DISTRESS REGULATION IN INFANCY: ATTACHMENT AND TEMPERAMENT IN THE CONTEXT OF ACUTE PAIN

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ABSTRACT

Through this study, the relationship between attachment, temperamental fear, and distress regulation during infants' 12-month immunizations was examined. Two broad research questions were answered: (1) Are attachment, temperamental fear, or the interaction between the two associated with pain-related distress reactivity or pain-related distress regulation? and (2) Do infant or caregiver behaviours pre- or post-needle predict attachment? A subsample of 130 caregiver-infant dyads was recruited from an ongoing longitudinal study. Dyads were videotaped during infants' routine immunizations at 12 months and subsequently invited to participate in an assessment of attachment and temperamental fear when infants were 12 to 18 months old. Immediately prior to immunization, avoidant infants exhibited significantly less distress than secure infants. Temperamental fear moderated the relationship between attachment and pain-related distress regulation; under conditions of high temperamental fear, avoidant infants regulated distress more slowly than secure infants but under conditions of low temperamental fear, secure infants regulated distress more slowly than avoidant and disorganized infants. Infants' efforts to snuggle into caregivers following immunization increased the odds of being secure rather than avoidant or disorganized. These novel findings indicate that pain-related distress regulation at 12 months of age is influenced by a dynamic interplay between attachment and temperament. None of the analyses in the current study distinguished organized from disorganized infants, underscoring the need to identify specific behavioural markers of disorganization within the pediatric setting. Clinical implications and suggestions for future research are discussed.

DEDICATION

For my grandparents, John and Thea Mills, and Charles and Audrey Horton, who inspire me to face each day with optimism.

> Success is failure turned inside out,
> The silver tint of the clouds of doubt,
> And you never can tell how close you are,
> It may be near when it seems afar,
> So stick to the fight when you're hardest hit,
> It's when things seem worse that you must not quit. (Anonymous)

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OVERVIEW

The ability to regulate distress in infancy is linked with a number of important developmental outcomes in both the physical and mental health domains (Bradley, 2000). Efforts are needed to identify infants at risk for distress regulation difficulties and to provide early intervention. Insecure caregiver-infant attachment is associated with difficulties regulating distress in infancy, with some evidence that temperament moderates these effects (Vaughn, Bost, & van IJzendoorn, 2008). The pediatric health care setting has been proposed as an ideal context within which to identify infants at risk for attachment and distress regulation difficulties, as immunization is a distress-provoking paradigm that the majority of infants experience with their primary caregivers (Pritchett, Minnis, Puckering, Rajendran, & Wilson, 2012). However, the relationships between attachment, temperament and distress regulation within the pediatric setting must first be empirically established.

Using the Development of Infant Acute Pain Responding (DIAPR) model (Pillai Riddell, Craig, Racine, & Campbell, in press) and attachment theory (Bowlby, 1969/1982) as guides, two broad research questions were developed: (1) Are attachment, temperament (specifically, temperamental fear), or the interaction between the two associated with pain-related distress reactivity or pain-related distress regulation? and (2) Do infant or caregiver behaviours *pre-* or *post-needle* predict attachment? It was hypothesized that temperamental fear would moderate the relationship between attachment and pain-related distress regulation and that post-needle behaviours would predict attachment.

A subsample of 130 caregiver-infant dyads were recruited from an ongoing longitudinal study. Dyads were videotaped during 12-month immunizations appointments and pain-related distress as well as caregiver and infant behaviours were coded. Caregivers and infants were subsequently invited to participate in an assessment of attachment and temperamental fear. Latent growth modeling within a structural equation modeling (SEM) framework and logistic regression analyses were used to answer the research questions.

The findings partially supported the hypotheses. Immediately prior to immunization, infants with an avoidant attachment style (i.e., those who avoid caregivers under stress) exhibited less behavioural distress than infants with a secure attachment style (i.e., those who effectively use caregivers to regulate distress). However, temperamental fear moderated the relationship between attachment and pain-related distress regulation. Under conditions of high temperamental fear, avoidant infants were slower to regulate distress following immunization than secure infants. Under conditions of low temperamental fear, secure infants were slower to regulate distress than avoidant and disorganized infants. Infant "snuggling" behaviour post-needle was a significant predictor of attachment, with infants who snuggled more likely to be secure than avoidant or disorganized.

Following immunization, avoidant and disorganized infants with low temperamental fear may be able to sustain avoidant strategies or may exhibit a dissociated behavioural response, respectively. Avoidant strategies may break down, however, for avoidant infants with high temperamental fear following immunization, as these infants have no effective way to cope with high levels of stress. In comparison with secure infants who are rated as less fearful, secure infants who were rated as highly fearful may be particularly adept at using caregivers for support following immunization. The number of resistant infants in this study was small (n = 8), which may have limited the power to detect differences between the resistant and secure groups. None of the analyses in the current study distinguished organized from disorganized infants. There is a need to identify clear and specific behavioural markers of disorganization, the attachment classification associated with the most maladaptive outcomes, in pediatric settings in order to provide early support for this vulnerable group.

The novel results extend previous research and empirically support attachment theory and the DIAPR model as a biopsychosocial model of acute pain in infancy. By 12 months, the ability to regulate pain-related distress is influenced by a dynamic interplay between attachment and temperament. The ways in which an infant regulates distress from medical procedures that cause acute pain may shed light on characteristics pertaining to infants' temperament and attachment, allowing for early identification of infants at risk for developing problems related to emotion regulation.

Introduction

> It is evident that the particular pattern taken by any one child's attachment behaviour turns partly on the initial biases that infant and mother each bring to their partnership and partly on the way that each affects the other during the course of it. (Bowlby, 1969/1982, p. 340)

Emotion Regulation as a Developmental Construct

The ability to regulate emotion is of critical importance to mental and physical well-being throughout life (Bradley, 2000; Cole, Michel, & Teti, 1994; Posner & Rothbart, 2000; Rosenblum, Dayton, & Muzik, 2009). While descriptions of emotion regulation vary across studies, Thompson (1994) provides a widely cited and comprehensive definition that is adopted herein:

> Emotion regulation consists of the extrinsic and intrinsic processes responsible for monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features, to accomplish one's goals (pp. 27-28).

According to Thompson's definition, emotion regulation is a complex and multidimensional process that relates to how an individual modulates her emotional reactions. Calkins and Hill (2007) note that the processes related to the regulation of emotion (e.g., "monitoring, evaluation, and modifying") may be conscious and effortful or unconscious and automatic. Thompson further draws attention to the importance of both the "intensive and temporal features" of emotion, that is, how much emotion is expressed and how emotion changes over time. Notably, Thompson suggests that what is considered adaptive or maladaptive emotion regulation depends on a number of contextual factors, including an individual's goals within a given situation.

Emotion regulation finds its roots in infancy, when extrinsic and intrinsic processes interact to lay the foundation for regulatory capacities across the lifespan (Bradley, 2000; Dodge, 1989; Rothbart, Ziaie, & O'Boyle, 1992; Thompson, 1994; Trevarthen, 2009). The ability to regulate distress, in particular, has been well studied in infancy. Across studies, difficulty regulating distress in infancy (e.g., taking a longer period of time to return to baseline levels of non-distress following a stressful event) is linked to a number of maladaptive developmental outcomes including those in the behavioural (Stifter, Spinard, & Braungart-Rieker, 1999), cognitive (Calkins & Marcovitch, 2010) and mental health domains (DeGangi et al., 2000). Given the impact of distress regulation in infancy on adaptive functioning later in life, early intervention for infants who exhibit difficulty regulating distress is of great importance.

Distress Regulation, Attachment and the Strange Situation Procedure

A central factor in the developmental of distress regulation that is also amenable to intervention (Bakermans-Kranenburg, van IJzendoorn, & Juffer, 2003) is the caregiver-infant attachment relationship (Bowlby, 1969/1982). While the caregiver plays different roles in a child's life (e.g., teacher, play-mate, mentor), the role the caregiver plays in responding to the infant's distress characterizes the attachment relationship (Goldberg, Grusec, & Jenkins, 1999). In his three volume treatise (1969/1982), Bowlby integrates theory and evidence from evolutionary and behavioural psychology, ethology, and biology to illustrate the critical importance of the caregiver-infant attachment relationship to emotional well-being throughout development. Although the majority of primary caregivers are mothers, the term "caregiver" is used in this paper to recognize the variety of caregivers who may be primarily responsible for an infant's care (e.g., fathers, grandparents).

The caregiver-infant attachment relationship begins to develop over the first year of life and is postulated to be the initial mechanism through which the developing person learns to regulate distress (Cassidy, 1994; Schore, 2000). All infants are dependent on their caregivers for survival due to physical and cognitive immaturity. According to attachment theory, infants are born with an instinctual predisposition to exhibit attachment behaviours (e.g., crying) when internal and external factors threaten infants' safety (Bowlby, 1969/1982). Infants' attachment behaviours have the set goal of soliciting proximity and care from caregivers, thereby increasing infants' safety and chances of survival. For example, conditions of pain and hunger trigger crying in most infants, and caregivers typically respond to these cries with efforts to address the needs of distressed infants. Caregivers, therefore, act as the external regulators of infants' distress, providing infants with protection and a sense of security under conditions of threat.

Through multiple interactions over the first year of life, an infant comes to recognize his or her caregiver as either able or unable to provide comfort when in distress. At the same time, the infant comes to recognize his or her own actions as either effective or ineffective at soliciting care. These "working models" of the caregiver and of the self set the foundation for patterns of attachment and distress regulation across the lifespan (Bowlby, 1969/1982). While infants are initially heavily dependent on caregivers to help them to regulate distress, children become increasingly self-reliant over the course of development as they gradually internalize regulatory processes and progress towards "self-regulation" (Calkins, 1994; Dodge, 1989). Although patterns of attachment emerge as early as four months, due to the initial plasticity of infants' developing emotional, social, and behavioural systems, the attachment relationship is not considered stable or reliably measured until 12 months of age (Ainsworth, Blehar, Waters, & Wall, 1978).

Based on Bowlby's revolutionary work, Ainsworth and colleagues developed the Strange Situation Procedure (SSP; Ainsworth et al., 1978; Ainsworth & Wittig, 1969), a controlled laboratory procedure designed to elucidate the quality of an infant's attachment relationship by inducing stress through separation from the caregiver. The SSP is the authoritative measure of attachment in infants 12 to 18 months of age and has been validated by over 30 years of research. At the beginning of the SSP, the caregiver and infant are introduced to a novel room where the infant is free to explore age-appropriate toys and his or her surroundings. The SSP consists of eight brief episodes during which a research assistant (RA) who acts as a "stranger" (i.e., the caregiver and infant have not met the RA previously), the caregiver, and the infant undergo a series of interactions, reunions, and separations that solicit attachment behaviours by placing cumulative stress on the attachment system (Appendix A). Based on behaviours exhibited during the SSP, particularly during two "reunion" episodes between the caregiver and infant following brief separations, an infant is classified as avoidant, secure, resistant, or disorganized. These four attachment classifications have different implications for the regulation of distress in infancy. The SSP is considered a mild-to-moderate stressor which represents situations that caregivers and infants are likely to experience in their day-to-day interactions (i.e., brief separations that last no more than 3 minutes).

Attachment and Prototypical Caregiver-Infant Interactions during Distress

Caregivers of secure infants are characterized as sensitive to infants' attachment needs. These caregivers respond promptly, appropriately, and consistently to infants' distress signals, are emotionally expressive, and are accepting of infants' negative and positive affect (Ainsworth et al., 1978). It follows that the secure infant is theorized to develop a working model of the caregiver as a reliable figure who provides feelings of safety during times of distress and a working model of the self as capable of soliciting support from the caregiver (Cassidy, 1994). Secure infants are comfortable openly expressing distress (e.g., crying) that matches their internal state, neither minimizing nor amplifying behavioural signals of distress. Secure infants have come to expect that their distress cues will solicit support from caregivers, thereby restoring feelings of safety and effectively regulating distress. Secure infants will therefore neither ignore nor resist interaction with caregivers when distressed and will actively use the caregiver as a "secure base" from which to explore when not distressed (Cassidy, 1994).

Caregivers of avoidant infants are characterized as rejecting of infants' attachment needs. These caregivers are slow to respond to infants' distress signals, exhibit a restricted range of emotional expressivity, and are uncomfortable with close body contact, particularly when their infants are distressed (Ainsworth et al., 1978). The avoidant infant is therefore likely to develop a working model of the caregiver as unwilling or unable to provide feelings of safety during times of distress and a working model of the self as unable to solicit support from the caregiver when distressed. Under conditions of stress, avoidant infants will minimize behavioural distress signals and evade interactions with caregivers in order to avoid rejection which, ultimately, exacerbates stress (Cassidy, 1994).

Caregivers of resistant infants are characterized as inconsistently responsive to infants' attachment needs. These caregivers are at times sensitive and at other times insensitive to infant distress, inept in physical comfort (e.g., preferring to use a distraction strategy than close physical soothing), and typically less rejecting than mothers of avoidant infants (Ainsworth et al., 1978). The resistant infant is theorized to develop a working model of the caregiver as inconsistent in his or her ability to provide feelings of safety under conditions of stress and a working model of the self as inconsistent in his or her own ability to solicit comfort when distressed. Subsequently, resistant infants heighten behavioural signals of distress in order to solicit support from caregivers and have difficulty exploring their environments away from caregivers, even under conditions that pose little to no threat (Cassidy, 1994).

Subsequent to the development of the SSP, Main and Solomon (1990) observed infant behaviours in the SSP that were difficult to classify as secure, avoidant, or resistant. These behaviours constituted a fourth attachment classification referred to as "disorganized." Caregivers of disorganized infants behave atypically, acting in dissociated, disoriented, frightened, or frightening ways towards the infant (Lyons-Ruth, Bronfman, & Parsons, 1999; Madigan et al., 2006; Out et al., 2009). As a result of atypical, often unpredictable, parenting behaviours, these caregivers are themselves a source of stress to the infant. Subsequently, infants have no clear way to organize their feelings of distress, wanting at once to be close to and to distance themselves from caregivers when the attachment system is activated. It follows that disorganized infants have no effective way of regulating distress, as they have not established clear expectations or working models of either the caregiver or the self when in distress (Beebe et al., 2012). The disorganized attachment category is overrepresented in high risk, clinical groups, including those in which infants have been the victims of maltreatment (van IJzendoorn, Schuengel, & Bakermans-Kranenburg, 1999). Using the *Indices of Disorganization and Disorientation* (Main & Solomon, 1990), the episodes in which the infant and caregiver are together are coded for the presence or absence of disorganized behaviours.

Attempts are first made to classify an infant into one of the "organized" attachment classifications: avoidant (A), secure (B), or resistant (C). The *Indices of Disorganization and Disorientation* is then used to code disorganized behaviours. Depending on the extent of disorganized behaviours observed during the SSP, an infant may or may not be classified as disorganized (D). An infant who is classified as disorganized (D) may display contradictory patterns of organized attachment behaviours (e.g., crying loudly for the caregiver while simultaneously moving away from the caregiver). Although infants with a D classification may have an underlying organized attachment style, each infant is ultimately classified into one of the four attachment styles: avoidant (A), secure (B), resistant (C) or disorganized (D; Solomon & George, 2008).

A meta-analysis of middle class, nonclinical samples in North America indicated that the distribution of attachment groups is approximately 15% avoidant, 62% secure, 9% resistant, and 15% disorganized (van IJzendoorn et al., 1999), similar to Ainsworth and colleagues' (1978) and Main and Solomon's (1990) original distributions. Attachment classifications measured in the SSP are predictive of infant and caregiver behaviours observed in the home (Ainsworth et al., 1978; Vaughn & Waters, 1990), underscoring the ecological validity of this procedure (Solomon & George, 2008). Furthermore, Fraley (2002) demonstrated in a meta-analysis that correlations between attachment measured using the SSP at 12 months and attachment measured between 13 and 20 months were between .40 and 1.00 for low risk samples, demonstrating that attachment is relatively stable within dyads over time.

Measuring Caregiver-Infant Attachment Using the SSP

In order to assess the caregiver-infant attachment relationship during the SSP, Ainsworth and colleagues (1978) developed the *Scoring System for Interactive Behaviours* (SSIB) in which four scales are used to code infant behaviour:

(1) Proximity- and Contact-Seeking: The intensity and persistence of the infant's efforts to gain (or to regain) proximity to or contact with the caregiver.

(2) Contact-Maintaining: The degree of activity and persistence in the infant's efforts to maintain contact with the caregiver once he or she has gained it.

(3) Resistant: The intensity and frequency or duration of resistant behavior (e.g., angry distress, temper tantrums involving kicking, pushing the caregiver away) evoked by the caregiver's initiations for contact, proximity, or play interactions.

(4) Avoidant: The intensity, persistence, duration, and promptness of the infant's avoidance of proximity and interaction with the caregiver even across a distance (e.g., averting gaze, turning the head or body away, hiding the face, ignoring the caregiver).

Each of the above scales is rated 1 to 7, where "1" is indicative of little or no behaviour and "7" is indicative of a strong expression of the behaviour. Based on the infant's behaviour in the SSP across the four scales, particularly when the infant is reunited with the caregiver following two brief separations (episodes 5 and 8), the infant is classified into one of three "organized" attachment classifications: secure (referred to as the "B" group), avoidant (referred to as the "A" group), or resistant (referred to as the "C" group).

Infants who receive moderate scores on the Proximity- and Contact-Seeking and Contact-Maintaining scales and scores that substantially decrease or remain low from episode 5 to 8 on the Resistant and Avoidant scales in the SSP are classified as secure. Secure infants (B) may or may not be distressed during the SSP separation episodes, but demonstrate clear greetings with their caregivers upon reunion (e.g., visually acknowledging the caregiver or physically approaching the caregiver) and are able to regulate distress effectively by using caregivers for support (e.g., actively seeking physical contact with caregivers).

Infants who receive low to moderate scores on the Proximity- and Contact-Seeking, Contact-Maintaining, and Resistant scales and scores that substantially increase or remain high from episode 5 to 8 on the Avoidance scale in the SSP are classified as avoidant. Avoidant infants (A) may or may not become distressed during the separation episodes of the SSP and will tend to ignore caregivers upon reunion, exhibiting minimal behavioural distress. Avoidant infants spend much of their time in the SSP exhibiting "low quality play" (Spangler & Grossmann, 1993), rarely using the caregiver as a secure base. Although avoidant infants exhibit minimal distress during the reunion episodes and seemingly take a short time to regulate distress, they have been shown to be equally or more physiologically stressed than secure infants (Hill-Soderlund et al., 2008; Spangler & Grossmann, 1993), suggesting that there is a mismatch between external behavioural displays of distress and internal stress states in avoidant infants.

Infants who receive high scores on the Proximity- and Contact-Seeking and Contact-Maintaining scales, scores that substantially increase or remain high from episode 5 to 8 on the Resistant scale, and low scores on the Avoidance scale in the SSP are classified as resistant. Resistant infants (C) typically become highly distressed during the separation episodes of the SSP. During reunion episodes, resistant infants exhibit a mixture of signaling caregivers for proximity or comfort (e.g., clambering up and clinging strongly to caregivers) while also actively resisting contact and interaction with caregivers by exhibiting angry, rejecting behaviour towards the caregiver (e.g., back arching and temper tantrums). These infants have difficulty regulating distress and require more time to soothe than either secure or avoidant infants, even though the caregiver is nearby and may attempt to provide comfort.

Using the *Indices of Disorganization and Disorientation* (Main & Solomon, 1990) as a guide, if the infant is observed to display atypical behaviours in the SSP that appear at odds with his or her underlying "organized" attachment classification (i.e., A, B or C), he or she may be classified as disorganized (referred to as the "D" group; Main, Solomon, Brazelton, & Yogman, 1986; Main & Solomon, 1990). The episodes in which the infant and caregiver are together (i.e., episodes 1, 2, 3, 5, and 8) are coded for disorganized behaviours on a 1 to 9 point scale with "1" signifying unsubstantiated disorganized behaviours and "9" signifying extreme disorganized behaviours. A total "D" score is assigned based on the number and intensity of disorganized behaviours observed and a cut-off score of 5 is used to determine a D classification. Infants with a D score of 5 may or may not be classified as disorganized (the coder must make a clinical judgment) whereas infants with a D score above 5 are automatically classified as D.

There are numerous ways to compare attachment classifications derived from the SSP. These comparisons allow researchers to compare attachment styles that differ in terms of their risk for difficulties pertaining to emotion regulation and mental health. The four-level A/B/C/D comparison examines differences between the secure (B), avoidant (A), resistant (C), and disorganized (D) groups separately. The secure attachment group is the lowest risk group for problems related to emotion regulation and is therefore commonly used as the comparison group in the A/B/C/D comparison. The ways in which avoidant and resistant infants regulate distress are theoretically and qualitatively distinct and it is therefore important to examine these groups separately. Alternatively, the two-level secure/insecure comparison compares the secure group with the insecure group made up of all avoidant (A), resistant (C) and disorganized (D) infants. This comparison allows for a direct examination between the low-risk (i.e., secure) and high-risk (i.e., avoidant, resistant and disorganized) group as a whole. The two-level organized/disorganized comparison groups the avoidant (A), secure (B) and resistant (C) infants together as the "organized" group and compares this group with the disorganized (D) group. As the disorganized group is considered the highest risk group, it is important to determine whether this group is distinct from all other groups using the organized/disorganized comparison.

Attachment and Distress Regulation Outside of the SSP

Sroufe and Waters (1977) asserted that behaviours related to attachment are predictable within the context of distress. This notion has been supported by research which has shown that, in stressful contexts other than the SSP, differences in infant behaviour emerge in predictable patterns according to attachment. For example, secure infants are more likely to seek social support from caregivers and are less physiologically stressed during challenging laboratory tasks than avoidant or disorganized infants (Schieche & Spangler, 2005). In laboratory tasks designed to elicit either frustration or fear, resistant infants spend a significantly greater proportion of time in distress and exhibit stronger distress behaviours (e.g., tantrums) than secure and avoidant infants, while avoidant infants spend less time in active mother-oriented behaviours (e.g., looking at mother, seeking proximity to mother) than secure and resistant infants (Leerkes &

Wong, 2011). These findings suggest that by the end of the first year of life, infants have developed attachment-related patterns of distress regulation behaviours that are predictable and stable across contexts.

Attachment differences in the behavioural response to stress have been associated with long-term developmental outcomes (Ranson & Urichuk, 2008). For example, infants classified as secure in the SSP are more socially competent in toddlerhood than insecure infants (Lutkenhaus, Grossmann, & Grossmann, 1985; Matas, Arend, & Sroufe, 1978; Sroufe, Egeland, Carlson, & Collins, 2005; Waters, Wippman, & Sroufe, 1979). Infants classified as resistant in the SSP at 12 months were more likely to exhibit anxiety disorders at 17.5 years of age, controlling for maternal anxiety and infant temperament (Warren, Huston, Egeland, & Sroufe, 1997). Infants classified as disorganized in the SSP are at highest risk for developing psychopathologies related to maladaptive emotion regulation (or "dysregulation") later in life in comparison with secure, avoidant, and resistant infants (van IJzendoorn et al., 1999). In the Minnesota Study of Risk and Adaptation from Birth to Adulthood, a landmark prospective longitudinal study of attachment spanning four decades, children identified as disorganized in infancy were more likely to exhibit dissociative behaviours and internalizing symptoms in childhood and higher levels of psychopathology at 17 years (Carlson, 1998). The predictive power of attachment in infancy with regards to outcomes related to self-regulation has led researchers to conceptualize attachment theory as, fundamentally, a theory of emotion regulation (Cassidy, 1994; Schore, 2000; Schore & Schore, 2008). In effect, the caregiver-infant attachment relationship is postulated to be the critical mechanism underlying emotion regulation abilities in the developing person.

Temperament and Distress Regulation

In addition to attachment, temperament is theorized to influence distress regulation, with some infants more prone to high distress reactivity and difficulties regulating distress than others (Rothbart & Sheese, 2007). Indeed, temperament is defined as "individual differences in reactivity and self-regulation" (Rothbart & Derryberry, 1981, p. 40). Although temperament was widely regarded as biologically-based, researchers now recognize temperament as the "product of complex interactions among genetic, biological, and environmental factors across time" (Shiner, Buss, McClowry, Putnam, Saudino & Zentner, 2012, p. 437).

Prior to examining the literature in this area, it is important to note that researchers have examined different dimensions of temperament depending on the goals of a given study. For example, some researchers have investigated the more general construct of "temperamental reactivity," defined as behavioural and physiological excitability, responsivity, or arousability (Rothbart & Derryberry, 1981). Other researchers have investigated a specific dimension of temperament (e.g., temperamental fear) depending on the theoretical underpinnings of the study. In general, "high temperamental reactivity" refers to proneness towards strong emotional reactions to arousing events, whereas specific temperamental dimensions, such as temperamental fear, relate to more narrowly-defined behavioural responses (e.g., behaviours related to temperamental fear will be salient during frightening events).

The way in which temperament is measured varies across studies, with researchers using either caregiver-report or laboratory observation of infant behaviour. Caregiver-report of infant temperament offers an advantage over a single observational laboratory visit in that caregivers provide an aggregate reflection of infant temperament across settings and time. Caregiver-reports may be influenced by caregiver characteristics such as depression, particularly within clinical samples (Parade & Leerkes, 2008). However, maternal ratings of temperament using the Infant Behavior Questionnaire – Revised (IBQ-R; Gartstein & Rothbart, 2003), a gold standard measure of infant temperament, are correlated with observational ratings of temperament and father's ratings of temperament, demonstrating convergent validity and inter-rater reliability, respectively, of this caregiver report measure (Parade & Leerkes, 2008).

Research has demonstrated an association between early temperament and distress regulation outcomes in later childhood and adolescence. For example, mother-rated temperamental fear in infancy is related to internalizing problems in toddlerhood (Gartstein et al., 2010). Difficult temperament in infancy is also associated with externalizing problems in childhood (Guerin, Gottfried, & Thomas, 1997). Maternal-reported temperamental fear in infancy and childhood has been associated with increased odds of developing social anxiety in adolescence (Chronis-Tuscano et al., 2009). Temperament has also been shown to impact the regulatory behaviours that infants exhibit when distressed. For example, Mangelsdorf, Shapiro, and Marzolf (1995) found that infants rated as temperamentally fearful by mothers spend more time in close proximity with mothers, engaged in more frequent and longer gaze aversion from strangers, more self-soothing, and less self-distraction than non-fearful or "bold" infants during stressful laboratory interactions with a stranger.

Attachment, Temperament, and Distress Regulation

A long-standing debate in the field of developmental psychology is whether attachment and temperament are, in effect, one construct or two (see Mangelsdorf & Frosch, 1999). In a classic study of the relationship between attachment and temperament, Belsky and Rovine (1987) found associations between maternal ratings of infants' difficult temperament at 3 months and the SSIB scores derived from the SSP when infants were 12 to 13 months of age. Specifically, avoidant infants and secure infants with less active proximity- and contact-seeking and contact-maintaining behavior were rated as less temperamentally difficult than resistant infants and secure infants with more active proximity- and contact-seeking and contact-maintaining behavior. The difference in temperament between these groups is commonly referred to as the "Belsky-Rovine split" (Vaughn et al., 2008).

Belsky and Rovine's (1987) findings have been replicated and extended in a number of studies (Braungart-Rieker, Garwood, Powers, & Wang, 2001; Marshall & Fox, 2005; Sroufe et al., 2005; Thompson, Connell, & Bridges, 1988). For example, Marshall and Fox (2005) found that temperamental negativity at 4 months of age predicted whether infants used more proximity- and contact-seeking and contact-maintenance behaviour in the SSP at 14 months of age, but was not related to attachment security. In terms of disorganized attachment, a meta-analysis found virtually no relationship between disorganization and temperament (van IJzendoorn et al., 1999). These studies have quelled the attachment-temperament debate and it is generally accepted that temperament and attachment are separate, but related, constructs: although temperament may play a role in how infants express and regulate distress, the quality of infant-caregiver interaction distinguishes security from insecurity (Sroufe, 1985; Vaughn et al., 2008).

Given the well-established roles of both attachment and temperament in the regulation of distress in infancy, researchers have more recently turned their attention to the interactive effects of temperament and attachment on emotion regulation (Calkins & Hill, 2007; Stevenson-Hinde, 2005; van IJzendoorn & Bakermans-Kranenburg, 2012; Vaughn et al., 2008). Researchers in this field have asserted that it is the dynamic interplay between infant characteristics such as temperament, and environmental influences, such as attachment, that shape emotion regulation capacities in infancy and across the lifespan (Keenan, 2000).

Rothbart and Bates (1998) suggested that infants at the extremes of the temperamental distribution (e.g., extremely high or low temperamental fearfulness) may be among the most vulnerable in terms of the development of emotion regulation difficulties. Research has subsequently pointed to the "dual risk" of insecure attachment and extremes in temperament to maladaptive distress regulation. For example, caregiver-reported high negative emotionality at 11 months of age, insecure attachment at 15 months of age (assessed in the SSP), and caregivers' perceived low control over child behaviour and development predicted significantly more psychosomatic problems in childhood (Hagekull & Bohlin, 2004). In another study, infants classified as avoidant at

14 months of age and who were temperamentally uninhibited (i.e., low temperamental fear) at 24 months exhibited a higher incidence of externalizing behaviour problems at 4 years (Burgess, Marshall, Rubin, & Fox, 2003). It has also been shown that infants who exhibited a negative mood, had low cognitive scores, and were insecurely attached as infants were more likely to exhibit affect dysregulation as toddlers and had more cognitive, social, and behavioural problems at 4.5 years of age (NICHD Early Child Care Research Network, 2004). In studies examining maternal sensitivity, the combination of insensitive maternal behaviour (characteristic of insecure attachment) and highly reactive infant temperament predicted both externalizing (Crockenberg, Leerkes, & Bárrig Jó, 2008) and internalizing (Crockenberg & Leerkes, 2006) problems in toddlerhood.

In contrast to research evidencing a dual risk for insecure attachment and extremes in temperament, Belsky, Bakermans-Kranenburg, and van IJzendoorn (2007) have proposed a "differential susceptibility" hypothesis that high temperamental reactivity (e.g., high fearful temperament) renders infants susceptible to environmental influences (e.g., caregiving) "for better and for worse." In effect, infants with high temperamental reactivity are more prone to the deleterious effects of insensitive caregiving characteristic of insecure attachment but also more likely to profit from the beneficial effects of sensitive caregiving characteristic of secure attachment (Belsky, 1997). Consequently, insecure infants with high temperamental reactivity will exhibit the least adaptive developmental outcomes while secure infants with high temperamental reactivity will exhibit the most adaptive developmental outcomes. Infants with either insecure or secure attachment styles but who have moderate levels of temperamental reactivity will fall between these two groups in terms of the adaptive quality of developmental outcomes.

Preliminary research supports the differential susceptibility hypothesis. For example, infants at 6 and 9 months of age who exhibited highly fearful responses and low reliance on mothers during laboratory-based challenges and whose mothers reported low psychological resources had the worse cognitive and language outcomes at 2 years of age (Robinson & Acevedo, 2001). Conversely, infants in this study who displayed high emotionality (positive, angry, and fearful reactions) and who exhibited high reliance on mothers had higher cognitive and language skills at 2 years compared with infants who displayed low emotionality and low reliance on mothers. Synchronous caregiver-infant interactions at 9 months and high temperamental difficulty (assessed at 3 and 9 months) predicted higher self-control (i.e., more compliance, less distress, and more cooperative behaviour) during a clean-up task at 2 years, while less synchronous caregiver-infant interactions and high temperamental difficulty predicted less self-control (Feldman, Greenbaum, & Yirmiya, 1999). Although these studies did not examine attachment directly, they suggest that the caregiver-infant relationship interacts with temperament to predict adaptive or less adaptive developmental outcomes, depending on the quality of the relationship. Further research is needed to clarify the ways in which temperament, attachment and emotion regulation are related in contexts that elicit distress.

The Pediatric Pain Context: An Optimal Setting in Which to Study the Influence of Attachment and Temperament on Distress Regulation

As outlined above, multiple studies point to the importance of infant attachment and temperament to distress regulation and long-term wellbeing. The importance of early intervention with dyads at risk for difficulties regulating distress is therefore of critical importance (C. Zeanah & P. Zeanah, 2009). P. Zeanah and Gleason (2009) argue that by integrating infant mental health into primary pediatric health care, early intervention is not only possible, but has the potential to benefit a large number of caregivers and infants. In Canada, the majority of caregivers and infants are seen regularly over the first year of life by health care practitioners during scheduled "well baby" visits at 2, 4, 6, and 12 months of age that include routine immunization (National Advisory Committee on Immunization, 2006). These appointments provide multiple opportunities for caregiver-infant dyads to be screened for potential disruptions in interaction that impact distress regulation and to be offered appropriate intervention should problems persist.

In addition to regular visits over the first year of life, the immunization procedure provides a controlled and distress-provoking paradigm with comparable stimuli and procedures across appointments at different ages. Consequently, the consistency in immunization procedures over the first year of life has the potential to allow health care professionals to discern adaptive from maladaptive patterns in pain-related distress regulation. The identification of overt and easily observable behaviours associated with maladaptive patterns of distress regulation is needed to help health care professionals differentiate low risk from high risk dyads. Once dyads at risk for emotion regulation difficulties are identified, health care professionals can offer *in situ* support for caregivers (e.g., in-the-moment feedback, access to educational materials or referrals to mental health professionals) to help them to better support their infants in distress.

Linking known child risk factors (e.g., insecure/disorganized attachment, extremes in temperamental fear, hostile parenting behaviours) to the regulation of pain-related distress from immunization offers an unparalleled opportunity to integrate mental and physical health. For example, if patterns in pain regulation that are associated with disorganized attachment are identified, interventions aimed at ameliorating the quality of the attachment relationship may be offered. There is a strong body of research demonstrating empirically-supported treatments for caregivers and infants with insecure attachment relationships (Bakermans-Kranenburg, Breddels-van Baardewijk, Juffer, Velderman, & van IJzendoorn, 2008; Bakermans-Kranenburg, van IJzendoorn, & Juffer, 2003). Brief interventions (5 sessions or less) have been shown to improve both caregiver sensitivity and attachment security (Bakermans-Kranenburg et al., 2003). These interventions have the potential to improve distress regulation both during doctors' appointments and outside of the healthcare setting as caregivers learn to better manage their infants' distress, ultimately improving emotion regulation outcomes for infants in the long-term.

Immunization: A Pain-Related Distress Regulation Paradigm

The regulation of pain-related distress in infancy due to medical procedures has been well-studied. Pain that is under-managed in infancy is linked with difficulties regulating pain-related distress and is associated with suboptimal health outcomes later in childhood, including lower pain thresholds (Taddio, Katz, Ilersich, & Koren, 1997;

Taddio, Shah, Gilbert-MacLeod, & Katz, 2002) and chronic pain syndromes (Mitchell & Boss, 2002). Despite the known negative outcomes related to under-managed infant pain, pain from acute pediatric medical procedures continues to be poorly managed (Sharek, Powers, Koehn, & Anand, 2006) with few established and effective non-pharmacological strategies available to decrease older infants' (i.e., 1 month to 3 years) distress from pain (Pillai Riddell et al., 2011). As such, there is an urgent need to improve clinical pain management practices for infants (Taddio et al., 2010).

An important point should be made regarding the timing of a child's response to an acutely painful stimulus. Based on Ramsay and Lewis' definitions (2003), "pain-related distress reactivity" refers to the infant's immediate reaction to an acutely painful stimulus (e.g., first 15 seconds post-immunization). "Pain-related distress regulation," on the other hand, refers to the recovery from an acutely painful stimulus or the time that it takes for an infant to become physiologically or behaviourally settled within a set time period post-immunization (Ramsay & Lewis, 2003). In this way, the definition of pain-related distress regulation echoes Thompson's (1994) definition of emotion regulation introduced above and represents the processes responsible for regulating pain-related distress reactivity.

Given that infant distress is generally present during all pediatric immunization appointments (Pillai Riddell et al., in press) the well-baby visit provides a commonly occurring distress paradigm in which to assess the impact of attachment and temperament on emotion regulation. Moreover, immunization is similar to the SSP in that the infant is introduced to a generally unfamiliar room and unfamiliar adults approach and interact with the infant (Favez & Berger, 2011). However, instead of separation from the caregiver as the trigger of the attachment system in the SSP, acute pain threatens the infant's sense of safety and triggers the attachment system in the context of immunization (Bowlby, 1969/1982). Therefore, while some infants' attachment systems may be mildly triggered pre-needle (due to the novelty of the examination room and interacting with unfamiliar health care professionals), the attachment system is expected to be strongly triggered for all infants upon administration of the needle.

Attachment and Temperament in the Context of Acute Pain

Immunization is both a painful and frightening experience for the infant who is unable to understand, predict, or control the procedure (Pillai Riddell & Horton, 2007). It follows that, in addition to attachment, temperamental fear should also be triggered during immunization. Fear develops in the latter half of the first year of life (Gartstein & Rothbart, 2003), when infants exhibit inhibitory responses to unfamiliar situations, stimuli, and people; factors which are all present during immunization. In this way, the development of temperamental fear coincides with the development of attachment.

By the end of the first year of life, infants have undergone multiple immunization procedures (at 2, 4, and 6 months of age). At the 12-month appointment, some infants exhibit distress immediately prior to receiving an immunization, suggesting that an anticipatory distress response (likely involving anxiety or fear) has developed as a result of pairing the painful stimulus (i.e., the needle) with the immunization appointment over multiple visits over the first year of life (Horton, Jalal, Pillai Riddell, Garfield, & Greenberg, 2011). Although fear and attachment develop during similar periods in development, they are seen as working in tandem as opposed to being synonymous constructs. A fearful emotional response will trigger the attachment system, however, Bowlby (1968/1982) notes that fear and the attachment system work in fundamentally different ways: while fear drives the infant away from threatening stimuli (e.g., by inhibiting the infant's approach to or mobilizing the infant away from a frightening stimulus), the attachment system drives the infant towards the primary caregiver under conditions of threat.

A number of variables have been shown to influence the infant's pain-related distress response to immunization. Variables that influence the infant pain response include the sex of infant (with female infants exhibiting higher pitched cries that male infants; Fuller, 2002), the number of needles infants receive (with more needles related to greater pain response; Klassen & Craig, 2007), medication provided pre-needle (with medication shown to attenuate the infant pain response; Halperin, McGrath, Smith, & Houston, 2000; O'Brien, Taddio, Ipp, Goldbach, & Koren, 2004) and pre-needle "baseline" distress (with higher baseline distress associated with higher pain-related distress reactivity and slower pain-related distress regulation; Ahola Kohut & Pillai Riddell, 2009; Hillgrove-Stuart, Pillai Riddell, Horton, & Greenberg, in press). Subsequently, these variables should be controlled in studies linking psychosocial variables such as attachment or temperament to pain in infancy.

Reviews of research in pediatric pain have asserted the importance of parents in influencing the infant pain response (Pillai Riddell & Racine, 2009). Research indicates that caregivers' behaviour during immunization impacts infants' pain-related distress-reactivity and regulation (e.g., Blount, Devine, Cheng, Simons, & Hayutin, 2008; Cohen, Bernard, McClellan, & MacLaren, 2005; Din, Pillai Riddell, & Gordner, 2008; Horton & Pillai Riddell, 2010; Pillai Riddell, Stevens, Cohen, Flora, & Greenberg, 2007). However, pediatric pain researchers have only recently begun to incorporate attachment theory into conceptualizations of the infant pain experience (Porter, Davis, & Keefe, 2007) despite Bowlby's (1969/1982) original assertion that pain will trigger the attachment system.

Studies examining the role of caregivers within the context of pediatric pain suggest that caregiving plays an influential role in infants' pain experiences. Maternal sensitivity during times of infant distress (i.e., attentiveness to infant distress signals, knowledge of their meaning, and appropriate responsiveness) is modestly associated with attachment, with more sensitive caregiving associated with secure attachment and less sensitive caregiving associated with insecure attachment (De Wolff & van IJzendoorn, 1997; Leerkes, 2011; McElwain & Booth-LaForce, 2006). One study found that maternal sensitivity accounted for 35% of the variance of pain behaviors exhibited by 18-month-olds undergoing immunization (Sweet, McGrath, & Symons, 1999). Specifically, infants of sensitive mothers expressed more pain-related distress reactivity (i.e., the immediate response to pain) than infants of less sensitive mothers. This finding supported the hypothesis that infants of sensitive mothers would be more comfortable openly expressing distress in the presence of caregivers who consistently respond to these signals. Although the authors found a direct positive association between infant temperamental difficulty and pain response among 6 month-olds, these associations were not confirmed among 18-month-olds.

In contrast to the work of Sweet et al. (1999), research from our lab found that maternal sensitivity (as measured by maternal emotional availability) predicted infant pain-related distress such that infants of more sensitive and appropriately responsive caregivers exhibited less pain immediately post-needle and 1minute post-needle than infants of less sensitive mothers (Din et al., 2008). The authors note that sensitive caregiving may help infants to regulate distress from pain and that less-sensitive caregiving (i.e., intrusive behaviours) may exacerbate infant distress following immunization. Additional research suggests that the influence of maternal sensitivity on the infant pain response grows stronger over the first year of life, with greater sensitivity associated with an attenuated pain response during the 12-month immunization appointment (Pillai Riddell et al., 2011). Given the equivocal nature of the findings from studies investigating associations between maternal sensitivity and infant pain, more work is needed.

Studies involving older children (more than 3 years old) have shown that attachment variables are related to pain in predictable ways (Bretherton, Ridgeway, & Cassidy, 1990; George & Solomon, 1996; Green, Stanley, Smith, & Goldwyn, 2000; Walsh, McGrath, & Symons, 2008; Walsh, Symons, & McGrath, 2004). For example, children classified as "controlling" (comparable to the disorganized, or D classification) had higher pain ratings and took longer to regulate pain-related distress (assessed during immunizations and everyday pain events) than children from secure attachment groups

(Walsh et al., 2008). Given that attachment is relatively stable from infancy to early childhood (Fraley, 2002) these studies suggest that attachment representations have an enduring impact on emotion regulation and, more specifically, pain-related distress regulation.

The above studies highlight the importance of attachment and the caregiver-infant relationship to infants' pain-related distress responses in the pediatric pain context. However, with the understanding that attachment and temperament may interact to predict differences in distress regulation, research is needed to better understand how these factors concurrently impact pediatric pain. Furthermore, work is needed to identify the behavioural markers of infants at high risk for emotion regulation difficulties within the context of immunization to translate this research into findings that have clinical applications.

Pritchett and colleagues (2012) investigated the feasibility of using caregiver behaviours exhibited during immunization at 4 years to predict attachment. Caregivers of secure children exhibited more pain-reducing behaviours (e.g., distraction and nonprocedural talk) than caregivers of insecure children, suggesting that immunization is a valid context in which to study and assess attachment. However, research is needed with infant populations to confirm the utility of the pediatric visit for assessing attachment in infancy.

Using a different approach to the study of attachment and pain-related behaviour during immunization, Favez and Berger (2011) created the Paediatric Attachment Style Indicator (PASI), a qualitative measure that illustrates infant and caregiver behaviours in the context of immunization that are hypothesized to be associated with attachment status. Through vignettes based on attachment theory and infant behaviours in the SSP, the PASI depicts caregiver and infant behaviour before, during, and after immunization according to prototypical secure, avoidant and resistant patterns of distress regulation.

According to the PASI, secure infants may express positive, neutral, or some wary behaviours pre-needle, socially referencing the caregiver and orienting towards them. Avoidant infants display minimal distress as well as minimal interaction with the caregiver pre-needle. Resistant infants are likely to be highly distressed prior to the needle, seeking immediate physical contact with caregivers. During immunization, secure infants may or may not become distressed. If distressed, the secure infant will seek physical comfort from the caregiver, who provides warm support and is able to quickly comfort the infant. Avoidant infants also may or may not become distressed in response to immunization. If they do become distressed, avoidant infants will regulate distress quickly without turning to caregivers or relying on them for support. Resistant infants are likely to become highly distressed during immunization, possibly exhibiting anger or passive helplessness, and strongly seek close physical comfort with caregivers. Following immunization, secure infants will use the caregiver as a secure base, returning to him or her when distressed, but effectively exploring their environment when not distressed. Avoidant infants will not seek contact with the caregiver following immunization and may appear "calm but vigilant" (Favez & Berger, 2011, p. 593). Resistant infants may remain distressed following immunization, displaying contradictory behaviours of wanting contact with caregivers while also resisting this contact.

The PASI represents a novel attempt to link attachment to pain behaviours seen during acute primary care. However, the use of three categorical vignettes may present challenges to observers of infant distress during immunization. As alluded to earlier when discussing the "Belsky-Rovine" split, many researchers recognize that while attachment classifications are treated as categorical, temperament may influence how an infant regulates distress. For example, a secure infant may regulate distress quickly by seeking physical proximity to the caregiver, while another secure infant may regulate distress by "checking in" with the caregiver across a greater distance. Furthermore, the PASI does not include a description of disorganized behaviours during immunization, limiting the clinical utility of the measure for this high risk group.

Fewer studies have examined the link between temperament and the infant pain response. Studies involving older children suggest that more difficult temperament ratings are associated with greater distress (see Ranger & Campbell-Yeo, 2008, for review). One study involving 18-month-old infants who had been born pre- or full-term examined the relationship between caregiver ratings of temperament and pain sensitivity (Grunau, Whitfield, & Petrie, 1994). Composite ratings of temperament (including shyness, sociability, emotionality, and activity) were related to pain sensitivity in all groups of infants with the exception of the extremely low birth weight infants. This study suggests that birth complications or extended hospitalizations after birth may impact the relationship between infant temperament and pain response.

In addition to the studies discussed above, there are two studies that directly inform the current study as they examine the interaction between attachment and temperament and its relationship to acute pain during medical procedures concurrently in infancy (Gunnar, Brodersen, Nachmias, Buss, & Rigatuso, 1996; Wolff et al., 2011). Gunnar and colleagues were among the first to examine the effects of avoidant, secure, and resistant attachment (measured using the SSP at 18 months; disorganized attachment was not assessed) and temperamental fear (via caregiver report at 15 and 18 months) on infants' pain-related distress during the 15-month immunization appointment. Infants' salivary cortisol responses were assessed before and after immunization and the SSP. There were no effects of attachment and temperamental fear on behavioural measures of infant pain-related distress. However, insecure infants with high temperamental fear had higher cortisol responses to both immunization and the SSP than secure infants with high temperamental fear. Infants with low-to-average temperamental fear did not differ in terms of their cortisol responses to immunization or the SSP. Other studies have replicated these results in non-pain contexts (Nachmias, Gunnar, Mangelsdorf, Parritz, & Buss, 1996). Gunnar and colleagues conclude that attachment and temperament are distinct constructs that interact to contribute to neuroendocrine functioning. The authors further postulate that secure attachment acts as a buffer against the deleterious effects of high temperamental fear on the physiological stress response across naturalistic (i.e., immunization) and laboratory (i.e., the SSP) contexts.

Wolff and colleagues (2011) investigated the effects of attachment and temperament on infant distress during venipuncture. Mothers rated infant temperament at

6 months of age using the fear, distress to limitations, recovery from distress, and sadness temperament scales of the IBQ-R. When infants were between 13 and 18 months of age, they took part in the SSP and the venipuncture procedure. Unlike the work by Gunnar and colleagues (1996), there was an interaction between attachment organization and temperamental fear such that disorganized infants with high temperamental fear exhibited significantly more distress than organized infants with high temperamental fear. These findings suggest that disorganized infants are more vulnerable to the negative effects of high temperamental fear on pain-related distress, whereas organized attachment serves as a buffer against high temperamental fear.

There are several limitations to the studies by Gunnar and colleagues (1996) and Wolff and colleagues (2011). In the study by Wolff and colleagues (2011), the SSP took place within the same appointment as the venipuncture, potentially confounding these two procedures. Although the authors made efforts to ensure that infants were behaviourally calm prior to the venipuncture, infants may not have returned to baseline levels of physiological stress prior to the painful procedure. Moreover, both Gunnar and colleagues (1996) and Wolff and colleagues (2011) used unvalidated average measures of pain-related distress following the needle, precluding the ability to examine differences between pain-related distress reactivity and pain-related distress regulation according to attachment and temperament. Furthermore, the distress measure used in the study by Wolff and colleagues (2011) combined pain-related distress behaviours (e.g., crying) with other, non-distress behaviours (e.g., information seeking), thereby confounding pain-related distress with behavioural strategies that may have differentiated attachment groups. Finally, neither of the studies used the four-level attachment classification comparison to examine differences among A, B, C, and D groups. Although the two-level secure/insecure and organized/disorganized comparisons are clinically useful (separating low-risk from high-risk groups), these comparisons may obscure important differences between avoidant and resistant infants (Stevenson-Hinde, 2005; Vaughn et al., 2008). Given that avoidant (A) and resistant (C) classifications regulate distress in divergent ways (i.e., avoidant infants minimize distress while resistant infants amplify distress in the presence of caregivers), collapsing these groups precludes the ability to test attachment-driven hypotheses about how infants from these groups respond to acute pain.

The Conceptual Framework for the Current Study: The DIAPR Model

Adopting a pediatric pain perspective, the aim for the current study is to understand the relationship between attachment and temperament on pain-related distress reactivity and pain-related distress regulation. The Development of Infant Acute Pain Responding Model (DIAPR model; Pillai Riddell, 2011; Pillai Riddell et al., in press) presents a comprehensive biopsychosocial conceptualization of infant acute pain (Figure 1). Based on longitudinal work that has thus far included over 760 healthy infants and caregivers followed at the 2-, 4-, 6- and 12-month immunization appointments, the DIAPR model distinguishes itself from past models of pediatric pain by highlighting the specific infant-related developmental and temporal factors that have been shown to impact the ways in which infants respond to acute nociceptive stimuli.

From a developmental perspective, the DIAPR model includes both intrinsic processes inherent to the caregiver and infant (e.g., infant temperament) and extrinsic processes (e.g., interactions with the caregiver) that are theorized to impact infant pain through feedback loops that dynamically shape pain reactivity and regulation over time.

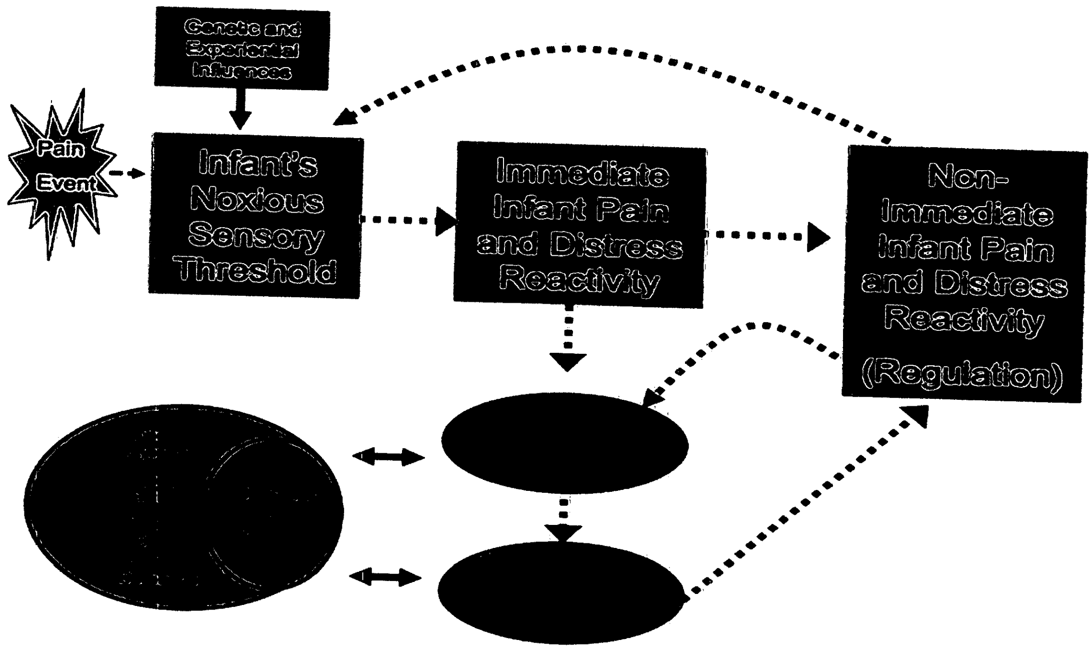

Figure 1. The Development of Infant Acute Pain Responding Model (The DIAPR Model; Pillai Riddell, Racine, Campbell & Craig, in press).

The model also takes into account the infant's developmental stage and asserts that extrinsic caregiver processes will exert more influence on pain-related distress reactivity and regulation over time. At 12 months of age, for example, interactions with the caregiver (e.g., the caregiver-infant attachment relationship) are theorized to exert a stronger influence on the infant pain response than at 2 months of age.

From a temporal perspective and in line with Ramsay and Lewis' (2003) definition of pain, the DIAPR model considers two phases of the acute pain response: the immediate infant pain and distress response, labeled "reactivity," and the non- immediate infant pain and distress response, labeled "regulation." Genetic and experiential factors pertaining to the infant (e.g., temperament) are theorized to exert a direct influence on pain-related distress reactivity but an indirect influence on pain-related distress regulation. External factors (e.g., caregiver's response to the infant in distress) are theorized to exert a direct influence on pain-related distress regulation but an indirect influence on subsequent pain-related distress reactivity through interactions over time.

Objective of the Current Study and Hypotheses

In an effort to address the gaps in the literature examining attachment, temperament, and pain-related distress, the design and hypotheses of the current study were based on the DIAPR model and attachment theory. The overarching objective of the current study was to examine how caregiver-infant attachment and infant temperamental fear are associated with infant and caregiver behaviour within the 12-month immunization appointment. The immunization appointment at 12 months was selected because attachment is considered to be stable and reliably measured at this age. Infant and caregiver behaviour was video recorded during immunization. Caregiver-infant attachment was assessed using the SSP when infants were 12 to 18 months of age. Following the SSP, caregivers completed the IBQ-R that included an evaluation of infant temperamental fear.

The relationship between attachment, temperament, and the immediate and regulatory pain-related distress response to needle pain at 12 months was examined. Immunization behaviour was operationalized two ways. First, the Modified Behavioral Pain Scale (MBPS; Taddio, Nulman, Koren, Stevens, & Koren, 1995), a well-established measure of infant distress, was utilized to measure infants' pain-related distress reactivity and pain-related distress regulation. Second, using the Ainsworth et al. (1978) and Main and Solomon (1990) measures as a guide, a list of immunization behaviours were incorporated in a new coding scheme created for use in this study. This new coding scheme, the *Measure of Immunization Behaviours and Attachment Behaviours in Infancy* (MIBABI; Horton & Pillai Riddell, 2012), was designed to parallel behaviours exhibited during the SSP but modified for applicability to immunization at 12 months. The MIBABI was used to determine if behaviours that occur during immunization, easily discernible to medical professionals, could be linked to SSP attachment classifications.

Two principle research questions were addressed in the current study. Both research questions were addressed using the A/B/C/D, secure/insecure, and organized/disorganized comparisons (i.e., separate, analogous analyses using these three comparison methods). The first research question was: (1) Are attachment, temperamental fear, or the interaction between attachment and temperamental fear associated with pain-related distress reactivity or pain-related distress regulation? Prior to including attachment and temperament variables as predictors of distress reactivity and regulation, other contextual variables known to impact the infant pain response (i.e., sex of infant, analgesic medication use, the number of needles administered, and baseline distress) were included as predictors of reactivity and regulation in an initial model. Baseline distress was included as both a predictor and an outcome. Significant predictor variables from the initial model were carried through to subsequent models that included attachment, temperamental fear, and attachment by temperamental fear interactions.

The primary hypothesis for the first research question was that both temperamental fear and attachment would impact infants' pain response, such that: (i) higher temperamental fear would predict higher pain-related distress reactivity based on the DIAPR model's assertion that temperament is a key factor that relates to pain sensory thresholds; and (ii) temperamental fear would moderate the relationship between attachment and pain-related distress regulation based on the DIAPR model, previous research (Wolff et al., 2011), and theory about attachment and affect regulation (Cassidy, 1994; Stevenson-Hinde, 2005). Specifically, under conditions of high temperamental fear, insecurely attached infants (A, C or D) were expected to regulate distress more slowly than securely attached infants.

The second research question consisted of two parts. The first part of the second research question was: (2a) Do infant or caregiver behaviours *pre-needle* predict attachment? It was hypothesized that none of the infant or caregiver MIBABI behaviours pre-needle would predict attachment, as the attachment system was not expected to be strongly triggered for all infants under conditions of milder stress (Solomon & George, 2008). The second part of the research question was: (2b) Do infant or caregiver behaviours *post-needle* predict attachment? Based on the theory that immunization should strongly trigger the attachment system for all infants (Bowlby, 1969/1982) and previous research (Leerkes & Wong, 2011), the primary hypotheses for the second part of the research question was that MIBABI behaviours post-needle would predict attachment such that: in line with the SSIB scales used to code organized attachment during the SSP (Ainsworth et al., 1978), (i) secure (B) and resistant (C) infants would exhibit more of the behaviours that mapped on to the Proximity- and Contact-Seeking and the Contact-Maintaining scales, resistant (C) infants would exhibit more of the behaviours that mapped on to the Resistant scale, and avoidant (A) infants would exhibit more of the behaviours that mapped on to the Avoidant scale; (ii) disorganized (D) infants would exhibit more disorganized MIBABI behaviours during the 12-month immunization than other infants, in line with the *Indices of Disorganization and Disorientation* (Main & Solomon, 1990) used to code disorganization in the SSP and previous work (Out et al., 2009); and (iii) caregivers of secure (B) infants would engage in more proximal soothing than caregivers of insecure (i.e., avoidant (A), resistant (C) or disorganized (D) infants, in line with attachment theory (Ainsworth et al., 1978; Bowlby, 1969/1982).

Method

Participants

The current study was subsumed under a longitudinal study which included a total of 760 caregiver-infant dyads. Participants were initially recruited for the larger study from three pediatric clinics in the Greater Toronto Area at either the 2-, 4- or 6-month well-baby immunization visit and observed at each subsequent visit until their 12-month immunization. Caregiver-infant dyads were recruited for the present study at the 12-month visit and invited to take part in the SSP when infants were between 12 and 18 months of age. Figure 2 is a flow-chart illustrating the recruitment process. Of the 286 caregivers approached at the 12-month appointment at the time of the current study, 175 (62%) agreed to participate. Due to scheduling difficulties, some caregivers were unable to bring their infants to the hospital prior to 18 months of age (the upper age limit for the SSP). Thus, the final sample consisted of 130 dyads. Sixty-four dyads were recruited from a pediatrician's office in midtown Toronto, 64 dyads were recruited from a pediatrician's office in downtown Toronto, and two dyads were recruited from a pediatrician's office in northwest Toronto.

Inclusion criteria required caregivers to be fluent in English in order to complete consent and a questionnaire about infant temperament. To control for factors that have been shown to impact infants' behavioural pain responses, only healthy infants born at 36 weeks gestation or later who had no suspected developmental delays or neurological impairments and without prolonged medical or foster care were included in the larger study.

Infants were the biological children of the caregivers taking part in the study with the exception of one adopted infant. The caregiver who brought his or her infant to the

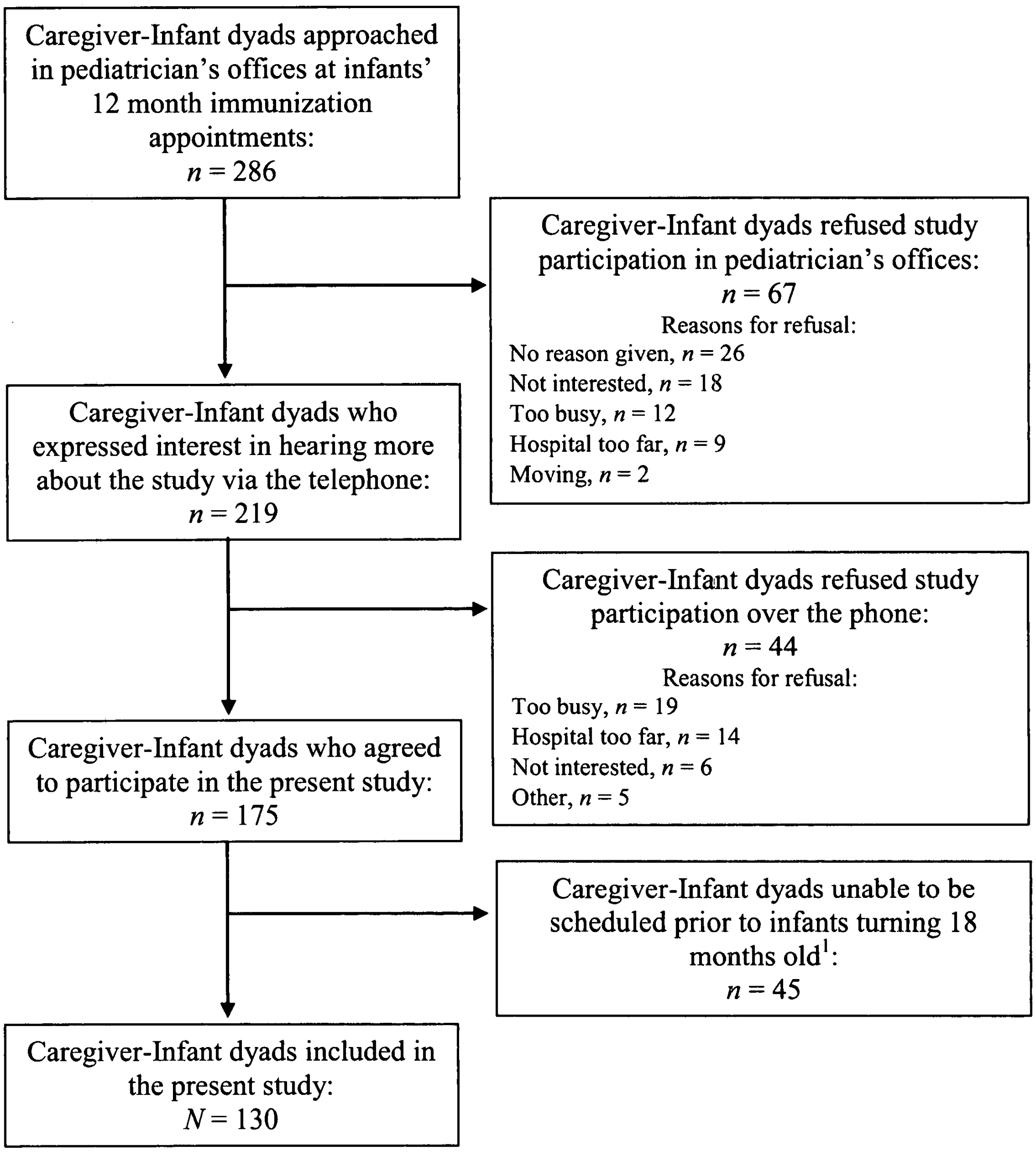

Figure 2. Recruitment flow chart for the present study.
[1] One infant was 20.7 months old at the time of the SSP; the SSP for this case was deemed valid by an expert SSP coder and retained in the final dataset.

12-month appointment was invited to take part in the SSP to maintain consistency in caregivers across appointments. If more than one caregiver accompanied the infant to the 12-month appointment, the primary caregiver was invited to take part in the SSP. "Primary caregiver" was defined as the caregiver who spent the most amount of time with the infant or who was primarily responsible for his or her child's care and caretaking decisions. The final sample of 130 dyads included 72 male and 58 female infants and 116 mothers and 14 fathers. At the time of the SSP appointment, infants were an average age of 13.74 months (range = 12.06 – 20.70, *SD* = 1.35) and the average age of caregivers was 34.70 years (range = 22.59 – 58.08, *SD* = 5.05). The majority of caregivers taking part in the SSP identified themselves as "primary caregivers" (95%).

As part of the ongoing longitudinal study, caregivers were asked to provide demographic information (e.g., marital status, education level) at their initial recruitment visit as well as medication status for their infants prior to the 12-month immunization procedure (e.g., topical anesthetic cream, Tylenol). Demographic information pertaining to caregivers is in Table 1. The majority of caregivers was married or in common-law relationships (94%) and educated at or above the university level (76%). The current study included a culturally diverse sample, with the majority of caregivers identifying as European or Canadian/North American (59%) and the second largest group of caregivers identifying as Asian (11%).

Procedure

Twelve-month immunization visits were filmed to record caregiver and infant behaviours. The procedure for the current follow-up study received separate ethics

Table 1

Demographic Characteristics

Demographic Variable	Description	*n*	%
Caregiver education	Graduate degree or professional training	47	36.2
	University graduate	52	40.0
	Partial University (at least 1 year)	6	4.6
	Trade school or community college	21	16.2
	High school graduate	3	2.3
	Some High School (minimum 10th Grade)	1	0.8
Marital status	Married	109	83.8
	Common Law	13	10.0
	Single/Never Married	5	3.8
	Divorced/Separated	1	0.8
	Engaged	1	0.8
	Other	1	0.8
Self-Reported Heritage Culture	European	57	43.8
	Canadian/North American	20	15.4
	Asian	14	10.8
	Central American/Caribbean	8	6.2
	South Asian	8	6.2
	South American	7	5.4
	African/Middle Eastern	7	5.4
	East Asian	5	3.8
	Other	4	3.1

Note. $N = 130$.

approval from York University and the Hospital for Sick Children (Appendix B). Caregiver-infant dyads were seen by the pediatrician in a private clinic room. An RA videotaped caregiver-infant interactions for up to three minutes pre-needle and up to five minutes post-needle. At the end of the appointment, the RA approached the caregiver to ask if he or she might be interested in participating in a follow-up study at the Hospital for Sick Children examining caregiver-infant interactions. Caregivers were informed that they would receive $10 to help cover the cost of travel and parking, an infant "onesie," a framed commemorative photo of their infant, and a DVD copy of their visit to the hospital.

Caregivers who expressed interest in participating in the follow-up study provided the RA with their contact information. A second RA contacted the caregiver via telephone to tell him or her more details about the study and, if they were interested, to book an appointment. When scheduling the SSP appointment, caregivers were consulted as to when the infant would be in an alert state and were encouraged to provide their infant with a snack prior to the visit to avoid confounds such as sleepiness or hunger. Caregivers were sent a confirmation e-mail that included directions to the hospital and pictures of compensation items (Appendix C). Caregivers were also telephoned a day or two prior to their appointment as a friendly reminder.

Immunization appointments took place between June 2009 and April 2012 and appointments at the hospital took place between September 2009 and April 2012. The average amount of time between the 12-month immunization visits and the hospital appointments was 42.88 days (SD = 38.48). When the caregiver and infant arrived at the hospital, a trained RA explained the purpose, potential benefits and harms of the study as well as the confidential and voluntary nature of the study using two consent forms: Consent to Participate and Consent to Videotape (Appendix D). Caregivers were also provided copies of the consent forms that included contact information for the RAs and the principal investigator.

After providing consent, the caregiver was provided brief instructions for the SSP. A copy of the instructions was provided during the procedure so that the caregiver could refer to them as needed. Following the SSP, caregivers were asked to complete the IBQ-R. The visit to the hospital, including the SSP and the completion of the IBQ-R, took approximately one hour.

Apparatus

Pediatric visit at 12 months. Two Canon HV20 High Definition Camcorders were used to record caregiver and infant behaviour. One camera was hand-held by an RA to record a close-up image of both the infant's and the caregiver's facial expressions. The second camera was mounted on a tripod and fitted with a wide angle lens to record caregiver-infant interactions from a distance.

Laboratory visit at 12 to 18 months. Two wall-mounted rotating video cameras were used to record infant behaviour during the SSP. The experimental room included a one-way mirror so that the researcher could unobtrusively observe the participants (caregiver, infant, and an RA who acted as the stranger) from an adjacent control room. Two chairs were arranged (one for the caregiver and one for the stranger) in the experimental room. A small table displaying magazines and caregivers' SSP instructions was placed between the two chairs. A number of age-appropriate toys were spread out on the laboratory floor in the middle of the room. The toys included three blocks, a pop-up toy, a puppet, two dolls, a toy truck, a toy stethoscope, two books, a stacking ring toy, a toy telephone, and a rattle. The same toys were used across SSPs and sterilized after each visit.

Measures

A timeline of when measures were coded during the 12-month immunization visit is included in Figure 3.

Infant baseline distress, pain-related distress reactivity, and pain-related distress regulation. *The Modified Behavioral Pain Scale* (MBPS; Taddio et al, 1995) was used to measure infant distress pre- and post-needle at the 12-month immunization visit. The MBPS (Appendix E) has been extensively validated as a pain measure within the context of immunization with infants up to 12-months of age (e.g., Ipp, Cohen, Goldbach, & Macarthur, 2004; O'Brien et al, 2004; Taddio et al, 1995). The MBPS consists of three parameters: facial expression, cry, and body movements. Each parameter is coded on a scale (0 to 3 for facial expression, 0 to 4 for cry, 0 to 3 for movements) where 0 indicates no distress or positive affect and the highest score indicates definite distress or negative affect. Each parameter is coded for a 15-second epoch and the maximal occurrence of that parameter during the epoch is recorded. All three parameter scores are then summed to create a total MBPS score ranging from 0 to 10, with 0 - 3 indicating mild pain-related distress, 4 - 6 indicating moderate pain-related distress, and 7 - 10 indicating severe pain-related distress across parameters.

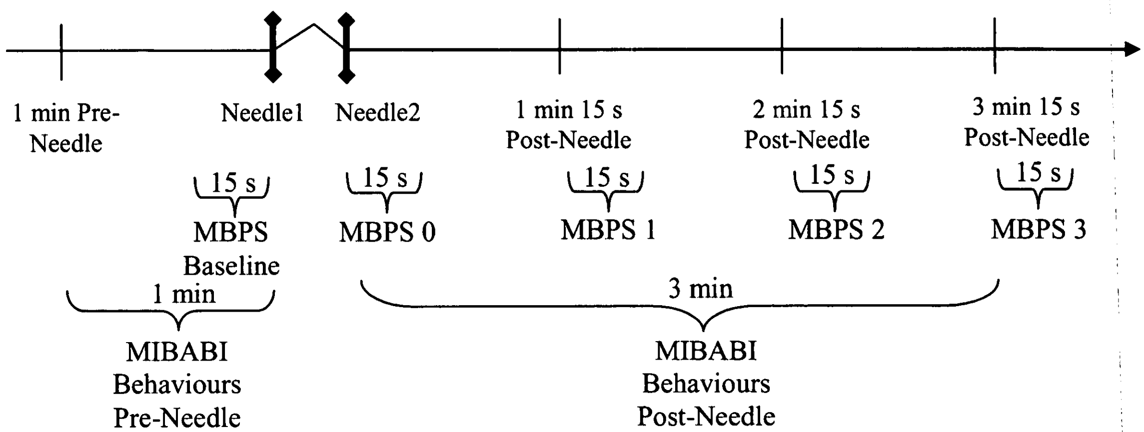

Figure 3. Timeline representing the measures coded during the 12 month "well-baby" visit. MBPS = Modified Behavioral Pain Scale; MIBABI = Measure of Immunization Behaviours and Attachment Behaviours in Infancy.

For the current study, every infant had a pain-related distress score for the 15-second epoch occurring immediately preceding the needle (MBPS Baseline), immediately following the needle (MBPS 0), 1 minute and 15 seconds after the needle (MBPS 1), 2 minutes and 15 seconds post-needle (MBPS 2) and 3-minutes and 15 seconds post-needle (MBPS 3).

The hypotheses required distinguishing an infant's immediate reaction to a painful stimulus from an infant's regulation of his or her distress over time. Research clearly demonstrates that the peak reaction to an immunization occurs immediately after the needle(s), with infants then regulating distress towards pre-needle or baseline levels (O'Brien et al., 2004; Taddio et al., 1995; Uhari, 1993). Following Ramsay and Lewis' (2003) definition of pain reactivity and pain regulation, Thompson's definition of emotion regulation (1994), and the DIAPR model (Pillai Riddell et al., in press), "pain-related distress reactivity" was operationalized as the behavioural distress exhibited immediately post-needle and "pain-related distress regulation" was operationalized as the rate of change in behavioural distress from immediately post-needle to 3 minutes and 15 seconds post-needle. Thus, "pain-related distress reactivity" was represented by the MBPS 0 score (i.e., a latent intercept factor in the statistical model), while the change in pain-related distress scores from MBPS 0 to MBPS 3 (i.e., a latent slope factor in the statistical model) represented "pain-related distress regulation."

To examine whether the amount of distress pre-needle contributed to the amount of distress post-needle, baseline distress was operationalized by the MBPS Baseline score. The variables of baseline distress, distress reactivity, and distress regulation are consistent with previous work in developmental psychology that examines a child's response in the period surrounding the application of a stressor that causes acute pain (e.g., Lilley, Craig & Grunau, 1997; Ramsay & Lewis, 2003; Wolff et al., 2011).

Twenty percent of the total sample in the longitudinal study (including the sample for the current study) was double-coded to assess ongoing reliability. The inter-rater reliability was strong with intra-class correlations ranging from .93 to .96.

Infant and caregiver behaviour during the 12-month immunization visit. A behavioural coding measure, *The Measure of Immunization Behaviour and Attachment Behaviour in Infancy* (MIBABI), was created for the present study. The MIBABI was designed to code infant and caregiver behaviours during the 12-month immunization visit that were hypothesized to be associated with different attachment classifications (Horton & Pillai Riddell, 2012). With the goal of knowledge mobilization among non-mental health professionals in primary care (e.g., general practitioner physicians, pediatricians, nurses), a concerted attempt was made to select overt behaviours that would be readily discernible to someone with minimal infant mental health training.

To generate the specific behaviours that would relate to secure (B), avoidant (A), or resistant (C) classifications, infant and caregiver behaviours were extracted and modified from the four scales of the SSIB (Ainsworth et al., 1978) used to code organized attachment during the SSP that were described in the introduction: Proximity- and Contact-Seeking, Contact-Maintaining, Resistant, and Avoidant. The extraction resulted in a list of 17 behaviours that pertained to proximity- and contact-seeking, contact-maintaining, resistant, and avoidant behaviour in the SSP (see Appendix F).

Thirty immunization DVDs were subsequently viewed by the current author to determine which of these behaviours occurred during immunization. Thirty DVDs were randomly selected from the first 66 videotaped interactions available at the time of the MIBABI development to obtain a cross-section of each attachment group. The item-generation sample included 10 secure (B) cases, 7 avoidant (A) cases, 3 resistant (C) cases, and 10 disorganized (D) cases.

Twelve of the original 17 behaviours were initially retained for potential inclusion in the MIBABI, as five did not occur in our immunization setting (i.e., approaches caregiver [creeping, crawling, or walking]; touches caregiver in an exploratory way; looks, smiles or interacts with caregiver across a distance; little kicks of the feet/steps angrily; does not greet caregiver upon return). Behaviours with overlapping definitions were combined for the MIBABI. Two behaviours that were not extracted from the SSP scales but were observed during immunization and considered to be potentially related to attachment were added during the initial item generation phase (*hugging infant* and *arm(s) between*; Appendix F). The initial MIBABI measure included nine behaviours. Six behaviours pertained to the infant: *reach* (towards caregiver), *cling* (on to caregiver), *snuggle* (in to caregiver), *back arch/pushes away* (caregiver or object, accompanied by fussy crying), *head away/averts gaze* (from caregiver), and *arm(s) between* (self and caregiver). Three behaviours pertained to the caregiver: *holding infant*, *hugging infant* (when infant not being held), and *continues holding infant* (only in response to infant protest at being put down). *Reach* mapped on to the Proximity and Contact-Seeking scale. *Cling*, *snuggle*, *holding infant*, *hugging infant* and *continues holding infant* mapped on to the Contact-Maintaining scale. *Back arch/pushes away* mapped on to the Resistant scale. *Head away/averts gaze* and *arm(s) between* mapped on to the Avoidant scale.

The above nine MIBABI behaviours were coded as present (1) or absent (0) for every 5 seconds of four 60-second epochs (1 minute pre-needle and 1, 2, and 3 minutes post-needle). As the pain-related distress measure (the MBPS) was coded for 15-second epochs, spaced 1 minute apart, a continuous distress item was added to the MIBABI to examine infant distress along with the other MIBABI behaviours as a potential discriminator of attachment groups. Thus, infant *cry/grimace* (adopting the most salient behaviours from the MBPS) was additionally coded on a 0 to 3 scale with 0 indicating positive expression/no distress and 3 indicating strong distress. *Cry/grimace* was coded for every 5 seconds of the four 60-second epochs in which the other behaviours were coded (1 minute pre-needle and 1, 2, and 3 minutes post-needle).

Despite the complexity and subtlety involved in discerning disorganized behaviours (van IJzendoorn et al., 1999), behavioural items that could be easily identified by a health professional not specializing in mental health that were hypothesized to be associated with the disorganized (D) classification were generated. Based on previous work (Out et al., 2009) and guided by the *Indices of Disorganization and Disorientation* used to code disorganized behaviours in the SSP (Main & Solomon, 1990; see Appendix G), 16 behaviours that were hypothesized to be associated with disorganized (D) attachment were generated (Appendix H). These behaviours were coded as present (1) or absent (0) during the entire post-needle phase.

To assess the comprehensiveness of the MIBABI, the initial version of the measure was approved by a study co-investigator and expert in the field of attachment and infant mental health (G. Moran, personal communication, June 4, 2011). The MIBABI was also presented at a national conference to solicit input and feedback from other experts in the field of attachment (Horton & Pillai Riddell, 2011). Decisive and positive feedback from these consultations provided confidence in the content validity of the MIBABI measure.

Three coders with a background in child development and blinded to the study hypotheses were trained on the MIBABI measure by the current author. Twenty-five percent of the sample was double-coded for reliability, while 10% of the sample was quadruple-coded to assess coder drift. Reliability meetings were held every two weeks over the course of the academic year. Operational definitions of behaviours were modified during the reliability meetings to clarify the definitional boundaries of the behaviours. As a result of these meetings, the infant behaviour *head away/averts gaze* was dropped from the measure because it occurred too frequently and quickly to be coded reliably. Conversely, the caregiver behaviours *hugging infant* and *continues holding infant* occurred too infrequently to achieve adequate reliability and were also dropped from the measure. Despite consistent collaborative coding meetings over the academic year among the same group of coders, adequate inter-rater reliability also could not be achieved for the set of behaviours that were hypothesized to be associated with disorganized (D) attachment. Thus, these behaviours were not included in the final version of the MIBABI. The final version of the MIBABI measure included the following seven behaviours: infant *cry/grimace*, *reach*, *cling*, *snuggle*, *back arch/pushes away*, and *arm(s) between* as well as the caregiver behaviour, *holding infant* (Appendix I). The operational definitions for the behaviours in the final version of the MIBABI are included in Appendix J.

Intraclass correlations between coders for the MIBABI behaviours pre- and post-needle are presented in Table 2. All combinations among coders were high (.90 to 1.0), with the exception of one behaviour pre-needle, which was moderate (.69 for the *arm(s) between* behaviour pre-needle).

Caregiver-infant attachment. As reviewed in the introduction, the *Strange Situation Procedure* (SSP; Ainsworth et al., 1978) is the gold standard measure of infant-caregiver attachment which is assessed over eight episodes involving infant, caregiver, and an RA who acts as a "stranger" (see Appendix A). *The Scoring System for Interactive Behaviors* (SSIB; Ainsworth et al., 1978) is used to code episodes 5 and 8 of the SSP (when infants are reunited with their caregivers after brief separations) to determine an infant's organized attachment classification (A, B or C). Efforts are first made to classify an infant according to one of the organized attachment styles (secure, avoidant or resistant). The *Indices of Disorganization and Disorientation* (Main & Solomon, 1990; Appendix G) is then used to code disorganized behaviours during the episodes in which the infant and caregiver are together.

For the current study, two researchers were trained in administering and coding the SSP. Reliability for both coders was achieved on the organized A, B, and C classifications. For the current study, an experienced and reliable SSP coder from an

Table 2

Reliability Intraclass Correlation Coefficients for MIBABI Behaviours

		MIBABI Behaviour						
Coders	*n*	Cry/ grimace	Reach	Cling	Snuggle	Back arch/pushes away	Arm(s) between	Holding infant
						Pre-Needle		
PC and C1	34	.98	.92	.99	.97	1.00	.99	.99
PC and C2	34	.97	.93	.93	.96	1.00	.69	.99
PC and C3	15	.99	1.00	.99	.98	1.00	.95	.99
C1 and C2	34	.97	.82	.91	.91	1.00	.98	.99
C1 and C3	15	.99	.95	.99	.98	1.00	.98	.99
C2 and C3	15	.99	.90	.98	.97	1.00	.88	1.00
						Post-Needle		
PC and C1	34	.98	.92	.99	.98	.93	.99	.99
PC and C2	34	.90	.95	.90	.90	.91	.98	.99
PC and C3	15	.98	.91	.99	.96	.94	.97	.99
C1 and C2	34	.93	.94	.98	.95	.95	.98	1.00
C1 and C3	15	.99	.96	.99	.94	.97	.98	1.00
C2 and C3	15	.93	.92	.98	.95	.98	.98	1.00

Note. PC = Primary Coder, C1 = Coder 1, C2 = Coder 2, C3 = Coder 3.

internationally renowned attachment laboratory coded the entire sample for A, B, C, and D classifications. Approximately 70% of the tapes were double-coded by two researchers for training purposes and to assess ongoing reliability. Tapes on which there were major disagreements were reviewed by a third highly-experienced SSP coder. Reliability scores between coders ranged from .71 to 1.00 (refer to Table 3 for reliability scores across attachment classification comparisons between coders on the SSP).

As noted above, attachment was operationalized in three ways: (1) the four-level A/B/C/D comparison (using secure as the reference group); (2) the two-level secure/insecure comparison (secure [B] vs. insecure [A, C and D groups combined]); and (3) two-level organized/disorganized comparison (organized [A, B and C groups combined] vs. disorganized [D]). These contrasts allowed for examinations of low versus high risk groups (i.e., secure vs. insecure and organized vs. disorganized) as well as examinations of attachment groups separately. Of the 130 cases, 31 (24%) were classified as avoidant (A), 68 (52%) were classified as secure (B), 8 (6%) were classified as resistant (C), and 23 (18%) were classified as disorganized (D). These proportions are consistent with non-clinical samples (Main & Soloman, 1990; van IJzendoorn et al., 1999).

Infant temperamental fear. Following the SSP, caregivers completed *The Infant Behavior Questionnaire – Revised* (IBQ-R; Gartstein & Rothbart, 2003) which was used to measure the temperamental construct of fearfulness when infants were between 12 and 18 months old.

Table 3

Intraclass Correlation Coefficients for Strange Situation Procedure Reliability

		Attachment Classification Comparison		
Coders	*n*	A/B/C/D	Secure (B)/Insecure (A, C and D)	Organized (A, B and C)/Disorganized (D)
PC and C1	68	.75	.71	.79
PC and C2	24	.80	.84	.84
C1 and C2	7	.93	.75	1.00

Note. PC = Primary Coder, C1 = Coder 1, C2 = Coder 2, C3 = Coder 3.

The IBQ-R was designed for infants 3 to 12 months of age and is recommended for infants up to 15 months of age[1]. The IBQ-R Fear Scale (Appendix K) measures the infant's "startle or distress to sudden changes in stimulation, novel physical objects or social stimuli; inhibited approach to novelty" (Gartstein & Rothbart, 2003, p. 72). It contains items pertaining to the frequency of fearful behaviour (e.g., startle or distress to sudden or loud noise, novel physical objects, or social stimuli) exhibited during the past week or two weeks rated on a seven-point Likert-type scale where 1 = never, 2 = very rarely, 3 = less than half the time, 4 = half the time, 5 = more than half the time, 6 = almost always, 7 = always. An eighth option, "does not apply," is coded 0. A summary score for the Fear scale is calculated by averaging the scores of the items that were endorsed with final scores ranging from 1 to 7, with 1 indicating low fear and 7 indicating high fear. The IBQ-R has strong inter-rater, inter-item, and item-total reliability (Gartstein & Rothbart, 2003). Mothers' reports of IBQ-R Fear are significantly correlated with observed fear in laboratory settings, demonstrating convergent validity (Parade & Leerkes, 2008).

Seven caregivers did not complete the IBQ-R, resulting in complete SSP and IBQ-R data for 123 dyads. Reasons for not completing the questionnaire included not having enough time at the end of the visit or the infant becoming too fussy, hungry, or tired at the end of the visit. Scores on the IBQ-R Fear scale ranged from 1.13 – 5.81 (M = 3.18, SD = .95). Using coefficient alpha, the internal consistency for the IBQ-R Fear

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[1] Due to scheduling difficulties, some caregiver-infant dyads completed the IBQ-R when infants were older than 15 months (n = 9). Analyses were run with and without these infants and the results were consistent; thus, these cases were retained in final analyses.

scale was .88, which is consistent with the internal consistency of the scale from the original standardization sample (Gartstein & Rothbart, 2003).

Results

Analysis Overview

Statistical analyses will be described in order of the two primary research questions. Each section will first describe the preliminary and primary analytic plan related to the specific research question before describing the results. As aforementioned, attachment categorizations were examined three ways across both research questions (A/B/C/D comparison, secure/insecure comparison, and organized/disorganized comparison). For ease of review, a summary of all the major results pertaining to each research question is presented in Appendix L.

Research question (1): Are attachment, temperamental fear, or the interaction between attachment and temperamental fear associated with pain-related distress reactivity or pain-related distress regulation?

Preliminary analyses (1). Descriptive statistics of variables central to analyses addressing the first research question were calculated. Differences in these variables were examined across pediatric clinics to determine whether pediatric clinic should be controlled in subsequent analyses. Bivariate relationships between variables were also examined prior to analyses.

Primary analyses (1). The relationships between attachment, temperamental fear, and their interaction (independent variables) with the dependent variables (baseline distress, distress reactivity, and distress regulation) during the 12-month immunization appointment were estimated using latent growth modeling (LGM) within a structural equation modeling (SEM) framework (Bollen & Curran, 2006).

Relevant contextual or demographic factors that have been shown to influence infants' distress response to immunization, specifically sex of infant (Fuller, 2002), the number of needles infants receive (Klassen & Craig, 2007), and medication provided pre-needle (Halperin et al., 2000; O'Brien et al., 2004) were included in an initial SEM model (Model 1). If a predictor variable was significantly related to either distress reactivity or distress regulation, it was retained in subsequent models (Models 2, 3, and 4). Baseline distress was included as both a predictor and an outcome variable in all models, as it has been shown to predict both distress reactivity and distress regulation in the context of immunization (Ahola Kohut & Pillai Riddell, 2009; Hillgrove-Stuart et al., in press) and was also predicted to be influenced by the predictor variables (i.e., gender of infant, medication received, number of needles, attachment, and temperamental fear).

The use of LGM presents a distinct advantage over alternate multivariate analyses (e.g., repeated measures analysis of variance) in that it permits the analysis of differences over time at both individual and group levels. Using infants' MBPS 0 scores immediately post-needle as a common starting-point for all infants (i.e., the latent intercept factor, labeled "distress reactivity"), LGM models the change in individual infants' MBPS distress scores over the 3 minutes post-needle (i.e., using a latent slope factor, labeled "distress regulation"). Since the mean slope of distress is negative (i.e., infants respond with a high degree of distress immediately post-needle which attenuates over the 3-minute period), scores that are further from 0 indicate greater regulation over time, whereas scores that are closer to 0 indicate less regulation over time. In other words, higher negative scores indicate greater decreases in distress from immediately post-needle to 3 minutes post-needle.

LGM models were estimated using Mplus version 6.1 (Muthén & Muthén, 2010). Maximum likelihood estimation with the Yuan–Bentler model χ^2 statistic (Yuan & Bentler, 2000) and robust standard errors were used to account for potential non-normality in the presence of missing data.

Model 1 (see Figure 4). Prior to including attachment or temperamental fear variables of central interest to this study, a baseline model (Model 1) was created. Model 1 included baseline distress, distress reactivity (the latent intercept factor) and distress regulation (the latent slope factor) as outcome variables. In order to account for prior distress predicting subsequent distress, baseline distress was included as a predictor of distress reactivity and regulation and distress reactivity was included as a predictor of distress regulation. Other predictor variables included sex of infant, number of needles, and analgesic medication. Model 1 was estimated using all available data at the time of analysis from the 12-month visit of the larger longitudinal study ($N = 530$). Subsequently, the amount of variance in distress reactivity and distress regulation explained by Model 1 was compared to the amount of variance explained by Models 2 to 4 to assess the contributions of attachment, temperamental fear, and the interaction between attachment and temperamental variables.

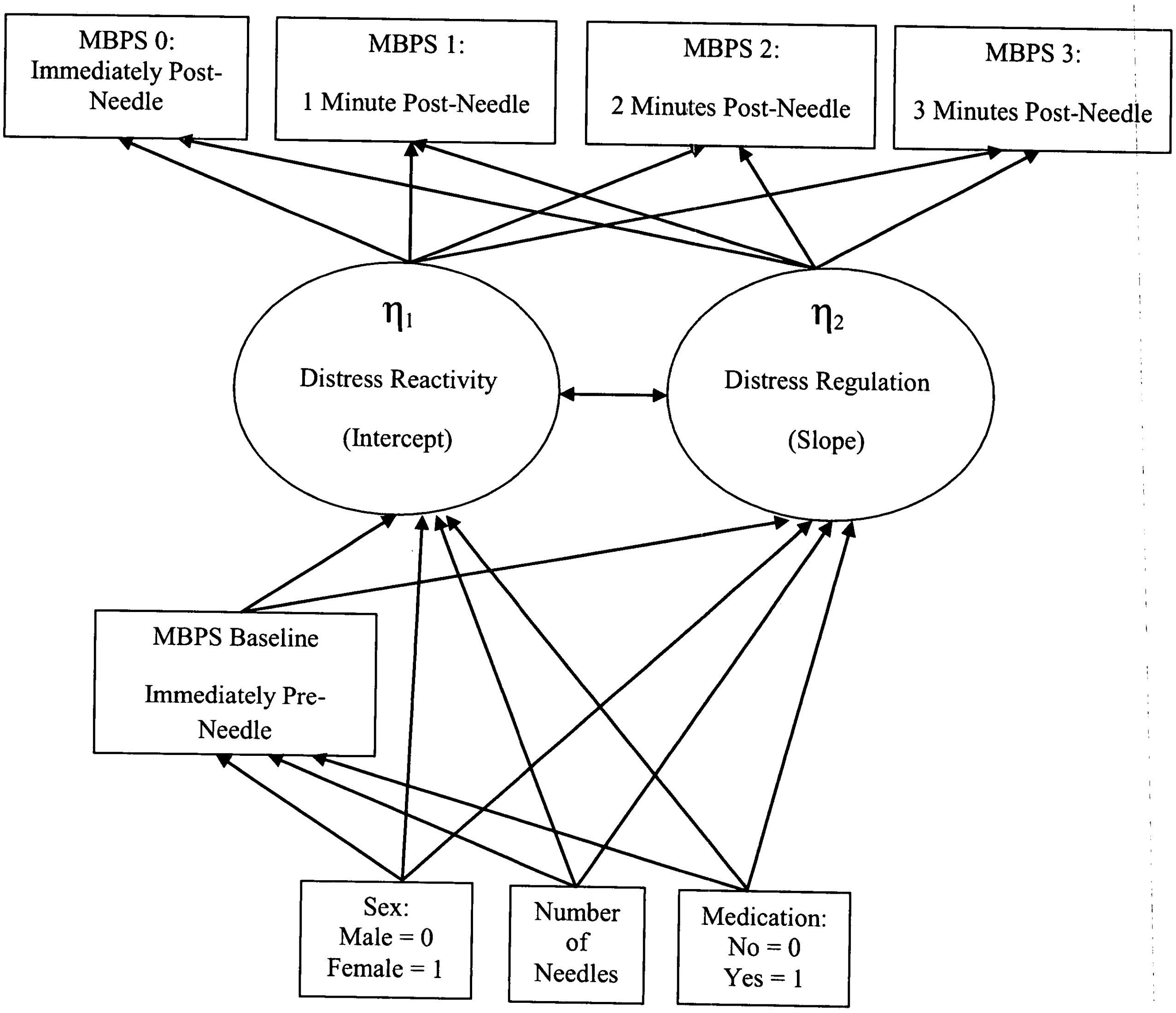

Figure 4. Path diagram for Model 1 with distress reactivity and distress regulation as dependent variables and baseline distress, sex, number of needles, and medication as the predictor variables.

Models 2 to 4 (see Figure 5). Significant predictor variables from Model 1 were carried over in Models 2 through 4. To test the hypothesis that temperamental fear moderates the relationship between attachment and distress reactivity or distress regulation, the following models were estimated based on three variations in attachment classification: In Model 2, A, B, C, and D attachment classifications, temperamental fear scores, and the interaction between A/B/C/D and temperamental fear were predictors of baseline distress, distress reactivity and distress regulation. Attachment classifications were dummy-coded with secure (B) as the comparison group to compare this group with each of the more high-risk groups (i.e., avoidant, resistant, and disorganized). In Model 3, secure/insecure attachment classifications, temperamental fear, and the interaction between secure/insecure and temperamental fear were predictors of baseline distress, distress reactivity and distress regulation. In Model 4, organized/disorganized attachment classifications, temperamental fear, and the interaction between organized/disorganized and temperamental fear were predictors of baseline distress, distress reactivity and distress regulation.

Preliminary Results (1).

Descriptive Statistics for Preliminary Results 1: Descriptive statistics of variables central to the first research question are presented in Table 4. Of the 530 infants included in the longitudinal study at 12 months, 48% were male and 52% were female. The majority of infants received two needles at the 12-month immunization (81%), while 14% received one needle and 5% received three or more needles. The majority of caregivers reported that they did not provide any pain medication for their infant prior to the 12-month

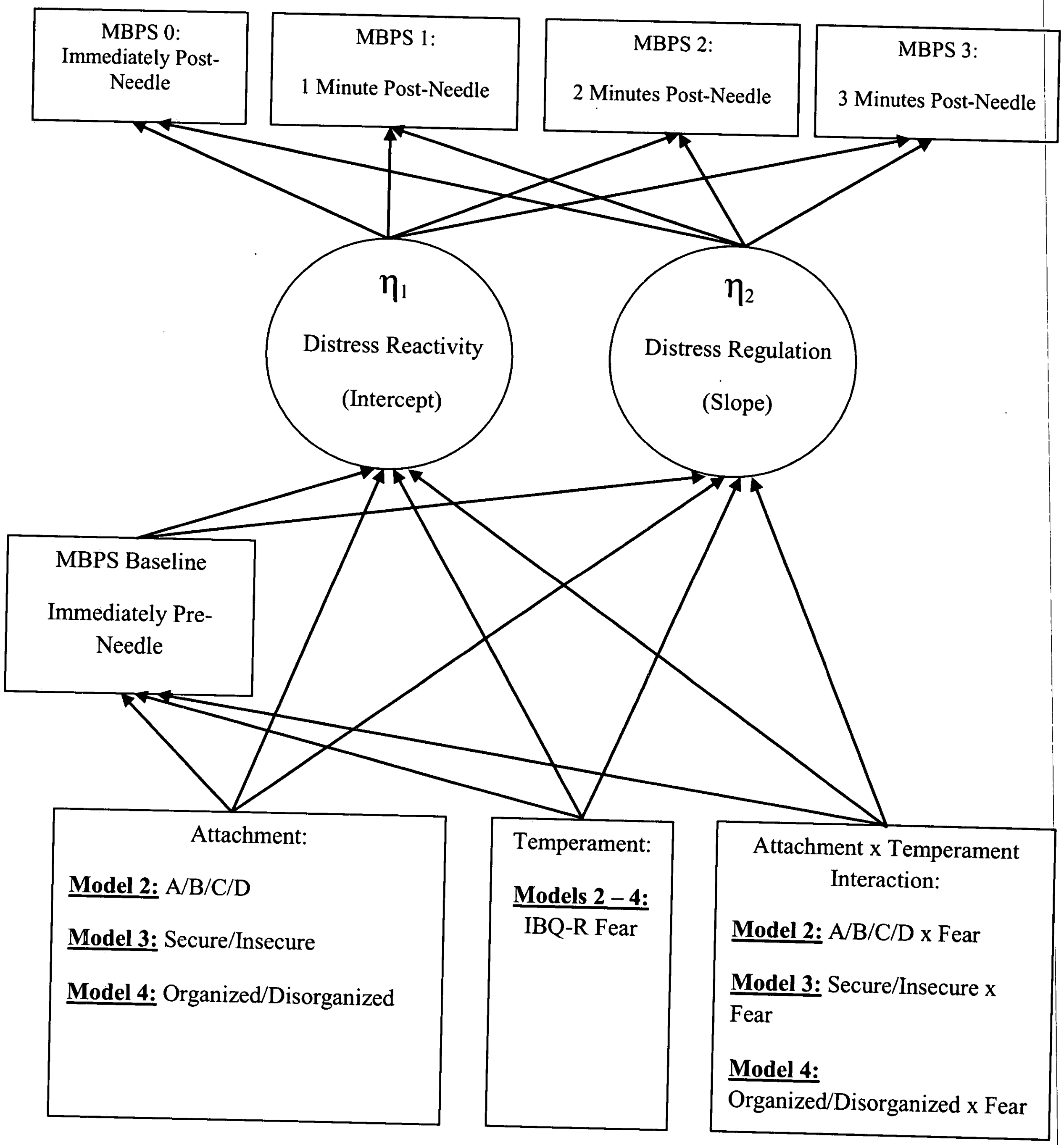

Figure 5. Path diagram summary for Models 2 - 4 with distress reactivity and distress regulation as dependent variables and baseline distress, attachment, temperament and attachment x temperament as the predictor variables.

Table 4

Descriptive Statistics of Variables Central to Research Question 1

Continuous Variables	*n*	Minimum	Maximum	*M*	*SD*
Baseline Distress+	520	.00	9.00	3.41	2.31
MBPS 0+	529	2.00	10.00	8.27	1.16
MBPS 1+	519	1.00	10.00	5.58	2.50
MBPS 2+	488	.00	10.00	4.77	2.58
MBPS 3+	436	.00	10.00	4.17	2.50
IBQ-R Fear (mean score)^	123	1.13	5.81	3.18	.95
Categorical Variables					
Sex+					
Male	257				
Female	273				
#Needles+					
1	76				
2	429				
3 or more	25				
Medication+					
None	462				
EMLA	1				
Tylenol/over-the-counter medication	40				
No response	27				
A/B/C/D^					
A (avoidant)	31				
B (secure)	68				
C (resistant)	8				
D (disorganized)	23				
Secure/Insecure^					
Secure (B)	68				
Insecure (A, C and D)	62				
Organized/Disorganized^					
Organized (A, B and C)	107				
Disorganized (D)	23				

Note. MBPS = Modified Behavioral Pain Scale; IBQ-R = Infant Behavior Questionnaire Revised.
+*N* = 530 for longitudinal study, ^*N* = 130 for the current follow up study.

immunization appointment (87%), while a minority of caregivers provided either EMLA cream (> 1%) or Tylenol or other over-the-counter pain medication (8%). The remaining 5% of caregivers did not answer this question. The number of caregivers who provided EMLA or Tylenol or other over-the-counter pain medication was collapsed in subsequent analyses so that the variable represented medication (assigned a value of 1) or no medication (assigned a value of 0). Within the sample of 123 infants examined in this study, the number of infants with MBPS scores of 4 or above (representing moderate to severe distress) was examined at each time period. Using this cut-off for moderate distress, one quarter of all infants (25%) were distressed pre-needle. All (100%) of the infants responded to immunization with moderate to severe levels of distress. The majority (68%) of infants were still distressed 1 minute following needle. At 2 minutes post-needle, over half of the infants (58%) continued to exhibit distress. At 3 minutes post-needle, 44% of infants were still moderately to severely distressed.

The number of infants classified as secure/insecure, χ^2 (1, N = 128) = 1.13, p = .38, and organized/disorganized, χ^2 (1, N = 128) = 0.05, p = .99, did not differ between the two pediatricians' offices from which 98.5% of participants were recruited. The third pediatric office was not included in these analyses because only two dyads were recruited from this site; the two infants from this third site were both coded as secure (B) in the SSP. Similarly, independent t-tests indicated that IBQ-R Fear scores and MBPS scores did not differ between the two main clinics. Therefore, samples were collapsed across pediatric clinics in subsequent analyses.

Bivariate Relationships for Preliminary Results 1: The bivariate relationships among the IBQ-R Fear scale, attachment, and MBPS scores were examined prior to SEM analyses. Independent samples *t*-tests (secure versus insecure comparisons and organized versus disorganized comparisons) and one-way ANOVAs (A, B, C and D comparisons) were used to examine whether IBQ-R Fear scale scores and MBPS scores differed according to attachment.

Resistant (C) infants were rated as the most temperamentally fearful ($M = 3.66$, $SD = 1.23$), followed by the disorganized (D) infants ($M = 3.43$, $SD = .85$), secure (B) infants ($M = 3.14$, $SD = .90$), and avoidant (A) infants ($M = 2.98$, $SD = 1.04$); however, these differences were non-significant, $F(3, 119) = 1.54$, $p = .21$. There were also no significant differences in IBQ-R Fear scores for infants from secure and insecure groups, $F(1, 121) = .38$, $p = .68$, or infants from organized and disorganized groups, $F(1, 121) = .80$, $p = .21$.

There were no significant differences (all *p*s > .10) in MBPS distress scores between groups of infants from avoidant, secure, resistant, and disorganized groups or between infants from secure and insecure groups at any time period (1 minute pre-needle, immediately post-needle, 1 minute post-needle, 2 minutes post-needle, and 3 minutes post-needle). Organized infants exhibited significantly more distress 3 minutes-post-needle ($M = 4.18$, $SD = 2.42$) than disorganized infants, ($M = 3.19$, $SD = 1.78$), $t(116) = 2.21$, $p = 0.03$. The IBQ-R Fear scale was not significantly correlated with MBPS distress scores at any time period, *r*s range from -.01 to -.12, with all *p*s > .10.

Primary results (1). Unstandardized estimates are reported in written text and figures. Both unstandardized and standardized estimates are reported in tables.

Model 1: Pain-related distress reactivity and pain-related distress regulation conditioned on sex of infant, the number of needles infants received, medication, and baseline distress. The mean values for MBPS 0 (M = 8.27), MBPS 1 (M = 5.58), MBPS 2 (M = 4.77), and MBPS 3 (M = 4.17) indicated that the overall growth trajectory shape (i.e., distress regulation) was not linear. Subsequently, a freed-loading model was estimated where the MBPS 1 and MBPS 2 slope factor loadings were freely estimated (rather than constrained to reflect linear growth; Bollen & Curran, 2006). The correlations and covariances for the variables used in Model 1 are provided in Table 5. Unstandardized parameter estimates for Model 1 are represented in Figure 6. Both standardized and unstandardized results for Model 1 are represented in Table 6.

The freed-loading model fit the data well. Using Hu and Bentler's (1998) two-index strategy for model fit assessment, a Standardized Root Mean Square Residual (SRMR) of .03 along with the Root Mean Square Error of Approximation (RMSEA) of .04 (90% CI: .02 - .06) indicated a close fit (Hu & Bentler, 1999).

The freed-loading model results indicated that the pain-related distress regulation non-linear slope factor loadings changed from $\lambda = .68$ to $\lambda = .88$ from 1 minute post-needle to 2 minutes post-needle. With pain-related distress reactivity constrained to 0 and distress at 3 minutes post-needle constrained to 1, these estimates suggest that most of the change in distress occurred during the first minute following the needle (68%), with moderate changes in distress during the second minute (20%) and third minute (12%) following needle.

Table 5

Correlations and Covariances among Variables for Model 1

Variable	1	2	3	4	5	6	7	8
1. Baseline Distress	5.38	.33**	.29**	.30**	.32**	.07	.09	.04
2. MBPS 0	.91	1.40	.38**	.33**	.30**	.07	.12	.00
3. MBPS 1	1.65	1.12	6.19	.54**	.40**	.04	.15*	.03
4. MBPS 2	1.80	1.02	3.49	6.73	.52**	.05	.12	.02
5. MBPS 3	1.89	.88	2.52	3.41	6.35	.00	.12	-.02
6. Sex	.08	.04	.05	.06	.00	.25	-.09	.00
7. #Needles	.10	.06	.17	.14	.14	-.02	.21	.09
8. Medication	.03	.00	.02	.01	-.01	.00	.01	.07

Note. Correlations are depicted above the diagonal in the shaded region. Covariances are depicted below the diagonal. MBPS = Modified Behavioral Pain Scale
* $p < .05$. ** $p < .01$.

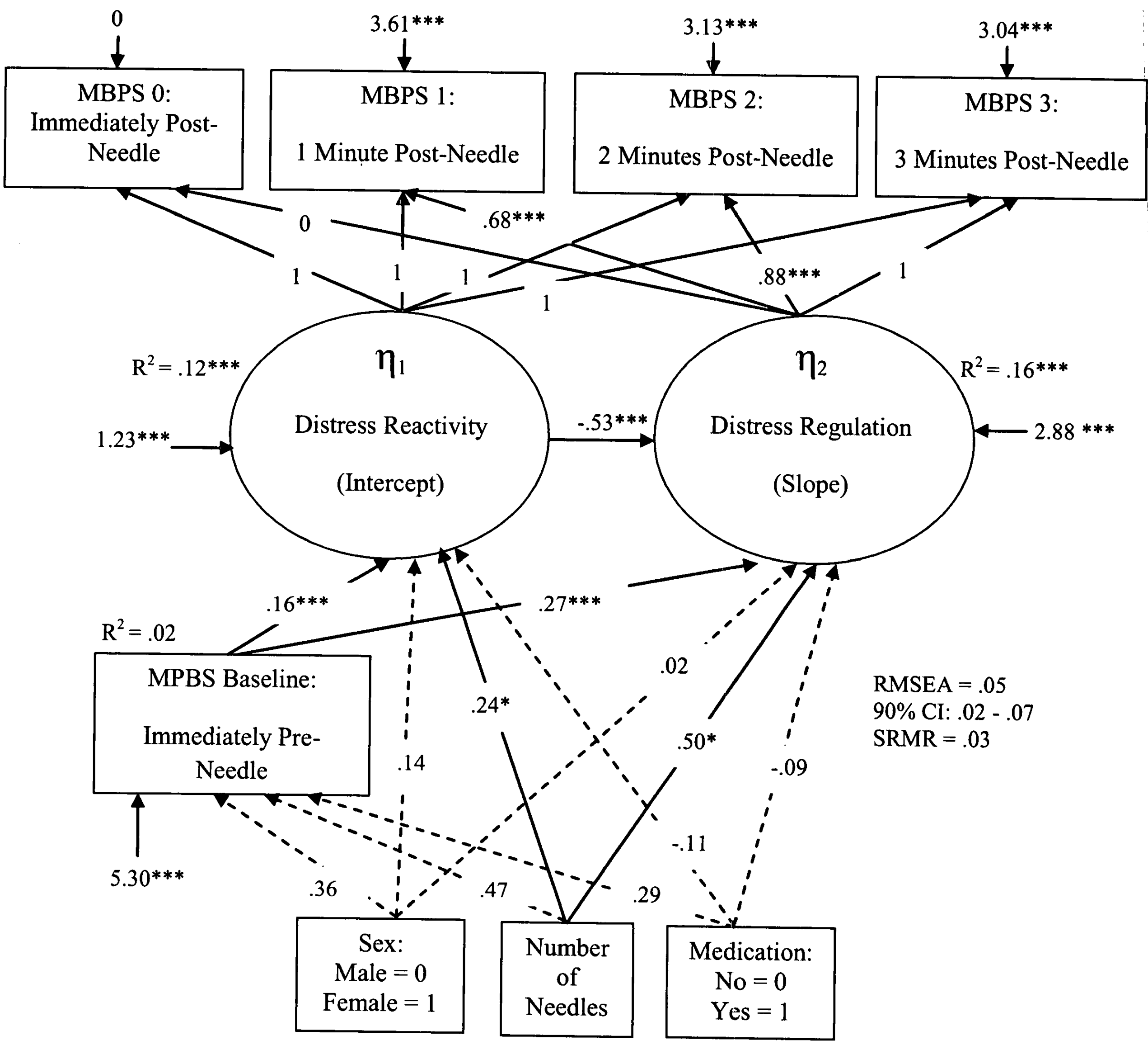

Figure 6. Unstandardized parameter estimates for Model 1.
Latent factors are shown in ellipses and observed variables are shown in rectangles. Dotted lines represent non-significant paths. Single headed arrows represent unstandardized parameter estimates for directional prospective prediction. RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; MBPS = Modified Behavioral Pain Scale; IBQ-R = Infant Behavior Questionnaire – Revised; $N = 530$.
$* p < .05$. $*** p < .001$.

Table 6

Estimates for Model 1

Variable	Un-Standardized Estimate	S.E.	Est./ S.E.	Two-Tailed P-Value	Standardized Estimate	S.E.	Est./ S.E.	Two-Tailed P-Value
Baseline Distress (Observed MBPS 1 minute pre-needle scores)								
Sex	.36	.21	1.70	.08	.07	.04	1.56	.12
#Needles	.47	.25	1.83	.07				
Medication	.29	.41	.71	.48	.04	.05	.89	.37
R^2	.02	.01	1.21	.23				
Distress Reactivity (Latent Intercept Factor)								
Baseline Distress	.16	.02	9.76	< .001	.32	.03	12.20	< .001
MBPS 0	1.00	.00			1.00	.00		
MBPS 1	1.00	.00			.48	.04	13.29	< .001
MBPS 2	1.00	.00			.47	.04	13.09	< .001
MBPS 3	1.00	.00			.45	.04	12.27	< .001
Sex	.14	.10	1.38	.17	.06	.04	1.38	.17
#Needles	.24	.11	2.12	< .05	.10	.05	2.12	< .05
Medication	-.11	.15	-.70	.48	-.03	.04	-.69	.49
R^2	.12	.02	6.03	< .001				
Distress Regulation (Latent Slope Factor)								
Baseline Distress	.27	.05	5.86	< .001	.34	.06	5.79	< .001
MBPS 0	.00	.00			.00	.00		
MBPS 1	.68	.03	24.28	< .001	.52	.03	18.36	< .001
MBPS 2	.88	.03	31.40	< .001	.64	.03	20.32	< .001
MBPS 3	1.00	.00			.70	.03	23.33	< .001
Sex	.02	.20	.12	.91	.01	.05	.12	.91
#Needles	.50	.22	2.25	< .05	.13	.06	2.23	< .05
Medication	-.09	.36	-.25	.80	-.01	.05	-.25	.80
Distress Reactivity	-.53	.07	-7.25	< .001	-.34	.06	-5.74	< .001
R^2	.16	.04	3.71	< .001				

Note. MBPS = Modified Behavioral Pain Scale; MBPS 0 = Distress Immediately Post-Needle; MBPS 1 = Distress 1 Minute Post-Needle; MBPS 2 = Distress 2 Minutes Post-Needle; MBPS 3 = Distress 3 Minutes Post-Needle.

Infant sex was not significantly related to baseline distress ($B = 0.36, p = .09$), pain-related distress reactivity ($B = 0.14, p = .17$), or pain-related distress regulation ($B = .02, p = .91$). The numbers of needles infants received was significantly related to distress reactivity ($b = 0.24, p = .04$) and distress regulation ($B = 0.50, p = .03$), such that the greater number of needles administered, the higher the distress reactivity and the slower the distress regulation. The number of needles was not significantly related to baseline distress ($B = 0.47, p = .07$). Medication was not significantly related to baseline distress ($B = .29, p = .48$), distress reactivity ($B = -0.11, p = .48$), or distress regulation ($B = -0.09, p = .80$). Baseline distress was significantly positively related to distress reactivity ($B = .16, p < .001$) such that higher levels of baseline distress were associated with higher levels of distress reactivity. Baseline distress was also significantly positively related to distress regulation ($B = 0.27, p < .001$) such that higher baseline distress was associated with slower distress regulation. Distress reactivity was significantly related to distress regulation ($B = -0.53, p < .001$) such that higher distress reactivity was associated with faster distress regulation.

Model 1 accounted for 2% of the variance in baseline distress ($R^2 = .02, p = .23$), 12% of the variance in distress reactivity ($R^2 = .12, p < .001$), and 16% of the variance in distress regulation ($R^2 = .16, p < .001$).

Models 2 – 4: Included Variables and Common Findings. Sex of infant and use of medication were not significantly associated with baseline distress, pain-related distress reactivity, or regulation in Model 1 and were therefore not included in Models 2 to 4. Based on significant relationships from Model 1, baseline distress and number of needles were included as predictors of pain-related distress reactivity and regulation in Models 2 to 4. Attachment and temperamental fear were also included as predictors of baseline distress in these models. The aforementioned variables were then included with different categorization options for attachment (Model 2: four-level main classification comparison, A/B/C/D with secure (B) as the comparison group; Model 3: two-level security comparison secure (B)/insecure (A, C and D); and Model 4: two-level organization comparison organized (A, B and C)/disorganized (D).

Consistent with Model 1, baseline distress was significantly positively related to pain-related distress reactivity ($p < .001$) across Models 2 to 4. However, baseline distress was not significantly related to pain-related distress regulation when temperament and attachment variables were included as predictors in Models 2 to 4 ($p > .10$). Similarly, consistent with Model 1, the number of needles was significantly related to pain-related distress reactivity in Models 2 to 4 ($p < .05$), but became non-significant when temperament and attachment variables were included ($p > .10$). With the inclusion of attachment and temperamental fear in Models 2 to 4, distress reactivity was no longer significantly related to distress regulation ($p > .10$).

The results pertaining to relationships between the temperament and attachment predictors in Models 2 to 4 (i.e., attachment, temperamental fear, and the interaction between attachment and temperamental fear) and baseline distress, pain-related distress reactivity, and regulation are reported below.

Model 2: Pain-related distress reactivity and pain-related distress regulation conditioned on A/B/C/D attachment groups, temperamental fear, the interaction

between A/B/C/D and temperamental fear, the number of needles infants received, and baseline distress. The correlations and covariances for the variables used in Model 2 are provided in Table 7. Unstandardized parameter estimates for Model 2 are represented in Figure 7. Both standardized and unstandardized results for Model 2 are represented in Table 8. The model fit the data well, RMSEA = .07 (90% CI: .03 - .11), SRMR = .05. Model 2 accounted for 6% of the variance in baseline distress ($R^2 = .06, p = .03$), 16% of the variance in distress reactivity ($R^2 = .16, p < .01$), and 20% of the variance in distress regulation ($R^2 = .20, p = .02$).

Controlling for the number of needles, B/C and B/D comparisons, temperamental fear, and the interaction between A/B/C/D and temperamental fear, the B/A comparison was significantly negatively related to baseline distress ($B = -.91, p < .01$) such that avoidant infants were significantly less distressed pre-needle than secure infants. Using MBPS cut-off score of 4 (representing moderate distress), post-hoc analyses indicated that 13% of avoidant infants were moderately distressed pre-needle, compared with 27% of secure infants, 38% of resistant infants and 35% of disorganized infants. A/B/C/D attachment, temperamental fear, and the interaction between A/B/C/D attachment and temperamental fear were not significantly related to distress reactivity (*p*s > .10).

The interaction between the B/A comparison and temperamental fear was significantly negatively related to distress regulation ($B = -1.23, p < .01$), as was the interaction between the B/D comparison and temperamental fear ($B = -1.29, p < .01$). Procedures outlined by Curran, Bauer, and Willoughby (2004) were used to probe the significant interactions. Infants in the upper and lower extremes of the temperamental

Table 7

Correlations and Covariances among Variables for Model 2

Variable	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Baseline Distress	4.68	.32**	.06	.04	.25**	.12	-.07	-.19	.00	.12	-.05	-.09	.05
2. MBPS 0	.66	.92	.39**	.37**	.25**	.23*	.09	-.01	.09	.02	-.03	.04	.14
3. MBPS 1	.31	.92	6.16	.43**	.25**	.21*	.11	.08	-.08	.06	-.05	.02	.20
4. MBPS 2	.21	.83	2.54	5.66	.44**	.13	-.02	-.01	.11	-.09	-.18	.02	-.15
5. MBPS 3	1.27	.55	1.43	2.40	5.38	.07	-.12	.08	-.07	-.14	-.23*	-.04	-.13
6. #Needles	.14	.12	.27	.16	.08	.28	.04	.02	.07	.06	-.06	.03	.07
7. IBQ-R Fear	-.15	.09	.27	-.05	-.26	.02	.91	-.12	.13	.12	.55**	.31**	.36**
8. B/A	-.18	.00	.08	-.01	.08	.00	-.05	.19	-.14	-.25**	-.17	-.06	-.07
9. B/C	.00	.02	-.05	.06	-.04	.01	.03	-.02	.05	-.11	.02	.38**	-.03
10. B/D	.09	.01	.06	-.07	-.12	.01	.04	-.04	-.01	.13.	.04	-.04	.27**
11. B/A* IBQ-R Fear	-.05	-.02	-.07	-.22	-.27	-.02	.27	-.04	.00	.01	.27	.01	.01
12. B/C* IBQ-R Fear	-.06	.01	.01	.02	-.03	.00	.09	-.01	.03	.00	.00	.09	-.01
13. B/D* IBQ-R Fear	.04	.05	.16	-.12	-.10	.01	.12	-.01	.00	.03	.00	.00	.12

Note. Correlations are depicted above the diagonal in the shaded region. Covariances are depicted below the diagonal. MBPS = Modified Behavioral Pain Scale; IBQ-R = Infant Behavior Questionnaire – Revised; B coded "0", A/C/D coded "1" for each dummy code.

* $p < .05$. ** $p < .01$.

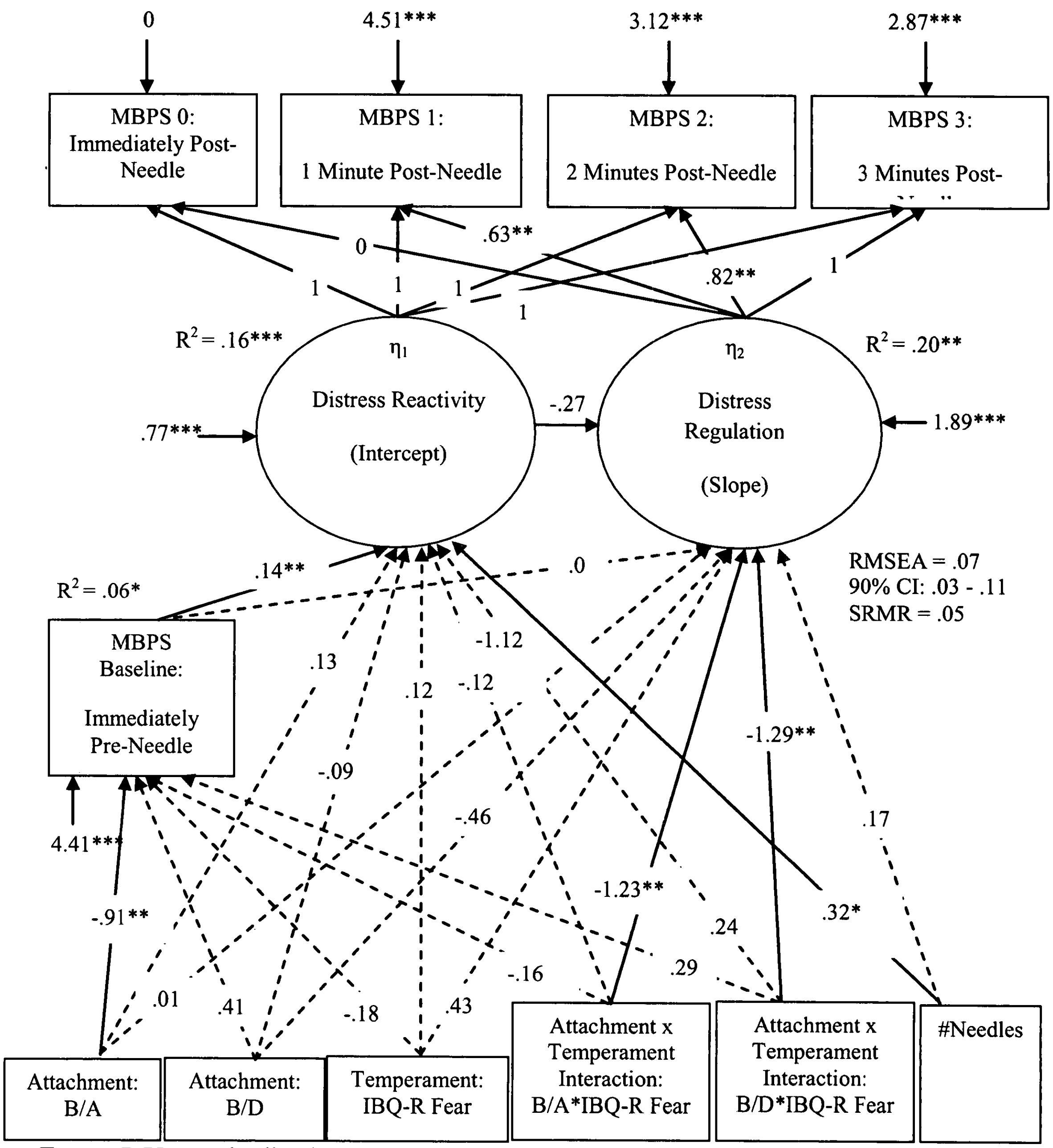

Figure 7. Unstandardized parameter estimates for Model 2.

Note. Main effects and interaction effects for B/C comparisons were non-significant and are not included above. Latent factors are shown in ellipses and observed variables are shown in rectangles. RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; MBPS = Modified Behavioral Pain Scale; IBQ-R = Infant Behavior Questionnaire – Revised; $N = 130$.

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

Table 8

Estimates for Model 2

Variable	Un-Standardized Estimate	S.E.	Est./ S.E.	Two-Tailed P-Value	Standardized Estimate	S.E.	Est./ S.E.	Two-Tailed P-Value
Baseline Distress (Observed MBPS 1 minute pre-needle scores)								
IBQ-R Fear	-.18	.27	-.65	.52	-.08	.12	-.65	.52
B/A	-.91	.34	-2.72	< .01	-.18	.06	-3.04	< .01
B/C	.20	.78	.26	.80	.02	.08	.26	.80
B/D	.41	.71	.58	.56	.07	.12	.58	.56
B/AxIBQ-R Fear	-.16	.41	-.38	.70	-.04	.10	-.38	.70
B/CxIBQ-R Fear	-.57	.46	-1.24	.22	-.08	.07	-1.14	.25
B/DxIBQ-R Fear	.29	.91	.32	.75	.05	.14	.32	.75
R^2	.06	.03	2.13	< .05				
Distress Reactivity (Latent Intercept Factor)								
Baseline Distress	.14	.04	3.72	< .001	.31	.08	3.88	< .001
MBPS 0	1.00	.00			1.00	.00		
MBPS 1	1.00	.00			.39	.05	8.27	< .001
MBPS 2	1.00	.00			.42	.05	8.30	< .001
MBPS 3	1.00	.00			.40	.05	7.86	< .001
#Needles	.32	.14	2.27	< .05	.18	.08	2.12	< .05
IBQ-R Fear	.12	.14	.82	.41	.12	.13	.87	.39
B/A	.13	.19	.65	.52	.06	.09	.66	.51
B/C	.31	.24	1.32	.19	.08	.06	1.33	.18
B/D	-.09	.20	-.46	.64	-.04	.08	-.46	.65
B/AxIBQ-R Fear	-.12	.19	-.61	.54	-.06	.10	-.63	.53
B/CxIBQ-R Fear	-.01	.19	-.07	.95	.00	.06	-.07	.95
B/DxIBQ-R Fear	.24	.28	.87	.38	.09	.10	.84	.40
R^2	.16	.05	3.20	< .01				
Distress Regulation (Latent Slope Factor)								
Baseline Distress	.06	.10	.62	.54	.08	.14	.62	.54
MBPS 0	.00	.00			.00	.00		
MBPS 1	.63	.06	11.38	< .001	.39	.05	7.46	< .001
MBPS 2	.82	.05	15.93	< .001	.55	.07	8.21	< .001
MBPS 3	1.00	.00			.64	.07	9.41	< .001
#Needles	.17	.27	.64	.53	.06	.09	.63	.53
IBQ-R Fear	.43	.26	1.65	.10	.27	.16	1.69	.09
B/A	.01	.41	.03	.98	.00	.12	.03	.98
B/C	-.42	.90	-.47	.64	-.06	.14	-.47	.64
B/D	-.46	.43	-1.08	.28	-.11	.10	-1.08	.28
B/AxIBQ-R Fear	-1.23	.36	-3.46	< .01	-.42	.13	-3.30	< .01
B/CxIBQ-R Fear	-.47	.44	-1.06	.29	-.09	.09	-1.01	.31
B/DxIBQ-R Fear	-1.29	.48	-2.69	< .01	-.28	.11	-2.50	< .05
Distress Reactivity	-.27	.18	-1.48	.14	-.16	.12	-1.44	.15

Table 8 (cont.)

R^2	.20	.08	2.43	< .05

Note. MBPS = Modified Behavioral Pain Scale; IBQ-R = Infant Behavior Questionnaire – Revised; MBPS 0 = Distress Immediately Post-Needle; MBPS 1 = Distress 1 Minute Post-Needle; MBPS 2 = Distress 2 Minutes Post-Needle; MBPS 3 = Distress 3 Minutes Post-Needle; B = secure; A = avoidant; C= resistant; D = disorganized.

fear distribution (approximately the upper and lower 15%; Kagan, 1989) are theorized to represent vulnerable groups (Bradley, 2000; Rothbart & Bates, 1998). Therefore, temperamental fear was centered at the 92.5^{th} percentile to represent infants with high temperamental fear and at the 7.5^{th} percentile to represent infants with low temperamental fear.

At high levels of temperamental fear, avoidant infants had a distress regulation slope which was significantly higher than that of secure infants ($B = 1.84, p < .01$). Thus, avoidant infants with high temperamental fear took significantly longer to regulate pain-related distress than secure infants with high temperamental fear. At high levels of temperamental fear, disorganized infants also had a distress regulation slope that was higher than secure infants, but the difference between slopes was non-significant ($B = 1.46, p = .10$). At low levels of temperamental fear, avoidant infants had a distress regulation slope that was significantly lower than secure infants ($B = -1.74, p < .01$). At low levels of temperamental fear, disorganized infants also had a distress regulation slope that was significantly lower than secure infants ($B = -2.30, p < .01$). Thus, avoidant and disorganized infants with low temperamental fear regulated pain-related distress significantly faster than secure infants with low temperamental fear. At average levels of temperamental fear, the distress regulation slopes for secure, avoidant, and disorganized infants were not significantly different (*p*s > .10). Graphical representations of baseline distress, pain-related distress reactivity, and pain-related distress regulation for avoidant, secure, resistant, and disorganized infants according to high, average, and low temperamental fear are depicted in Figure 8.

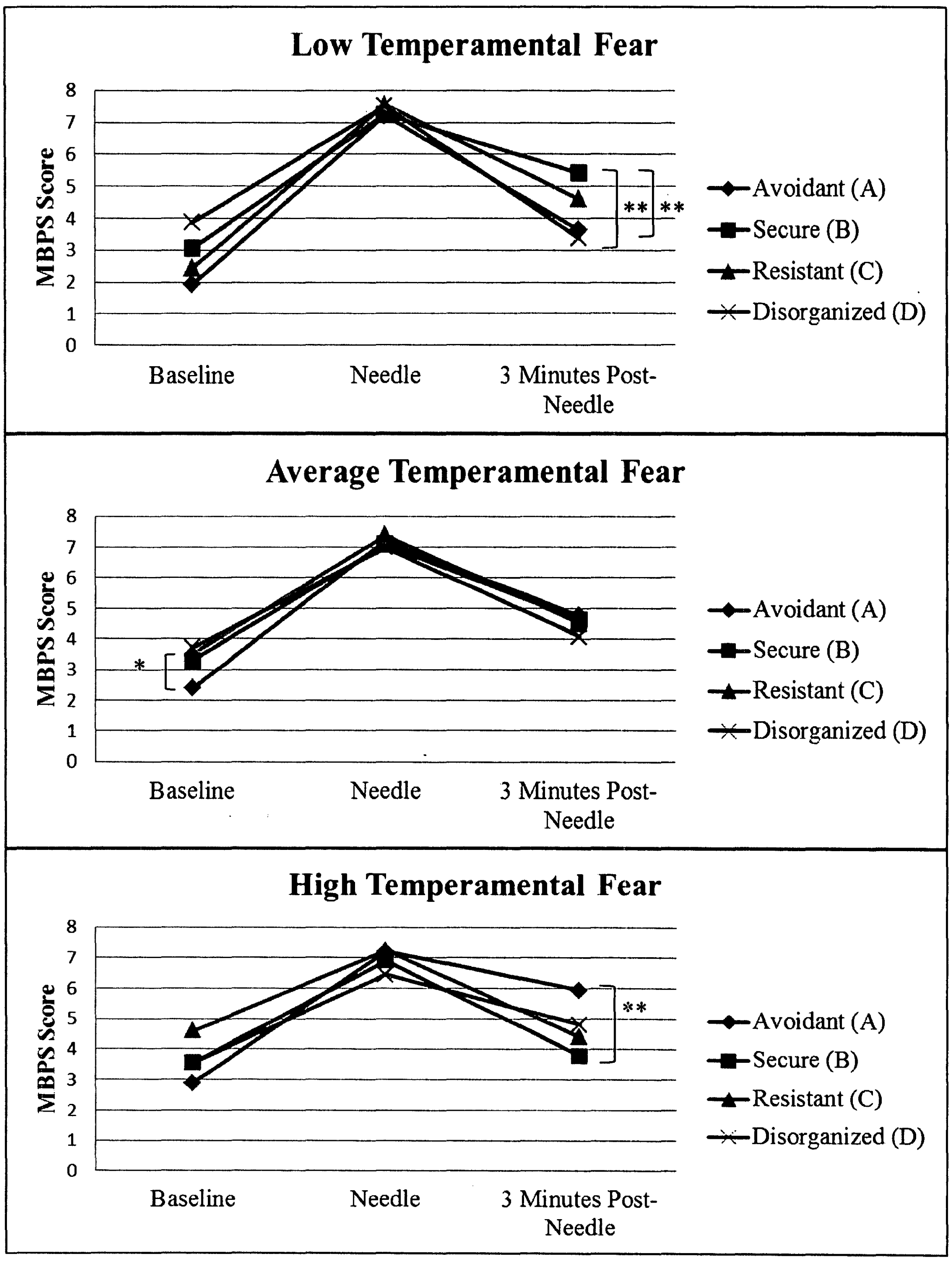

Figure 8. Trajectories of distress for A/B/C/D attachment groups according to temperamental fear level.
* $p < .05$. ** $p < .01$.

Model 3: Pain-related distress reactivity and pain-related distress regulation conditioned on secure/insecure attachment groups, temperamental fear, the interaction between secure/insecure and temperamental fear, the number of needle s infants received, and baseline distress. The correlations and covariances for the variables used in Model 3 are provided in Table 9. Unstandardized parameter estimates for Model 3 are represented in Figure 9. Both standardized and unstandardized results for Model 3 are represented in Table 10. The model fit the data well, RMSEA = .06 (90% CI: .00 - .11), SRMR = .06. Model 3 accounted for 1% of the variance in baseline distress ($R^2 = .01, p = .54$), 14% of the variance in distress reactivity ($R^2 = .14, p < .01$), and 17% of the variance in distress regulation ($R^2 = .17, p = .03$).

Secure/insecure attachment, temperamental fear, and the interaction between secure/insecure attachment and temperamental fear were not significantly related to baseline distress or distress reactivity (*ps* > .10). The interaction between secure/insecure attachment and temperamental fear was significantly negatively related to distress regulation ($B = -1.15, p < .01$). The interaction was probed with temperamental fear centered at the 92.5th and 7.5th percentiles, as described above.

At high levels of temperamental fear, insecure infants had a distress regulation slope that was significantly higher than secure infants ($B = 1.56, p = .01$). Thus, insecure infants with high temperamental fear took significantly longer to regulate pain-related distress than secure infants with high temperamental fear. At low levels of temperamental fear, insecure infants had a distress regulation slope that was significantly lower than secure infants ($B = -1.80, p < .01$). Thus, insecure infants with low

Table 9

Correlations and Covariances among Variables for Model 3

Variable	1	2	3	4	5	6	7	8	9
1. Baseline Distress	4.68	.32**	.06	.04	.25**	.12	-.07	-.08	-.05
2. MBPS 0	.66	.92	.39**	.37**	.25**	.23*	.09	.05	.06
3. MBPS 1	.32	.92	6.15	.43**	.25**	.21*	.11	.07	.05
4. MBPS 2	.25	.83	2.58	5.62	.44**	.13	-.02	-.01	-.19
5. MBPS 3	1.29	.57	1.50	2.40	5.37	.07	-.12	-.06	-.24*
6. #Needles	.14	.12	.27	.15	.08	.28	.04	.09	.00
7. IBQ-R Fear	-.15	.09	.24	-.04	-.24	.02	.91	.04	.73**
8. Secure/Insecure	-.09	.03	.09	-.01	-.06	.02	.02	.25	.03
9. Secure/Insecure* IBQ-R Fear	-.07	.04	.08	-.31	-.38	.00	.48	.01	.48

Note. Correlations are depicted above the diagonal in the shaded region. Covariances are depicted below the diagonal. MBPS = Modified Behavioral Pain Scale; IBQ-R = Infant Behavior Questionnaire – Revised. Secure coded "0", insecure coded "1".
* $p < .05$. ** $p < .01$.

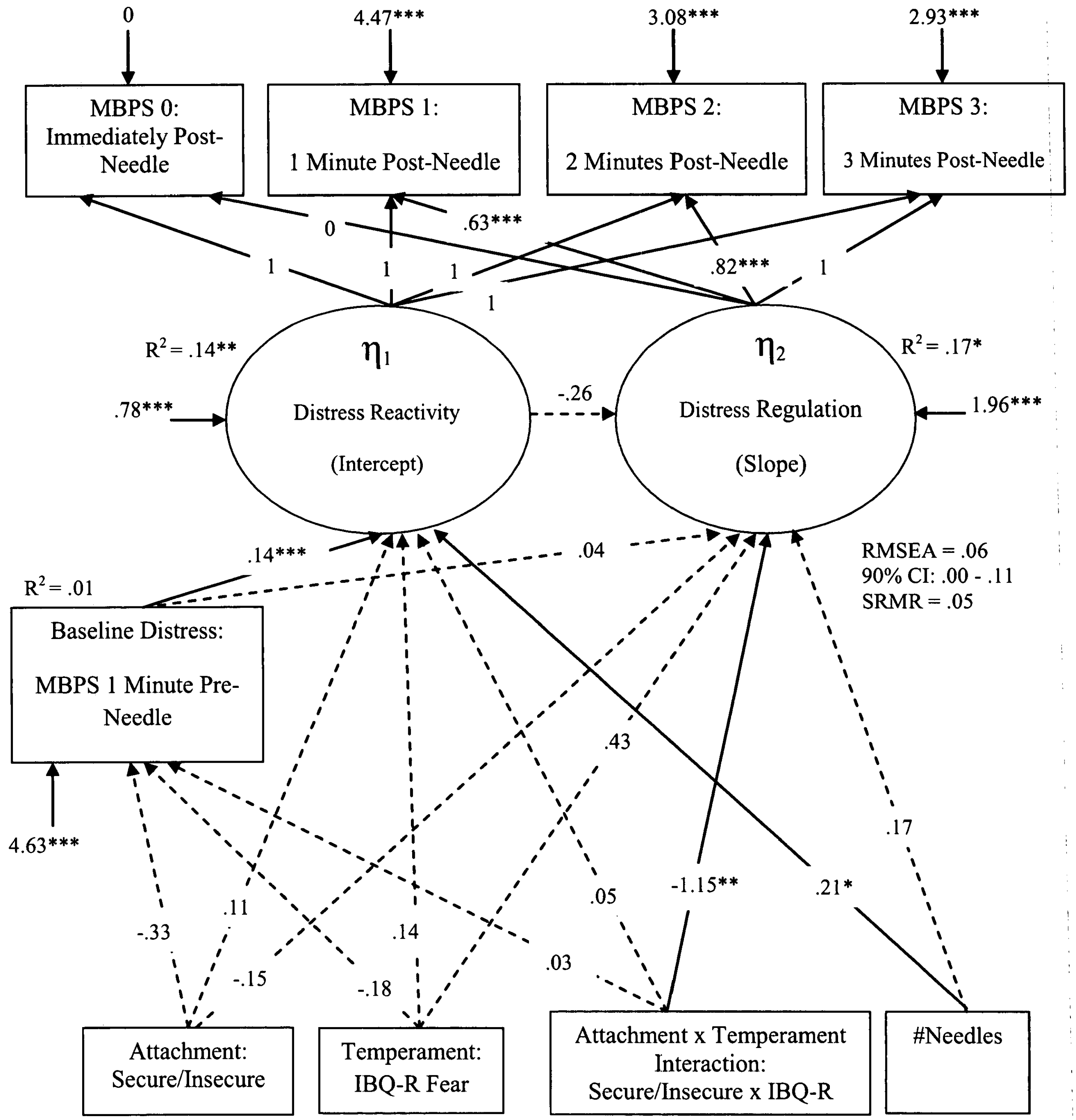

Figure 9. Unstandardized parameter estimates for Model 3. Latent constructs are shown in ellipses and observed variables are shown in rectangles. Dotted lines represent non-significant paths. Single headed arrows represent unstandardized parameter estimates for directional prospective prediction. RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; MBPS = Modified Behavioral Pain Scale; IBQ-R = Infant Behavior Questionnaire – Revised.
* $p < .05$. ** $p < .01$. *** $p < .001$.

Table 10

Estimates for Model 3

Variable	Un-Standard-ized Estimate	S.E.	Est./S.E.	Two-Tailed P-Value	Standardized Estimate	S.E.	Est./S.E.	Two-Tailed P-Value
Baseline Distress (Observed MBPS 1 minute pre-needle scores)								
IBQ-R Fear	-.18	.27	-.65	.52	-.08	.12	-.65	.52
S/I	-.33	.39	-.86	.39	-.08	.09	-.87	.39
S/I*IBQ-R Fear	.03	.40	.08	.94	.01	.13	.08	.94
R^2	.01	.03	.61	.54				
Distress Reactivity (Intercept Factor)								
Baseline Distress	.14	.04	3.81	< .001	.31	.08	4.05	< .001
MBPS 0	1.00	.00			1.00	.00		
MBPS 1	1.00	.00			.39	.05	8.29	< .001
MBPS 2	1.00	.00			.42	.05	8.32	< .001
MBPS 3	1.00	.00			.40	.05	7.87	< .001
#Needles	.34	.14	2.35	< .05	.19	.09	2.18	< .05
IBQ-R Fear	.12	.14	.81	.42	.12	.13	.86	.39
S/I	.11	.15	.69	.49	.06	.08	.71	.48
S/IxIBQ-R Fear	-.02	.17	-.09	.93	-.01	.12	-.09	.93
R^2	.14	.05	2.98	< .01				
Distress Regulation (Slope Factor)								
Baseline Distress	.04	.10	.38	.70	.05	.14	.38	.70
MBPS 0	.00	.00			.00	.00		
MBPS 1	.63	.06	11.52	< .001	.39	.05	7.46	< .001
MBPS 2	.82	.05	16.26	< .001	.55	.07	8.30	< .001
MBPS 3	1.00	.00			.64	.07	9.34	< .001
#Needles	.17	.28	.60	.55	.06	.10	.60	.55
IBQ-R Fear	.43	.26	1.64	.10	.27	.16	1.67	.10
S/I	-.15	.34	-.45	.66	-.05	.11	-.45	.65
S/IxIBQ-R Fear	-1.15	.33	-3.45	< .001	-.52	.15	-3.47	< .001
Distress Reactivity (Intercept Factor)	-.26	.18	-1.41	.16	-.16	.12	-1.37	.17
R^2	.17	.08	2.25	< .05				

Note. MBPS = Modified Behavioral Pain Scale; IBQ-R = Infant Behavior Questionnaire – Revised; MBPS 0 = Distress Immediately Post-Needle; MBPS 1 = Distress 1 Minute Post-Needle; MBPS 2 = Distress 2 Minutes Post-Needle; MBPS 3 = Distress 3 Minutes Post-Needle; S = secure (B group); I = insecure (A, C and D groups). Secure coded "0" and insecure coded "1".

temperamental fear regulated distress significantly faster than secure infants with low temperamental fear. At average levels of temperamental fear, the distress regulation scores for secure and insecure infants were not significantly different ($p > .10$).

Graphical representations of baseline distress, pain-related distress reactivity, and pain-related distress regulation for secure and insecure infants according to high, average, and low temperamental fear are depicted in Figure 10.

Model 4: Pain-related distress reactivity and pain-related distress regulation conditioned on organized/disorganized attachment groups, temperamental fear, the interaction between organized/disorganized and temperamental fear, the number of needles infants received, and baseline distress. The correlations and covariances for the variables used in Model 4 are provided in Table 11. Unstandardized parameter estimates for Model 4 are represented in Figure 11. Both standardized and unstandardized results for Model 4 are represented in Table 12. The model fit the data marginally well, RMSEA = .08 (90% CI: .03 - .13), SRMR = .06. Model 4 accounted for 2% of the variance in baseline distress ($R^2 = .02, p = .39$), 15% of the variance in distress reactivity ($R^2 = .15, p < .01$), and 9% of the variance in distress regulation ($R^2 = .09, p = .11$).

Organized/disorganized attachment, temperamental fear, and the interaction between organized/disorganized attachment and temperamental fear were not significantly related to baseline distress or distress reactivity (ps > .10). Organized/disorganized attachment ($p = .25$) and temperamental fear ($p = .76$) were not significantly related to distress regulation. The interaction between

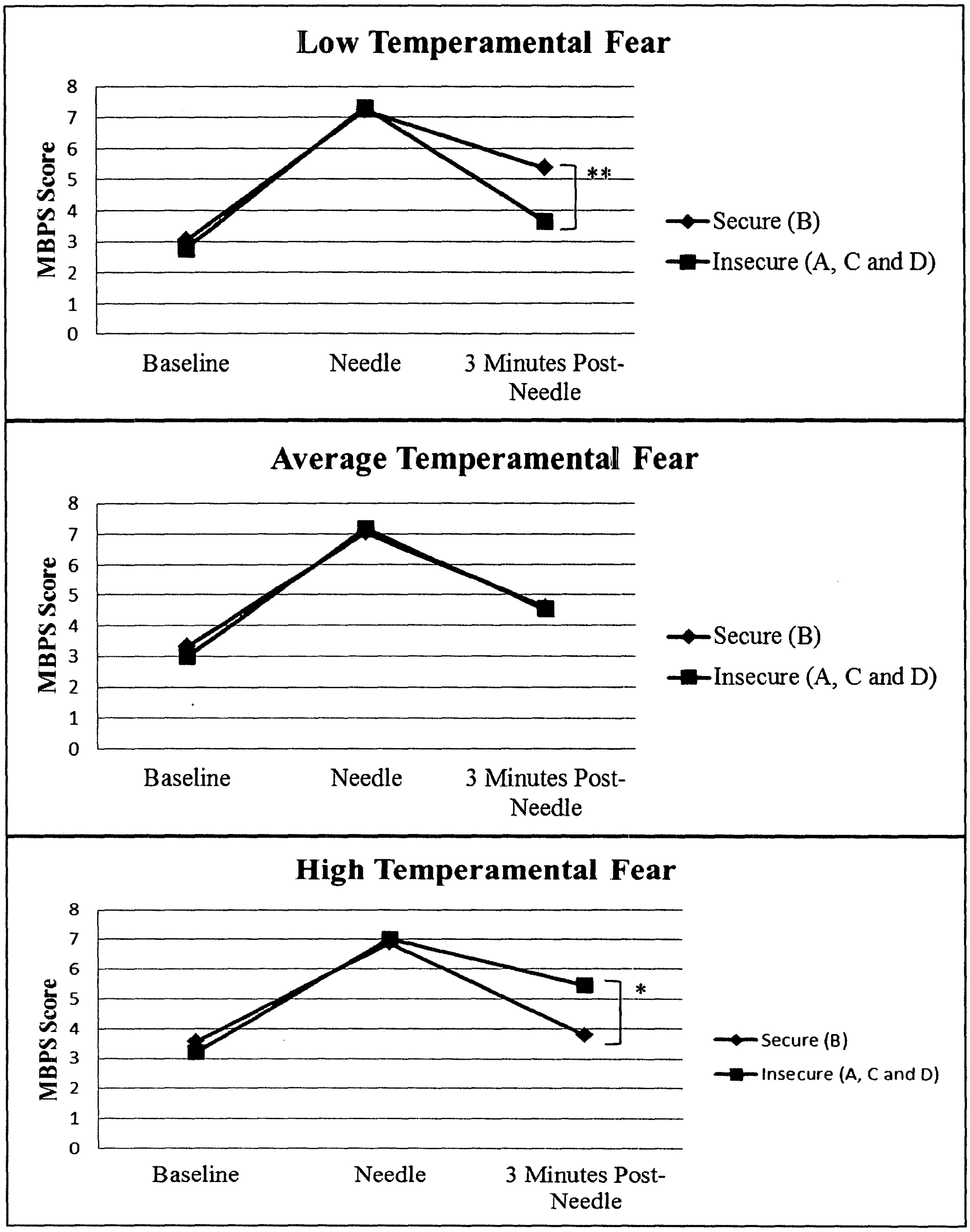

Figure 10. Trajectories of distress for secure/insecure attachment groups according to temperamental fear level.
* $p < .05$. ** $p < .01$.

Table 11

Correlations and Covariances among Variables for Model 4

Variable	1	2	3	4	5	6	7	8	9
1. Baseline Distress	4.68	.32**	.06	.04	.25**	.12	-.07	.12	.05
2. MBPS 0	.66	.92	.39**	.37**	.25**	.23*	.09	.02	.14
3. MBPS 1	.31	.92	6.17	.43**	.25**	.21*	.11	.07	.20
4. MBPS 2	.23	.84	2.54	5.68	.44**	.13	-.02	-.09	-.15
5. MBPS 3	1.29	.56	1.48	2.44	5.40	.07	-.12	-.14	-.13
6. #Needles	.14	.12	.27	.16	.09	.28	.04	.06	.07
7. IBQ-R Fear	-.15	.09	.27	-.06	-.25	.02	.91	.12	.36**
8. Organized/Disorganized	.09	.01	.06	-.08	-.12	.01	.04	.13	.27**
9. Organized/Disorganizedx IBQ-R Fear	.04	.05	.17	-.12	-.10	.01	.12	.03	.12

Note. Correlations are depicted above the diagonal in the shaded region. Covariances are depicted below the diagonal. MBPS = Modified Behavioral Pain Scale; IBQ-R = Infant Behavior Questionnaire – Revised. Organized coded "0", disorganized coded "1".
* $p < .05$. ** $p < .01$.

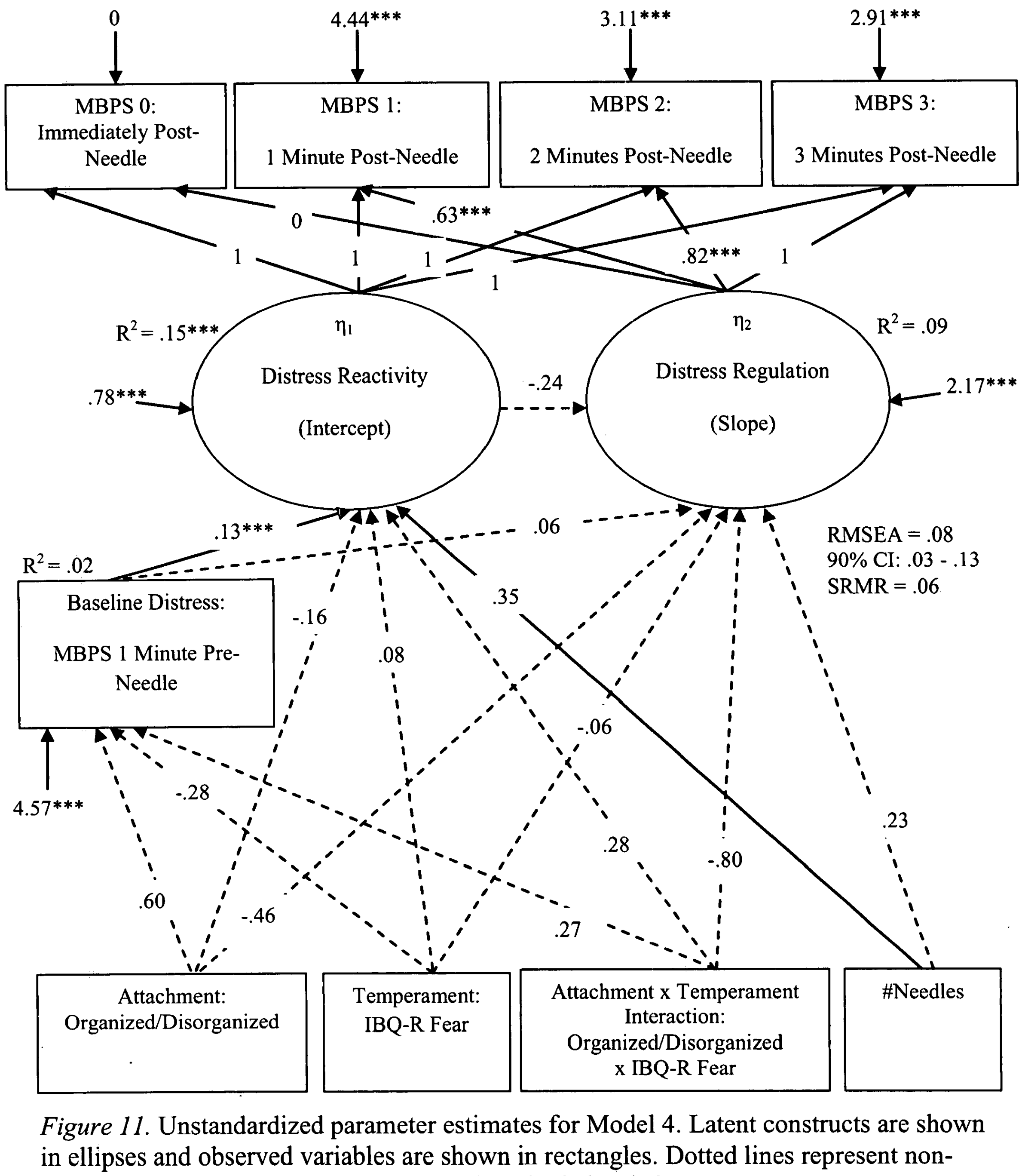

Figure 11. Unstandardized parameter estimates for Model 4. Latent constructs are shown in ellipses and observed variables are shown in rectangles. Dotted lines represent non-significant and marginally significant paths. Single headed arrows represent unstandardized parameter estimates for directional prospective prediction. RMSEA = root mean square error of approximation; SRMR = standardized root mean square residual; MBPS = Modified Behavioral Pain Scale; IBQ-R = Infant Behavior Questionnaire – Revised.

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

Table 12

Estimates for Model 4

Variable	Un-Standard-ized Estimate	S.E.	Est./ S.E.	Two-Tailed P-Value	Standard-ized Estimate	S.E.	Est./ S.E.	Two-Tailed P-Value
Baseline Distress (Observed MBPS 1 minute pre-needle scores)								
IBQ-R Fear	-.24	.18	-1.33	.18	-.11	.08	-1.34	.18
O/D	.68	.68	1.01	.31	.11	.11	1.02	.31
O/D* IBQ-R Fear	.35	.89	.40	.69	.06	.14	.40	.69
R^2	.02	.03	.86	.39				
Distress Reactivity (Intercept Factor)								
Baseline Distress	.13	.04	3.76	< .001	.30	.08	3.85	< .001
MBPS 0	1.00	.00			1.00	.00		
MBPS 1	1.00	.00			.39	.05	8.21	< .001
MBPS 2	1.00	.00			.42	.05	8.26	< .001
MBPS 3	1.00	.00			.40	.05	7.87	< .001
#Needles	.35	.15	2.24	< .05	.19	.09	2.12	< .05
IBQ-R Fear	.08	.09	.89	.38	.08	.09	.93	.35
O/D	-.16	.19	-.84	.40	-.06	.07	-.82	.41
O/D* IBQ-R Fear	.28	.26	1.08	.28	.10	.09	1.05	.30
R^2	.15	.05	3.00	< .01				
Distress Regulation (Slope Factor)								
Baseline Distress	.06	.10	.55	.58	.08	.14	.55	.58
MBPS 0	.00	.00			.00	.00		
MBPS 1	.63	.06	11.25	< .001	.40	.05	7.39	< .001
MBPS 2	.82	.05	16.02	< .001	.55	.07	8.33	< .001
MBPS 3	1.00	.00			.64	.07	9.15	< .001
#Needles	.23	.30	.77	.44	.08	.10	.76	.45
IBQ-R Fear	-.06	.19	-.30	.76	-.04	.12	-.30	.76
O/D	-.46	.40	-1.16	.25	-.11	.09	-1.17	.24
O/D* IBQ-R Fear	-.80	.44	-1.82	.07	-.18	.10	-1.74	.08
Distress Reactivity (Intercept Factor)	-.24	.18	-1.37	.17	-.15	.11	-1.35	.18
R^2	.09	.05	1.62	.11				

Note. MBPS = Modified Behavioral Pain Scale; IBQ-R = Infant Behavior Questionnaire – Revised; MBPS 0 = Distress Immediately Post-Needle; MBPS 1 = Distress 1 Minute Post-Needle; MBPS 2 = Distress 2 Minutes Post-Needle; MBPS 3 = Distress 3 Minutes Post-Needle; O = organized (A, B and C groups); D = disorganized (D group). Organized coded "0" and disorganized coded "1".

organized/disorganized attachment and temperamental fear was also not significantly related to distress regulation ($p = .07$).

Research Question (2a): Do Infant or Caregiver Behaviours *Pre-Needle* Predict Attachment? and (2b): Does Infant or Caregiver Behaviour and Temperamental Fear *Post-Needle* Predict Attachment?

Preliminary analyses (2a) and (2b). For the two main phases of the study (i.e., the 1-minute period pre-needle, and the 3-minute period post-needle), a mean score was calculated for both the pre- and post-needle phases of each of the seven behaviours of the MIBABI (i.e., scores for infant *cry/grimace*, *reach*, *cling*, *snuggle*, *back arch/pushes away*, *arm(s) between* behaviours, and caregiver *holding infant* behaviour). Mean scores were obtained for the MIBABI behaviours for cases that had at least 60% of the data within a 60-second time period. Cases with more than 40% of data missing within a 60-second time period were deleted. Reasons for missing data included limited footage required for adequate coding (e.g., video recording starting 5 seconds before needle or caregivers and infants leaving the pediatrician's office prior to the end of the 3-minute period post-needle) or blocked footage (e.g., pediatrician obstructs view of caregiver-infant interactions). With the exception of *cry/grimace*, all MIBABI behaviours were scored as present or absent during each 5-second epoch. Therefore, the summary score (pre-needle or post-needle) represented the average amount of time a given behaviour was observed and ranged from 0.0 to 1.0 (i.e., 0% to 100% of the time). The exception was *cry/grimace,* as it was scored to allow for varying intensity. *Cry/grimace* was summarized by a value ranging from 0 to 3, which represented the average level of crying/grimacing over the pre- or post-needle period.

Prior to primary analysis, the MIBABI pre- and post-needle predictor variables were examined separately for each attachment group (A, B, C, D, insecure, and organized groups) in terms of the accuracy of data entry, data distribution and missing values.

Primary analyses (2a) and (2b). Logistic regression was used to answer the second research question and to assess the prediction of attachment classification membership, given an infant's pattern of MIBABI behaviours pre- or post-needle. Logistic regression is more flexible than other statistical approaches to categorical outcomes such as discriminant function analysis, as it requires fewer assumptions to be met (e.g., the normal distribution of data).

Six initial logistic regression models were estimated (LRs 1 to 6) to determine whether the MIBABI behaviours, as a group, predicted attachment. A multinomial logistic regression (LR 1) determined whether the pre-needle MIBABI behaviours predicted the four attachment groups (A/B/C/D). A binomial logistic regression (LR 2) determined whether the pre-needle MIBABI behaviours predicted secure (B) and insecure (A, C, and D combined) groups. Another binomial logistic regression (LR 3) determined whether the pre-needle MIBABI behaviours predicted organized (A, B, and C combined) and disorganized (D) groups. These grouping variations were repeated in the same sequence for the LRs examining the post-needle MIBABI behaviours (LRs 4 to 6). Following the six initial LRs, separate single-predictor logistic regression models, one for each MIBABI behaviour, were estimated to determine whether a specific behaviour, ignoring the other behaviours, predicted attachment. Parameter estimates from these models were tested using a Bonferroni correction. In each model, cases with larger Studentized residuals (> 2.5) and either large Cook's distance (> 1) or large DFbeta statistics (> 1) were considered outliers. Outliers were omitted from analyses, as specified below.

Pearson correlations between predictor variables pre- and post-needle are presented in Table 13. Descriptive statistics for the MIBABI behaviours pre- and post-needle are presented in Table 14 and descriptive statistics of the MIBABI behaviours pre- and post-needle according to attachment classification are presented in Table 15.

Preliminary Results (2a). More than 90% of infants did not exhibit the *back arch/pushes away* behaviour pre-needle and this behaviour was subsequently not included in analyses. Thus, the MIBABI behaviours examined pre-needle as predictors of attachment classification were infant *cry/grimace*, *cling*, *reach*, *snuggle*, and *arm(s) between* behaviours and caregiver *holding* behaviour.

Primary Results (2a).

LR 1: MIBABI behaviours pre-needle as predictors and A/B/C/D attachment classifications as the grouping variable. A multinomial logistic regression indicated that the group of MIBABI behaviours pre-needle did not predict A/B/C/D attachment classifications, χ^2 (18, N = 130) = 15.471, p = .63. No influential outliers were identified. In the models examining each individual MIBABI behaviour pre-needle as a separate predictor of A/B/C/D attachment, none of the MIBABI behaviours pre-needle were significant, ps > .10 (see Table 16).

Table 13

Pearson Correlations between MIBABI Behaviours Pre- and Post-Needle

Variable	1	2	3	4	5	6	7
1. Cry/Grimace	-	-.05	.15	.30**	-	.03	.19*
2. Reach	.01	-	-.12	-.09	-	-.11	-.33**
3. Cling	.28**	-.11	-	.35**	-	-.19*	.42**
4. Snuggle	.29**	-.17	.49**	-	-	-.12	.21*
5. Back arch/pushes away	.20*	.09	-.02	-.02	-	-	-
6. Arm(s) between	.01	.06	-.37**	-.21*	.24**	-	.25**
7. Holding infant	.23**	-.21*	.51**	.30**	.15	.14	-

Note. Correlations for pre-needle behaviours are presented above the diagonal in the shaded region (Back arch/pushes away not included in pre-needle analyses). Correlations for post-needle behaviours are presented below the diagonal.
$^*p < .05$. $^{**}p < .01$.

Table 14

Descriptive Statistics of MIBABI behaviours Pre- and Post-Needle

Predictor Variables	*n*	Possible Range	Min.	Max.	*M*	*SD*
MIBABI Behaviours Pre-Needle						
Cry/Grimace	130	0-3	.50	3.00	1.20	.40
Reach	130	0-1	.00	.50	.03	.07
Cling	130	0-1	.00	1.00	.52	.38
Snuggle	130	0-1	.00	1.00	.07	.16
Back arch/pushes away	130	0-1	.00	.33	.01	.05
Arm(s) between	130	0-1	.00	1.00	.07	.19
Holding infant	130	0-1	.00	1.00	.67	.37
MIBABI Behaviours Post-Needle						
Cry/Grimace	126	0-3	1.06	3.00	1.97	.46
Reach	126	0-1	.00	.25	.02	.05
Cling	126	0-1	.00	1.00	.62	.29
Snuggle	126	0-1	.00	1.00	.18	.25
Back arch/pushes away	126	0-1	.00	.19	.01	.03
Arm(s) between	126	0-1	.00	.75	.07	.14
Holding infant	126	0-1	.03	1.00	.72	.29

Note. MIBABI = Measure of Immunization Behaviour and Attachment Behaviour in Infancy. Please refer to Table 4 for descriptive statistics regarding attachment classifications.

Table 15

Means and Standard Deviations of Predictor MIBABI Variables Pre- and Post-Needle across A/B/C/D Attachment Classifications

	Grouping Variables							
	A (avoidant)		B (secure)		C (resistant)		D (disorganized)	
Predictor Variables	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
MIBABI Behaviours Pre-Needle	n = 31		n = 68		n = 8		n = 23	
Cry/Grimace	1.09	.22	1.27	.44	1.23	.22	1.25	.41
Reach	.03	.07	.03	.09	.01	.03	.01	.03
Cling	.45	.36	.55	.38	.47	.44	.56	.40
Snuggle	.02	.07	.09	.19	.04	.08	.07	.15
Arm(s) between	.05	.15	.08	.21	.10	.26	.08	.19
Holding infant	.59	.38	.68	.37	.68	.39	.76	.32
MIBABI Behaviours Post-Needle	n = 31		n = 66		n = 7		n = 22	
Cry/ Grimace	1.93	.44	1.98	.50	2.11	.31	1.96	.38
Reach	.03	.05	.02	.04	.04	.04	.03	.06
Cling	.59	.28	.64	.30	.64	.33	.58	.30
Snuggle	.09	.15	.25	.29	.25	.29	.11	.16
Back arch/pushes away	.01	.02	.01	.04	.01	.01	.01	.02
Arm(s) between	.08	.14	.07	.16	.06	.12	.05	.10
Holding infant	.69	.28	.74	.30	.64	.37	.71	.28

Note. Back arch/pushes away pre-needle was dropped from analyses as more than 90% of infants did not exhibit this behaviour.

Table 16

Overall Model Evaluation Statistics for Multiple Logistic Regression Analyses of A/B/C/D Attachment as a Function of Individual MIBABI Behaviours Pre-Needle

Predictor Variable	χ^2	*df*	*p*
Cry/Grimace	5.826	3	.12
Reach	2.49	3	.48
Cling	1.805	3	.61
Snuggle	6.045	3	.12
Arm(s) Between	.877	3	.83
Holding Infant	3.014	3	.39

Note. N = 130.

LR 2: MIBABI behaviours pre-needle as predictors and secure/insecure attachment classifications as the grouping variable. A binary logistic regression indicated that the group of MIBABI behaviours pre-needle did not predict secure/insecure attachment classifications, χ^2 (6, N = 130) = 6.493, p = .37. No influential outliers were identified. In the models examining each individual MIBABI behaviour pre-needle as a separate predictor of secure/insecure attachment, none of the MIBABI behaviours pre-needle were significant, ps $\geq$ .06 (see Table 17).

LR 3: MIBABI behaviours pre-needle as predictors and organized/disorganized attachment classifications as the grouping variable. A binary logistic regression indicated that the group of MIBABI behaviours pre-needle did not predict organized/disorganized attachment classifications, χ^2 (6, N = 130) = 2.886, p = .82. Three outliers with Studentized residuals greater than 2.5 were identified; however, these cases were not influential and were retained in the analysis. In the models examining each individual MIBABI behaviour pre-needle as a separate predictor of organized/disorganized attachment, none of the MIBABI behaviours pre-needle were significant, ps > .10 (see Table 18).

Research Question (2b): Do Infant or Caregiver Behaviour *Post-Needle* Predict Attachment?

Preliminary Results (2b). Of the original 130 cases, four cases were deleted due to missing data. Missing data appeared to be randomly scattered throughout groups and predictors and included two B cases, one C case, and one D case.

Primary results (2b).

Table 17

Overall Model Evaluation Statistics for Binary Logistic Regression Analyses of Secure/Insecure Attachment as a Function of Individual MIBABI Behaviours Pre-Needle

Predictor Variable	χ^2	*df*	*p*
Cry/Grimace	1.735	1	.19
Reach	1.127	1	.29
Cling	.778	1	.38
Snuggle	3.474	1	.06
Arm(s) Between	.067	1	.80
Holding Infant	.019	1	.89

Note. N = 130.

Table 18

Overall Model Evaluation Statistics for Binary Logistic Regression Analyses of Organized/Disorganized Attachment as a Function of Individual MIBABI Behaviours Pre-Needle

Predictor Variable	χ^2	*df*	*p*
Cry/Grimace	.317	1	.57
Reach	1.650	1	.20
Cling	.200	1	.65
Snuggle	.001	1	.98
Arm(s) Between	.077	1	.78
Holding Infant	1.864	1	.17

Note. N = 130.

LR 4: MIBABI behaviours post-needle as predictors and A/B/C/ D attachment classifications as the grouping variable. A multinomial logistic regression indicated that the group of MIBABI behaviours post-needle did not predict A/B/C/D attachment classifications, χ^2 (21, N = 126) = 20.44, p = .49. No influential outliers were identified. In the models examining each individual MIBABI behaviour pre-needle as a separate predictor of A/B/C/D attachment, the model that included snuggling behaviour post-needle was significant, χ^2 (3, N = 126) = 13.13, p = .004 (see Table 19). Snuggling differentiates secure from avoidant and disorganized infants, B = -3.61, χ^2 (3) = 6.50, p = .01, OR = .03 and B = -2.78, χ^2 (3) = 3.93, p = .047, OR = .06, respectively. Infants who snuggled more were more likely to be secure than avoidant or disorganized. The value of the odds ratio for avoidant versus secure infants implies that for each unit increase in snuggling, the odds of being avoidant rather than secure decreased by 97%. The value of the odds ratio for disorganized infants implies that for each unit increase in snuggling, the odds of being disorganized rather than secure decreased by 94%. The regression coefficient for resistant versus secure infants was non-significant, p = .98, indicating that snuggling does not differentiate secure from resistant infants.

LR 5: MIBABI behaviours post-needle as predictors and secure/insecure attachment classifications as the grouping variable. A binary logistic regression indicated that the group of MIBABI behaviours post-needle marginally significantly predicted secure/insecure attachment classifications, χ^2 (7, N = 126) = 13.79, p = .055. No influential outliers were identified. The regression coefficients for LR 5 are presented in Table 20. Within the group of predictors, only the MIBABI snuggling behaviour post-

Table 19

Overall Model Evaluation Statistics for Multiple Logistic Regression Analyses of A/B/C/D Attachment as a Function of Individual MIBABI Behaviours Post-Needle

Predictor Variable	χ^2	*df*	*p*
Cry/Grimace	.956	3	.81
Reach	1.810	3	.61
Cling	1.095	3	.78
Snuggle	13.130	3	.004
Back Arches/Pushes Away	1.589	3	.662
Arm(s) Between	.615	3	.89
Holding Infant	1.242	3	.74

Note. N = 126.

Table 20

Regression Coefficients for a Multivariate Logistic Regression Analysis of Secure/Insecure Attachment as a Function of MIBABI Behaviours Post-Needle

Variable by Attachment Category	*B*	SE	Wald's χ^2	*df*	*p*	*OR*	95% CI for *OR*	
							Lower	*Upper*
Cry/Grimace	0.41	0.45	0.85	1	0.358	1.51	0.627	3.64
Cling	0.19	0.91	0.05	1	0.832	1.21	0.204	7.217
Back Arches/ Pushes Away	-11.22	8.38	1.79	1	0.181	0	0	183.023
Reach	4.17	4.32	0.93	1	0.335	64.71	0.014	309354.8
Snuggle	-2.90	1.04	7.78	1	0.005	0.06	0.007	0.423
Arm(s) Between	-0.78	1.66	0.22	1	0.638	0.46	0.018	11.767
Held	0.13	0.83	0.03	1	0.872	1.14	0.226	5.782
Cry/Grimace	0.41	0.45	0.85	1	0.358	1.51	0.627	3.64

Note. N = 126. The reference category is secure (B). CI = confidence interval for odds ratio (*OR*).

needle significantly predicted secure/insecure attachment classifications, $B = -2.90$, χ^2 (1, N = 126) = 7.78, $p = .005$, $OR = .06$. Infants who snuggled more were more likely to be secure than insecure such that for each unit increase in *snuggling* the odds of being insecure decreased by 94%.

In the models examining each individual MIBABI behaviour post-needle as a separate predictor of secure/insecure attachment, the model that included snuggling behaviour post-needle was significant, χ^2 (3, N = 126) = 9.954, $p = .002$ (see Table 21). Snuggling differentiates secure from insecure infants, $B = -2.51$, χ^2 (1, N = 126) = 7.70, $p = .005$, $OR = .08$. As stated above, infants who snuggled more were more likely to be secure than insecure, such that for each unit increase in *snuggling*, the odds of being insecure decreased by 92%.

LR 6: MIBABI behaviours post-needle as predictors and organized/disorganized attachment classifications as the grouping variable. A multinomial logistic regression indicated that the group of MIBABI behaviours post-needle did not predict organized/disorganized attachment classifications, χ^2 (7, N = 126) = 5.65, $p = .58$. Six outliers with Studentized residuals greater than 2.5 were identified. Of these outliers, two cases had DFbeta statistics greater than 2. Upon examination of the data, these cases were disorganized infants who exhibited greater *back arches/pushes away* behaviour. With these influential cases omitted from analysis, there was a slight improvement in the model; however, the set of predictors was still non-significant, χ^2 (7, N = 124) = 8.205, $p = .32$.

Table 21

Overall Model Evaluation Statistics for Binary Logistic Regression Analyses of Secure/Insecure Attachment as a Function of Individual MIBABI Behaviours Post-Needle

Predictor Variable	χ^2	*df*	*P*
Cry/Grimace	.047	1	.83
Reach	1.719	1	.19
Cling	.851	1	.36
Snuggle	9.654	1	.002
Back Arches/Pushes Away	1.585	1	.21
Arm(s) Between	.015	1	.90
Holding Infant	.918	1	.34

Note. N = 126.

In the models examining each individual MIBABI behaviour post-needle as a separate predictor of organized/disorganized attachment, none of the MIBABI behaviours post-needle were significant, *ps* $\geq$ .09 (see Table 22).

Discussion

Through this study, two broad research questions were answered: (1) Are attachment, temperamental fear, or the interaction between attachment and temperamental fear associated with pain-related distress reactivity or pain-related distress regulation? and (2) Do infant or caregiver behaviours *pre-needle* or *post-needle* predict attachment?

With respect to the first research question, the interaction between temperamental fear and attachment was associated with pain-related distress regulation, supporting the hypotheses. Temperamental fear impacts pain-related distress regulation in different ways, depending on the quality of the caregiver-infant attachment relationship. When temperamental fear is high, an avoidant attachment relationship renders an infant susceptible to difficulties regulating distress following immunization, while a secure attachment relationship appears to support infants' abilities to regulate distress more effectively following immunization. In support of the DIAPR model, the results indicate that intrinsic infant factors and the caregiver-infant relationship interact to influence the ways in which infants regulate distress from pain at the end of the first year of life.

In terms of the second research question, the combined set of predictors included in the MIBABI measure did not predict attachment, although there was some tendency of MIBABI post-needle behaviours to predict secure/insecure categorizations. These

Table 22

Overall Model Evaluation Statistics for Binary Logistic Regression Analyses of Organized/Disorganized Attachment as a Function of Individual MIBABI Behaviours Post-Needle

Predictor Variable	χ^2	*df*	*P*
Cry/Grimace	.018	1	.90
Reach	.330	1	.57
Cling	.468	1	.49
Snuggle	2.961	1	.09
Back Arches/Pushes Away†	1.180	1	.28
Arm(s) Between	.401	1	.53
Holding Infant	.016	1	.90

Note. N = 126.

† One outlier was identified in the *back arches/pushes away* regression. This case had a studentized residual > 2.5 and a DFbeta statistic greater than 2. This case was omitted in the final analysis.

findings do not support the MIBABI as a measure of attachment during the 12-month immunization procedure. However, in partial support of the hypotheses, infant snuggling behaviour post-needle predicted attachment such that increased levels of snuggling following immunization were associated with a greater likelihood of infants being secure rather than avoidant, disorganized or insecure as a group (resistant, avoidant, and disorganized groups combined). This finding supports attachment theory and complements the findings from research question (1).

Findings from Research Question (1): Are Attachment, Temperamental Fear, or the Interaction Between Attachment and Temperamental Fear Associated With Pain-Related Distress Reactivity or Pain-Related Distress Regulation?

A novel approach to the analysis of infant emotion regulation in an acute pain context was adopted in this study by examining both pain-related distress reactivity (i.e., the immediate pain response) and pain-related distress regulation (i.e., how distress changed over time). Improving on methodology used in previous research, rather than calculating differences in average levels of distress within an immunization procedure, latent growth modeling (LGM) within a structural equation modeling (SEM) framework was used to assess latent trajectories of distress. Both pain-related distress reactivity and pain-related distress regulation were latent variables based on repeated observations of infant pain-related distress immediately following needle up until 3 minutes post-needle. The use of LGM is an important advancement in the field of emotion regulation, as it allows for examinations of the regulation of distress as a dynamic process that unfolds over time.

Preliminary results (1). Preliminary analyses indicated that infants with organized attachment styles (A, B, and C) exhibited significantly more distress 3 minutes post-needle than disorganized (D) infants. However, this result should be interpreted in light of subsequent analyses between organized and disorganized infants. Although organized infants exhibited more distress at the 3-minute time period post-needle, there were no differences between organized and disorganized infants in terms of pain-related distress regulation (i.e., how distress changes over time). This finding highlights the importance of examining the process of distress regulation as it unfolds over time in addition to examining distress at key points in time (e.g., distress reactivity occurring immediately following an acute painful stimuli) in order to gain a comprehensive understanding of emotion regulation.

Primary results (1). In total, four models were estimated to address the first research question. Prior to including the temperamental fear and attachment variables as predictors of pain-related distress reactivity and regulation, an initial model (Model 1) was estimated using all available data from the longitudinal study at 12 months (N = 530). Predictor variables that are known to influence pain and distress during immunization were included in Model 1. Specifically, baseline distress, the sex of the infant, the number of needles infants received, and analgesic medication infants received prior to immunization were included as predictors of pain-related distress reactivity and pain-related distress regulation.

Subsequent to Model 1, Models 2, 3, and 4 included the significant predictor variables from Model 1 as well as the temperament and attachment variables of central interest to the first research question. The only difference across Models 2, 3, and 4 was the way in which attachment was operationalized. These three models allowed for the comparison of attachment styles that differ in terms of their risk for developmental problems related to emotion regulation. The secure attachment group is considered the lowest risk group and it was of interest to compare this group with the relatively higher risk, insecure group (made up of avoidant, resistant and disorganized infants), hence the two-level secure/insecure comparison (Model 3). However, the ways in which avoidant and resistant infants regulate distress are theoretically and fundamentally different, and it was therefore important to include an analysis in which these groups were examined separately from each other, hence the four-level comparison between A/B/C/D groups, using secure as the comparison group (Model 2). Finally, the disorganized group is considered the highest risk group and it was important to determine whether this group was distinct from the other organized groups (made of avoidant, secure and resistant infants; Model 4). By comparing Models 2, 3, and 4 to Model 1, the unique contributions of temperamental fear and attachment to pain-related distress reactivity and regulation were examined.

Model 1: Sex of infant, medication administered pre-needle, number of needles, and baseline distress as predictors of pain-related distress reactivity and regulation. Using all available data from the longitudinal study at the 12-month immunization appointment ($N = 530$), sex of infant, the number of needles infants received, whether or not the infant received medication prior to immunization, and infants' baseline distress scores were included as predictors of pain-related distress reactivity and regulation. Pain-related distress reactivity was also used as a predictor of pain-related distress regulation.

Sex of Infant. The sex of the infant was not significantly related to distress reactivity or distress regulation. At 7 to 12 months of age, female infants have been found to exhibit higher pitched cries than male infants (Fuller, 2002). However, in this study, distress was measured using the MBPS, which assesses facial expression and body movements in addition to crying, which did not include an evaluation of pitch. When examining distress using multiple indicators, sex differences in pain-related distress appear to be minimal.

Medication Administered Pre-Needle. Medication (i.e., EMLA, Tylenol, or other over-the-counter medication) did not predict distress reactivity or regulation during the 12-month immunization appointment, contrary to previous research (e.g., Halperin et al., 2000; O'Brien et al., 2004, Uhari, 1993). However, only 8% of caregivers provided medication to their infants prior to immunization, with only one caregiver providing EMLA. While evidence for the efficacy of Tylenol and other over-the-counter medications in reducing distress is inconsistent for infants older than 1 year (Ipp et al., 1987), EMLA has been consistently demonstrated as an effective analgesic for immunization pain at 12 months (Halperin et al., 2000; Uhari, 1993). With the small proportion of caregivers providing medication in the sample, this study did not have the power to detect differences in pain-related distress reactivity and regulation for infants who had received medication in comparison with those who had not. This study reflects previous research with Canadian samples that demonstrates that fewer than 10% of caregivers provide analgesic to their infants prior to immunization (Taddio et al., 2007).

Number of Needles. The number of needles infants received at the 12-month visit was significantly related to pain-related distress reactivity and regulation in Model 1. This finding confirms previous research demonstrating that the greater the number of needles administered, the greater the distress post-needle (Klassen & Craig, 2007). Combination vaccines should be used whenever available to reduce the impact of multiple needles on infant distress. Moreover, combination vaccines have been shown to improve adherence to immunization schedules (Kalies et al., 2006), likely because they reduce the amount of distress experienced by both infants and caregivers (Harrington, Woodman, & Shannon, 2000; Taddio et al., 2009). Given that 81% of infants in the longitudinal study received two needles (5% received three or more needles), efforts are needed to reduce the number of needles that are considered standard care at the 12-month visit.

Baseline Distress. Twenty five percent of infants in the longitudinal study at 12 months exhibited moderate to severe expressions of distress prior to immunization with 75% of infants exhibiting no or minimal distress. Baseline distress was significantly associated with higher distress reactivity and slower distress regulation post-needle, consistent with previous analyses of the same sample (Ahola Kohut & Pillai Riddell, 2009; Hillgrove-Stuart et al., in press; Horton et al., 2011). This finding highlights the impact of non-pain-related distress (e.g., anxiety, fear) on pain-related distress from common medical procedures. The distress that some infants displayed prior to immunization may have been due to fear of an unfamiliar adult (such as the pediatrician or nurse) or wariness of a novel environment. Alternatively, by 12 months of age, the pediatric environment and health care practitioners may have become associated with pain after infants were exposed to immunizations at 2, 4, and 6 months of age (Taddio et al., 2002). Indeed, Bowlby (1973) noted that "it is of great biological advantage to an animal to learn to recognize potentially painful situations from associated distal cues" (p. 127). Research from our lab has shown that higher pain-related distress at earlier immunization appointments predicted higher baseline distress at subsequent appointments (Horton et al., 2011), suggesting that some infants are conditioned to respond to the pediatric visit with distress, particularly when previous experiences with immunization were highly distressing. Efforts to reduce pain-related distress at pediatric appointments are needed.

Pain-Related Distress Reactivity. Pain-related distress reactivity was significantly associated with pain-related distress regulation, such that high reactivity predicted faster regulation. In other words, infants who initially reacted with higher distress to the needle exhibited a greater change in distress over the first three minutes post-needle than infants who initially reacted with less distress to the needle. Conceptually, if an infant has a lower initial pain-related distress response, his or her regulation towards baseline will be less steep than an infant who has a higher initial response. While higher baseline distress was indirectly related to faster distress regulation via higher pain reactivity, this indirect relationship may simply be a statistical artifact of regression towards the mean, such that the higher the pain response to the needle, the steeper the trajectory of regulation on the way to homeostasis.

The finding that many infants are distressed pre-needle along with the finding that medication is under-used in pediatric settings suggests that there is an urgent need to educate caregivers about the availability of pain medications that reduce distress in response to immunization. Evidence-based pharmacological interventions such as EMLA (Halperin et al., 2000; Uhari, 1993) that are implemented at an early age may prevent infants from developing a conditioned anticipatory distress-response to pediatric health care settings, reducing the distress that both infants and caregivers experience as a result of medical visits and procedures. Moreover, infants who exhibit pre-needle distress and who subsequently display more distress post-needle are at risk for needle-anxiety and avoidance of health care later in life (Taddio et al., 2009; Taddio et al., 2002; Uhari, 1993). Therefore, interventions aimed at reducing distress following immunization may also prove critical to ensuring that health care practices (e.g., annual flu shots) are maintained in the long-term.

Model 2, 3, and 4: Number of needles, baseline distress, attachment and temperamental fear as predictors of pain-related distress reactivity and regulation. Models 2, 3, and 4 included the significant predictors of pain-related distress reactivity and regulation from Model 1 (i.e., number of needles and baseline distress) as well as attachment and temperamental fear variables as predictors of baseline distress, pain-related distress reactivity and regulation. Temperamental fear and attachment were also included as predictors of baseline distress, as it was theoretically possible for these variables to impact distress pre-needle as unfamiliar health care professionals or an association between the pediatric setting and pain may have triggered fearful responses and attachment behaviours in some infants.

Attachment. Using the four-level attachment comparison (A/B/C/D) in Model 2 with the secure group as the comparison group, secure infants exhibited significantly more baseline distress than avoidant (A) infants. Only 13% of avoidant infants were moderately to severely distressed pre-needle, compared with 27% of secure infants, 38% of resistant infants, and 35% of disorganized infants. Secure infants are theorized to be more comfortable openly expressing distress in the presence of caregivers than avoidant infants (Ainsworth et al., 1978). The immunization setting may have triggered a baseline distress response in secure infants as a result of the novel environment, proximity to strangers (e.g., the pediatrician), or a conditioned distress response due to previous exposures to immunization (as discussed above). Avoidant infants, on the other hand, are theorized to be less comfortable expressing distress in the presence of caregivers and may have minimized distress signals (i.e., crying, body movements, facial expressions) pre-needle even though they are physiologically aroused (Spangler & Grossmann, 1993).

Secure/insecure attachment comparisons and organized/disorganized attachment comparisons were not significant predictors of baseline distress, suggesting that the difference in baseline distress emerged due to differences between the secure and avoidant groups, specifically. Note that the introduction to the pediatric office parallels the introduction to the novel SSP room. During the pre-separation episodes of the SSP, avoidant infants are not expected to become distressed. Secure infants, on the other hand, may exhibit some apprehension during the first few episodes of the SSP (Ainsworth et al., 1978; Sroufe & Waters, 1977) and it follows that some secure infants did, in fact, become distressed prior to immunization. In their qualitative measure of infant behaviour during immunization (the PASI), Favez and Berger (2011) note that secure infants may exhibit some wariness pre-immunization while avoidant infants are not expected to show any distress prior to the procedure. The current findings lend quantitative support to the PASI in this regard and underscore the validity of immunization as an attachment paradigm analogous to the SSP.

Across Models 2, 3, and 4, attachment was not associated with pain-related distress reactivity. This finding suggests that attachment is not directly related to the immediate expression of pain-related distress following immunization at 12 months of age. Although Bowlby (1969/1982) theorized that pain would trigger the attachment system, specific attachment styles appear not to differentially impact infants' immediate pain-related distress. The finding that virtually all infants respond to immunization with moderate to severe expressions of distress suggests that immunization is a highly stressful event for all infants, regardless of their attachment style. Attachment was, however, related to pain-related distress regulation, qualified by an interaction effect between attachment and temperament. This finding is discussed below.

Temperamental Fear. Across Models 2, 3 and 4, temperamental fear did not have a direct effect on baseline distress or pain-related distress reactivity at 12 months. Using the DIAPR model as a theoretical guide, it was hypothesized that higher temperamental fear would predict higher pain-related distress reactivity. This hypothesis was not supported. It may be that, by 12 months of age, infant temperament exerts less of a direct impact on pain-related distress reactivity than other factors such as previous experience with immunization or caregiver behaviour. Indeed, the DIAPR model asserts that external factors will exert a stronger influence on infant pain-related distress later in infancy than intrinsic factors such as infant temperament (Pillai Riddell et al., under revision). In line with this assertion, Sweet et al. (1999) found an association between infant difficultness and pain response at 6 months of age but not at 18 months of age. Temperament may play a central role in pain-related distress reactivity early in the first year. By the end of the first year, however, interactions between infant temperament and the caregiving environment (e.g., caregiver pain management) are likely to play a larger role in infants' responses to painful stimuli as these interactions have become more stable and influential over time. Further research examining the impact of temperament on pain-related distress reactivity earlier in the first year of life (e.g., the 2-, 4- and 6-month immunization appointments) may find a stronger relationship between these variables. Temperamental fear was, however related to pain-related distress regulation, qualified by an interaction effect between attachment and temperament. This finding is discussed below.

Interactions between Temperamental Fear and Attachment. Consistent with the study hypotheses, there was no significant interaction between attachment and temperamental fear on pain-related distress reactivity in Models 2, 3, or 4. There was a ceiling effect immediately post-needle such that all infants responded with moderate to severe distress to the needle, regardless of variations in attachment status or temperamental fear. In contrast to distress that builds slowly over time (as a result of hunger, for example), the behavioural response to immunization is expected to be strong and immediate for all infants. Indeed, Bowlby (1969/1982) notes that "crying from pain is loud from the start" (p. 245). Confirming this assertion, all of the infants in the study responded to immunization with moderate to strong expressions of distress.

In contrast to pain-related distress reactivity, it was hypothesized that there would be an interaction between attachment and temperamental fear on pain-related distress regulation such that, among infants with high temperamental fear, insecure infants would take longer to regulate distress than secure infants. This hypothesis was supported. Temperamental fear moderated the relationship between attachment and distress regulation in Models 2 and 3, but not in Model 4.

In Model 2 (based on the four-level A/B/C/D attachment comparison), avoidant infants with high temperamental fear took significantly longer to regulate pain-related distress than secure infants with high temperamental fear. At average levels of temperamental fear, the difference in pain-related distress regulation according to attachment classifications was non-significant. At low levels of temperamental fear, avoidant and disorganized infants regulated distress significantly faster than secure infants. There were no differences in pain-related distress regulation between secure and resistant infants according to temperamental fear. This finding was likely due, in part, to the small number of cases classified as resistant ($n = 8$). Alternatively, secure and resistant infants may regulate distress in similar ways following immunization. Further research is needed with larger samples of resistant infants to adequately compare distress regulation across all four attachment groups.

In Model 3 (based on the two-level, secure/insecure attachment comparison), the patterns described above were consistent for secure versus insecure infants (A, C, and D groups combined). At high levels of temperamental fear, insecure infants took significantly longer to regulate pain-related distress than secure infants. At average levels of temperamental fear, these differences were non-significant. At low levels of temperamental fear, insecure infants regulated distress significantly more quickly than secure infants. It is important to note that, given the relatively small number of resistant infants included in analyses, the insecure group is more representative of the avoidant and disorganized groups than the resistant group (87% of the insecure groups was avoidant or disorganized). Differences between secure and insecure groups, therefore, are more likely to be due to differences between secure and avoidant/disorganized groups, in particular.

In Model 4 (based on the two-level organized/disorganized attachment comparison), temperament did not moderate the relationship between organized/disorganized attachment and pain-related distress regulation. This finding is unsurprising given that temperament moderated the relationship between the insecure/secure attachment and pain-related distress regulation (in which secure infants were separated from avoidant and disorganized infants), but the secure and avoidant groups were combined in the organized/disorganized attachment comparison. In other words, by combining the secure and avoidant groups, differences between organized and disorganized groups were obscured.

In contrast to the differential susceptibility hypothesis (Belsky et al., 2007), the finding that both high and low temperamental fear predicted significant differences among attachment groups points to the contrasting effects of temperament on attachment in the context of pain-related distress regulation (van IJzendoorn & Bakermans-Kranenburg, 2012). While high temperamental fear predicted slower distress regulation for avoidant infants, it predicted faster distress regulation for secure infants. Low temperamental fear had the opposite effect, predicting faster distress regulation for avoidant and disorganized infants and slower distress regulation for secure infants.

Avoidant infants minimize distress in order to maintain proximity to caregivers and to avoid rejection from caregivers (Ainsworth et al., 1978; Cassidy, 1994). However, avoidant strategies (e.g., distraction through exploration) may break down in the face of highly threatening situations when temperamental fear is high. The current findings pertaining to attachment and baseline distress support this theory. As discussed above, prior to the immunization, avoidant infants exhibited significantly less baseline distress than secure infants. This finding suggests that, under conditions of mild or moderate threat such as the introduction to the pediatric office, avoidant infants exhibit the least amount of distress while in the presence of the caregiver, regardless of temperamental fear. Similarly, the SSP may be considered a moderate stressor in which avoidant infants are able to minimize distress effectively when the caregiver returns after brief separations. However, under conditions which pose a high degree of threat such as pain, avoidant infants with high temperamental fear may be unable to maintain an organized avoidant strategy which minimizes distress. Without an effective strategy to effectively cope with high levels of distress, avoidant infants with high temperamental fear subsequently take significantly longer to regulate high distress following the needle in comparison with other infants.

Complementing these results, Gunnar and colleagues found that insecure infants (71% of whom were avoidant) with high temperamental fear had significantly higher cortisol responses to stress than secure infants with high temperamental fear (Gunnar et al., 1996; Nachmias et al., 1996). Specifically, insecure infants with high temperamental fear had significantly higher cortisol responses than secure infants in response to immunization at 15 months. Similarly, Nachmias and colleagues found that insecure infants with high temperamental fear were the only infants to exhibit elevations in cortisol following novel, arousing laboratory tasks. The authors noted that elevations in cortisol following stressful events are atypical responses for infants between the ages of 6 and 18 months of age. Consequently, cortisol reactions to stress among insecure infants with high temperamental fear may represent a failure to effectively cope with stress and may characterize a specific vulnerability to stress.

Infants' cortisol responses to immunization were not measured in this study. However, research by Gunnar and colleagues (Gunnar et al., 1996; Nachmias et al., 1996) sheds light on the meaning of the patterns of pain-related distress regulation among avoidant and secure infants in our study. In light of Gunnar and colleagues' findings, avoidant infants with high temperamental fear may have exhibited difficulty regulating distress following immunization because they were also experiencing the highest physiological stress responses to immunization. Elevations in physiological stress may prohibit avoidant infants with high temperamental fear from effectively regulating distress (see Bradley, 2000, p. 70), similar to Nachmias et al.'s conceptualization of "failed coping".

Secure infants with high temperamental fear, on the other hand, exhibit significantly lower cortisol responses to immunization than insecure infants with high temperamental fear (Gunnar et al., 1996). Secure infants may not have as vigorous a cortisol response to stress because they have come to expect that caregivers are available to provide support and feel confident in their own abilities to solicit this support when in distress (Ainsworth et al., 1978). Moreover, secure infants with high temperamental fear may have become adept at clearly expressing signals of distress immediately post-needle and in mobilizing effective coping strategies in response to highly stressful situations such as immunization to better regulate distress from pain.

Contrary to high temperamental fear, low temperamental fear interacted with attachment to predict significantly faster distress regulation in avoidant and disorganized infants in comparison with secure infants. Among infants with low temperamental fear, insecure infants have been shown to exhibit lower cortisol responses to immunization compared to insecure infants with high temperamental fear (Gunnar et al., 1996). In the current study, avoidant infants with low temperamental fear may have experienced less physiological stress, allowing them to sustain an avoidant coping strategy that effectively minimized distress following immunization. On the other hand, disorganized infants rated as having low temperamental fear may have exhibited blunted responses to stress as a result of chronic stress experienced in disorganizing environments (Schore, 2001). Disorganized infants have been observed to dissociate during the SSP as a strategy to mentally escape a stressful situation that cannot be physically avoided. It is possible that disorganized infants rated as having low temperamental fear may have dissociated following immunization, resulting in a steeper distress regulation trajectory.

Secure infants who were rated by caregivers as having low temperamental fear were likely those who do not typically react with strong negative emotion to mildly stressful events (e.g., visiting a new place). These infants may be less adept at regulating high levels of distress compared to secure infants with high temperamental fear, causing them to take longer to regulate distress from a highly stressful event such as immunization. Secure infants are comfortable openly expressing distress with caregivers, and secure infants with low temperamental fear may have been especially motivated to signal distress to their caregivers when experiencing acute pain.

The current findings underscore Thompson's (1994) definition of emotion regulation and highlight the importance of the temporal aspect of emotion regulation (i.e., how emotions change over time) that warrants study. Our findings also lend support to the DIAPR model (Pillai Riddell et al., in press) and Ramsay and Lewis' (2003) assertions that the immediate pain response is distinct from how an infant regulates distress over time. The finding that temperament moderates the effect of attachment on pain-related distress regulation supports the DIAPR model and the notion that intrinsic infant factors interact with external factors (e.g., caregivers' management of pain) over the first year of life to predict regulation from pain and to impact the process of emotion regulation.

Predictor Variables Carried Over from Model 1: Number of Needles, Baseline Distress and Pain-Related Distress Reactivity. Similar to Model 1, the number of needles that infants received and baseline distress were significant predictors of pain-related distress reactivity across Models 2, 3, and 4. However, these variables were no longer significant predictors of pain-related distress regulation when temperamental fear and attachment variables were included as predictors in Models 2, 3, and 4. While baseline distress and the number of needles appear to play important roles in pain-related distress reactivity (i.e., how much distress infants display immediately post-needle), it is evident that temperamental fear and attachment play a more influential role in how infants regulate distress from pain at 12 months of age. Similarly, pain-related distress reactivity was significantly related to pain-related distress regulation in Model 1. However, this relationship was non-significant when temperament and attachment variables were included in Models 2, 3, and 4. Taken together, these findings suggest that factors which are taking place within the immunization procedure itself (i.e., distress infants exhibit immediately prior to immunization and the number of needles infants receive) exert a strong influence on the amount of distress 12-month old infants display immediately following the needle. Variables pertaining to the infant and caregiver, however, appear to play a more influential role in how infants regulate distress in the period following the needle at 12 months.

Summary of Findings from Research Question (1). In summary, Models 1 through 4 allowed for the identification of significant predictors of baseline distress, pain-related distress reactivity, and pain-related distress regulation during the 12-month immunization appointment.

Baseline distress was predicted by attachment, with avoidant infants exhibiting significantly less distress than secure infants. This finding suggests that, under conditions that pose mild to moderate threat, avoidant infants are effective at minimizing distress while in the presence of the caregiver, regardless of their level of temperamental fear.

Pain-related distress reactivity was predicted by immediate factors taking place within the immunization procedure itself, specifically, baseline distress and the number of needles infants received. Efforts are needed to reduce baseline distress that some infants exhibit (e.g., by providing EMLA cream at all immunization appointments over the first year of life) and to reduce the number of needles infants receive to diminish the distress that virtually all infants exhibit immediately following immunization.

Temperament was not directly related to pain reactivity in any of the models, failing to support the hypotheses. However, it is possible that temperament exerts a stronger influence on pain-related reactivity earlier in the first year of life. Further research is needed to explore this hypothesis.

Pain-related distress regulation was predicted by the interaction between attachment and temperamental fear. The contrasting effects of high and low temperamental fear on secure versus insecure attachment indicate that temperamental fear impacts pain-related distress regulation in different ways, depending on the quality of the caregiver-infant attachment relationship. Avoidant infants with high temperamental fear take the longest to regulate distress from pain and may exhibit what can be considered a failure to cope with the highly stressful experience of immunization. In support of the DIAPR model, the results indicate that temperament and the caregiver-infant relationship interact to dynamically influence the ways in which infants regulate distress from pain at the end of the first year of life.

Model 2 explained the most variance in baseline distress and pain-related distress regulation in comparison with the other three models in this study, suggesting that attachment and temperament play an important role in infant distress exhibited during the 12-month immunization. Once attachment and temperamental fear variables were included as predictors of pain-related distress regulation in Models 2 through 4, immediate context-specific variables related to pain (i.e., baseline distress, number of needles and pain-related distress reactivity) no longer predicted the regulation of pain. These findings underscore the influence of the infant and caregiver characteristics on pain-related distress regulation. Researchers who develop interventions aimed at improving pain-related outcomes for infants must take infant and caregiver characteristics, including attachment and temperament, into account.

The finding that Model 2 distinguished the secure group from the avoidant group and the disorganized group underscores methodological issues in collapsing attachment groups into secure/insecure and organized/disorganized dichotomies. Despite their common use in the attachment literature (often due to lack of power in testing A/B/C/D comparisons), the two-level comparison methods (secure/insecure and organized/disorganized) may obscure important differences in regulatory strategies among avoidant, resistant, and disorganized infants.

Findings from Research Question (2a): Do Infant or Caregiver Behaviours *Pre-Needle* Predict Attachment? and (2b): Do Infant or Caregiver Behaviours *Post-Needle* Predict Attachment?

This is the first known study to demonstrate empirically how infants and caregivers from different attachment relationships behave in a naturalistic pain context. The *Measure of Immunization Behaviour and Attachment Behaviour in Infancy* (the MIBABI) was created to define and code behaviours that are theoretically related to the different attachment classifications in the context of immunization at 12 months. Logistic regression was used to examine whether infant and caregiver behaviours exhibited pre- or post-needle predicted attachment groups. As in research question 1, attachment was operationalized three ways using the four-level A/B/C/D comparison, the two-level insecure/secure comparison, and the two-level organized/disorganized comparison.

Preliminary results (2a) and (2b). The MIBABI behaviours *cry/grimace*, *cling*, *snuggle*, and *holding infant* increased post-needle, suggesting these behaviours are triggered by acute pain and are relevant within the context of immunization.

Primary results (2a). Confirming the hypotheses, none of the MIBABI behaviours pre-needle, either as a set or individually, predicted attachment groups. The attachment system was not expected to be triggered for all infants prior to immunization because the majority of infants were not anticipated to become distressed pre-needle.

Solomon and George (2008) have noted that milder stressors may not adequately activate the attachment system and may fail to strongly differentiate attachment groups. Furthermore, Sroufe and Waters (1977) have asserted that attachment is not a trait, *per se*, and that behaviours will not remain consistent across conditions according to attachment. Rather, it is the "organization of behaviours, the adaptational patterns and the quality of the affective bond" (Sroufe & Waters, 1977, p. 1193) that characterizes the attachment relationship, specifically under conditions that elicit distress. As discussed above, attachment was associated with differences in distress exhibited pre-needle. However, only about 25% of all infants exhibited moderate to severe behavioural distress pre-needle. Other regulatory behaviours may not become salient predictors of attachment until the attachment system is triggered for all infants.

Primary results (2b). In contrast to MIBABI behaviours pre-needle, the MIBABI infant *snuggle* behaviour post-needle distinguished secure infants from avoidant and disorganized infants (and insecure infants as a group), confirming the hypotheses that behaviour displayed post-immunization is related to attachment. The attachment system was expected to be triggered for the majority of infants post-needle, as the pain from the needle was hypothesized to provoke distress for all infants. Indeed, all infants exhibited moderate to severe levels of distress immediately following needle, suggesting that the attachment system was activated for all infants.

The *snuggle* behaviour mapped onto the Contact-Maintaining scale used to code the SSP and is representative of infants' efforts to maintain proximity to caregivers. *Snuggle* post-needle was the only significant predictor of attachment groups, with snuggling predictive of secure attachment, in comparison with avoidant and disorganized attachment, confirming the hypotheses for this behaviour. It should be noted that the *snuggle* behaviour was only coded when infants actively sought close proximity with their caregivers; if a caregiver pulled the infant into his or her body, *snuggle* was not coded unless the infant relaxed and kept his or her head snuggled in (e.g., when the caregiver removed his or her hand). Therefore, *snuggle* was an infant-driven behaviour that was representative of infants' active efforts to maintain close proximity to caregivers.

The results are consistent with previous research which has shown that secure infants spend more time in "mother-oriented" regulation behaviours than do avoidant infants when frustrated or fearful (Leerkes & Wong, 2011). In accordance with attachment theory and infant behaviour in the SSP, the current results suggest that secure infants are comfortable relying on caregivers to help them regulate distress from immunization and actively seek proximity to caregivers as a coping strategy. The results support attachment theory in that avoidant and disorganized infants are uncomfortable relying on caregivers when distressed following immunization and are more likely to avoid proximity or contact with caregivers, paralleling avoidant and disorganized behaviour in the SSP.

The *snuggle* behaviour also distinguished secure infants from insecure infants. However, this finding was likely due to the high proportion of avoidant and disorganized infants in the insecure group in comparison with the number of resistant infants (only 8 out of 62 insecure infants were resistant). It is therefore evident that secure infants can be distinguished from avoidant and disorganized infants following immunization based on infants' active efforts to gain proximity to caregivers. Secure infants did not differ from resistant infants in terms of snuggling behaviour. Similar to secure infants, resistant infants increase proximity to caregivers when in distress during the SSP. According to attachment theory, resistant infants who are distressed strongly seek proximity to caregivers who are inconsistent in providing support (Ainsworth et al., 1978), and the present findings support this theory.

Of the seven MIBABI behaviours included in analyses, only *snuggle* post-needle was a significant predictor of attachment groups. The other MIBABI behaviours were related to attachment in expected directions, but were not significant predictors of attachment. For example, infant *clinging* behaviour post-needle was highest for secure and resistant infants post-needle, as expected, but this behaviour was not a significant predictor of attachment in analyses. Similarly, the *arm(s) between* behaviour (mapping onto the Avoidant scale used to code attachment the SSP) was exhibited in expected directions and was most frequently exhibited by avoidant infants post-needle but was also not a significant predictor of attachment groups. Avoidant infants were the only infants to exhibit increases in the *arm(s) between* behaviour from the pre-needle period to the post-needle period. In the SSP, an increase in avoidant behaviour from episode 5 to episode 8 is indicative of avoidant attachment. This observation suggests that it may be worth examining changes in MIBABI behaviour from pre-needle to post-needle within each attachment group to determine whether changes in behaviours parallel behaviours in the SSP from episode 5 to episode 8.

Although *holding infant* was not a significant discriminator of attachment groups, note that caregivers of resistant infants held their infants for the least amount of time post-needle (64%, on average) while caregivers of secure infants held their infants for the most amount of time post-needle (74%, on average). This finding is in keeping with attachment theory and Ainsworth's observations that caregivers of resistant infants are less comfortable with physical soothing than caregivers of secure infants. Resistant infants reached more towards caregivers than did other infants. The caregivers of resistant infants spent less time than caregivers of secure infants holding their infants. Therefore, resistant infants may have been more likely to reach for their caregivers in an effort to re-gain proximity or maintain contact. Further research is needed to explore this hypothesis. An examination of MIBABI behaviours concurrently or sequentially (e.g., caregiver puts infant down, infant immediately reaches for caregiver) may reveal patterns in caregiver-infant behaviour that better differentiate attachment groups.

The *back arch/pushes away* behaviour, which mapped on to the Resistant scale used to code attachment in the SSP, was expected to differentiate resistant infants from the other infants but was not a significant predictor of attachment. In fact, the mean score of infant *back arch/pushes away* behaviour did not differ among attachment groups and was a low-occurring behaviour, exhibited approximately 1% of the time post-needle across attachment groups. There may be other resistant behaviours that infants exhibit post-needle which were not captured by the MIBABI. Given that there were only three resistant infants included in the item generation phase of the MIBABI, more research with larger numbers of resistant infants is needed to determine potential behavioural markers of resistance during immunization.

The infant *cry/grimace* behaviour was also not a significant predictor of attachment groups post-needle. Given that temperament was found to moderate the relationship between attachment and pain-related distress regulation in research question (1), this finding is better understood. In light of the findings from research question (1), the distress that infants exhibit during immunization is associated with attachment, but this association is influenced by temperamental fear. These findings suggest that researchers who wish to use distress following needle as an indicator of attachment must also take temperamental variability into account.

No MIBABI behaviours pre- or post-needle were effective at discriminating the organized group from the disorganized group. Further work is needed to develop behavioural markers of disorganization that can be easily observed within an immunization appointment. This task is likely to present a challenge, as there is an inherent subtlety to disorganized behaviours. However, the identification of disorganized behaviours in medical settings such as immunization may prove to be of great clinical importance, as it would allow for the early identification of infants at highest risk of mental health problems later in life (van IJzendoorn et al., 1999). Consultation with experts in coding disorganization is needed.

Summary of Findings from Research Question (2a) and (2b). In line with the findings from the first research question, the results from the second research question further support immunization as a context in which to study attachment and they corroborate Sroufe and Waters' (1977) assertion that behaviours related to attachment follow predictable patterns in contexts that elicit distress. In summary, the finding that infants exhibit different amounts of snuggling behaviour according to their attachment relationship highlights the tenet that infants use attachment-driven coping strategies to regulate pain-related distress (Cassidy, 1994). Supporting previous research in non-pain contexts (Leerkes & Wong, 2011) and reflecting behaviours exhibited in the SSP, secure infants use more approach strategies when in distress from pain, while avoidant and disorganized infants are less likely to initiate close physical contact with caregivers. These findings are also in keeping with Favez and Berger's (2011) measure of attachment during immunization, in which secure and resistant infants are expected to seek contact with caregivers while avoidant infants are expected to avoid this contact following the needle. Attachment-driven behaviours that the infant uses to gain physical proximity to the caregiver appear to be consistent across pain-related and non-pain related distress-provoking contexts (Sroufe & Waters, 1977).

The present findings provide weak support for the construct validity of the MIBABI as a proxy measure of attachment. Only one MIBABI behaviour, *snuggle*, was a reliable predictor of attachment groups post-needle. It is possible that other behavioural predictors of attachment in the context of immunization may have inadvertently been omitted in this study. For example, a recent study found that caregivers of securely attached 4-year old children exhibit significantly more pain-reducing behaviours (e.g., engaging the child in distraction or nonprocedural talk) than caregivers of insecurely attached children (Pritchett et al., 2012). Infant behaviours such as self-soothing (e.g., sucking thumb) and distraction (e.g., playing with the paper on the change table) were also not included in the MIBABI measure but may be salient coping strategies that infants with different attachment styles use in the context of immunization. More research is needed to explore other possible behavioural markers of attachment status within the immunization setting.

An alternative possibility is that the behavioural differences infants exhibit during immunization are not as pronounced as in the SSP, or that the number of coping strategies that infants use during immunization may be more limited than in the SSP. Most infants are held by their caregivers for the majority of the immunization procedure, whereas infants can move about freely in the SSP. When held close to caregivers during immunization, infants may be limited to use either a "snuggle" coping strategy or a "no snuggle" coping strategy in an effort to regulate distress. Alternatively, immunization may be so highly stressful that infants abandon strategies that might otherwise differentiate them in the SSP.

It is possible that a more global, qualitative, "macro" coding system of attachment in the immunization setting is needed to capture differences in the caregiver-infant attachment relationship, in contrast to the MIBABI, a quantitative, "micro" coding system. It seems promising that sequential analysis of the MIBABI behaviours may shed light on the patterns of behaviour between caregivers and infants that emerge following immunization and has the potential to provide empirical support for qualitative measures such as the PASI (Favez & Berger, 2011). Similar to the SSIB used to code the SSP, the MIBABI might be adapted as both a quantitative and qualitative measure in which coders rate the intensity and persistence of behaviours while also assessing behavioural patterns across phases of the immunization to ultimately classify infants based on these patterns. Given that infants exhibited MIBABI behaviours that were in the hypothesized directions for each classification, this approach seems feasible. More work is needed to bridge the gap between quantitative and qualitative measures of attachment during immunization. As this area of research has only begun to unfold, there are many exciting possibilities for the development of the MIBABI and other measures of attachment within pediatric contexts.

Clinical Implications from Research Questions 1 and 2 and Future Directions

Taken together, the results from research questions 1 and 2 complement each other and provide novel contributions to the field of infant mental health. The current results underscore the importance of context when evaluating attachment behaviour and validate immunization as a paradigm in which to study and understand relationships between attachment, temperament, and emotion regulation. Notably, the results from the current study have implications for clinical intervention for infants undergoing immunization and for infants at high risk for emotion regulation difficulties.

As discussed above, efforts to increase the use of evidence-based pharmacological interventions such as EMLA and to reduce the number of needles during immunization are needed to reduce pain-related distress for all infants. Reducing pain in relation to immunization is also likely to reduce distress related to the uncertainty, unpredictability, and frightening nature of the procedure for infants. These interventions would also alleviate distress experienced by caregivers who report a degree of helplessness and discomfort related to witnessing their infants undergoing immunization (Favez & Berger, 2011; Harrington et al., 2000).

Building on a foundation of research and theory in the development of emotion regulation in infancy (e.g., Bradley, 2000; Dodge, 1989; Trevarthen, 2009), this study demonstrates that distress regulation in infancy is shaped by the biopsychosocial context in which infants develop. Both temperamental fear and attachment are triggered following immunization, but it is the interplay between the two that impacts how infants regulate distress post-immunization needle. The contrastive effects of temperamental fear on attachment and distress regulation demand that we pay attention to *how* an individual regulates distress and not simply *how quickly* distress is regulated. An examination of the behaviours that infants exhibit while regulating distress from pain provides insight into the quality of pain-related distress regulation and is an important component to discerning adaptive from maladaptive emotion regulation.

Avoidant and disorganized infants exhibited the least amount of snuggling behaviour with caregivers following immunization, suggesting that they did not actively use caregivers to help them regulate distress. Secure infants, on the other hand, effectively used caregivers by snuggling in to them to regulate distress following immunization. Even in the presence of high temperamental fear, secure infants were able to regulate distress more quickly than avoidant and disorganized infants, presumably because they felt confident in their ability to solicit support from caregivers and were able to use caregivers effectively in this regard.

Insecure infants with extremes in temperamental fear (either high or low) exhibited what can be considered less adaptive pain-related distress regulation. Avoidant infants with high temperamental fear who take longer to regulate distress in comparison with secure infants are theorized to have difficulties inhibiting their pain-related distress response, likely because they are also experiencing the most physiological stress (Gunnar et al., 1996) and are less comfortable depending on caregivers for support (Ainsworth et al., 1978). Avoidant and disorganized infants with low temperament fear, on the other hand, may miscue caregivers by preemptively shutting off the distress response. Infants with disorganized attachment who regulate behavioural distress quickly and do not rely on caregivers for support may be exhibiting a blunted or dissociative distress response, which in itself is a correlate of psychopathology (Liotti, 2006).

Although insecure infants with extremes in temperamental fear may be at higher risk for regulation difficulties later in life, Thompson's (1994) definition of emotion regulation highlights the importance of considering an individual's goals within an emotion regulation context. In contrast to outcomes related to emotion regulation such as externalizing and internalizing problems, it is more difficult to label patterns in pain-related distress regulation as broadly "adaptive" or "maladaptive." However, when one considers attachment as a goal-directed system, the concept of adaptive and maladaptive regulation will differ for each attachment group.

Cassidy (1994) states that the ways in which infants regulate emotion serve two attachment-driven goals: to maintain proximity to the caregiver during situations that threaten an infant's safety, and to maintain the caregiver's own "state of mind" in relation to attachment (pp. 248). For example, the avoidant infant with low temperamental fear who minimizes distress and does not seek the caregiver for support following immunization is subsequently able to avoid rejection from the caregiver, meeting the first goal of the avoidant attachment system. This infant also sustains the caregiver's dismissal of attachment as a valued construct, thereby satisfying the second goal of the avoidant attachment system. The avoidant infant with low temperament fear is therefore well-suited to the dyad's attachment goals and exhibits what might be considered a more adaptive response to immunization. Although avoidant behaviours work to maintain the goals of the attachment system in the short-term (e.g., the minimization of attachment needs), this style of coping may be detrimental in the long-term as it does not allow for the development of pro-social, support-seeking skills when distressed (Burgess et al., 2003).

The avoidant infant with high temperamental fear, on the other hand, is unable to minimize pain-related distress following immunization. These infants may be at highest risk for problems in emotion regulation because the goals of the avoidant attachment relationship are not effectively managed. This interpretation offers an explanation as to why avoidant infants with high temperamental fear exhibit the highest physiological stress response to immunization (Gunnar et al., 1996), as they are not able to maintain the goals of the attachment system under highly stressful conditions, exacerbating stress. In this light, avoidant infants with high temperamental fear display what can be considered the most "maladaptive" pain-related distress regulation response because their temperamental characteristics are mismatched to the attachment relationship.

The present results support Gunnar and colleagues' (1996) assertion that security acts as a buffer against high temperamental fear and that insecurity in combination with high temperamental fear may create a specific vulnerability for emotion regulation difficulties in infancy. The findings point to the additive risk effects of an insecure attachment and high temperamental fear on emotion regulation (Stevenson-Hinde, 2005). Posner and Rothbart (2000) have suggested that "pathologies of development may arise when regulatory and reactive systems fail to reach the balance that allow for both self-expression and socially acceptable behavior" (p. 427). Research has supported these assertions. For example, infants classified as insecure in the SSP and whose caregivers rate them as having higher negative emotionality in infancy exhibit more eating problems in early childhood compared to insecure infants with low negative emotionality and secure infants with high or low negative emotionality (Hagekull & Bohlin, 2004). The findings of the current study speak to the concept of a "goodness of fit" between caregivers and infants, particularly when infants have predispositions towards high emotional expressivity (Mangelsdorf, Gunnar, Kestenbaum, Lang, & Andreas, 1990). The longitudinal study under which the current study is subsumed will ultimately be able to determine whether secure infants with high temperamental fear in the current study exhibit more adaptive outcomes in later childhood in comparison with insecure infants with high temperamental fear.

Although caregivers were asked to rate their infants' temperamental fear, they were not asked how comfortable they were with their infants' expressions of fear or distress. Cassidy (1994) has suggested that caregivers of secure infants accept variations in infants' temperament fear, whereas caregivers of insecure infants either reject (in the case of avoidance) or amplify (in the case of resistance) infants' fearful dispositions. Caregivers of avoidant infants who rated them as highly fearful were likely less comfortable with their infants' displays of distress during immunization than caregivers of secure infants. It follows that caregivers of avoidant infants may have subsequently been less emotionally or physically available to help their infants cope with distress during immunization, leading avoidant infants with high temperamental fear to take longer to regulate distress than secure infants with high temperamental fear. Nachmias and colleagues (1996) have pointed out that temperamental fearfulness is itself a coping strategy that infants use to help them regulate distress. In situations such as the novelty of a new toy, temperamentally fearful children will inhibit their approach to the object until they have regulated distress and are "ready" to approach. In situations such as immunization, however, infants with high temperamental fear cannot effectively inhibit their approach to the pediatrician or to the painful needle. These infants must subsequently use other strategies to help them regulate distress. The results suggest that the secure infant who is highly fearful is able to use the caregiver (by snuggling in to him or her) to effectively regulate distress, whereas the avoidant infant with high temperamental fear does not (and theoretically cannot) effectively use the caregiver in the same way.

It is noteworthy that some avoidant infants exhibit *more* distress during separation episodes of the SSP than secure infants who exhibit less proximity- and contact-seeking and less contact-maintenance (Braungart & Stifter, 1991). However, it is in the avoidance of proximity- or contact-seeking with caregivers upon their return that distinguishes these infants as avoidant. Similarly, in the current study, the distress that infants displayed following immunization was related to attachment status but qualified by an interaction with temperament. The quality of infants' interactions with caregivers, however, reflected the caregiver-infant attachment relationship; infants who actively sought physical comfort from caregivers were more likely to be secure, whereas infants who did not seek physical comfort from caregivers were more likely to be avoidant or disorganized.

Limitations

There are several limitations to note. The inclusion criteria for the current study required caregivers to be fluent in English to understand and complete two consent forms and the IBQ-R, precluding the inclusion of non-English-speaking caregivers and limiting the generalizability of the results. The caregivers included in this study were also highly educated (76% had a university or graduate education). With education as a proxy for social economic class, our results may not generalize to less-educated caregivers and more high-risk populations.

IBQ-R questionnaires and SSP procedures were completed approximately 1.5 months following the 12-month immunization appointment, but were included as predictors of immunization distress in SEM analyses. Given that temperamental fear (Rothbart, Derryberry, & Hershey, 2000) and attachment (Fraley, 2002) have been shown to be moderately stable over time, these constructs were theorized to undergo little change in the 1.5 months between visits. Therefore, attachment and temperament were conceptualized as pre-existing factors in this study, even though they were measured following the immunization appointment.

Due to caregivers completing the IBQ-R following the SSP, there is a possibility that caregiver's perceptions of their infants in the SSP may have influenced their responses to the questionnaire, thus confounding attachment with temperamental fear. Indeed, the SSP is theorized to trigger both the attachment system and temperamental fear in infants (Stevenson-Hinde & Shouldice, 1993). Moreover, some of the questions in the IBQ-R Fear Scale pertain to infants' responses to unfamiliar adults and a novel environment, situations that parallel those in the SSP. The mean caregiver ratings of temperamental fear across attachment groups did, in fact, reflect behavioural differences exhibited by infants in the SSP. Resistant (C) infants were rated as the most fearful, in keeping with these infants' tendencies to exhibit high levels of distress in the SSP. In turn, avoidant (A) infants were rated as the least fearful, in keeping with these infants' tendencies to exhibit minimal distress during the SSP. Nonetheless, temperamental fear ratings did not differ significantly across attachment groups. These findings support assertions by Sroufe (1985) that although temperamental fear and attachment are interrelated (both are likely to be triggered under threat), they remain separate constructs. The IBQ-R was also completed 1.5 months, on average, following the immunization appointment and it is also possible that infant distress during immunization may have influenced caregivers' ratings, thereby confounding these variables. Indeed, similar to the SSP, the immunization was theorized to trigger both temperamental fear and attachment and it was expected that infants' responses to immunization would influence caregivers' ratings of temperamental fear. However, temperamental fear was not correlated with immunization distress at any time point, thus these variables were considered to represent independent constructs in analyses.

Temperamental fear was not examined in association with MIBABI behaviours. With the finding of an interaction between temperament and attachment on distress regulation, temperamental fear may also moderate the relationship between behaviours exhibited during immunization and attachment. Further research is needed to examine the ways in which temperament may influence the expression of behaviours during immunization.

Maternal sensitivity to infant distress during immunization was not assessed in this study, even though maternal sensitivity during times of distress is associated with attachment (Leerkes, 2011; McElwain & Booth-LaForce, 2006), with caregivers of avoidant, resistant, and disorganized infants expected to respond less sensitively to their infants' distress cues (Ainsworth et al., 1978). Insensitive behaviours may be particularly salient when avoidant and disorganized infants with high temperamental fear take longer to regulate distress following immunization, as these caregivers are theorized to be uncomfortable when their infants are distressed (or to behave in atypical ways, in the case of disorganization). Behaviours that are related to maternal sensitivity may be important predictors of attachment in the pediatric setting.

The IBQ-R was chosen as the measure of infant temperamental fear in this study because caregiver reports allow for ratings that reflect infant behaviour across numerous contexts and settings, unlike a single laboratory visit. However, as the IBQ-R is a caregiver-report measure, there is a possibility that caregivers' ratings may have been influenced by caregiver characteristics such as personal attachment histories or psychopathology (e.g., depression). For example, women who report histories of parental emotional rejection and avoidance in adult relationships are more likely to respond with amusement to observed infant fear (Leerkes & Siepak, 2006), which may distort reported fear in the IBQ-R. Similarly, fathers' self-reported depression has been shown to reduce the concordance between observed fear and reported fear when depression is average or high (Parade & Leerkes, 2008). Moreover, Sroufe (2005) has noted that temperament measured later in infancy is likely to represent "a complex product of infant and environment interacting over time" (p. 354) rather than purely child-related characteristics.

It follows that an alternate interpretation of the current results is that infant and caregiver characteristics captured by the IBQ-R (e.g., infant temperament and caregiver depression) and attachment interact to predict distress regulation. This interpretation is still in keeping with attachment theory. Caregivers of avoidant infants, for example, are theorized to be uncomfortable and rejecting when their infants exhibit distress, while caregivers of secure infants are theorized to be comfortable and accepting of their infants' emotional distress (Ainsworth et al., 1978; Cassidy, 1994). Subsequently, in comparison with caregivers of secure infants, caregivers of avoidant infants may over-estimate infant fearfulness when infants take longer to regulate distress (in situations such as immunization) or may under-estimate infant fearfulness when infants regulate distress quickly. In other words, caregivers of avoidant infants may hold perceptions of their infants as being either "bad regulators" or "good regulators" (D. Pederson, personal communication, June 21, 2012), whereas caregivers of secure infants are more accepting of variability in infants' temperamental fear (Cassidy, 1994). Indeed, mothers who are classified as "dismissive" in the Adult Attachment Interview, a style of caregiving associated with avoidant attachment, were more likely to distort their infants' distress cues (DeOliveira, Moran, & Pederson, 2005). Future research that includes measurement of caregiver factors (e.g., comfort with infant distress) is needed to better understand the effect of caregiver variables on infant pain-related distress regulation.

Conclusion

The findings of the current study underscore the notion that distress regulation develops within a biopsychosocial context. By allowing comparisons between infants' coping behaviours with caregivers and distress regulation across naturalistic and laboratory contexts, this project bridges pediatric pain and infant mental health literatures. This linkage serves as a foundation for identifying infants at risk for problems in distress regulation and for empirically-validated primary care interventions aimed at improving the caregiver-infant attachment relationship and associated emotion regulation outcomes. However, more research is necessary in order to consolidate the link between different trajectories of pain-related distress regulation and well-being later in childhood.

Thompson's (1994) definition of emotion regulation introduced at the beginning of this paper highlights the importance of considering intrinsic (e.g., temperament), extrinsic (e.g., caregiver-infant interaction), and behavioural (e.g., MIBABI behaviours) processes that influence emotion regulation. Thompson asserts that multiple processes are responsible for "monitoring, evaluating, and modifying emotional reactions, especially their intensive and temporal features, to accomplish one's goals" (pp. 27-28). The findings of the current study support this view in that interactions between temperament and attachment influence pain-related distress regulation and the amount of *snuggling* behaviour infants displayed following immunization was related to attachment. The finding that both intrinsic infant factors and extrinsic factors related to the caregiver-infant relationship impact pain-related distress regulation also supports the DIAPR model as a biopsychosocial model of infant acute pain.

From an affect-regulation perspective, the ability to express distress openly and to seek support from others constitutes adaptive emotion regulation during infancy, as it allows others to recognize distress signals and to provide care. For infants who are rated as having low temperamental fear, secure infants regulate pain-related distress more slowly than avoidant or disorganized infants. However, secure infants are also more likely to seek close physical proximity to the caregiver following immunization. This finding is consistent with attachment theory that posits that secure infants are more comfortable openly expressing distress when in the presence of caregivers who are responsive to their distress signals such as crying, facial expression, and body movement (Ainsworth et al., 1978). An infant who regulates behavioural distress very quickly, on the other hand, but does not seek support from caregivers may be relying on avoidant strategies to regulate distress or may be exhibiting disorganized behaviours (e.g., dissociating) and may be at risk for problems in emotion regulation that are associated with insecure attachment. Infants who take a longer period of time to regulate distress and do not actively seek physical comfort from caregivers may be at highest risk for problems related to distress regulation. These infants exhibit what can be considered a poor fit between temperamental characteristics and the caregiving environment, as their proneness to becoming highly distressed is in conflict with the goals of an avoidant attachment system.

The results highlight the ways in which individual characteristics of the infant and caregiver influence the infant's response to painful medical procedures and call for an individualized-approach to health care. Ranger and Campbell-Yeo (2008) suggest that specific training pertaining to the dynamic influence of biopsychosocial factors on pain-related distress may be incorporated into educational programs for health care professionals. The authors further argue that by tailoring the medical environment to the needs of the infant and caregiver, the "goodness of fit" between environment and infant-caregiver characteristics can be improved (Ranger & Campbell-Yeo, 2008). Similarly, P. Zeanah and Gleason (2009) have drawn attention to the potential of in-the-moment teaching during pediatric visits that may change caregiver behaviour and ultimately facilitate positive change in infant mental health.

The findings from the current study shed light on the kinds of *in situ* interventions that might be offered to caregivers. For example, caregivers with dyads that appear to be "miscuing" each other during immunization (e.g., the infant who is highly distressed but is not seeking close proximity to the caregiver, or the caregiver who puts the infant down when the infant is highly distressed and continues to signal proximity) can be offered suggestions as to how to respond to the infant in pain. Health care professionals may also highlight what is working in the dyad to reinforce the caregiver's attention to the infants' attachment needs (e.g., "Your baby seems comforted by being close to you"). In cases in which infants are highly distressed for prolonged periods and do not seek caregivers for support, evidence-based attachment interventions might be offered (Bakermans-Kranenburg et al., 2003). These interventions have been shown to improve caregivers' sensitivity to infant distress and, ultimately, attachment security. By ameliorating security within the caregiver-infant attachment relationship, infants' distress regulation abilities are enhanced and these skills, in turn, set the foundation for effectively coping with stress across the lifespan. Given the well-established links between distress regulation and wellbeing, the positive impact of early identification and intervention for infants at risk for emotion regulation difficulties cannot be underestimated.

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Appendix A

Strange Situation Procedure Episodes (adapted from Ainsworth et al., 1978)

Episode #	Duration	Description
1	30 seconds	The caregiver and infant are introduced to a novel room by the researcher who instructs the caregiver to carry the baby into the room, engage them with the toys and sit in a chair where he or she is free to peruse a magazine.
2	3 minutes	Begins when the caregiver places the infant on the floor in front of the toys, facing the one-way mirror. The infant is subsequently left to explore the toys and/or room while the caregiver refrains from initiating interaction with the baby from his or her chair unless the baby initiates interaction, in which case, the caregiver is instructed to respond in a way he or she deems appropriate. If the infant has not settled into exploring the toys or the room after two minutes' time, the observer may knock on the one-way mirror as a cue to the caregiver to attempt to engage the infant in play/exploration for one minute (timed by the observer)
3	3 minutes	A stranger enters the room and takes a seat in the second chair where she remains silent for a minute. During the second minute, the stranger engages the caregiver in conversation and provides further instructions. During the third minute of the episode, the stranger approaches the infant and engages him or her in play. A knock from the observer at the end of the third minute cues the caregiver to unobtrusively leave the room.
4	3 minutes or less	During the first separation episode, the stranger interacts with the infant, taking his or her cues from the infant. If the infant becomes markedly distressed and is not able to resume play or exploration, the observer may wish to terminate the episode prior to 3 minutes by sending the caregiver back into the room.
5	3 minutes or more	The first reunion episode begins when the caregiver returns to the room, pausing at the door in order to allow the baby to great her spontaneously. Following the greeting between caregiver and infant, the stranger surreptitiously leaves the room. The observer may wish to prolong the episode if the baby takes a long time to become re-involved in play or exploration. Caregiver then leaves baby alone in the room, saying "bye bye" upon her departure.
6	3 minutes or less	The baby is left alone in the room during the second separation episode which the observer may wish to cut short by sending the stranger into the room if the baby is markedly distressed prior to the end of the 3 minutes.
7	3 minutes or less	The second separation from caregiver continues during this episode when the stranger enters the room and interacts with the baby, following his or her cues. Again, the observer may wish to cut the episode short by sending the caregiver into the room if the baby is markedly distressed prior to the end of the 3 minutes.
8	3 minutes	During the second reunion episode, the caregiver returns to the room and pauses at the door to allow baby to greet her spontaneously. After the caregiver and infant have greeted each other, the stranger leaves unobtrusively.

Appendix B
Ethics Approval from York University and The Hospital for Sick Children

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RENEWAL

Certificate #:	**2009 - 216**
3rd Renewal Approved: 08/20/12	
2nd Renewal Approved: 08/04/11	
Renewal Approved: 08/3/10	
Approval Period:	**08/20/12-08/20/13**

OFFICE OF RESEARCH ETHICS (ORE)
Fifth Floor, YRT

4700 Keele St.
Toronto ON
Canada M3J 1P3
Tel 416 736 5914
Fax 416 736 5837
www.research.yorku.ca

Memo

To: Dr. Rebecca Pillai Riddell, Faculty of Health
rpr@yorku.ca

From: Alison M. Collins-Mrakas, Sr. Manager and Policy Advisor, Research Ethics
(on behalf of Duff Waring, Chair, Human Participants Review Committee)

Date: **Monday August 20th, 2012**

Re: Ethics Approval

Synergizing Infant Health and Infant Mental Health: Applying Attachment Theory to the Context of Infant Pain

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With respect to your research project titled, "Synergizing Infant Health and Infant Mental Health: Applying Attachment Theory to the Context of Infant Pain", the committee notes that, as there are no substantive changes to either the methodology employed or the risks to participants in the research project or any other aspect of the project, a renewal of approval re the above project is granted.

Should you have any questions, please feel free to contact me at: 416-736-5914 or via email at: acollins@yorku.ca.

Yours sincerely,

Alison M. Collins-Mrakas M.Sc., LLM
Sr. Manager and Policy Advisor,
Office of Research Ethics

SickKids

THE HOSPITAL FOR
SICK CHILDREN

RESEARCH ETHICS BOARD

August 12, 2011

Dr. Rebecca Pillai Riddell
Psychiatry
The Hospital for Sick Children

Dear Dr. Pillai Riddell:

Your study "Synergizing Infant Health and Infant Mental Health: Applying Attachment Theory to the Context of Infant Pain"

REB File No.: 1000013477

On behalf of the REB, I am writing to confirm that the above noted study was re-approved by the REB for one year ending in August 2012. The REB approved continuing review at level 1B. As necessary, the Clinical Research Office will be contacting you to arrange follow-up.

Please note that, in accordance with the Personal Health Information Protection Act of Ontario, you are responsible for adhering to all conditions and restrictions imposed by the REB governing the use, security, disclosure, return and disposal of the research subjects' personal health information. You are also responsible for reporting immediately any privacy breaches to the REB Chair and to Janice Campbell, the Sick Kids privacy officer.

Yours truly,

Richard Sugarman

Richard Sugarman
Chair, Research Ethics Board

Co-Investigator(s): Rachel Horton, Jessica Hillgrove

555 University Ave
Toronto, Ontario
Canada M5G 1X8

www.sickkids.ca

Appendix C

Information Package for Participating Parents

Directions to Sick Kids

The Hospital for Sick Children (SickKids) is located at 555 University Avenue (Corner of University and Gerrard).

How to get to SickKids by TTC - subway:
Exit at Queen's Park subway station and walk south two blocks on University Avenue. For bus and subway information, call the 24-hour ttc line at (416) 393-4636 or visit their Web site: www.ttc.ca

How to get to SickKids by car:
If driving from a **northern direction**, take the Don Valley Parkway south (downtown). Exit at Bloor Street and make a left on to Castle Frank Road then a right onto Bloor Street. Follow Bloor (travelling west) to Bay Street (Bay Street is one intersection west of Yonge). Travel south on Bay and make a right on to Elm Street. Parking and the hospital can be found one block west, on your right side.

If driving from a **southern direction**, exit the Gardiner Expressway at the York Street/Bay Street exit. Take the York Street ramp. Go straight on York Street. Turn left onto University Avenue. Travel north on University Avenue up to Elm Street. Make a right on Elm. The hospital's underground parking can be found one block east, on your left side.

If driving from the **east or west**, take the 401 to the Don Valley Parkway south (downtown). Follow the directions from above, driving from a northern direction.

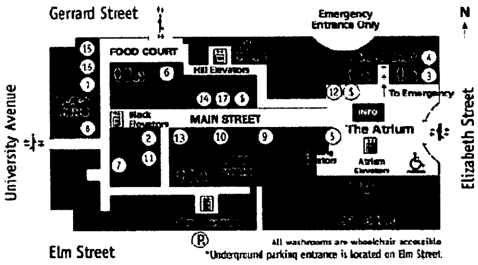
Where to go at Sick Kids...

ON SATURDAY AND SUNDAYS, PLEASE USE THE ELIZABETH STREET ENTRANCE

Once at the Hospital, take the Black Wing Elevators (in front of the Shoppers Drug Mart and closest to the University Avenue entrance) to the 4th Floor.

A research assistant will be waiting for you at the Black Wing elevators on the 4th Floor. We will be taking you to the Psychiatry Research Wing.

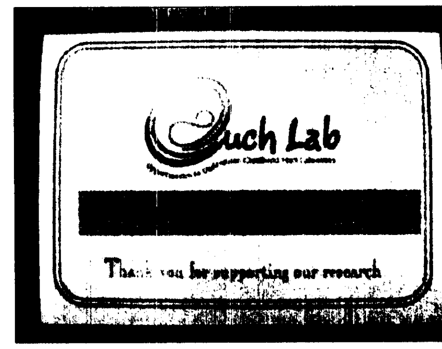
If you get lost, call the OUCH lab and leave a message as to where you are (and a contact number if you have your cell), we'll be checking messages- 416 736-2100 X20177

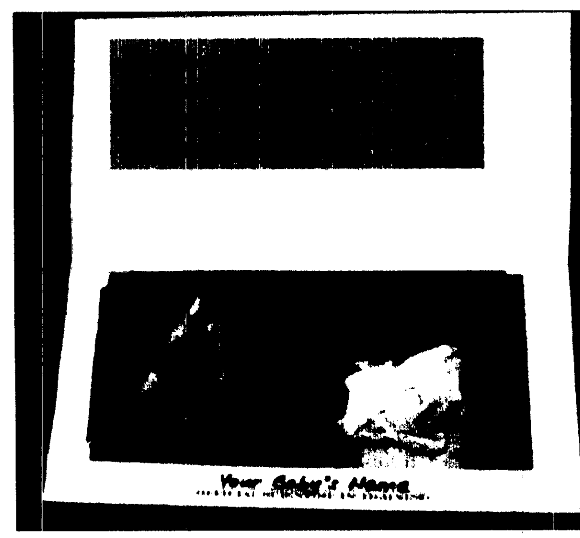


Map of main floor at Sick Kids

THE FUN STUFF...

the post-study souvenirs for you and your baby





Appendix D
Research Consent Form and Video Consent Form

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SickKids®
THE HOSPITAL FOR
SICK CHILDREN
Research Ethics Board

Date: September 20th, 2008
Version Code: 1

Research Consent Form

Title of Research Project:
Synergizing Infant Health and Infant Mental Health: Applying Attachment Theory to the Context of Infant Pain

Investigator(s):
Principal Investigator:

Dr. Rebecca Pillai Riddell, PhD, CPsych
(416) 736-2100, ext. 33204 (York University)
(416) 813-6854 (Sick Kids)

Co-Investigators:

Rachel Horton, MA, Clinical Developmental Psychology
Doctoral Student, York University
Supervisor: Dr. R. Pillai Riddell
Clinical Research Assistant, The Hospital for Sick Children
(416) 736-2100, ext. 20177 (York University)

Jessica Hillgrove, Clinical Developmental Psychology
Doctoral Student, York University
Supervisor: Dr. R. Pillai Riddell
Clinical Research Assistant, The Hospital for Sick Children
(416) 736-2100, ext. 20177 (York University)

Purpose of the Research:
We are doing this study to understand ways that we can help infants when they are having pain. Specifically, we are interested in finding out if the ways in which caregivers and their infants interact impacts how infants experience and express pain.

Description of the Research:
We are interested in looking at parents and infants when infants are between 12 and 18 months of age. We will be videotaping your infant's immunization visit today and would

like to invite you to a laboratory visit at the Hospital for Sick Children in the next two week that will involve everyday interactions between yourself, your infant and a research assistant. This visit will take no longer than 45 minutes and you will receive a small token of our appreciation as well as compensation for travel to and from the hospital.

1) We will use information from your participation in our earlier study at Dr. Greenberg's/Dr. Garfield's clinic.
2) You will receive reminders via phone, mail or email regarding your upcoming hospital visit appointment.
3) You and your infant will be videotaped during the laboratory visit. You will be asked to fill out a separate consent form regarding videotaping.

Potential Harms:
We know of no harm that taking part in this study could cause you or your baby.

Potential Discomforts or Inconvenience:
The only potential inconvenience with participating in this study is that you and your child will be taking time out of your day to travel to the Hospital for Sick Children. TTC travel costs (to and from the Hospital) or parking costs (at the Hospital) will be provided to minimize your inconvenience.

Potential Benefits:

To individual subjects:
You and your child will not benefit directly from participation in this study. If you are interested in our findings, please let the research assistant know by filling out the attached sheet and he/she will arrange to send a summary of the results to you after the study is completed. Specific findings pertaining to you and your child will not be available.

To society:
We hope that the results of this study will help us to understand pain in infants so that we can determine ways to manage it better.

Confidentiality:
We will respect your privacy. No information about who you are or who your child is will be given to anyone or be published without your permission, unless required by law. For example, the law could make us give information about you if a child has been abused, if you have an illness that could spread to others, if you or someone else talks about suicide (killing themselves), or if the court orders us to give them the study papers.

Sick Kids Clinical Research Monitors, employees of the funder or sponsor [Canadian Institutes of Health Research], or the regulator of the study may see your health record to check on the study. By signing this consent form, you agree to let these people look at your records. We will give you a copy of the consent form for your records.

The data produced from this study will be stored in a secure, locked location. Only members of the research team (and maybe those individuals described above) will have access to the data. This could include external research team members. Following completion of the research study the data will be kept as long as required then destroyed as required by Sick Kids policy. Published study results will not reveal your identity.

Reimbursement:
In addition to TTC or parking costs, after completing the study we will also provide you with a certificate of participation and a small token of appreciation (infant t-shirt) in recognition of your time and effort. If after beginning the study, you want to stop taking part, we will still pay you for your TTC or parking expenses.

Participation:
It is your choice to take part in this study with your infant. You can stop at any time. The care you get at Sick Kids or by your pediatrician will not be affected in any way by whether you take part in this study or withdraw from this study. Nor will your refusal/withdrawal jeopardize current or future relationships with the researchers at any of the institutions involved with this study (e.g. York University).

New information that we get while we are doing this study may affect your decision to take part in this study. If this happens, we will tell you about this new information. And we will ask you again if you still want to be in the study.

During this study we may create new tests or other things that may be worth some money. Although we may make money from these findings, we cannot give you [or your child] any of this money now or in the future because you [or your child] took part in this study.

If you or your child becomes ill or are harmed because of study participation, we will treat you or your child for free. Your signing this consent form does not interfere with your legal rights in any way. The staff of the study, any people who gave money for the study, or the hospital/pediatrician's office are still responsible, legally and professionally, for what they do.

Sponsorship:
The sponsor of this research is the Canadian Institutes of Health Research. The discretionary funding has been allocated to Dr. R. Pillai Riddell as a result of New Investigator Award.

Conflict of Interest:
None of the research team members have any conflicts of interest to declare.

Consent :
By signing this form, I agree that:
1) You have explained this study to me. You have answered all my questions.

2) You have explained the possible harms and benefits (if any) of this study.
3) I know what I could do instead of having my child take part in this study. I understand that I have the right to refuse to let my child take part in the study. I also have the right to take my child out of the study at any time. My decision about my child taking part in the study will not affect my child's health care at Sick Kids or by my child's pediatrician.
4) I am free now, and in the future, to ask questions about the study.
5) I have been told that my child's medical records will be kept private except as described to me.
6) I understand that no information about my child will be given to anyone or be published without first asking my permission.
7) I agree, or consent, that my child ____________________ may take part in this study.
*(Baby's **first** and **last** name)*

____

Printed Name of Parent/Legal Guardian   Parent/Legal Guardian's signature & date

____

Printed Name of person who explained consent   Signature of Person who explained consent & date

If you have any questions about this study, please call Dr. Rebecca Pillai Riddell at 416-736-2100, extension 33204 or 416-813-6854 (Sick Kids). If you have any questions about your rights as a participant a study or injuries during a study, please contact Ms. Alison Collins-Mrakas, Manager, Research Ethics, 309 York Lanes, York University [telephone (416)736-5914 or e-mail acollins@yorku.ca] or Ms. Margo Farren, Research Ethics Manager, Hospital for Sick Children, Room 5255 Black Wing, Sick Kids [telephone (416 813-5718 or email margo.farren@sickkids.ca].

CONTACT INFORMATION:

I consent for researchers to contact me via mail, email or phone regarding:

Check which statements applies:

☐ No further contact aside from contact directly related to participation in this study.

☐ Further contact for results of this study.

☐ Further contact for results of this study and opportunities for participation in new future studies.

Mailing address:
Email address:
Phone number:

Please print clearly

YORK UNIVERSITÉ UNIVERSITY

SickKids®
THE HOSPITAL FOR
SICK CHILDREN
Research Ethics Board

Date: September 20th, 2008
Version Code: 1

Videos, Photographs, & Sound Recordings Consent Form

Title of Research Project: Synergizing Infant Health and Infant Mental Health: Applying Attachment Theory to the Context of Infant Pain

Investigator(s):

Principal Investigator:

Dr. Rebecca Pillai Riddell, PhD, CPsych
(416) 736-2100, ext. 33204 (York University)
(416) 813-6854 (Sick Kids)

Co-Investigators:

Rachel Horton, MA, Clinical Developmental Psychology
Doctoral Student, York University
Supervisor: Dr. R. Pillai Riddell
Clinical Research Assistant, The Hospital for Sick Children
(416) 736-2100, ext. 20177 (York University)

Jessica Hillgrove, Clinical Developmental Psychology
Doctoral Student, York University
Supervisor: Dr. R. Pillai Riddell
Clinical Research Assistant, The Hospital for Sick Children
(416) 736-2100, ext. 20177 (York University)

Confidentiality:
The pictures or tapes produced from this study will be stored in a secure, locked location. Only members of the research team (and maybe the SickKids monitor) will have access to them. Following completion of the study the tapes/pictures will be kept for 7 years post-publication. They will then be destroyed according to this same policy.

Consent:
By signing this form,

1) I agree for my child and I to be taped during this study. These tapes/photographs will be used to provide information regarding how caregivers can help infants in pain.
2) I understand that I have the right to refuse to take part in this study. I also have the right to withdraw from this part of the study at any time e.g. before or even after the tapes or photographs

are made. My decision will not affect my health care at SickKids or by my child's pediatrician.

3) I am free now, and in the future, to ask questions about the taping/picture taking.

4) I have been told that my medical records will be kept private. You will give no one information about me, unless the law requires disclosure.

5) I understand that no information about me (including these tapes/pictures) will be given to anyone or be published without first asking my permission.

6) I have read and understood both pages of this consent form. I agree, or consent, to having my picture taken/being taped as part of the study.

Questions about the Videotaping? If you have questions about the research in general or about your role in the study, please feel free to contact Dr. Rebecca Pillai Riddell either by telephone at (416) 736-2100, extension 33204 or at (416) 813-6854 or by e-mail (rpr@yorku.ca). This research has been reviewed by the Human Participants Review Committee in accordance with York's Senate Policy on Research Ethics (York University) and the HSC's Research Ethics Board. This study conforms to the standards of the Canadian Tri-Council Research Ethics guidelines. If you have any questions about this process or about your rights as a participant in the study, please contact Ms. Alison Collins-Mrakas, Manager, Research Ethics, 277 York Lanes, York University [telephone (416)736-5914 or e-mail acollins@yorku.ca] or Ms. Margo Farren, Research Ethics Manager, Hospital for Sick Children, Room 5255 Black Wing, Sick Kids [telephone (416 813-5718 or email margo.farren@sickkids.ca].

I agree to be videotaped along with my child in this study entitled "Synergizing Infant Health and Infant Mental Health: Applying Attachment Theory to the Context of Infant Pain". I have also received a copy of this consent form for my own records.

In addition, I agree or consent for this tape(s)/photograph(s) to be used for:

1. Other studies on the same topic **o**
2. Teaching and demonstration at York University/SickKids. **o**
3. Teaching and demonstration at meetings outside York /SickKids. **o**
4. Not to be used for anything else. **o**

In agreeing to the use of the tape(s)/photograph(s) for other purposes, I have been offered a chance to view/hear the tape(s)/photograph(s). I also have the right to withdraw my permission for other uses of the tape(s)/photograph(s) at any time.

Printed Name of Participant	*Participant's signature & date*
Printed Name of person who explained consent	*Signature & date*
Printed Witness' name (i.e. when Participant does not read English)	*Witness' signature & date*

Appendix E

The Modified Behavioral Pain Scale (MBPS; Taddio, Nulman, Koren, Stevens & Koren, 1995)

Parameter	Finding	Points
facial expression	definite positive expression (smiling)	0
	neutral expression	1
	slightly negative expression (grimace)	2
	definite negative expression (furrowed brow eyes closed tightly)	3
cry	laughing or giggling	0
	not crying	1
	moaning quiet vocalizing gentle or whimpering cry	2
	full lunged cry or sobbing	3
	full lunged cry more than baseline cry (scored only if child crying at baseline)	4
movements	usual movements and activity	0
	resting and relaxed	0
	partial movement (squirming arching limb tensing clenching)	2
	attempt to avoid pain by withdrawing the limb where puncture is done	2
	agitation with complex/generalized movements involving the head torso or other limbs	3
	rigidity	3

Where:

- Slightly negative expressions include brow bulging and naso-labial furrow.

Appendix F

Behaviours Extracted for MIBABI Coding Measure

Scoring System for Interactive Behaviors Scales	Behaviours Extracted from the "Scoring System for Interactive Behaviors" Scales	Behaviours Included in the MIBABI Measure
Proximity- and Contact-Seeking	1. Reaches (or equivalent) towards caregiver (may be actively and strongly straining/leaning towards caregiver or using a "directed cry") 2. Offers a toy to caregiver 3. Grasps hold of caregiver 4. Approaches caregiver (creeping, crawling or walking) 5. Touches caregiver in exploratory way 6. Looks, smiles or interacts with caregiver across a distance	1. *Reach:* Reaches towards caregiver (infant may be offering caregiver an object or toy)
Contact-Maintaining	7. Reaches towards caregiver when put down 8. Grasps hold of/clambers up/clings to/ caregiver after being put down 9. Sinking in/reclining against/burying face into the caregiver 10. **Held by caregiver** 11. **Caregiver continues to hold infant in response to infant protest at being put down**	2. *Cling:* Grasps hold of caregiver 3. *Snuggle:* Sinking in/reclining against the caregiver 4. ***Holding infant:*** **Held by caregiver** 5. ***Continues holding infant:*** **Caregiver continues to hold infant in response to infant protest at being put down** 6. ***Hugging infant:*** **Caregiver hugs infant (when not held)**
Resistant	12. Becomes rigid or stiff/struggles/squirms to be put down 13. Repeatedly hits caregiver 14. Pushes away strongly (caregiver or toys) accompanied by cranky fussing/angry-pouting/petulance/angry distress/full-blown temper tantrum 15. Little kicks of the feet/steps angrily	7. *Back arches/pushes away:* Becoming rigid or stiff /pushing caregiver/toys away accompanied by cranky fussing
Avoidant	16. Turns head away/averts gaze/leans away/ignores/turns body away 17. Does not greet caregiver upon return	8. *Head away/averts gaze:* Turns head away/averts gaze from caregiver 9. *Arm(s) between:* Places arms between self and caregiver

Note. Non-bolded behaviours indicated those pertaining to the infant; bolded behaviours indicate those pertaining to the caregiver. MIBABI *continues holding infant*, *hugging infant* and *head away/averts gaze* behaviours were not included in the final measure.

Appendix G

Indices of Disorganization and Disorientation (Main & Solomon, 1990)

I. Sequential display of contradictory behaviour patterns

II. Simultaneous display of contradictory behaviour patterns

III. Undirected, misdirected, incomplete, and interrupted movements and expressions

IV. Stereotypies, asymmetrical movements, mistimed movements, and anomalous postures

V. Freezing, stilling, and slowed movements and expressions

VI. Direct indices of apprehension regarding the caregiver

VII. Direct indices of disorganization or disorientation

For detailed descriptions, see Main & Solomon, 1990.

Reference: Main, M. & Solomon, J. (1990). Procedures for identifying infants as disorganized/disoriented during the Ainsworth Strange Situation. In Mark T. Greenberg, Dante Cicchetti, & E. Mark Cummings (Eds.), *Attachment in the Preschool Years: Theory, Research and Intervention* (pp. 121-160). Chicago: The University of Chicago Press.

Appendix H

Other Significant Behaviours to Be Coded for General Presence/Absence

Infant Behaviours	**Present (give one check for each occurrence)**	**Time (start-end):**
1.) Showing distress and walking or orienting away (i.e., body turned away) from caregiver		
2.) Infant holds arms and legs away from parent while being held, limbs stiff, tense and straight (starfish)		
3.) Infant hurting self (e.g. strikes, pushes, or pinches themselves)		
4.) Infant looked as though they want caregiver while distressed, but quickly changes mind (e.g., reaches for caregiver and then *quickly* pulls arms back)		
5.) Infant twists own hair or pulls own ears (longer than five seconds) while caregiver is holding infant		
6.) Infant gives a prolonged (longer than 5 seconds) low, growling cry		
7.) Freezing lasting 5 seconds or more (body is like a statue), or "zoning out" (eyes look glazed over) for 5 seconds or more		
8.) Showing any *overt* fear of caregiver (e.g., hand to mouth with a fear face, cowering (i.e., hunching shoulders) when caregiver approaches or brings infant closer		
9.) *Rapidly* changing between laughing and crying		
10.) Infant pushes at caregiver's face		
11.) Other (please describe):		

Caregiver Behaviours:	**Present (give one check for each occurrence)**	**Time (start-end):**
1.) Ignoring infant distress or not actively soothing (e.g. caregiver dressing a crying infant without empathy/affection behaviour [such as calming statements, kissing, hugging]; staring blankly		

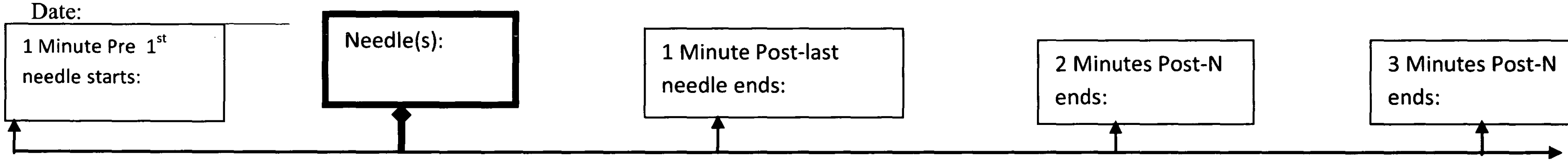
/flatly at infant's distress without any or very feeble attempt at soothing; parent seems "emotionally absent"). *Be careful NOT to code this simply because parent is talking to doctor (ensure parent is not holding, kissing, rocking, stroking, patting baby while talking to doctor)		
2.) Strong smiling/laughing while the infant is highly distressed (distress = 3)		
3.) Eliciting reassurance or affection from the infant ('Mommy's sad you got a needle, give mommy kisses'; asking the infant's permission to do something; threatening to cry (e.g., if the infant does not stop crying)		
4.) Behaviours suggesting that the caregiver appears frightened of infant's distress		
5.) Hostile Behaviours; may be physical (e.g., grabs infant by the wrist; rolls eyes at distressed infant) or verbal (e.g., hushes the crying infant in a way that is not comforting, or uses a voice that is loud, sharp or angry; threatens infant "I'll leave you here if you don't stop crying", "I won't pick you up until you stop crying").		
6.) Puts infant down on floor or table within 1 minute of the needle poke, despite infant still being **continuously highly distressed** (i.e. do not code if infant calms down for more than five seconds and then mom puts baby down on table causing baby to get high distress again)		
7.) Other (please describe):		

Appendix I

Measure of Immunization Behaviour and Attachment Behaviour in Infancy: Final Version of Coding Sheet

MIBABI CODING SHEET

ID Number: ____________
Coder Name: ___________
Date: ____________



Write in Needle times, then fill in other boxes (be sure to double check)

1 Minute **Pre**-Needle: Starts: Ends (i.e., the time of the first needle):

Min 1 Pre-N	1 … 5	10	15	20	25	30	35	40	45	50	55	60
CRY/ GRIM (0,1,2,3)												
REACH (0,1)												
CLING (0,1)												
SNUG (0,1)												
BACK ARCH/ PUSH* (0,1)												
ARM(S) BTWN (0,1)												
HOLD (0,1)												

Minute 1 **Post**-Needle: Starts (i.e., time of the LAST needle): Ends:

Min 1 Pre-N	1 5	10	15	20	25	30	35	40	45	50	55	60
CRY/ GRIM (0,1,2,3)												
REACH (0,1)												
CLING (0,1)												
SNUG (0,1)												
BACK ARCH/ PUSH* (0,1)												
ARM(S) BTWN (0,1)												
HOLD (0,1)												

Minute 2 **Post**-Needle: Starts: Ends:

Min 2 Post-N	1 5	10	15	20	25	30	35	40	45	50	55	60
CRY/ GRIM (0,1,2,3)												
REACH (0,1)												
CLING (0,1)												
SNUG (0,1)												
BACK ARCH/ PUSH* (0,1)												
ARM(S) BTWN (0,1)												
HOLD (0,1)												

Minute 3 **Post**-Needle: Starts: Ends:

Min 3 Post-N	1 5	10	15	20	25	30	35	40	45	50	55	60
CRY/ GRIM (0,1,2,3)												
REACH (0,1)												
CLING (0,1)												
SNUG (0,1)												
BACK ARCH/ PUSH* (0,1)												
ARM(S) BTWN (0,1)												
HOLD (0,1)												

*** Only coded when infant is distressed and is being held**

__Note:__ If any behaviour is absolutely impossible to code for a given epoch (i.e., coder cannot make an educated guess on the behaviour he or she is coding because the infant is not on the screen, or is blocked by the caregiver, etc.), the epoch is marked X (and entered as **999** in the data spreadsheet). In some situations, you may still be able to code certain behaviours, even if the infant or caregiver cannot be seen. For example, if the caregiver is blocking the infant completely, but you can hear the infant crying, you can code cry/grimace. Or, if the caregiver is holding the infant, the dyad is then off-screen for 8 seconds, and when the dyad re-appears and the parent is still holding the infant, we can make an educated assumption that the parent was holding the infant during the epoch in which we could not see them. Even if the parent or infant if off-screen for a few seconds within an epoch, we can still code that epoch using the data we have within that epoch.

Appendix J

The Measure of Immunization Behaviour and Attachment Behaviour in Infancy

Label on Coding Sheet	Name and Definition
Infant Behaviour	
CRY/GRIM	*Cry/Grimace:* Infant cries or displays a negative facial expression, in an effort to signal distress to the caregiver. Rated as 1, 2, or 3 (adapted from Taddio et al., 1995); score the highest expression for each epoch: 1 = Neutral expression and not crying 2 = Slightly negative expression and/or whimper cry 3 = Definite negative expression (furrowed brow, eyes closed tightly) and/or full-lunged cry or sobbing
REACH	*Reach:* Infant raises arms up/across and leans towards caregiver when caregiver is out of infant's arms' reach (infant may be offering an object or toy to caregiver)
CLING	*Cling:* Infant grasps onto or has open palm on the caregiver by clinging on to caregivers' clothes, neck or body using hands in an effort to maintain contact. **If you cannot see the infant's hand, but his/her arm is around the caregiver, assume the infant is clinging**
SNUG	*Snuggle:* Infant seeks comfort by snuggling head (can be cheek or face) in to caregiver's body (can be caregiver's face, neck or body), do not count if infant is resting chin on caregiver's shoulder, do not count accidental grazing; if caregiver pulls infant head into self, do not count UNLESS infant relaxes and keeps their head snuggled in, even when caregiver removes hand
BACK ARCH/PUSH*	*Back arch/pushes away:* Infant arches back in protest or pushes caregiver's body when distressed; may be accompanied by angry or fussy crying **(*only this behaviour when infant is distressed and is being held or hugged)**
ARM(S) BTWN	*Arm(s) between:* Infant keeps one or both arms between themselves and the caregiver when being held; **infant is NOT clinging on to parent (with one or both hands)**
Caregiver Behaviour	
HOLD	*Holding infant:* Caregiver is holding infant in arms or in lap, completely carrying the weight of the infant (infant not supported by other objects such as table or floor)

Appendix K

IBQ-R Fear Scale Questions

Fear Scale (16 items)

Definition: The baby's startle or distress to sudden changes in stimulation, novel physical objects or social stimuli; inhibited approach to novelty.

Daily Activities: How often during the last week did the baby:

90 cry or show distress at a change in parent's appearance, (glasses off, shower cap on, etc.)?

94 startle at a sudden change in body position (e.g., when moved suddenly)?

99 startle to a sudden or loud noise?

Two Week Time Span (during the last two weeks):

When introduced to an unfamiliar adult, how often did the baby:

150 cling to a parent?

151 refuse to go to the unfamiliar person?

152 hang back from the adult?

153 never "warm up" to the unfamiliar adult?

When in the presence of several unfamiliar adults, how often did the baby:

154 cling to a parent?

155 cry?

156 continue to be upset for 10 minutes or longer?

When visiting a new place, how often did the baby?:

157 show distress for the first few minutes?

158 continue to be upset for 10 minutes or more?

When your baby was approached by an unfamiliar person when you and s/he were out (for example, shopping), how often did the baby:

161 show distress?

162 cry?

When an unfamiliar person came to your home or apartment, how often did your baby:

163 (reverse coded) allow her/himself to be picked up without protest?

164 cry when the visitor attempted to pick her/him up?

Appendix L

Summary of Analyses and Results

Research Question 1: Are Attachment, Temperamental Fear, or the Interaction Between Attachment and Temperamental Fear Associated With Distress Reactivity or Distress Regulation?

Analysis: Latent growth modeling within a structural equation modeling framework.

Results:

- B/A predicts baseline distress such that secure infants have significantly higher baseline distress than avoidant infants
- Baseline distress positively predicts distress reactivity
- Number of needles positively predicts distress reactivity
- B/A and B/D X IBQ-R Fear interaction significantly predicts distress regulation, such that at high levels of temperamental fear, avoidant infants are significantly slower to regulate distress than secure infants. At average levels of temperamental fear, the difference in distress regulation according to attachment is non-significant. At low levels of temperamental fear, avoidant and disorganized infants regulate distress significantly faster than secure infants
- S/I X IBQ-R Fear interaction significantly predicts distress regulation, such that at high levels of temperamental fear, insecure infants (A, C and D) are significantly slower to regulate distress than secure infants. At average levels of temperamental fear, the difference in distress regulation between secure and insecure infants is non-significant. At low levels of temperamental fear, insecure infants regulate distress significantly faster than secure infants

Research Question (2a): Do Infant or Caregiver Behaviours *Pre-Needle* Predict Attachment? and (2b): Do Infant or Caregiver Behaviours *Post-Needle* Predict Attachment?

Analysis: Logistic Regression

Results:

- None of the infant or caregiver MIBABI behaviours pre-needle, as a set or independently, predicted attachment.
- The MIBABI infant *snuggle* behaviour post-needle predicted A/B/C/D attachment such that secure infants were more likely to snuggle into their caregivers than avoidant and disorganized infants.
- The MIBABI infant *snuggle* behaviour post-needle also predicted secure/insecure attachment such that secure infants were more likely to snuggle into their caregivers than insecure infants as a group (A, C and D groups combined)
- None of the infant or caregiver MIBABI behaviours post-needle, as a set or independently, predicted organized/disorganized attachment.