomes such as rage, paralysing anxiety, despair, or violence.

Numerous studies have shown that soothing, comforting touch, in particular, plays an important role in reducing infant stress and regulating emotional distress (Stack and Muir, 1990; Michelsson et al., 1996; Pelaiz-Nogueras et al., 1996), often with a potency that is superior to vocal or visual communication (Grossman et al., 1985; Korner, 1990). In contrast, when a mother is physically unavailable, emotion dysregulation can occur, resulting in disorganization of affect, sleep and activity (Field, 1987, 1994). Animal models have also shown that maternal tactile stimulation regulates an infant’s activity level, vocalization, sleep–wake states, neurochemical and endocrine systems (Kehoe and Blass, 1986; Hall and Oppenheim, 1987; Hofer, 1987; Levine and Stanton, 1990; Liu et al., 1997). Even postnatal handling and petting of animals by humans appears to reduce emotional reactivity in later life, enhancing the animal’s ability to cope effectively with stressful tasks or unusual, novel conditions (Meaney et al., 1990; Gschanes et al., 1995). Our results resonate with these animal studies, suggesting that nurturing touch may serve as a protective factor for human infants in their development of regulatory strategies for coping with their emotions and their environment. Our data show that infants who receive less nurturing touch and more harsh touch show signs of more depression, anxiety and withdrawal by age 2. These findings are in concert with other human research which has indicated a link between the felt satisfaction from touch received as a child and both depression and later ability to cope with stress as an adult (Cochrane, 1990).

Diverse Touch as a Source of Enrichment

Complex or diverse maternal touch had no impact on psychosocial outcomes for more socially competent infants. But, for infants who were less responsive to their caregivers early in life, the diversity of maternal touch was linked to better
adaptive outcomes at 2 years of age. Less responsiveness is typically noted in babies with more CNS immaturity (Lester et al., 1985) so it is highly likely that the overall sensory and neural sophistication of this group of infants was limited. Specifically, there is evidence of abnormalities in synapse formation, development of neuronal connections and myelination in higher risk, low birth weight infants (Mutch et al., 1993). Under such conditions, the earlier ontological development of skin sensations may give touch special importance in providing external input to the baby about the world. In our study, more diverse touch involved the use of a broad array of tactile gestures by mothers as well as contact with a wide variety of the infant’s body parts. This enriched stimulation may provide less responsive infants (whose visual and auditory systems are not well developed) with an essential foundation of experience otherwise not available. Indeed, research has shown that infants transfer much of the information learned through touch to visual and auditory knowledge as they develop (Hatwell, 1987; Helders et al., 1988; Pineau and Streri, 1990; Rose, 1990).

Our results imply that more vulnerable infants (with less ability to respond to their environments visually or motorically) may rely, to a greater degree, on the tactile stimulation provided by mothers for much of their environmental enrichment. In contrast, the robust infant, possessing a more adequate perceptual apparatus for extracting and integrating information about the world, would be less dependent on the variety and diversity of maternal touch. These findings support other studies documenting the role of environmental stimulation in refining immature neural circuitry (Katz and Shatz, 1996). Diverse maternal touch may enhance such neural development, with implications for improvement in any cerebral dysfunction that could limit the child’s adaptive capacity and personal functioning later in life. In particular, our data suggest its effects on essential living skills such as bowel and bladder control, independent eating, and taking initial responsibility for toys and clothing.

**Frequent Touch as a Risk Factor**

Frequent touch was linked to more problems (primarily externalizing disorders) for all infants in the sample. Its specific relationship to increased aggressive and destructive behaviour raises the possibility that frequent touch is experienced by more vulnerable infants as intrusive or unwelcome. If the frequency of maternal touch is not modulated consistently, the child may eventually (a) come to see the world as an insensitive place, and (b) develop regulatory failures in emotional and behavioural control. Our results demonstrate that less responsive infants were particularly susceptible to frequent touch. For this group of babies, frequent touch accounted for an additional 6% of the variance in their likelihood of developing aggressive or destructive behaviour by age 2. These findings may again underscore the fragile and underdeveloped nervous systems of the less responsive babies. Frequent touch may especially overload their neural apparatus, impeding their ability to process the myriad stimuli to which they are exposed. Less responsive infants with more complicated courses show both a diminished ability to modulate their arousal (Aylward et al., 1984) and substantial avoidance of interaction (Bennett, 1997) in an apparent attempt to manage their arousal. In addition, the painful probing and pricking experienced by very high risk infants in the course of their medical care may create some tactile aversion in these children which impedes their ability to effectively integrate tactile input later on (DeMaio-Feldman, 1994).
Less responsive infants have fewer interactive skills available to communicate to their mothers any hyperarousal or aversion they may experience from the touch they receive. They have limited access to more sophisticated regulatory strategies such as gaze aversion or crying to help repair an intrusive or overstimulating interaction. This situation could be doubly problematic in light of the fact that mothers of smaller and less responsive infants often compensate for the baby’s inactivity by high levels of engagement and frequent stimulation of the infant (Millot et al., 1988; Spiker et al., 1993).

**Touch and the Caregiving Gestalt**

Considered as a whole, our results for the second aim provide minimal support for the hypothesis that maternal touch is a somewhat transparent reflection of the overarching caregiving style used by a mother. We found no association between either frequent or diverse touch and a mother’s other caregiving behaviour. The small number of mothers using any harsh touch limited the statistical power necessary to detect subtle relationships but we found no association between harsh touch and a mother’s rejection of her infant or her responsiveness to distress. Our finding that mothers who used harsh touch also used nurturing touch with their infants suggested that these mothers may be ‘tactually expressive’ for a spectrum of positive and negative affect. This may explain their trend toward higher scores for socioemotional growth fostering behaviour with the infant because the NCAST social-emotional growth fostering subscale assesses the affective domain of the mother’s caregiving interaction (including such behaviours as varying the pitch and tone of the voice or showing changes in facial expression toward the infant). However, the subscale also assesses interactional warmth toward the infant, a behaviour that is conceptually at odds with slapping, hitting or pinching the child. But, as noted earlier, mothers who used harsh touch did so on average only 2% of their total touch, leaving ample time for a substantial amount of nurturing touch as well.

Our one set of findings that may implicate maternal touch as a marker of the mother’s overarching caregiving style was related to nurturing touch. For more responsive infants, there was a modest relationship between use of nurturing touch and maternal warmth. However, this association did not exist for less responsive babies. The group specificity of the association and its relatively small effect size would suggest that the two variables may naturally co-occur as part of caregiving but without any clear redundancy or interdependence. Our results showing a relationship between less optimal caregiving behaviour and the absence of any nurturing touch toward the infant provided the strongest support for touch as a marker. This finding suggests that a certain basic maternal warmth and concern for the child’s socioemotional well-being may well be indexed by some equally basic display of nurturing touch.

In the main, our data support the view that specific properties of maternal touch may play a semi-autonomous role in the infant’s development while converging to some extent with other related aspects of the caregiving gestalt. This hypothesis has some support from previous research. For instance, Polan and Hofer (1999) provide evidence that different sensory modalities may play unique and essential roles in the development and survival of infants of other species, including forms of tactile stimulation. They propose a tightly specified multisensory complex with distinct roles for various sensory systems which shape the developing physiology and behaviour of the infant. Other research has also suggested a potentially autonomous role for touch in adult–infant interactions.
communication (LePage and Stack, 1992; Dickson et al., 1997; Pelaiz-Nogueras et al., 1996). While further study is necessary to elaborate the meaning of touch in a mother’s overall constellation of caregiving, our findings indicate that it is premature to assume touch is simply a marker for other caregiving attitudes or behaviour.

**Conclusion**

Prior to any application of our findings, the results of this research must be replicated and reinforced by clinical trials that test the effects of specific programmes of tactile stimulation on a variety of psychosocial parameters at regularized points throughout the child’s development. It will also be important to examine more critically the various ways in which touch may interact with other caregiving influence to influence psychosocial outcomes. However, these findings give preliminary credence to the importance of both the quality and quantity of touch experienced by low birth weight infants during their early months. Our findings support invaluable animal research regarding the role of tactile stimulation (especially nurturing touch) as a potential regulator of emotional and behavioural homeostasis in the infant. They also give piquancy to previous theories regarding the developmental importance of an enriched tactile environment, especially for more vulnerable, less responsive low birth weight infants. And for these less socially competent infants, the results speak to an urgent need for careful assessment of their individual reactions to the overall amount of touch they receive. Family interventions to sensitize parents to the potential effects of touch may inspire more optimal mental health and social adaptation for their child in the long term.

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