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The Roles of Child Reactivity and Parenting Context in Infant Pain Response

by

Susan D. Sweet

**Submitted in partial fulfilment of the requirements
for the degree of
Doctor of Philosophy**

at

**Dalhousie University
Halifax, Nova Scotia
Month, 1997**

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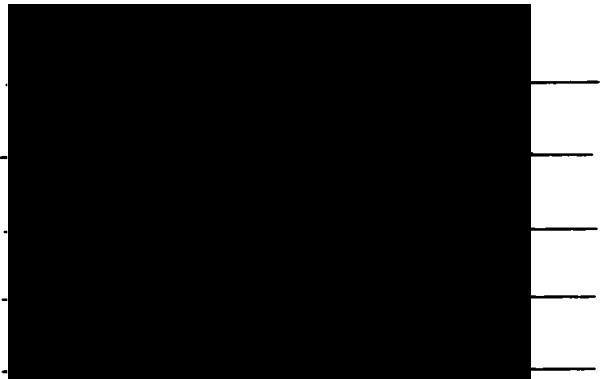
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by Susan Druanne Sweet

in partial fulfillment of the requirements for the degree of Doctor of Philosophy.

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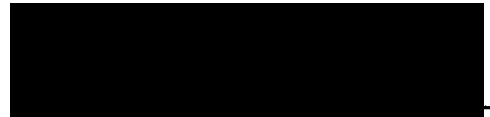
AUTHOR: Susan D. Sweet

TITLE: The Roles of Child Reactivity and Parenting Context in Infant Pain Response

DEPARTMENT OR SCHOOL: Psychology, Dalhousie University

DEGREE: Ph. D. CONVOCATION: October YEAR: 1998

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Abstract

This study examined the relative importance of and developmental changes in biologically-based child variables (child vagal tone and child difficultness) and parental contextual variables (maternal behavior during pain and maternal sensitivity) in the prediction of children's pain behavior during routine immunization. Using a cross-section design, a non-random convenience sample of 60 mother-infant dyads were assessed when infants were approximately 6 ($N = 30$) or 18 ($N = 30$) months of age. During the first session, which was carried out at a university psychology department, mothers completed a demographic interview, a maternal report measure of infant difficultness, and a self-report measure of parental stress; infants' resting EKG signals were also recorded. Following this session, maternal sensitivity was rated by a trained observer and children's resting EKG signals were used to calculate a measure of child vagal tone, based on spectral analysis. During the second session, which was carried out at a university-affiliated outpatient health clinic, infants' pain behavior during immunization was video-recorded. Using the recordings, infant state prior to immunization, maternal vocalizations during immunization, and child pain behavior during immunization were rated by blind coders. The results indicated that there were developmental shifts in the factors which best predicted children's pain behavior. At 6 months of age, 44% of the variability in infant pain behavior was predicted by infant difficultness and mothers' vocalizations during immunization. At 18 months of age, 35% of the variability in infant pain behavior was predicted by maternal sensitivity and child vagal tone. Individual differences in children's emotion regulation skills and socialization histories may underlie the pattern of factors which predicted child pain behavior at each age period.

Abbreviations and Symbols

Demographic Terms:

ESL	English Second Language
SES	Socioeconomic Status

Physiological and Medical Terms:

ANS	Autonomic Nervous System
BMA	Bone Marrow Aspiration
DMNX	Dorsal Motor Nucleus
EKG	Electrocardiogram
ELBW	Extremely Low Birth Weight
FBW	Full Birth Weight
Hz	Hertz
LP	Lumbar Puncture
NA	Nucleus Ambiguus
NICU	Neonatal Intensive Care Unit
PKU	Phenylketonuria
PNS	Parasympathetic Nervous System
RSA	Respiratory Sinus Arrhythmia
S-A Node	Sino-atrial Node
SNS	Sympathetic Nervous System

Measures:

BAADS	Behavioral Approach-Avoidance and Distress Scale
CAMPIS-R	Child-Adult Medical Procedure Interaction Scale - Revised
DPIS	Dyadic Prestressor Interaction Scale
FACS	Facial Action Coding System
HSQ	Home Screening Questionnaire

ICQ	Infant Characteristics Questionnaire
MBQ	Maternal Behavior Q-sort
NFCS	Neonatal Facial Action Coding System
ORBRS	Operating Room Behavior Rating Scale
OSBD	Observational Scale of Behavioral Distress
PBRS	Procedure Behavior Rating Scale
PIC	Personality Inventory for Children
PSI	Parenting Stress Index
PTQ	Parent Temperament Questionnaire
VAS	Visual Analogue Scale

Statistical Symbols:

α	Alpha or Probability Level
β	Beta Weight
df	Degrees of Freedom
F	F-statistic
M	Mean
N	Number of Participants
p	Probability or Alpha Level
r	Correlation Coefficient
R	Multiple Correlation Coefficient
R ²	Squared Multiple Correlation Coefficient
SD	Standard Deviation
t	t-statistic
χ^2	Chi-square

Acknowledgements

My thesis work has resulted only with the support and help of many persons, all of whom deserve mention and much thanks. First and foremost, I owe a great deal of thanks to my thesis supervisor, Dr. Patrick McGrath. I am extremely grateful to Dr. McGrath for his constant encouragement of my curiosity, his excitement about my work, and the positive manner in which he encouraged my growth as a researcher. His love of research could not be anything but inspiring.

I would also like to express my heartfelt thanks to my parents, Dr. Lowell and Judy Sweet, my siblings, Krista, Jill, and Graeme; as well as to Stephen Kerr. This network of people provided me with a constant supply of support, encouragement, and at times, perspective throughout the past five years. Thank-you for tolerating the somewhat chaotic lifestyle of a graduate student, and for always expressing interest in my work, my progress, and my happiness.

I would like to both acknowledge and thank my committee members, Dr. Doug Symons, and Dr. Joseph Byrne, for their contributions, advice, and support throughout my thesis work. Both Dr. Symons and Dr. Byrne added my thesis work to the already extensive list of obligations they both face. Thank-you for creating a thought-provoking, collegial atmosphere throughout our many contacts. I would also like to thank Dr. Ronald Blount, and Dr. Ken Craig and his graduate student Cheryl Gilbert for their valuable advice and aid in training my coders. These people openly welcomed my inquiries into their work, despite their busy schedules.

There are many other persons who need to be mentioned, without whom this research would not have been possible. The parents and children who took the time to participate in my study have my deepest gratitude. I would also like to thank the staff of Dalhousie Health Services. I would particularly like to thank the nursing staff (Dietlind, Nancy, Carolyn, Judy, and Beth), who, in addition to not treating me as an intrusion, made me feel genuinely welcome.

I am grateful to my peers and colleagues in the Dalhousie Psychology Pain Research Lab, and my peers in the Clinical Psychology Ph.D. program at Dalhousie. I was very fortunate to have the opportunity to conduct my work in an atmosphere of productivity, curiosity, and support. I would also like to thank the people who devoted many hours to coding my data, including Jina Faraj MacEachern, Evita Strobele, Andrea Townsend, Kathy Silver, and Lilli Ju. Special thanks go to Beth Currie for her invaluable research assistance throughout the study.

Finally, my work was supported by a Social Sciences and Humanities Research Council of Canada doctoral studentship, a Dalhousie University Graduate Studies Research and Development Grant, and an undesignated grant from Bristol-Myers-Squibb.

CHAPTER 1. INTRODUCTION

Overview

Pain is a complex and individual phenomenon defined as "An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage....Each individual learns the application of the word through experience related to injury in early life" (International Association for the Study of Pain, 1994, p. 210). The individual nature of pain is evidenced by the variability which occurs in its behavioral expression.

Although individual variability in pain response has been observed even early in life (e.g., Schechter, Bernstein, Beck, Hart, & Scherzer, 1991), the factors underlying such differences are not well understood. Gaining insight into the etiology of variability in children's pain behavior is an area which is currently of critical interest to clinicians involved in the assessment and management of children's pain. A better understanding of the factors underlying children's reactions to pain may be helpful in improving both our ability to assess how much pain children are experiencing, and to make such pain as manageable as possible (Erickson, 1990; Schechter et al., 1991).

On a broad level, differences in children's pain behavior may be attributed to biologically-based individual factors, and environmental contextual factors. For example, individual levels of reactivity may influence individual pain behavior. Individual levels of reactivity have been proposed to be reflected by both children's physiology (e.g., vagal tone levels) and their behavioral styles (e.g., temperamental dispositions). Children with higher biologically-based levels of reactivity, as evidenced by their vagal tone levels and

temperamental dispositions, may also react more strongly to pain than may children with lower levels of reactivity.

The definition of pain, however, acknowledges that experience is also important in determining pain behavior. Differences in pain behavior may be related to the environmental context surrounding early pain experiences. Among the variety of possible contextual variables, caregiver behavior may be particularly important, as it plays such a large part in the infant's world. Infants' pain behavior may be related to parental behavior immediately at the time of an incident of child pain. Parental behavior at that time may serve to either increase or decrease child pain expression. Infants' pain behavior may also be related to general patterns of parental behavior over time. As infants build up experience with their caregivers' general patterns of behavior, they may form expectations concerning caregiver behavior during incidents of child pain, and concerning acceptable methods of pain expression (Craig, 1986). These expectations may then modify children's pain behavior, tailoring it to the particular caregiver behavior to which they have been exposed.

This suggests a developmental progression in the relative importance of biologically-based factors and environmental context in the prediction of child pain behavior. In early infancy, children have not yet experienced substantial amounts of socialization (Matheny, Riese, & Wilson, 1985). Therefore, it would be expected that early in infancy, children's pain behavior would best be predicted by their biologically-based levels of reactivity (as evidenced by both their vagal tone levels and temperamental dispositions). However, later in infancy, children become increasingly susceptible to the

effects of socialization. At this time, it would be expected that children's pain behavior would best be predicted by the individual parenting contexts (both parental behavior specifically at the time of child pain, and general patterns of parental behavior over time) to which they have been exposed.

This hypothesis will be tested in a study involving two groups of normally-developing infants. Reactivity level (vagal tone and temperament) and parenting context (immediate and general patterns of maternal behavior) will be assessed in dyads of 6- and 18-month-old infants and their mothers. The relative importance of these factors will then be compared in relation to child pain behavior during infant immunization.

Biologically-Based Reactivity Level

Individual differences in children's biologically-based levels of reactivity may underlie their individual reactions to pain. Child reactivity has been assessed in both physiological and behavior terms. In the following sections, basic definitions and processes involved in the physiological processes underlying reactivity, physiological evidence of reactivity, and behavioral evidence of reactivity will be presented. Further, the existing literature on the relations between both physiological and behavioral evidence of reactivity, respectively, and children's pain behavior will be examined.

Physiological Processes Involved in Reactivity

Individual differences in physiology may underlie individual differences in reactivity. The autonomic nervous system (ANS) plays a major role in determining differences in reactivity level (DiPietro, Porges, & Uhly, 1992). There are two branches

of the ANS, and each plays a different role in reactivity. While the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS) both originate in the brainstem and affect a variety of target organs, they act in opposing fashions. The PNS is involved in the regulation of homeostasis; it helps the body to conserve energy and rest vital organs, almost independently of the SNS. It does this mainly through its ability to cause internal changes in the viscera, and through its influence on anabolic activities which affect growth and restorative systems (Porges, 1992). When an external event presents a challenge, however, homeostasis is disrupted and the relative balance of activity in the ANS shifts from that of the PNS to the SNS. The SNS prepares the body to react to challenge by producing metabolic output for muscular action (Porges, 1992).

Despite the SNS's role in the excitation of the body, it is actually the PNS which is sensitive to stress and underlies reactivity (Porges, 1992). The ability of the PNS to shut down when homeostasis is disrupted causes parallel increases in the activity of the SNS, which allows a reaction to occur. Individual differences in the ability of the PNS to shut down, thereby activating the SNS, may determine how well an organism is able to react and respond to challenge.

Physiological Evidence of Reactivity Level

One way of examining physiologically-based individual differences in reactivity is to observe the changes in cardiac activity which parallel the functioning of the PNS. Although the heart is innervated by both the PNS and SNS, their effects are antagonistic (Porges, Doussard-Roosevelt, & Maiti, 1994). The PNS is involved in slowing the heart rate during normal homeostatic function (Jemerin & Boyce, 1990). When stress disrupts

the system, however, the activity of the PNS is inhibited, which therefore activates the SNS leading to increased heart rate (Jemerin & Boyce, 1990).

Although heart rate indicates the relative activity of the PNS and SNS, simple heart rate does not solely reflect the activity of the PNS, as its variability has components which are both neurally and extraneurally mediated (Litvack, Oberlander, Carney, & Saul, 1995). Only some of these components produce regularly recurring (periodic) changes in heart rate; these include respiratory sinus arrhythmia (RSA), and a slower periodic variation involved in blood pressure control. Irregular (aperiodic) components of heart rate include variability due to movement or sympathetic activation (Jemerin & Boyce, 1990). The effects of the PNS on heart rate and its relation to reactivity must be examined through a solely neurally mediated, periodic source of PNS input to the heart.

Vagal Tone

Vagal tone is a neurally mediated periodic influence on the heart which plays an important role in individual differences in reactivity. Vagal tone is defined as "the amount of inhibitory influence on the heart by the parasympathetic nervous system," indicating the amount of autonomic arousal at rest (Field, Pickens, Fox, Nawrocki, & Gonzalez, 1995, p. 227). Vagal tone is produced by the activity of the vagal system, which is the primary component of the PNS (Porges et al., 1994). The vagal system is a complex bidirectional system, containing the vagus or 10th cranial nerve. This nerve, which originates in the brainstem, projects to many organs, including the heart, independently of the spinal cord. It links the heart and the brainstem, and because "the vagus contains both efferent (i.e., motor) and afferent (i.e., sensory) fibers, it promotes

dynamic feedback between brain control centers and the target organs to regulate homeostasis" (Porges et al., 1994, p. 169).

Vagal tone is typically assessed via respiratory sinus arrhythmia (RSA). RSA is a neural periodic PNS influence on the heart, which indexes the rhythmic increases and decreases in heart rate that occur with breathing. The magnitude of these rhythmical shifts reflects the "gating" of vagal efferent tone to the heart by respiration (Porges, 1992). With inspiration, heart rate increases, due to interruption of vagal (PNS) influence on the heart and the subsequent increase in SNS input. With expiration, heart rate decreases due to the reinstatement of vagal (PNS) influence.

The specific mechanism behind the gating of heart rate with respiration is proposed to involve the source nuclei of the vagus (Porges, 1995). The right and left branches of the vagal system are organized ipsilaterally. Both right and left vagal sensory fibers terminate in a brainstem area known as the nucleus tractus solitarius, which integrates sensory information and communicates, through the use of interneurons, with the primary source nuclei of the vagal system (Porges, 1996). Each side of the vagal system has two source nuclei: the dorsal motor nucleus (DMNX) and the nucleus ambiguus (NA; Porges, 1995). The NA is found only in mammals and it affects mainly supradiaphragmatic structures. As part of the ventral vagal complex, it is related to processes associated with attention, motion, emotion, and communication; it reflects conscious, voluntary, social, and flexible activities (Porges, 1995). The DMNX exists in both mammals and reptiles and it affects mainly subdiaphragmatic structures. As part of the dorsal vagal complex, it is involved in the regulation of vegetative processes, such as

those which facilitate digestion and orienting (Porges, 1995).

Although both of these nuclei project to the heart, Porges (1995) has proposed a polyvagal theory in which it is the action of the NA system (primarily along the right vagus) which is responsible for RSA. Vagal fibers from the right NA send inhibitory messages to the sino-atrial (S-A) node of the heart, which regulates atrial rate. Increases in NA (vagal) input to the S-A node lead to increased parasympathetic activity and decreases in the onset of heart rate. Decreases in NA (vagal) input to the S-A node lead to parallel increases in sympathetic activity and increases in heart rate. Therefore, the activity of the right NA provides the primary central regulation of homeostasis and peripheral physiological reactivity, and mediates most rapid heart rate changes by removing vagal input, which then increases SNS activity and prepares the body to react to external challenges (Porges, 1995).

Individual resting levels of NA (PNS) input, as indexed through vagal tone, may underlie individual differences in reactivity (Izard et al., 1991). Resting levels of vagal tone indicate the functional status of the central nervous system's regulatory mechanisms, the efficiency of neural feedback mechanisms, and the potential of the vagal system to inhibit PNS activity and homeostatic processes during stress (Izard et al., 1991). Therefore, individual resting levels of vagal tone may predict individual stress reactivity (Jemerin & Boyce, 1990).

Higher tonic levels of vagal tone, as evidenced by a slow variable heart rate, indicate greater baseline PNS input, and therefore more efferent vagal input influencing the cardiac pattern. In this case, neural feedback and control are more efficient, so the

system is capable of more organized consistent autonomic responses and larger deviations from the mean or constant level (Izard et al., 1991). The system is also more capable of rapidly withdrawing or reinstating PNS tone, and can therefore change (react) more flexibly from homeostasis to a stress response and back again (Porges, 1992); responses are of a shorter latency and higher magnitude (Izard et al., 1991). Lower tonic levels of vagal tone, as evidenced by a high steady heart rate, indicate lower baseline PNS input, and therefore less efferent vagal input influencing the cardiac pattern. In this case, neural feedback and control are less efficient and the system is less capable of organized consistent autonomic responses. The system is also less capable of rapidly withdrawing or reinstating PNS tone, and is therefore slower to react to stress and less capable of re-establishing homeostasis after stress (Porges, 1992); responses are of a longer latency and lower magnitude (Izard et al., 1991).

Assessment of Vagal Tone

Vagal tone may be estimated in several ways. Two important considerations, however, are common to each method: variation in heart period and parasympathetic control (Litvack et al., 1995). There must be some measure of the peak to trough change in R-R interval during a single breath averaged over some number of breaths, and there must be some measure of decreases in R-R interval caused by withdrawal of vagal (PNS) input to the heart.

The two most commonly used methods of assessing vagal tone are linear detrended heart rate power spectral analysis and Porges' technique of filtered variance (Litvack et al., 1995). In spectral analysis, a continuous segment of EKG signal is

converted to R-R (peak to peak) intervals. Changes in R-R interval are then converted from the time domain to the frequency domain by plotting the amplitude (or power) of each oscillation over a range of frequencies (Muzi & Ebert, 1993). This allows analysis of the different components of heart rate frequency, and isolation of that part of heart rate variance which is related to respiration by matching it in frequency to respiratory activity (Litvack et al., 1995). In spectral analysis, there are three main frequencies of interest, and these contain the majority of the heart rate power. These include a high, mid, and low frequency peak. The high-frequency peak includes changes in heart rate due to vagal input, and it is related to respiration; it is typically centered around 0.2 Hz, but it includes frequencies above 0.15 Hz (Muzi & Ebert, 1993). The power (area) in this high frequency peak may provide a quantitative measure of vagal heart rate modulation (Litvack et al., 1995). The mid-frequency peak usually occurs between 0.05 and 0.15 Hz (Muzi & Ebert, 1993). It is due to both vagal and sympathetic input to the S-A node, such as low frequency respiratory activity and arterial and cardiopulmonary baroreceptor feedback (Litvack et al., 1995). The low-frequency peak occurs between 0 and 0.04 Hz (Muzi & Ebert, 1993). It is due to slower fluctuations in heart rate that may be related to thermoregulatory or humeral mechanisms, but more research into its origins is needed (Muzi & Ebert, 1993).

Porges (1985) designed a measurement system using respiratory sinus arrhythmia (RSA) and digital filtering to quantify vagal tone in a continuous non-invasive manner. In this approach, vagal tone is measured by modelling of the heart-rate pattern to extract that part of the variance in heart rate due solely to RSA (Izard et al., 1991). In order to

do this, Porges uses a time domain method in which complex aperiodic trends, which may not be related to respiratory activity, are removed from the heart signal prior to assessing the variance. The R-R signal is filtered by a process termed the moving polynomial filter, which consists of subtracting the convolution of the original signal with a third-order 21-point polynomial (which removes low frequency power and complex trends associated with nonstationarity) from a time-shifted version of the original signal. The signal is then band-pass filtered to extract the variability in heart period in the frequency band associated with breathing (0.24 to 1.02 Hz for 5-month-olds). The final step involves taking the natural logarithm of the variance of the filtered signal (defined as the square of the standard deviation of the output signal). This is used as a measure of vagal tone.

The various methods of quantifying vagal tone have been found to produce similar results and vagal tone estimates based on any of them should be comparable (Grossman, Van Beek, & Wientjes, 1990; Litvack et al., 1995). Despite this, some cautions are necessary when using any one of them. Under standard physiologic conditions, the high-frequency components of heart rate variability may be used to estimate vagal modulation. However, when phasic changes occur in heart period, a tonic index of parasympathetic activity cannot be obtained (Grossman, Karemaker, & Wieling, 1991). Changes in heart rate and respiration can result in phasic changes in vagal input. For example, tachycardia or bradycardia may lead to inaccurate assessments, as may changes in respiration depth (Muzi & Ebert, 1993) and rate (Grossman et al., 1991).

Studies indicate that vagal tone is relatively stable across development (e.g.,

Fracasso, Porges, Lamb, & Rosenberg, 1994), with moderate stability found at about five months of age (r 's between .4 and .6 in Fox, 1989). For example, three to four-year-old preschoolers who were assessed six months apart had vagal tone scores which were correlated at .89 (Fox & Field, 1989). Although vagal tone is stable at a young age, it tends to increase slightly over time, due to developmental increases in the myelination of the nervous system, and developmental increases in heart rate variability (Izard et al., 1991). Despite the increases, however, children maintain their relative rankings in terms of vagal tone level over time (Fox, 1989; Porges, Doussard-Roosevelt, Portales, & Suess, 1994). For example, Porges et al. (1994) found a developmental increase in baseline vagal tone from 9 months to three years of age; however, they also found that when they correlated individual subjects' vagal tone levels across the two time periods, they were relatively stable ($r = .55$). Nonetheless, vagal tone levels is expected to be higher in group comparisons between older versus younger children.

Vagal Tone and Child Pain

There are two possible patterns of relation between vagal tone level and reactivity to pain. The first involves observing changes in vagal tone level at the time of pain. The second involves using resting vagal tone level to predict future pain response.

When changes in vagal tone level are examined during pain, vagal tone is found to decrease (and therefore SNS activity increases). For example, Gunnar, Porter, Wolf, Rigatuso, and Larson (1995) found that infant vagal tone decreased significantly from baseline to heel stick. Porter, Porges, and Marshall (1988) also found that during a surgical intervention period, vagal tone was significantly lower for 32 newborns being

circumcised versus those infants who were not.

When resting vagal tone level is used to predict future pain response, those with higher resting vagal tone are found to be more reactive to pain than are those with lower resting vagal tone. For example, Gunnar et al. (1995) found that baseline measures of vagal tone level in newborns were significantly correlated with cortisol level following heel stick ($r = .35$). Porter et al. (1988) also found that baseline measures of vagal tone level were significantly correlated with the magnitude of change in heart period from baseline through circumcision procedures ($r = .50$) during unanesthetized circumcision in 1-2 day old full term infants. Studies to date, however, have not examined developmental changes in the relations between vagal tone and child behavior, nor have they examined the relative importance of vagal tone in comparison to other predictors of child pain.

Based on the theoretical relations between vagal tone level and reactivity, and the literature examining vagal tone level and child pain, it is expected that children with higher vagal tone will be more reactive to pain than will children with lower vagal tone.

Behavioral Evidence of Reactivity Level

In addition to physiological evidence, physiologically-based individual levels of reactivity may also be demonstrated in behavioral terms. Individual differences in children's typical behavioral styles may also indicate their individual levels of reactivity.

Temperament

Temperament is proposed to be a behavioral measure indexing individual differences in biologically-based levels of reactivity. It is a psychobiological construct, reflecting differences in physiological processes through differences in individual

behavior (Izard et al., 1991). Individual differences in behavioral reactivity are proposed to underlie the relation between temperament and physiology (DiPietro et al., 1992).

There are several different definitions of temperament. For example, Goldsmith et al. (1987) reviewed four current approaches to capturing temperament. They reviewed Thomas and Chess's definition of temperament as the "stylistic component of behavior - that is, the *how* of behaviour as differentiated from motivation, the *why* of behaviour, and abilities, the *what* of behaviour" (Goldsmith et al., 1987, p. 508). In this theory, temperament is made up of rhythmicity of biological functions, activity level, approach to or withdrawal from new stimuli, adaptability, sensory threshold, predominant quality of mood, intensity of mood expression, distractibility, and persistence/attention span. These 9 categories may be used to form three general types of behavior: easy, difficult, or slow-to-warm-up (Thomas & Chess, 1984). The "easy" child (about 40% of children) is characterized by regularity, positive approach responses to new stimuli, high adaptability to change, and mildly or moderately intense mood that is mainly positive. The "difficult" child (about 10% of children) is characterized by irregularity in biological functions, negative adaptability to change, and intense mood expressions that are frequently negative. The "slow-to-warm-up" child (about 15% of children) is characterized by mild intensity of reaction (positive or negative), negative responses to new stimuli, and slow adaptability. Not all children fit in a single group, and those who do vary in the degree to which they match the prototypical pattern.

Goldsmith et al. (1987) also reviewed Buss and Plomin's definition of temperament, which is "a set of inherited personality traits that appear early in life" which

are genetic in origin (see Goldsmith et al., 1987, p. 508). In this theory, the elements of temperament are emotionality, activity, and sociability. Goldsmith et al. (1987) also reviewed Rothbart's definition of temperament, which is "relatively stable, primarily biologically based individual differences in reactivity and self-regulation" (p. 510). In this psychobiological approach, the elements of temperament are smiling and laughter, fear, distress to limitations (frustration), soothability, activity level, and duration of orienting. Finally, Goldsmith et al. (1987) reviewed Goldsmith and Campos's definition of temperament, which is "individual differences in the probability of experiencing and expressing the primary emotions and arousal" (p. 510). In this theory, the elements of temperament are individual differences in the expression of primary emotions (e.g., anger, sadness, fear, joy and pleasure, disgust, interest, surprise) and motor activity level, which is seen as reflecting, at least in part, emotional arousal. There are many other conceptualizations of temperament, in addition to the ones mentioned here.

Despite the many definitions of temperament, and disagreements regarding its boundaries and dimensions, the distinction between temperament and personality, and the use of the term "difficult temperament" (Goldsmith et al., 1987), theoreticians generally agree that temperament is a physiologically-based individual difference variable composed of a group of related traits, and that it reflects behavioral tendencies rather than specific behavioral acts (Goldsmith et al., 1987).

Assessment of Temperament

Temperament may be assessed via parental report, observer report, or physiological recording. Among these measures, child temperament is most often

assessed using parental, rather than observer, report on questionnaires. Observers generally cannot equal parents as informants about infant behavior, as they spend only limited time with infants and thus view only a small sample of their behavior, while caregivers view their infants' behavior over longer time periods and across a greater number of situations (Sameroff, Seifer, & Elias, 1982; Thomas, Chess, & Korn, 1982).

Although parental report of child temperament is common, there are some concerns about this method. For example, although some studies have found moderate convergent validity between maternal ratings of temperament and laboratory behavioral observations (Rothbart, 1986), others have found low inter-rater agreement between parents and observers (Bates, 1980). As mentioned, this may be due to their different knowledge bases or reporting biases.

With parental report, there is also some concern that ratings may reflect parental variables, rather than, or in addition to, child characteristics. This is controversial and relations, when present, are inconsistent. For example, Sameroff et al. (1982) found that in 4-month-olds, social status, anxiety level, and mental health of mothers from sociologically extreme groups were related to their ratings of temperament on the Carey Infant Temperament Questionnaire. Bates and Bayles (1984), however, found little relation between SES and maternal perceptions of child temperament. Some studies have also found relations between parental personality and ratings of child temperament (e.g., Bates & Bayles, 1984), while others have not (e.g., Lyon & Plomin, 1981). Generally, when relations have been found between ratings of child temperament and maternal variables, they typically have not been strong (e.g., personality ratings and mother report

were correlated from .17 to .24 and background and mother's report were correlated from .15 to .23 in Bates & Bayles, 1984). Relations may also vary depending upon the specific temperamental trait being rated. For example, Bates and Bales (1984) found that the lowest proportion of significant correlations between maternal personality and child temperament was in the area of difficultness. At the present time, parental-report temperament questionnaires remain the most widely used and accepted method of assessing child temperament.

Temperament and Child Pain

Several studies have examined the relations between temperament and its subcomponents and children's pain behavior (see Table 1). In general, these studies indicate that temperament is indeed related to pain behavior (e.g., Grunau, Whitfield, & Petrie, 1994). When these relations were examined in greater detail, two patterns emerged. Greater pain behavior was related to both a more difficult temperament (e.g., Davison, Faull, & Nicol, 1986; Lee & White-Traut, 1996; Schechter et al., 1991), and to problems with adaptability and approaching new situations (e.g., Davison et al., 1986; Schechter et al., 1991; Williams, Murray, Lund, Harkiss, & DeFranco, 1985; Young & Fu, 1988). These studies do not, however, provide insight into developmental changes in the relations between child temperament and pain, nor do they provide an understanding of the relative importance of temperament in relation to other predictors of child pain.

Insert Table 1 About Here

Based on the nature of difficult temperament, and the literature examining temperament and pain, it is expected that children with more difficult temperaments will be more reactive to pain. As young infants do not react the same way to unfamiliar people or objects as do older children (Kagan & Snidman, 1991), measures of sociability should not typically be used with this age group. Therefore, approach was not investigated as a predictor of child pain in this study.

Relations Between Physiological and Behavioral Evidence of Reactivity Level

In accordance with the proposition that vagal tone and temperament both reflect biologically-based individual differences in reactivity level, these two measures should also be related to each other. Indeed, several studies have found that resting vagal tone is related to child temperament, usually based on maternal report (see Table 2). When these studies were examined in more detail, it was found that resting vagal tone tends to be related to particular aspects of temperament, which seem to reflect reactivity. Children with higher vagal tone were rated as showing higher levels of vocalization, crying to frustration, positive and negative reactions (intensity), and activity. They were also rated higher on measures of difficulty, as well as on measures of many of its subcomponents (e.g., irritability, less consolability, less smiling and laughter, negative mood; see, DiPietro, Larson, & Porges, 1987; Healy, 1989; Porges et al., 1994; Stifter & Fox, 1990). In fact, Porges et al. (1994) say that vagal tone is a physiological correlate of difficultness.

Insert Table 2 About Here

Although the pattern of relations between vagal tone and temperamental reactivity was fairly consistent, Fox and Field (1989) found that lower vagal tone, not higher, was related to temperamental difficulty. This may be due to the ages of the children examined. In Fox and Field (1989), the subjects were three to four years of age, which is significantly older than the subjects tested in any of the other studies reviewed, with the exception of the second group tested in Porges et al. (1994). While Porges et al. (1994) found that 9-month-olds showed a positive relation between vagal tone and difficultness, they found no relation between these variables at three years of age. With age, children with higher vagal tone may become increasingly able to control their reactivity, due to an increasing ability to self-regulate (Porges, 1992), and they may therefore be seen as less difficult over time. However, younger children may not yet have developed these abilities, and may therefore exhibit behaviors consistent with difficultness.

Another inconsistent relation was found between vagal tone and the temperamental characteristic approach. Approach should be problematic for the difficult child (and thus those with high vagal tone). Positive relations between vagal tone and approach have been reported (e.g., Healy, 1989), but so have negative relations (e.g., Fox, 1989). This discrepancy may be due to the lack of stability in both physiological and behavioral manifestations of inhibition until the beginning of the second year of life (Kagan, 1982). Again, measures of sociability should not typically be used with young infants (Kagan & Snidman, 1991). Sociability may also vary over time as vagal control assumes a greater role in the mediation of attentional responses involved in reaction to novelty, leading to increased organization of behavior (e.g., state regulation, approach,

adaptability) in those with higher vagal tone (Porges, 1991). For this reason, approach and adaptability may be inappropriate traits on which to differentiate young infants.

Based on this review, it is expected that there will be relations between temperament traits and vagal tone level. Specifically, it is predicted that children with higher vagal tone will also be rated as having more difficult temperaments than will children with lower vagal tone.

Environmental Contextual Variables

In addition to biologically-based child variables, environmental variables may also play a role in influencing children's reactions to pain. The very definition of pain acknowledges that such factors are important. Among the factors making up children's environmental contexts, parental behavior may be particularly influential, as it plays such a large part in children's lives. Both specific parental behaviors and general patterns of parental behaviors may be involved in children's pain behavior. In the following sections, basic definitions and processes involved in the role of parental behaviors (both specific and general) in children's pain will be presented. Further, the existing literature on the relations between these variables and children's pain behavior will be examined.

Parenting Context

Children may become aware of both their parents' attitudes and expectations surrounding pain, and their parents' actual responses to their pain expressions. The method of transmission of this knowledge from parent to child may include observational learning, direct instruction, and physical guidance and control (Craig, 1986). Parents,

when asked, do in fact perceive themselves as transmitting pain-related coping strategies to their children through their parenting styles and through verbal suggestion and reassurance (Bennett-Branson & Craig, 1993).

When parental attitudes are studied in relation to child pain, some associations are found. For example, in Bachanas and Roberts (1995), higher levels of child distress to finger-prick were related to negative maternal attitudes concerning health care. In addition, mothers' attitudes were significantly correlated with child attitudes. Other studies, however, have not found these relations. For example, Schechter et al. (1991) did not find any relations between child distress to immunization and parental attitudes concerning child pain.

For young children, the actual behavioral expression of parents' attitudes and feelings concerning pain may be more salient and therefore more influential in modifying their pain behavior. Parental behaviors in relation to child pain may occur on two levels: immediate and general. Parents' immediate behaviors may influence children's reactions to pain. General patterns of parental responsiveness to child signals generalized over many incidents in a child's memory may also influence child pain behavior on any one occasion.

Specific Parenting Context

Immediate Parental Behavior

During child rearing, children are subject to specific parenting contexts involving their parents' immediate reactions to their current behavior (Maccoby, Snow, & Jacklin, 1984), including their pain behavior. On these occasions, children receive specific

guidance concerning parental expectations for their behavior through both explicit and implicit messages (Kopp, 1982). These parental behaviors may then serve to increase or decrease the expression of children's pain.

Several types of painful incidents during childhood may provide children with the opportunity to observe and learn about their parents' immediate behavior to their pain. Such incidents include illness, everyday pain, and medically-related pain. Children gain most of their experience with pain through illnesses, or bumps and scrapes (everyday pain). During the years 1-3, Parmalee, Jr. (1986) estimates that a child experiences 9 illnesses per year, and children themselves cite everyday pain incidents as being even more common than illness (e.g., Harbeck & Peterson, 1992). Such incidents also seem to be fairly uniform in occurrence across children. Fearon, McGrath, and Achat (1996) found that in a 28 to 81-month-old group, no age or sex differences were found in the severity or frequency of everyday pain experienced. Despite its high frequency of occurrence, there has been little study focusing on the relations between parental behavior and child response to everyday pain and illness, mainly stemming from their lack of predictability within home or community based-settings. Rather, studies frequently examine relations between parental behavior and child distress during incidents of medically-related child pain, due to their necessity and predicted time of onset.

Assessment of Immediate Parental Behavior

Studies examining parental behavior during incidents of child pain typically use parental self-report measures, or behavioral observation. Of the two methods, behavioral observation is generally preferred over self-report, as it is less subject to demand

characteristics, and can be measured using uniform criteria across ratings.

Immediate Parental Behavior and Child Pain

Studies examining relations between immediate parental behavior and child pain behavior during incidents of medically-related pain report several patterns of association (see Table 3). In a few cases, parental behavior at the time of child pain is not related to child distress (e.g., Broome & Endsley, 1989b), but the large majority of studies find relations between parental behavior and child distress during pain. On the broadest level, parental presence versus absence is related to increased child distress. Although children are initially distressed when their parents leave the room (Gonzalez et al., 1989), they subsequently show less distress during painful procedures than do children whose parents are present (Gonzalez et al., 1989; O'Laughlin & Ridley-Johnson, 1995). It is important to note, however, that most children report preferring to have their parents present (e.g., Gonzalez et al., 1989; Ross & Ross, 1984) and perceive their parents' actions as helpful during pain (Bennett-Branson & Craig, 1993).

Insert Table 3 About Here

On the next level, when parents are present, children of parents who merely observe painful procedures without interacting with their children show less distress than do children whose parents interact with them (Broome & Endsley, 1989b; O'Laughlin & Ridley-Johnson, 1995). Some parental behaviors, in addition to presence versus absence, must affect child pain behavior. It appears that specific parental behaviors are related to

increased child distress, while others are related to decreased child distress.

Parental behaviors, whether spontaneously exhibited or trained, which are related to decreased child distress include humor (Blount, Landolf-Fritsche, Powers, & Sturges, 1991; Frank, Blount, Smith, Manimala, & Martin, 1995) and distraction (Blount et al., 1989; Blount et al., 1991; Bush, Melamed, Sheras, & Greenbaum, 1986; Frank et al., 1995; Gonzalez, Routh, & Armstrong, 1993; Manne, Bakeman, et al., 1992; Manne et al., 1990; O'Laughlin & Ridley-Johnson, 1995). Although the relation between parental distraction and child coping is quite consistent, Vessey, Carlson, and McGill (1994) and Jacobsen et al. (1990) caution that, in order for a distracter to work, pain intensity must be low enough and the distracter must command high enough attention.

Parental behaviors which are related to increased child distress include parental reassurance (Blount et al., 1989; Blount et al., 1991; Blount, Sturges, & Powers, 1990; Broome & Endsley, 1989b; Dahlquist, Power, & Carlson, 1995; Dahlquist, Power, Cox, & Fernbach, 1994; Frank et al., 1995; Gonzalez et al., 1993) apologizing to the child, giving control to the child, making empathetic statements to the child, information giving/explaining, and praise (Blount et al., 1989; Blount et al., 1991; Blount et al., 1990; Dahlquist et al., 1994; Frank et al., 1995; Manne, Bakeman, et al., 1992). Of these behaviors, studies have shown that parental reassurance and support are the most common parental behaviors during incidents of child pain (e.g., Broome & Endsley, 1989b; Dahlquist et al., 1995; Jacobsen et al., 1990).

Not all "positive" parental behaviors, however, are related to increased child distress. The degree of the positive behavior may be important in predicting the child's

reaction. For example, Broome and Endsley (1989b) found that while smiling and encouraging by parents were related to increased distress, a relaxed face and some verbal reassurance were related to decreased distress. Other behaviors parents use at the time of pain may also affect the child's reaction to positive behaviors. For example, Broome and Endsley (1989a) found that the combination of high control/high warmth was related to significantly less child distress than the combination of low control/low warmth, high control/low warmth, or low control/high warmth by parents (Broome & Endsley, 1989a).

Some "positive" behaviors show inconsistent relations with child pain. For example, reassurance (Broome & Endsley, 1989b) and explanation (Jacobsen et al., 1990) are related to both increased and decreased child distress. Coaching a child to cope and to use behavioral strategies is also related to both increased (Dahlquist et al., 1995; Manne, Bakeman, et al., 1992) and decreased child distress (Blount et al., 1991; Blount et al., 1990; Frank et al., 1995; Manne et al., 1990), as is giving control to the child (Blount et al., 1989; Blount et al., 1990; Frank et al., 1995; Manne, Bakeman, et al., 1992). These inconsistencies may be related to the timing of such parental behaviors, the child's distress level at the time (Jacobsen et al., 1990), the nature of the coping/behavioral directives, and the nature of the control given to the child (Manne, Bakeman, et al., 1992). These inconsistencies may also be related to interactions between parental behavior and individual child characteristics.

Only in the small minority of cases do parents interact negatively with their children during pain (e.g., Broome & Endsley, 1989b). In these cases, parental behaviors are related to poor child coping. For example admonishing/criticizing (Blount et al.,

1991; Blount et al., 1989; Blount et al., 1990; Broome & Endsley, 1989b; Dahlquist et al., 1995; Frank et al., 1995; Manne, Bakeman, et al., 1992), and discouraging (Dunn-Geier, McGrath, Rourke, Latter, & D'Astous, 1986) children during pain are all related to increased behavioral distress.

Finally, the pattern of parental behaviors exhibited during child pain may vary with the age of the child. With younger children, mothers have been found to use more verbal calming, while they have been found to use more distraction and less soothing with children in their second year of life (Craig, McMahon, Morison, & Zaskow, 1984). Age has also been found to be negatively correlated with the overall interaction rate for parents during both the anticipatory and procedural phases of child bone marrow aspirations and lumbar punctures (Dahlquist et al., 1995).

Based on these findings, it is expected that reassurance and comforting will be related to increased child pain behavior, while distraction and humour will be related to decreased child pain behavior. It is also expected that there will be age-related changes in parents' behavior at the time of child pain. Parents will use more reassurance with younger versus older children, and more distraction with older versus younger children. Parents are also predicted to be more interactive with older versus younger children. Based on the studies reviewed, predictions cannot be made about the relative importance of parental behaviors in relation to other factors which are involved in children's pain behavior. Moreover, the studies reviewed all examined pain in children over one year of age; it is unknown whether or not the findings, based on older age groups, will extend to children in their first year of life. It is also important to note that these studies examined

medically-related pain, which was usually short and sharp in nature, and that predictions based on these results may be limited to similar pain stimuli.

There is some evidence that parental psychological variables may also play a role in children's pain-related behavior. Due to the relative rarity of medically-related pain in most children's lives, these situations may be associated with increased anxiety for parents managing such pain. If, as Melzack and Wall (1965) and Melzack and Casey (1968) theorize, pain is made up of both sensory/discriminative components and affective/motivational components (how upsetting it is), parental anxiety may affect children's pain behavior through its influence on their cognitive interpretations of the painful situations they experience. Children may perceive parental anxiety, and it may then affect both their ability to cope with pain and the distress levels they exhibit.

Studies have found that children's pain-related behavior is, indeed, related to parental anxiety. Bennett-Branson and Craig (1993) found that parental anxiety (on the State Scale of the State-Trait Anxiety Inventory; Spielberger, Gorsuch, & Lushene, 1970) was negatively related to the use of cognitive coping strategies in children aged 7-16 years, who underwent minor surgery (Bennett-Branson & Craig, 1993). Jay, Ozolins, Elliott, and Caldwell (1983) found that parental anxiety (Trait anxiety on the State-Trait Anxiety Inventory, and self-reported anxiety on a Parent Evaluation Questionnaire) was positively related to distress in children and adolescents with cancer aged 2-20 years undergoing BMA procedures. Although Jay et al. (1983) reported relations for both state and trait measures of parental anxiety, relations are most often reported between parental state, rather than trait, anxiety and child pain behavior. For example, Jacobsen et al.

(1990) found that in children with cancer aged 3-10 years undergoing venipuncture, parental anxiety based on the Trait Form of the State-Trait Anxiety Inventory was not related to child distress, but parental self-reported anxiety prior to the procedure on a 10-cm VAS (state anxiety) was significantly positively related to child distress. Dahlquist et al. (1984) also found that only parental state anxiety (and not trait anxiety) on the State-Trait Anxiety Inventory was positively correlated with observed child distress in children with cancer aged 8-17 years undergoing BMA/LP.

Interestingly, parental trait anxiety, and not state anxiety, is associated with parental behavior during incidents of child pain. Trait anxiety is significantly negatively correlated with parental reassurance during the anticipatory phase and significantly positively correlated with parental agitation during the procedural phase of bone marrow aspirations or lumbar punctures in children with cancer aged 2-7 years of age, but not in children 8-17 years of age (Dahlquist et al., 1994).

Based on these findings, it is expected that parental psychological variables may be involved in children's pain. Specifically, higher parental state anxiety will be related to increased child distress during pain. It is also expected that higher trait anxiety, or overall stress level, will be related to parents' behavior at the time of the medical procedure; higher parental stress will be related to increased levels of parental agitation and decreased levels of parental reassurance during child pain. Further, stress may moderate the relation between maternal pain response and child pain behavior.

General Parenting Context

In addition to parental behavior specifically in response to child pain, children's

pain behavior may be affected by the general patterns of parental behavior to which they are subject on a daily basis. Most young children have far more experience with their parents' responses to their cues concerning daily basic needs than they do with their parents' responses to their cues concerning pain. Through these experiences, children may learn about their parents' general responsiveness, and about their own ability to elicit responses from their caregivers through their behavior. These interactions, generalized over many incidents in a child's memory, may be important in determining child pain behavior on any specific occasion. Therefore, everyday experiences create a process wherein children gradually adapt to their parents' behavior through their cumulative shared experiences (Maccoby et al., 1984).

Maternal Sensitivity

General parental responsiveness to child cues may be reflected by maternal sensitivity (Ainsworth, Blehar, Waters, & Wall, 1978). Maternal sensitivity is a global term encompassing variability in many parental behaviors, such as style of child care and interaction, attentiveness, and communication skills (Moran, Pederson, Pettit, & Krupka, 1992). Generally, higher sensitivity is indicated by attentiveness to infant signals, knowledge of their meaning, and appropriate responses, even when competing demands for attention are present (Pederson et al., 1990). The affective relation between parent and child also varies with sensitivity; there may be differences in the levels of emotional and physical contact parents have with their children, their feelings of connectedness to their children, and the warmth and acceptance they show their children (Biringen & Robinson, 1991). Higher sensitivity is indicated by a harmonious, emotionally close

mother-infant relationship (Symons, Noiles, & Richards, in press).

Individual differences in sensitivity tend to vary with several other factors.

Differences in sensitivity are related to parents' experiences with their own parents' behavior, and to parents' perceptions of their relationships with their children (Lojkasek, Cohen, & Muir, 1994). Sensitivity has been found to decrease with increases in negative personality traits (Fish & Stifter, 1993), covert anxiety (Biringen, 1990), and stress (Pianta, Sroufe, & Egeland, 1989). For example, trait anxious parents report setting fewer rules and using less responsive and nurturant discipline practices than other parents (Dahlquist et al., 1994), while state anxious parents report being less consistent, nurturing, and organized, and more punishing than other parents (Dahlquist et al., 1994).

Sensitivity also tends to decrease as social support decreases (Crockenberg & McCluskey, 1986), and to increase as parity, which is itself related to greater feelings of self-efficacy and self-confidence, increases (Walker, Crain, & Thompson, 1986).

Maternal sensitivity, however, is not related to social class, income, occupational status, maternal age, or infant age (Moran et al., 1992; Pederson et al., 1990). The relation between sensitivity and educational level is unclear; it has been found to be both related (Pederson et al., 1990), and unrelated (Moran et al., 1992) to sensitivity.

Assessment of Maternal Sensitivity

There are several ways in which maternal sensitivity may be assessed. It may be assessed via behavioral coding, global rating scales, or Q-sort methodology. Behavioral coding of mother-child interaction codes specific patterns of interaction either in structured environments or the home. It is designed to be objective and free of particular

theoretical views, but these factors may make results inconsistent, as they do not take the context of a particular interaction into account. The different meanings interactions may have in different dyads is also not taken into account in these coding schemes.

Global clinical ratings based on theoretical descriptions of the mother-child relationship are also based on observation of mother-child interaction in structured environments or the home. Measuring sensitivity using this system results in a global description based on the judgement of the observer (e.g., the Ainsworth Scales). While these measures tend to be more consistent than behavioral scales, they are broad and do not provide much information about individual differences. Use of these scales also requires the observer to have an understanding of the mother's psychological processes and the infant's needs, and observations must be carried out in situations in which subtle attributes can be discerned (Pederson et al., 1990).

A third approach to the assessment of sensitivity is Q-sort methodology. Waters and Deane (1985) have described the Q-set and its use in Q-sorting procedures. Q-sort methodology involves the use of descriptive statements printed on individual cards to describe a particular domain of personality, attitude, or behavior. They further allow the rater to order the descriptive statements from those most to least like the person being described. Q-sort procedures appear to contain good behavioral detail, context specification, and structural fidelity; they can be used to assess quantitative or qualitative developmental changes; the fixed distribution reduces response biases; and they allow a variety of data reduction and analytic strategies to be used (Waters & Deane, 1985).

Maternal Sensitivity and Child Pain

Maternal sensitivity is an important part of infants' early interaction experiences (Bohlin, Hagekull, German, Andersson, & Lindberg, 1989), including their experiences surrounding pain. When children are in pain, they may seek out their caregivers in attempts to decrease their pain (Kopp, 1989). Based on their prior experiences with caregiver accessibility and responsiveness, and their beliefs about their ability to elicit behaviors from caregivers, infants may form a template of expectations for parental responsiveness to their signals, including signals indicating pain (Mikail, Henderson, & Tasca, 1994). Based on this template, they may modify how they seek help from their caregivers during times of pain and illness (Lyddon, Bradford, & Nelson, 1993). Therefore, differences in sensitivity may lead to different parental responses to child pain, which may then lead to modifications in child pain behavior.

Based on the characteristics associated with sensitive and insensitive parenting, children's pain reactions may be predicted. Cassidy (1994) reports that if a child believes her signals will be responded to sensitively, she will be more likely to signal her "wishes directly and freely and to share her emotions with the parent" (p. 233). Although it is expected that under most circumstances, children of sensitive parents will exhibit little negative affect, when they do experience negative affect, they will be open, direct, and active in its expression, rather than hiding their distress (Cassidy, 1994). Experience with insensitive parenting, in contrast, may lead to diminished pain expression, as children learn that their signals will not bring about relief from distress.

There is a paucity of research directly examining the prediction that children of

sensitive parents will be more reactive to pain than will children of insensitive parents. Several studies have, however, examined the relation between sensitivity and child coping. For example, Spangler, Schieche, Ilg, Maier, and Ackermann (1994) found that sensitivity was related to children's ability to cope with a distressing situation. At three months of age, infants of highly insensitive mothers showed an increase in negative emotional behavior (both negative vocalization and motoric restlessness) during a 15 minute play situation (assumed to be demanding for the infants). Grunau, Whitfield, and Petrie (1994) found that at age four and a half, the combination of family relationships, neonatal intensive care experience, poor maternal sensitivity to child cues in mother-child interaction observed at age three years, and child avoidance of touch or holding at age three predicted somatization symptoms prior to school entry. Fish and Stifter (1993) found that children of sensitive mothers cried less to arm restraint than did children of less sensitive mothers. Only Dahlquist et al. (1994), however, examined the relation between sensitivity and child pain behavior during an actual incident of child pain. They found that younger children (ages 2-7 versus 8-17 years) whose parents reported less responsive and less nurturant disciplinary styles showed more behavioral distress than other children prior to bone marrow aspiration or lumbar puncture, but not during it.

Based on the characteristics associated with sensitivity, and the studies examining the relations between sensitivity and child behavior, children's ability to cope with distress and pain may differ from their initial reactivity to pain. It appears that children of insensitive parents may cope poorly with distressing situations and have poor pain-coping strategies. It may be predicted, however, that children of sensitive parents will exhibit the

greatest reactivity to actual incidents of pain. Since it takes repeated incidents of pain for the child's knowledge of parent's reactions to be learned, these relations may be stronger at 18 months than at 6 months. It must be noted, however, that these predictions are based on little empirical evidence, and are speculative in nature.

Developmental Changes in the Factors Predicting Child Pain

Both children's pain behavior and the factors which predict children's pain behavior are not believed to be uniform across development. Rather, children's pain behavior and the predictors of children's pain are expected to vary with the age and developmental level of the children under study.

Studies have examined changes in children's pain expression over time. Such studies consistently find that older children show less pain-related behavior (Blount et al., 1991; Craig et al., 1984; Dahlquist et al., 1995; Dahlquist et al., 1994; Fowler-Kerry & Lander, 1987; Gonzalez et al., 1989; Jacobsen et al., 1990; Manne, Bakeman, Jacobsen, & Redd, 1993) and more coping (Manne et al., 1993) than do younger children. Despite the consistent findings with regard to children's pain behavior, changes in the predictors of pain, and the factors underlying the modification of children's pain behavior over time have not been well studied.

One important factor which may play a major role in predicting and modifying children's reactions to pain over time is children's increasing susceptibility to the effects of socialization. Young children have not yet experienced substantial amounts of socialization (Matheny et al., 1985). As they develop, however, they become increasingly

susceptible to the effects of their environments and to the effects of socialization. Over time, pain behavior, in addition to other behaviors, may become socialized through the ongoing interaction between a child and his or her environment.

Before children can internalize the standards for behavior present in their environments and modify their pain behavior accordingly, several developmental changes must occur. Changes which allow infants to better understand parental expectations for pain-related behavior, and changes which allow infants to better monitor and control their own pain behavior are particularly important in this process.

Skills which facilitate socialization first begin to develop during the later part of the first year of life, and during the second year of life. During this time, children become more proficient at regulating and sustaining attention (Kopp, 1982), which allows them to better notice their parents' general behavior patterns, and their responses to pain in particular. Their memories also improve (Kopp, 1982), allowing them to better recall past patterns of interaction surrounding pain. Children begin to develop self-awareness and an identity, and to differentiate self from other and from objects (Kopp, 1982), which allows them to better understand parental behavior in relation to their own behavior.

Toward the end of the first year of life, children begin to exhibit more advanced social behaviors, such as joint attention, social referencing, and protocommunicative acts (see Moore & Corkum, 1994). Children's abilities to participate in these kinds of behaviors indicate that they have "coordinated representations of others' activities with certain expectancies about their own instrumental actions in relation to others" (Moore & Corkum, 1994, p. 368). This indicates that children are increasingly capable of

understanding the interactive process between parent and child, and the effectiveness of their behavior in bringing about caretaking behavior in their parents. Their increasing understanding of causal associations and temporal sequence (Kopp, 1989), also allows them to better understand the behaviors their pain expressions elicit from their parents.

During this time, children begin to use language, which is generally seen as an important prerequisite for the accomplishment of socialization (Maccoby, 1992). Language development increases children's attempts to actively communicate with adults (Fagot & Kavanagh, 1993) and their efficiency in communicating with adults (Kopp, 1989), and it decreases their passivity in communication. Parents, in turn, use instruction and direction more often with 18- than with 12-month-olds (Fagot & Kavanagh, 1993). With the development of language, children are better able to understand emotions, and therefore approval or disapproval (Kopp, 1989), making it easier for them to learn expectations for their behavior.

Between early infancy and the second year of life, infants gain more voluntary control over their behavior, leading to an increased ability to comply with caregiver requests (Kopp, 1982). Kopp (1982) found that between 9 and 18 months of age, children developed the ability to notice "social or task demands that have been defined by caregivers, and to initiate, maintain, modulate, or cease physical acts, communication, and emotional signals accordingly" (p. 204). This allows children increasing control over their behavioral displays of pain.

With specific respect to pain, another important change occurs towards the end of the first year of life. The increase in mobility during this period dramatically increases

the opportunities children have to learn about painful events (e.g., bumps and falls), and about their parents' pain-related behavior and their expectations for child behavior.

The perceptual, cognitive, and motor advances (refer to Kopp, 1982, 1989) reviewed allow children to be increasingly capable of socialization, both with respect to behavior in general, and with respect to pain behavior more specifically. Therefore, it is expected that the importance of the environment in predicting children's pain behavior should increase over time. The effects of parents in particular should increase in importance over time, as they make up a large part of children's environmental contexts, and they are the major socializing agents of young children (Maccoby, 1992). Research has indeed found that there is an increasing correlation between parent and child behaviors over time (Martin, Maccoby, Baran, & Jacklin, 1981), and that children are increasingly able to participate in the teaching-learning process. For example, Maccoby et al. (1984) found that at 12 months of age, there was little or no relation between mothers' teaching behavior and children's task orientation, but at 18 months of age there were significantly correlated and teaching-learning functions were coordinated.

Therefore, it is expected that parents may hold an increasingly important role in influencing their children's levels of self-control and behavior regulation over time (Kopp, 1982; Maccoby, 1992), including their regulation of pain behavior. Accordingly, it is expected that once children are developmentally ready for socialization, their biologically-mediated pain behavior may be modified in accord with their individual caregiver contexts.

Studies Examining Child and Parental Variables in Relation to Child Pain

Although there is evidence that both child characteristics and parental behaviors are both important in determining children's pain expressions, few studies have examined both of these factors in relation to child pain. Moreover, the studies which do exist contain design issues which limit their ability to examine the relations among child characteristics, parenting context, and child pain behavior. These issues center around their reliance on parental report of both child temperament and parenting behavior, their lack of objective observer ratings, and their lack of direct observations of child pain. In addition to limitations based on their methodology, these studies also rarely examine either the relative contributions of child versus parental factors to child pain behavior, or interactions between child and parental factors in the prediction of child pain behavior. The studies which have included some examination of child and parental factors in relation to child pain will be reviewed.

Schechter et al. (1991) examined 65 families of five-year-olds scheduled to receive a diphtheria-tetanus-pertussis immunization shot. Temperament was measured via parental report on the Behavioral Style Questionnaire (McDevitt & Carey, 1978). Parental behavior regarding pain was assessed using several questionnaires. Parents rated their beliefs about several medically related attributes, and their beliefs about their children on five-point scales. Parents also reported, on five-point scales and in vignettes, their beliefs about children's ability to handle pain in general, and about the role of parents in comforting children in pain. Finally, parents were asked to predict the amount of discomfort they thought their children would experience from the needle. Children's

responses to the needle were coded by observers using the Procedure Behavior Rating Scale - Revised (Katz, Kellerman, & Siegel, 1980), and a global estimate of pain using a five-point scale, and coded by self-reports of pain using the Oucher (Beyer, 1984).

Both mothers' and fathers' ratings of child adaptability were significantly correlated with child distress level ($r = .43$ and $r = .22$ respectively); less adaptable children (higher scores on the adaptability scale) showed more distress during the needle than more adaptable children (Schechter et al., 1991). Mothers' ratings of rhythmicity were also significantly related to child distress ($r = .21$); less rhythmic children showed more distress during the needle than less rhythmic children. Child difficulty was also positively related to pain behavior. Analyses of parents' self-reports as they related to child pain behavior resulted in almost no significant relations. The results of this study are limited by its reliance on parental report measures, except for the direct observation of child pain response. Further, no attempts in this study were made to examine the relative importance of or interactions between child and parental variables in the prediction of child pain, and there was no examination of developmental changes in the patterns found.

Grunau, Whitfield, and Petrie (1994) conducted a study of two groups of extremely low-birth-weight children (49 children with birth weights of 480-800 grams and 75 children with birth weights of 801-1000 grams) and two control groups of 42 heavier preterm (1500-2499 grams) and 29 full-birth-weight children (>2500 grams). All children were assessed at 18 months corrected age. Temperament was assessed via maternal report (or in 5-9% of cases across groups, paternal report) on Buss and Plomin's temperament questionnaire (Buss & Plomin, 1984). Only the composite measure of

temperament (combined multiple correlation of shyness, emotionality, sociability, and activity) was used in calculating the results. Parental behavior was assessed via the Home Screening Questionnaire (Frankenburg & Coons, 1986), which assesses organization and variety in the home, and acceptance, involvement, and responsivity with the child. Child pain sensitivity was measured by retrospective maternal report on a 1-5 point scale using the statement "Child is very sensitive to pain of bumps or cuts or other common hurts."

The composite temperament score was not related to pain sensitivity in the lowest birth weight group, but it was significantly related in the second lowest group ($R = 0.48$), the second highest group ($R = 0.51$), and the full birth weight group ($R = .80$). No significant relations were found between self-reported parenting style and parental reports of child pain sensitivity (Grunau, Whitfield, & Petrie, 1994). This study is limited in its ability to uncover relations between temperament and child pain by its use of a composite measure of temperament, as previous studies have shown that the components of temperament are differentially related to child pain behavior (see Table 1). Further, this study also relied on parental report measures, and did not include a direct observation of an incident of child pain, using instead a single-item retrospective parental-report measure. Finally, there was no examination of the relative weights of child and parental factors in pain prediction, no examination of their interaction, and no examination of developmental changes in the patterns found.

Grunau, Whitfield, Petrie, and Fryer (1994) examined 36 extremely low birth weight (<1000 grams) preterm infants, and 36 matched full-term controls. When children were three years of age, temperament was assessed via maternal report on Buss and

Plomin's temperament questionnaire (Buss & Plomin, 1984). Parental behavior was again assessed via the Home Screening Questionnaire (Frankenburg & Coons, 1986), and mother-child interaction was assessed via observer report using Crnic, Greenburg, Ragozin, Robinson, and Basham's (1983) system. This system includes six 5-point rating scales related to affective style, three pertaining to the mother (gratification from interaction, sensitivity to child cues and rhythm, and general affect), and three pertaining to the child (gratification from interaction, responsiveness to mother, and general affect). Child pain sensitivity was again measured using retrospective maternal report on a one-to-five point sensitivity scale. When children were four and a half years of age, mothers completed the Personality Inventory for Children (PIC: Wirt, Lachar, Klinedinst, & Seat, 1977), which includes a Family Relations subscale and a Child Somatization subscale.

In the ELBW groups, maternal sensitivity to child cues was associated with low somatization, and involvement (HSQ) was associated with high somatization. In the full-term group, child responsiveness to mothers during interaction was associated with low somatization and the temperamental trait of high emotionality was related to high somatization. The Family Relations scale from the PIC was significantly related to somatization in both groups. In a step-wise regression analysis, the combination of the Family Relations Scale, NICU experience, maternal sensitivity to child cues, and child avoidance of touch significantly predicted somatization. The additive contribution of each predictor variable was as follows: Family Relations Scale ($R = .40$), NICU experience ($R = .47$), maternal sensitivity to the child's cues ($R = .51$), and child avoidance of touch ($R = .55$). Finally, the combination of maternal sensitivity to child

cues, child avoidance of touch, maternal gratification from interaction with the child, child temperamental emotionality and sociability, and maternal involvement and responsivity correctly identified 100% of the high somatization group and 96% of the normal somatization group of ELBW children. While this study included an observer-based measure of mother-child interaction, the remaining measures were based on parental report, and an actual incident of child pain was not included. In this study, the stepwise analysis of factors predicting somatization indicated the relative weights of factors in one sense, based on their order of acceptance into the model, and there was some comparison of patterns between premature and fullterm children. However, there was no mention of any examination of interactions between child and parental factors.

Finally, Lumley, Abeles, Melamed, Pistone, and Johnson (1990) studied 71 mother-child pairs in which the child (age range 4 to 10.2 years) underwent a stressful and/or painful medical procedure (anesthesia induction with a mask or intravenously). On the day before children were scheduled for surgery, child temperament was assessed via maternal report on the Parent Temperament Questionnaire (PTQ; Thomas & Chess, 1977). Following a venipuncture (which mothers attended), maternal behavior in the examination room was assessed via observer rating on the Dyadic Prestressor Interaction Scale (DPIS; Melamed & Bush, 1988). On the day of surgery child distress was assessed during anesthesia induction (with mothers absent) via observer report on the Operating Room Behavior Rating Scale (ORBRS; Melamed, Dearborn, & Hermez, 1983).

Although neither the child's temperament nor the mother's behavior had significant main effects, their interaction predicted child coping. There was a significant

Approach/Withdrawal (child temperament) x Distraction versus Informing (maternal behavior) interaction, partial $R^2 = .114$. In children with approaching temperaments, low informing and high distracting by mothers were related to increased child distress, while low distracting and high informing were related to decreased distress. In children with withdrawing temperaments, low informing and high distracting by mothers were related to decreased child distress, while low distracting and high informing were related to increased distress. There was also a significant Adaptability x Emotional Noninvolvement interaction, partial $R^2 = .065$. Low-adaptable children with emotionally non-involved mothers showed increased distress during anesthesia induction, while low-adaptable children with emotionally involved mothers showed decreased distress. These relations did not appear with highly adaptable children. The authors suggest that children who adapt poorly to change may be more susceptible to maternal influence during stress, and that children with approaching temperaments may respond better when provided with information, while children with avoiding temperaments may respond better when distracted. This study is limited in its ability to uncover the factors involved in child pain, as the authors grouped together data from children who experienced anaesthesia induction with a mask, which presumably would be stressful but not painful, with data from children who were induced intravenously, which presumably would be both stressful and painful. In addition, mothers were not present at the time of the stressful procedure; their behavior on the previous day was used to predict child pain behavior during induction. Finally, although interactions between child and parental variables were examined, developmental changes in these patterns were not discussed.

Despite the drawbacks of these studies, they do seem to consistently show that temperament is related to child pain behavior. They did not, however, find clear relations between parental behavior and child pain behavior. There was some indication that, in addition to its relation to child pain behavior, temperament may mediate the relation between parental behavior and child pain behavior (Lumley et al., 1990). Davison et al. (1986) suggest that pain distress represents an interaction between a vulnerable temperamental style and environmental stressors. Therefore, children with easier temperaments may be better able to handle pain situations, regardless of parental behavior, while children with difficult temperaments may be more susceptible to the effects of parental behavior during periods of stress. There may also be interactions between child vagal tone and parental variables, as vagal tone also reflects reactional style. There is a paucity of research, however, to support or refute this.

The Present Study and Hypotheses

The present study examined the relative importance of and developmental changes in child reactivity level, as indexed by child vagal tone and child difficultness, and parenting context, as indexed by maternal sensitivity and maternal response to child pain, in the prediction of child pain behavior. This study included both subjective and objective measures of child and maternal attributes, through its inclusion of physiological measures of child reactivity (vagal tone), maternal reports of child difficultness, and observer ratings of mothers' immediate responses to child pain, maternal sensitivity, and child pain behavior. Finally, this study included an exploratory examination of

interactions between child and maternal factors in the prediction of child pain behavior.

Age-related Changes

Prior to examination of the primary hypotheses, age-related changes in the factors predicting child pain, and the behavioral expression of child pain were examined. Due to the developmental changes between 6 and 18 months of age, not all predictor and dependent variables were expected to be uniform across time. Specifically:

Hypothesis (a): Mean vagal tone was expected to increase from 6 to 18 months.

Hypothesis (b): Maternal behavior was expected to change with child age.

Specifically, mothers were predicted to be more reassuring (distress promoting) with their 6-month-olds than with their 18-month-olds, and to use more distraction (coping promoting) with their 18-month-olds than with their 6-month-olds. The overall rate of interaction (number of comments made) was also expected to change with age; mothers were predicted to make significantly more comments to their 18-month-olds than to their 6-month-olds during pain.

Hypothesis (c): Child pain behavior was expected to decrease from 6 to 18 months of age.

Relations Among Predictor Variables

Prior to examination of the primary hypotheses, relations among the predictor variables were also examined. It was expected that there would be some consistency in measures representing child biological variables or maternal behaviors, respectively.

Hypothesis (a): It was hypothesized that child difficulty would be positively related to child vagal tone level.

Hypothesis (b): It was hypothesized that mothers general patterns of behavior (maternal sensitivity) would be positively related to their behavior specifically at the time of child pain.

Primary Hypotheses

Based on the literature reviewed, it was predicted that at 6 months of age, children's responses to incidents of pain would be more strongly associated with their individual levels of reactivity (as evidenced by child vagal tone and child difficulty) than with the individual parenting contexts to which they had been exposed (as evidenced by maternal sensitivity and maternal behavior at the time of immunization). Over time, however, the relative importance of these variables was predicted to shift. It was predicted that at 18 months of age, children's responses to incidents of pain would be more strongly associated with their individual parenting contexts than with their individual levels of reactivity. According to the literature, the direction of significant relations between the main predictors and child pain behavior predicted was: positive relations with child vagal tone, child difficultness, and maternal sensitivity, and negative relations with the ratio of coping/distress promoting maternal behaviors during child pain.

Interactions between maternal and child variables were also investigated. It was predicted that children with more "vulnerable" reactional styles (i.e., children with higher vagal tone and difficulty scores) would be more susceptible to the effects of maternal behavior than would children with less "vulnerable" reactional styles. However, as the proportion of variance accounted for by interactions reported in the literature was not high (6.5% to 11.4% in Lumley et al., 1990), these analyses were considered exploratory.

Secondary Hypotheses

Although maternal anxiety and stress were not central to the model of pain tested, there was evidence that they might play a role in the pain experience. Therefore, in order to provide a more comprehensive picture of the complex nature of the factors involved in the pain experience, primary analyses were supplemented with additional tests to examine whether or not maternal psychological state influenced maternal behaviors during child pain, or child pain behaviors, or if they played mediating roles in the pain experience,.

Hypothesis (a): It was hypothesized that maternal stress would be related to mothers' immediate behavior at the time of child pain. It was also hypothesized that maternal stress would moderate the relation between maternal pain response and child pain behavior.

Hypothesis (b): It was hypothesized that if maternal behavior at the time of the needle and maternal sensitivity were not related, stress or anxiety would moderate this discrepancy.

Hypothesis (c): It was hypothesized that maternal anxiety prior to immunization would be positively related to child pain behavior during immunization.

CHAPTER 2. METHOD

Participants

This study was approved by the Human Ethics Committee of the Faculty of Graduate Studies at Dalhousie University, and participants were treated in accordance with the Social Sciences and Humanities Research Council of Canada's guidelines for human participants. The staff of Dalhousie Health Services also reviewed this study and gave ethical consent for their clients to be recruited. Participant recruitment was carried out through Dalhousie Health Services, whose clientele consisted primarily of staff (professional and non-professional) and students of Dalhousie University, and their families.

Before testing began, an a priori power analysis was conducted in order to determine how many participants were necessary to reject a false null hypothesis. As the primary analyses planned were based on multiple correlation and regression, a power analysis specifically for R^2 was conducted, using Cohen and Cohen (1983). Based on the research plan, the number of independent variables to be entered into the regression equations predicting child pain behavior at each age period was four (one variable each reflecting child vagal tone, child difficultness, maternal behavior during immunization, and maternal sensitivity). The significance criterion to be used in the power analysis was set at $\alpha = .05$, and the desired level of power was set at .80. Then, the appropriate value of L for four independent variables at a power of .80 was noted in the tables in Cohen and Cohen (1983). This value was 11.94. Then the population effect size of interest was determined. It was decided that a population effect size for an R^2 of .35 would be

considered of interest. With an R^2 of .35, the population effect size was estimated to be $R^2 / 1 - R^2$, or .54. Finally, n was calculated as $L/\text{population effect size} + \text{the number of independent variables} + 1$, or $11.91/.54 + 4 + 1$. This indicated that 27.11 participants were necessary in each group for which the four independent variables would be entered into regression analyses. Based on this analysis, 30 mother-infant dyads were tested at each age period, for a total of 60 participants in the study*.

Mothers of appropriate children (based on dates of birth) were contacted by the staff of Dalhousie Health Services in order to request permission that they be contacted further about the study. In addition, posters advertising the study were placed in the waiting room at the clinic and interested mothers were invited to call Dalhousie University for more information. Mothers who were contacted by telephone, or who contacted the department on their own, were informed about the study using a standard script concerning the purpose of the study and what their participation would entail (see Appendix A). They were also informed that babysitting services were available for children other than those participating in the study, and that they would be provided with a \$20 honorarium in order to help cover any transportation costs or babysitting costs (for mothers who chose not to make use of the babysitting services provided).

To be eligible to participate, infants and mothers had to meet several criteria. Children had to be approximately 6 or 18 months of age, they had to be between 37 and

*It is assumed that most mothers will bring their children for their immunizations, and that they are the primary caregivers. This is why mothers, as opposed to fathers, were tested. This is not intended to diminish the influence fathers have on their children.

42 weeks gestation at birth, they had to be 2500 grams or more at birth, and they had to be in good health at the time of the study. Mothers had to speak English well enough to understand the questionnaires and they had to be clients of Dalhousie Health Services. One mother of a child who was not a patient of Dalhousie Health Services was included in the study, as she obtained permission from her physician to participate and her physician had previously been involved in immunization pain research with Dalhousie University. Mothers and children who met the inclusion criteria and who wished to participate were scheduled to visit the Pain Research Laboratory during the same month as their children were anticipated to receive their 6 or 18 month immunizations.

In total, 116 mothers were informed about the study over the nine month period from July, 1996, to March, 1997. Of those, 91 mother-child dyads were eligible to participate. Seventy-two (79%) of these mothers agreed to participate. Finally, of the total number of participants who completed the study, 12 mother-infant dyads had to be excluded due to problems in data collection. The reasons for which mothers were ineligible to participate, for which mothers declined to participate, and for which participants were excluded from the study are presented in Appendix B.

The participants included in data analyses were 60 mother-child dyads. The 6-month-old group ranged in age from 5 months to 8 months ($M = 6$ months, $SD = 18$ days). Of these children, 12 (40%) were male and 18 (60%) were female. The ethnic backgrounds of these children included 26 English Canadians (86.7%), one French Canadian (3.3%), one bi-racial Canadian (3.3%), one Italian Canadian (3.3%), and one Arabian Canadian (3.3%). Twelve (40%) of these children were first borns, 13 (43.3%)

were second borns, four (13.3%) were third borns, and one (3.3%) was a fourth born.

The 18-month-old group ranged in age from 17 months to 19 months ($M = 18$ months, $SD = 15$ days). Of these children, 11 (36.7 %) were male and 19 (63.3%) were female. The ethnic backgrounds of these children included 26 English Canadians (86.7%), two African Canadians (6.7%), one bi-racial Canadian (3.3%), and one Hungarian Canadian (3.3%). Thirteen (43.3%) of these children were first borns, 11 (36.7%) were second borns, four (13.3%) were third borns, and two (6.7%) were fourth borns.

All mothers in this study were the biological parents of their children. As independent samples t-tests and chi-square analyses examining differences in maternal characteristics between the 6- and 18-month-old groups revealed no significant differences ($p > .05$), mothers are described as a total group. Mothers ranged in age from 21.92 years to 40.67 years ($M = 31.60$ years, $SD = 4.83$ years). The ethnic backgrounds of mothers included 55 English Canadians (91.7%), four French Canadians (6.7%), and one Hungarian (1.7%). Fifty-one (85%) mothers were married, two (3.3%) were single, one (1.7%) was separated, five (8.3%) were living common law, and one (1.7%) was a widow. Fourteen (23.3%) mothers were working full time, eight (13.3%) were working part-time, 12 (20%) were on maternity leave but regularly worked full time, three (5%) were on maternity leave but regularly worked part time, and 23 (38.3%) were not working outside the home. Twenty-four mothers (40%) had one child, 24 (40%) had two children, nine (15%) had three children, and three mothers (5%) had four children ($M = 1.85$, $SD = .86$). The educational level among the mothers was graduate or professional training for

13 mothers (level 1 = 21.7%), university graduation for 20 mothers (level 2 = 33.3%), partial university or college level training for 23 mothers (level 3 = 38.3%), trade school/apprenticeship/high school graduation for two mothers (level 4 = 3.3%), partial high school for one mother (level 5 = 1.7%), and junior high school for one mother (level 6 = 1.7%) ($M = \text{level } 2.35$, $SD = 1.02$).

Using Hollingshead's Two-Factor Index of Social Position (Miller, 1977), the highest level of SES was calculated per household (based on both mother and father data). The values obtained were Level 1 for nine households (15%), Level 2 for 25 households (41.7%), Level 3 for 16 households (26.7%), Level 4 for nine households (15%), and Level 5 for one household (1.7%) ($M = 2.47$, $SD = .98$), with lower scores indicating higher SES (possible range = 1 to 7).

The educational level and SES among the participants was relatively high, making it unlikely that this sample is reflective of the general population. This was expected, based on the clientele of Dalhousie Health Services. However, when a sample is used to test a prediction of what should happen in a particular case, the issue of external validity is reduced; the sample need not be representative of the general population in order to provide support for a theory (Mook, 1983). According to Mook (1983), the value of this type of study is based on the success of its predictions in the setting of interest, and not in its naturalness or representativeness.

Measures

Mothers completed a demographic interview (see Appendix C), which asked them

to report on family background variables, their experience with needle procedures, their children's experience with incidents of everyday pain, and their children's general health. In addition, the demographic questionnaire included several questions related to the Maternal Behavior Q-sort (see review of MBQ).

Measurement of Primary Predictors

Four measures were used in this study to capture the four primary constructs of interest: child vagal tone level, child difficultness, maternal behavior during child pain, and maternal sensitivity. In each case, measures were condensed down to a single score representing each construct, in order to reduce the number of variables entered into data analyses. With all measures, scores used in data analyses were based on the primary coders' ratings. The secondary coder's ratings were used solely to determine the inter-rater reliability of the measures.

Child Vagal Tone

Measurement. Vagal tone was estimated using spectral analysis. The reliability of the spectral analysis of RSA has been found to be good ($>.80$) in 14-, 20-, and 26-week-old infants (Richards, 1995). Generally, the longer the sampling interval and the larger the number of beats sampled, the more accurate the mean value of the generated time series produced (Richards, 1995). Richards (1995) suggests that a five minute period may provide an adequate EKG sample, while sampling intervals shorter than one minute tend to produce spurious results.

To measure vagal tone, a resting EKG signal was collected non-invasively from each child using the FlexComp VI.51b system (Thought Technology, Ltd., Montreal,

Canada, © 1992). This system produces a time-series of interbeat intervals (R-R intervals), with the detection of the R-wave timed to the nearest msec. Using this system, one channel was configured to record both EKG interbeat interval and EKG waveform. A 60 Hz notch was used in order to filter out extraneous electrical signals. No averaging constant was used as short-term fluctuations in signal were to be examined, rather than longer-term trends, and so greater detail in the signal was desired. Signals were saved at a rate of 496 samples/second in order to help provide finer detail over a shorter time period.

Using this EKG signal, an estimate of vagal tone was calculated using linear detrended heart rate spectral analysis. Specifically, the method used was that reported by Finley, Nugent, and Hellenbrand (1987). In this method, a segment of resting EKG is selected for use. The segment is selected from the recording to be free of sudden changes in respiratory activity, such as sighs or movement artifact, based on visual inspection of the EKG signal. Then the R-peak in the QRS complex of EKG data is identified. The length of period between two consecutive R-peaks (R-R interval) is determined and R-R interval files are converted to heart rate files, as heart rate is the inverse of R-R interval. This allows the frequency peak associated with respiration to be examined. The frequency range associated with breathing was taken to be .15 to .60 Hz in this study. Within this range, the apparent peak (amplitude) associated with breathing was identified for each child. A 0.05 Hz band on each side of this peak was selected and used as the band of interest. Once the band was determined, the area under this peak was calculated and used as an estimate of vagal tone.

Although researchers examining vagal tone have used both the area under the frequency peak associated with breathing and the amplitude of this curve as measures of vagal tone, and these methods are well-correlated ($r = .87$; Finley et al., 1987), the area under the curve was chosen for use in this study as it contains more data points than the peak value. Further, the use of a predetermined peak or amplitude across all individuals involves more potential error than does the use of the area under a curve. Individual peak values may be difficult to pinpoint, while individual curves are more likely to contain each individual's peak within the band measured.

Although the term "vagal tone" was used to reflect the measure of heart rate variability calculated, the technique used was not that of Porges. However, studies have shown spectral analysis of RSA and Porges' technique of quantifying RSA to be highly comparable. For example, Litvack et al. (1995) found that the measurement of high-frequency R-R interval variance with linear detrended heart rate power spectral analysis and Porges' technique of filtered variance yielded substantially similar trends across a range of physiological conditions, but the Porges' technique resulted in the amplification of variance values near its low-frequency cutoff, especially when a large percentage of the variance was near 0.43 Hz. Grossman et al., (1990) also found that spectral techniques and Porges' technique produced similar results. In their study, inter-individual correlations between measures resulted in correlation coefficients above .92, and the mean within-subject correlation across 42 persons was .96. These studies indicate that spectral analysis and Porges' technique are highly comparable as indices of cardiac vagal tone.

Operationalization. In this study, vagal tone was operationalized as a log-transformation of each child's continuous individual raw score. Logarithmic transformation of raw vagal tone scores is commonly carried out in research on vagal tone, in order to normalize the distribution (e.g., Finley et al., 1987). The range of vagal tone scores was unlimited, due to its continuous nature. However, based on the participants in this study, transformed scores ranged from -1.393 to .306.

Reliability. In order to determine the reliability of the measure of vagal tone, five EKG files were randomly selected for a second, blind analysis by the primary coder. When the vagal tone estimates based on the primary analysis of files were compared with the vagal tone estimates based on the secondary (blind) analysis of files, it was found that the reliability of the method of calculating vagal tone across occasions was .994, based on an intraclass correlation.

Child Difficultness

Measurement. Bates designed the Infant Characteristics Questionnaire (ICQ: Bates et al., 1979) specifically to function as a short, factor-analytic screening measure for difficultness. Bates provides a very specific definition of temperament for this measure, focusing on intense negative mood, which is demonstrated by frequent fussing and crying, intensity of protest, difficulty being soothed, and lability in mood (Bates, 1980).

The ICQ was developed on a group of 322 mothers and their 4 to 6-month-old infants, but it has since been expanded into forms for 13- and 24-month-olds (Bates et al., 1979). Each version uses a 7-point rating scale for behavior and takes approximately 15-20 minutes to complete. The 6-month-old version has 24 items which compose the

subscales Fussy-Difficult, Unadaptable, Dull, and Unpredictable. The 13-month-old version has 32 items which compose the subscales Fussy/Difficult/ Demanding, Unadaptable, Persistent, and Unsociable. The 24-month-old version also has 32 items, which compose the subscales Difficult, Negative Adaptation to Change, Unstoppable, Dependent, Irregular, Sober, and Factor Seven. Because the individual items making up the "difficult" scales are more similar between the 6- and 24-month forms than between the 6- and 13-month forms, the 24-month-old form was used to assess 18-month-old children in this study (see Appendix D).

The ICQ has shown evidence of reliability over time (Bates et al., 1979). The test-retest factor scores for reliability range from $r = .47$ to $.70$, with a median $r = .56$. The internal consistency factor alpha coefficients range from $.39$ to $.79$, with a median of $.63$. The stability of the Bates series from 6 months to 24 months is $r = .57$, and from 13 months to 24 months $r = .71$. Hubert, Wachs, Peters-Martin, and Gandour (1982) report moderate to high stability particularly for the Difficult dimension given at 6 and 13 months (alpha range of $.63$ to $.88$, median $r = .76$).

There is evidence to support the convergent validity of the ICQ. Mother-report converges with father-report and with home data collected by independent observers. For example, in Bates et al. (1979), mother-father convergence ranged from $.38$ to $.61$ (median $r = .40$), and observer-parent convergence was $.34$ (mothers) and $.40$ (fathers) for Fussy-Difficult. Zeanah, Keener, Anders, and Levine (1986) also found moderate inter-parental agreement about infant temperament (mean $r = .44$), and moderate convergence between observer-rated infant responsiveness and mothers' ($r = .57$) and fathers' ($r = .45$)

ratings of infant difficulty.

The ICQ is related to other proposed measures of child temperament. For example, it is significantly related to Rothbart's Infant Behavior Questionnaire (IBQ; Rothbart, 1981). Goldsmith, Rieser-Danner, and Briggs (1991) found that the correlations between scores from scales purportedly measuring the same or very similar constructs from the ICQ and IBQ were significantly related. The correlation between the fussy-difficult scale of the ICQ and the distress to limitations scale of the IBQ was .66.

The ICQ has previously been used in studies examining the relations between vagal tone and temperament (e.g., DeGangi, DiPietro, Greenspan, & Porges, 1991; Porges et al., 1994). Porges argues for the use of this measure of temperament because of the theoretical link between difficultness and cardiac vagal tone, and the contention that difficultness is rated relatively objectively (see DeGangi et al., 1991). Although Bates notes that maternal perceptions are important in temperament perception and that they are relevant to temperament research (Bates, 1980), he argues an objective basis for perceptions of difficultness (Bates & Bayles, 1984). Further, Bates reports that "The lowest proportion of significant correlations between personality and mother report measures is in the area of difficultness" (Bates & Bayles, 1984, p. 122). Temperament as measured by the ICQ has also been found unrelated to observations of maternal parenting sensitivity (Seifer, Schiller, Sameroff, Resnick, & Riordan, 1996). The correlation specifically between sensitivity and the ICQ fussy-difficult score was $r = .11$ at 6 months and $r = .04$ at 9 months.

Operationalization. In this study, child difficultness was operationalized as

mothers' impressions of their children's difficulty, based on their ratings of their children on the "Fussy-Difficult" scale of the 6-month ICQ, or the "Difficulty" scale of the 24-month ICQ, respectively. As the 6-month scale is composed of six items, and the 24-month scale is composed of seven items, children's raw scores were converted into average scores on each age-version, in order scores might be compared across age periods. Therefore, averages of children's raw scores on their respective difficulty scales (based on maternal report) were used to represent child difficulty. The possible range of average scores was 1 to 7, across age periods, with higher scores indicating higher perceived child difficulty.

Reliability. The characteristics of children's difficulty scores were examined, as this measure relied on accurate maternal-report. It was found that the mean difficulty scores and standard deviations between children in this study and those in the normative sample were similar (see Table 4). This provides support for mothers' appropriate use of this measure in this study, and for the comparability between maternal ratings of child difficulty in this sample with that in other samples.

Insert Table 4 About Here

The relations between child difficulty and both maternal demographic and maternal psychological variables were examined, using Pearson correlations, for possible confounding effects of maternal background with maternal ratings of child difficulty. At both 6 and 18 months of age, there were no significant relations between maternal

demographic variables and child ratings of difficulty (see Table 5). Maternal psychological variables, however, did show some relations with child difficulty (see Table 6). At 6 months of age, maternal stress (as measured on Parenting Domain Scale of the PSI) was significantly related to child difficulty ($r = .395$, $p = .031$). At 18 months of age, both maternal anxiety ($r = .563$, $p = .002$) and maternal stress ($r = .493$, $p = .006$) were significantly related to child difficulty.

Insert Tables 5 and 6 About Here

The lack of relations between child difficulty and maternal demographic variables, combined with the comparability of the mean difficulty scores and standard deviations with those in the normative sample, provide evidence for the appropriate rating of child difficulty in this study, and for its general independence from maternal demographic variables. Although relations were found between maternal psychological variables and maternal ratings of child difficulty, relations were few. Further, the direction of these relations is not clear based on the correlational analyses conducted.

Maternal Behavior During Immunization

Measurement. Mothers' vocalizations during the immunization were coded using the Child-Adult Medical Procedure Interaction Scale - Revised (CAMPIS-R: Blount et al., 1990). This measure combines the 35-code CAMPIS into 6-codes. Codes are based on the categorization of the subject, speaker, phase of medical procedure, verbal content, affective tone, and to whom the vocalizations are directed (the child or other adults).

Adult vocalizations are coded as Coping Promoting (non-procedural talk or humor directed to the child, commands to engage in coping strategies), Distress Promoting (reassuring comments, apologies, giving control to the child, criticism, and empathetic statements), or Neutral (humor to adults, non-procedural talk to adults, child's condition talk, command for procedural activity, praise, notification of procedure to come, behavioral commands to child, checking child's status). Child vocalizations may also be coded. However, as so few vocalizations were made by the infants in this study, child vocalizations were not coded with this measure.

Interobserver reliability is reported to be high for each parental code of the CAMPIS-R (Cohen's kappa for Parent Coping Promoting = .78, Parent Distress Promoting = .82, Parent Neutral = .65; Blount et al., 1997). Investigations of the validity of the CAMPIS-R with preschool children receiving routine immunizations indicated that the categories of Parent Distress Promoting and Coping Promoting were supported (Blount et al., 1997). All significant correlations between these categories and multiple observational scales (Observational Scale of Behavioral Distress, Behavioral Approach-Avoidance and Distress Scale, 5-point rating scale of avoidance/approach), and nurse VAS of child pain, parent VAS of child pain, and child self-report of pain and fear, were in the predicted directions. Coping Promoting was positively related to BAADS Approach-Avoidance scores and to staff's ratings of child cooperation, and inversely related to BAADS Distress and to staff ratings of child distress. Distress Promoting was positively related to OSBD distress and BAADS Distress, and to parents' reports of child fear and pain, staff reports of child distress, and children's self-reports of their pain.

Distress Promoting was also inversely related to BAADS Approach-Avoidance scores, parents' ratings of their ability to help their child, and staff ratings of cooperation. Parent Neutral behaviors, however, were inversely related to child OSBD distress, parents' ratings of their children's fear, staff ratings of child distress, and children's self-reports of fear. Parent Neutral behaviors were also positively related to BAADS Approach-Avoidance scores.

In the present study, mothers' verbalizations were recorded with a Panasonic Camescope S-VHS AG-455P color camera and Super VHS T120 video tapes. All conversation during each immunization was transcribed. Each transcript was reviewed by two persons, to ensure that it accurately identified the content, speaker, and sequence of vocalizations. Within each transcript, conversation was time blocked to correspond to the time periods used in NFCS coding (see NFCS section). A Panasonic Super VHS 4-head AG-1970 VCR and Panasonic CT-2084 19-inch viewable screen playback color monitor were used during video coding. Raters coded using both the transcripts and the videotape, in order to help them determine the affect necessary for some coding.

Operationalization. Maternal behavior during immunization was operationalized as the ratio of mothers' Coping Promoting to Distress Promoting vocalizations, according to the CAMPIS-R. Mothers' raw scores on the Coping Promoting and Distress Promoting subscales of the CAMPIS-R, based on the primary coder, were made continuous by calculating the proportion of each type of verbalization within each time period. In this method, the total number of instances that a given CAMPIS-R code category (either Coping Promoting or Distress Promoting) was designated as occurring

was divided by the total number of coded behaviors for that person, to create proportions, which therefore ranged from 0 to 1.0. This method is frequently used by the author of this scale (e.g., Blount et al., 1997). To create the final summary score (ratio) used in analyses, the proportion of Coping Promoting verbalizations within each time period was divided by the proportion of Distress Promoting verbalizations within the same time period. Before division occurred, a constant of one was added to all scores, in order to correct for divisions by zero. This yielded three ratio scores, which corresponded to the three time periods coded for child pain (see Child Pain Behavior section). The final scores had a possible range of .5 to 2, with higher scores indicating more Coping Promoting relative to Distress Promoting verbalizations.

Reliability. Two coders, who were blind to the other variables for each infant-mother dyad, were trained on the CAMPIS-R. Before data coding began, coders established inter-rater reliability on a series of five practice tapes and transcripts. On these tapes, the primary and secondary coders achieved an inter-rater reliability of .826 (Adult Neutral), .826 (Adult Positive), and .866 (Adult Negative), using Cohen's kappa. Prior to rating test tapes, coders achieved 100% agreement on the subject, phase, and speaker in training tapes, and 95% agreement for affect codes, and 92% agreement on individual verbal codes.

Twenty-five percent (15) of tapes were randomly selected and coded for inter-rater reliability. The overall inter-rater reliability kappas for these cases were as follows: Adult Neutral = .800 (92% agreement), Adult Coping Promoting = .789 (92% agreement), Adult Distress Promoting = .834 (94% agreement), and the overall kappa

across adult codes was .808 (93% agreement). Adult reliability kappas were also examined separately for behaviors exhibited by mothers and clinic staff. The inter-rater reliability kappas for mothers were as follows: Neutral = .838 (93% agreement), Coping Promoting = .768 (89% agreement), Distress Promoting = .786 (90% agreement), and the overall kappa across maternal codes was .797 (91% agreement). The inter-rater reliability kappas for staff were as follows: Neutral = .762 (91% agreement), Coping Promoting = .810 (95% agreement), Distress Promoting = .881 (97% agreement), and the overall kappa across staff codes was .818 (94% agreement).

Maternal Sensitivity

Measurement. Maternal sensitivity was estimated using two measures in this study: the Pederson and Moran Maternal Behavior Q-sort (MBQ), which was developed by Pederson et al. (1990), based on the work of Waters and Deane (1985), and the Ainsworth, Bell, and Stayton (1974) Sensitivity Scale.

The Maternal Behavior Q-sort (MBQ: Pederson et al., 1990) describes mother-child interaction using a set of 90 cards, which are sorted by a trained observer into nine piles of 10 cards each. These piles vary from most like the mother to least like the mother. Piles are then correlated with a prototypical criterion sort of a sensitive mother.

The MBQ was developed from an original pool of more than 150 items, which were based on theoretical and empirical descriptions of maternal sensitivity (Pederson et al., 1990). These items were narrowed, based on the opinions of faculty and graduate students with expertise in the area. Items which were ambiguous or could not be reliably sorted were eliminated. The 90 remaining items focus on mothers' abilities to "*detect*

and recognize signals or situations that might require her response, to *respond promptly* to these situations, and to *respond appropriately*" (Pederson et al., 1990, p. 1976).

The MBQ is applicable across a wide variety of age groups, as judgements made by observers are relative (e.g., Moran et al., 1992; Waters & Deane, 1985). MBQ sorts of maternal sensitivity are also independent of potential biases of the home environment where observations occur (Pederson et al., 1990).

There is evidence for both the reliability and validity of this measure. High inter-observer agreement has been found using the MBQ. For example, Symons (1997) found that the agreement between two observers using the MBQ was $r = .88$ over a sample of 55 mothers. MBQ sorts have also been found significantly related to ratings of maternal sensitivity and involvement using the Ainsworth Sensitivity Scales, the HOME inventory, and the Bromwich Parent Behavior Progression; r values ranged from .43 to .62 (Moran et al., 1992). Pederson et al. (1990) also found that the MBQ was related to the mean aggregated Ainsworth maternal behavior rating ($r = .90$). Q-sorts using the MBQ have also been found to be inversely related to negative maternal behavior during play and clean-up tasks with children two years of age ($r = -.27$ and $-.43$ respectively), which provides evidence for its concurrent validity (Symons et al., in press). Finally, several studies have found that MBQ sorts of maternal sensitivity are related to attachment security, as would be expected (e.g., $r = .52$ in Pederson et al, 1990).

Knowledge of several behavioral interactions which observers may not have access to are necessary for the MBQ (e.g., bedtime). Therefore, each Q-sort item was examined and those which were unlikely to be observed during the visit were noted and

incorporated into the demographic interview (see Appendix E). The actual items these questions were designed to reflect, and the loadings of these items are presented in Appendix F. Similar procedures have been used in other studies (e.g., Moran et al., 1992).

The Ainsworth et al. (1974) Sensitivity Scale is a nine-point rating scale used to make global estimations of sensitivity, with specific regard to infants' signals and communications. It evolved from intensive home observations of mother-infant dyads. According to this scale, a sensitive mother perceives "her baby's signals, interprets them accurately, and responds appropriately and promptly, unless no response is the most appropriate under the circumstances" (Ainsworth et al., 1978, p. 142). In addition, she acknowledges the baby's communication, and her responses are temporally contingent upon those of her child (Ainsworth et al., 1978). Therefore, although this scale expresses sensitivity in a single number, it reflects several components of maternal sensitivity (e.g., alertness to signals, promptness of response).

This scale has been used in many studies of maternal sensitivity (e.g., Biringen, 1990; Pianta et al., 1989; Spangler et al., 1994). The mean inter-rater reliability of this measure has been found to be high (.89 in Ainsworth et al., 1978; .96-.98 in Biringen, 1990). Pianta et al. (1989), who defined inter-rater agreement as no more than a 2-point discrepancy on ratings based on the Ainsworth et al. (1974) Sensitivity Scale, found inter-rater agreement to be .66 over 45 cases. The reliability between ratings at three and 12 months has been found to be .92 (Cohen's kappa; Spangler et al., 1994). Ratings based on this measure have also been found to be significantly related to ratings of sensitivity using

the Maternal Behavior Q-sort. Moran et al., (1992) found the correlation between these measures to be .55 ($p < .05$), and Pederson et al. (1990) found it to be .90 ($p < .001$).

Operationalization. As measures of sensitivity are seldom used in a lab situation, two measures of sensitivity were included in order that the appropriateness of the rating of sensitivity in this study could be examined in greater detail. Because the Ainsworth scale provides a single metric to measure a very complex construct, it was intended to act as an adjunct to the MBQ. The MBQ, which rates sensitivity based on multiple maternal characteristics and traits, rather than a global impression, was considered the primary measure of maternal sensitivity in this study and scores derived from the MBQ were used to represent sensitivity in all analyses. Maternal sensitivity was therefore operationalized as each mother's r score (the correlation between her sort and the criterion sort), as rated by the primary coder. Scores were correlations, and therefore ranged from -1 to +1, with higher scores indicating more sensitive behavior. Analyses were replicated with sensitivity scores based on mothers raw scores (1-9 point rating) on the Ainsworth et al. (1974) Sensitivity Scale, with no resulting changes in the patterns of significant and non-significant relations.

Reliability. In this study, two observers were trained to sort the MBQ, according to the procedures of Pederson and Moran (1995), and to provide a global rating of sensitivity using the Ainsworth et al. (1974) Sensitivity Scale. Training was coordinated by a sorter with extensive experience and training in observational methods (D. Symons). The first step required observers to acquire an understanding of the mother-infant relationship, attachment, maternal sensitivity and Q-sort methodology. This involved

reading and discussing a series of studies involving these issues (e.g., Hinde, 1987; Pederson et al., 1990; Sroufe & Fleeson, 1988; Waters & Deane, 1985). Q-sort items were discussed individually before observers conducted a sort of a prototypical sensitive mother, which was correlated with a criterion sort of a sensitive mother. The sorters' correlations with the criterion sort were .887 and .917 respectively, and the correlation between the two raters' criterion sorts was .864. Raters extensively discussed the different ratings possible using the Ainsworth scale prior to rating study participants.

During coding, 30% (18) of cases were randomly selected cases for observation by a second coder. This coder observed the initial meeting with the mother and child unobtrusively through a one-way window and completed both the MBQ and the Ainsworth et al. (1974) Sensitivity Scale. On the MBQ, the mean inter-rater reliability of the two coders (based on the correlation between each card in one rater's sort with the parallel card in the other rater's sort) was .843. The inter-rater reliability between their individual overall scores for mothers, based on an intraclass correlation, was .979. On the Ainsworth Scale, the inter-rater reliability between the two raters' scores, using an intraclass correlation, was .985, with no more than a one-point discrepancy between each pair of scores.

In order to determine the comparability of these two measures in rating maternal sensitivity, each mother's score on the MBQ was compared with her score on the Ainsworth Scale. It was found, using Spearman's r , that the correlation between each mother's sensitivity rating using the MBQ and the Ainsworth Scale was .939. This lends support to the ability of these measures to capture a similar construct, and to their use in

measuring sensitivity in a lab situation.

Measurement of Secondary Predictors

In addition to the primary measures, several secondary measures were also included, in order to better represent and assess the complex relations among the factors predicting child pain. Once again, each measure was condensed down to a single score (based on the primary coder's ratings) representing each construct, in order to reduce the number of variables entered into data analyses. The secondary coder's ratings were used solely to determine the inter-rater reliability of the measures.

Maternal Stress

Measurement. Maternal stress was assessed using the Parenting Stress Index, Third Edition (PSI; Abidin, 1995). This instrument was designed as a screening, diagnostic, and research tool for parents of children ranging from one month to 12 years of age (Abidin, 1995). This measure generally requires a fifth-grade educational level to complete and is usually completed by the mother in about 20 minutes (Loyd & Abidin, 1985). Most items on this measure are rated on a 1 (strongly agree) to 5 (strongly disagree) point Likert-type scale.

The PSI yields 16 possible scores which identify parent stress, child-related stress, and total stress (Abidin, 1995). Seven of the scores are in the Child Domain (Adaptability, Acceptability, Demandingness, Mood, Distractibility/Hyperactivity, Reinforces Parent, Total). These scores reflect child temperament and parental perception of the effects of that temperament upon parenting. Eight of the scores are in the Parent Domain (Depression, Attachment, Restrictions of Role, Sense of Competence,

Sense of Isolation, Relationship with Spouse, Parental Health, Total). These scores reflect parental characteristics and family context variables which are related to parental functioning. The Child and Parent scores are combined to yield a Total Stress score. Percentile ranks are provided for the Total Score, Child Domain, Parent Domain, and all subscale scores. The PSI also yields an optional Life Stress score.

Normative data for the PSI are based on 2,633 mothers of children aged one month to 12 years, and 200 fathers of children aged 6 months to 6 years. These parents were predominantly from Central Virginia; however, this test has also been used in a variety of cultures. The items for the PSI were chosen according to research in the fields of child-rearing and child psychology. The initial items were rated and revised by six researchers and clinicians renowned in these areas (Abidin, 1986). These items were then field tested and revised to form the 101 items on the final version, plus the optional 19 items which compose the Life Stress Scale.

Internal consistency estimates for the Child Domain subscales range from .70 to .84, and for the Parent Domain from .70 to .83 (Abidin, 1995). Better reliability scores result for the overall Child Domain score (.90), Parent Domain score (.93), and Total Stress score (.95) (Abidin, 1995). Stability over 1-3 month periods is reported to be .63 for the Child Domain, .91 for the Parent Domain, and .96 for the Total Stress score (Abidin, 1995).

There is some evidence for the factor, content, concurrent, construct, and discriminant validity of the PSI (Abidin, 1995). The factor structure of this test is supported by factor analyses showing that the factors in the Child Domain account for

41% of the variance in the data and the factors in the Parent Domain account for 44% of the variance in the data (Abidin, 1995). The pattern of loadings supports the contention that each subscale is measuring a moderately distinct source of stress.

The construct validity of the PSI is supported by significant correlations between the PSI Child Domain Score and the Child Behavior Problems Checklist, and between the PSI Parent Domain Score and the State-Trait Anxiety Scale. Discriminant validity is supported by the ability of the PSI to separate physically abusive and non-abusive mothers, to discriminate level of husband support, and to discriminate between single and married mothers.

Operationalization. The Child Domain of the PSI shows a significant overlap with maternal sensitivity, as assessed by the Maternal Behavior Q-sort ($r = -.36$; Pederson et al., 1990). The Child Domain score is also expected to overlap with child temperament, as this subscale was partially designed to reflect it. For these reasons, the Child Domain and the Total Stress score (of which the Child Domain score is a component) were not used to represent maternal stress in this study. Maternal stress was operationalized as mothers' scores on the Parental Stress scale of the PSI, based on their self-reports. Each mother's raw score on the Parental Stress scale was converted to a percentile rank, based on tables provided in the PSI manual. Therefore, the possible range of score was 0 to 100%, with higher scores indicating greater maternal stress.

Maternal Anxiety

Measurement. Prior to the immunization, mothers were asked to rate their own anxiety concerning the needle on a scale of 0 to 10 (see Appendix G). Rating scales of

parental anxiety have been used in several studies of child needle procedures (e.g., Broome & Endsley, 1989b; Bush et al., 1986; Fradet, McGrath, Kay, Adams, & Luke, 1990). The specific anchors used in this study were those used by Fradet et al. (1990): "very calm, very relaxed" to "very upset, very distressed."

Operationalization. Anxiety was operationalized as mothers' self-reported raw scores on the 0 to 10 point scale, with higher scores indicating greater anxiety levels.

Infant State

Measurement. Infant state has been found related to infants' reactions to pain (Grunau & Craig, 1987; Gunnar et al, 1985). For example, Grunau and Craig (1987) found that quiet awake (alert) infants exhibited significantly more facial action than those in quiet sleep during heel-lance. Therefore, infant state prior to immunization was rated using a seven-point scale designed by Campos (1989, 1994). Campos adapted this scale from Giacomani (1971), and made modifications based on Thoman's (1975) work. This rating system has been used in other studies coding pain reactions (e.g., Campos, 1989). The seven states rated include: crying (0), fussing (1), alert activity (2), alert inactivity (3), drowsy (4), quiet sleep (5), and active sleep (6) (see Appendix H). Campos (1994) found that the inter-rater reliability for this measure ranged from .59 to .97 (Cohen's Kappa) in his study, and averaged .77.

Operationalization. Infant state was operationalized as children's raw scores, based on the primary coder, on the 0-6 point scale. Higher scores indicated less aroused states and lower scores indicated more aroused states prior to immunization.

Reliability. Infant state prior to immunization was coded by a primary blind rater,

and a secondary rater. Raters coded state, based on video-tapes, during the 20-second period immediately preceding insertion of the needle, in order to keep ratings standard. On a series of 5 training tapes, the inter-rater reliability between the two raters was 1.00, based on an intraclass correlation. During the study, 25% (15) of tapes were randomly selected for coding by the second rater for inter-rater reliability. The intraclass correlation between the two raters' categorizations of state on these tapes was .990.

Measurement of Dependent Variable

In this study, there was one primary dependent variable of interest: children's pain behavior. A single measure was used to reflect child pain in all analyses. As in the case of the predictor variables, this measure was condensed down to a single score representing child pain behavior, in order to reduce the number of variables entered into data analyses. Once again, scores used in data analyses were based on the primary coder's ratings. The secondary coder's ratings were used solely to determine the inter-rater reliability of the measure of pain.

Child Pain Behavior

Measurement. Although self-report measures are currently the gold standard in pain measurement, they cannot be used with infants and young children, as they are limited in their ability to verbally communicate pain. Young children can, however, demonstrate pain behaviorally. In infancy, facial action and cry are the two most widely studied behavioral responses to pain (Lawrence et al., 1993). Further, facial action is also the most consistent behavioral response to pain (Johnston & Strada, 1986), and variability in facial activity is more influential than is variability in cry pitch in determining adults'

ratings of infant pain (Craig, Grunau, & Aquan-Assee, 1988). Facial action may be assessed in very young infants, as facial responses to pain are present at birth (Craig, 1992). Assessing facial action also has practical benefits over other behavioral measures of pain. For example, infants are often held during medical procedures, limiting the amount of possible behavioral evidence of pain. In addition to facial action, global observer ratings are frequently used to measure infant pain behavior. In particular, visual analogue scales (VAS) are one of the most widely used tools to provide global ratings of pain behavior (Ekblom & Hansson, 1988). For these reasons, children's distress to immunization was rated using both the Neonatal Facial Action Coding System (NFCS: Grunau & Craig, 1987; Grunau & Craig, 1990), and a 100 mm Visual Analogue Scale.

The NFCS has previously been used with needle pain (e.g., Johnston, Stevens, Craig, & Grunau, 1993), and with infants from birth to 18 months of age (e.g., Grunau & Craig, 1987). This system is designed to give an anatomically based objective description of infant pain. It is based on the FACS approach, incorporating the recommendations made by Oster (1978) about applying the FACS to infants. The NFCS is flexible in that it allows coding of several specific time segments, and it provides users with a moment-by-moment account of changes in facial action. Facial action measures, in general, yield graded, rather than binary, information (Prkachin & Mercer, 1989), and the NFCS in particular shows sensitivity to variations in the severity of pain, and therefore has the potential to discriminate between different levels of pain (Grunau & Craig, 1987).

The NFCS assesses the presence or absence of 10 different facial actions during a given time period, based on viewing video recordings of infant faces in stop-frame and

slow motion to detect movement. Total facial action is calculated as the sum occurrence of all facial actions within a given time period. The actions which are coded are: brow bulge (a bulging created by lowering and drawing together of the eyebrows), eye squeeze (squeezing or bulging of the eyelids), naso-labial furrow (pulling upwards and deepening of the crease projecting from the wing of the nose to the lip corners), open lips (any separation of the lips), vertical mouth stretch (an extension of an open mouth characterized by a tautness at the lip corners coupled with a pronounced downward pull on the jaw), horizontal mouth stretch (a distinct horizontal pull at the corners of the mouth), taut tongue (a raised cupped tongue with sharp tensed edges), chin quiver (a high frequency up-down motion of the lower jaw), lip purse (the lips appear as if an "oo" sound is being produced), and tongue protrusion (tongue visible between the lips, extending beyond the mouth). A "pain face" includes the following cluster of facial actions: lowering of the brow, eyes tightly squeezed, deepening of the naso-labial furrow, mouth stretched open, and a taut tongue (Grunau & Craig, 1987; Grunau, Johnston & Craig, 1990).

Facial action has been criticized based on the fact that it may capture only initial pain reactions. However, in the case of acute pain, this is appropriate (McGrath, 1987). The NFCS, as in other behavioral measures of pain, can be expected to show the best reliability and validity when measuring short sharp pain (McGrath, Mathews, & Pigeon, 1991).

The NFCS shows good inter-rater reliability, ranging from .88 (Craig et al., 1988; Grunau & Craig, 1987) to .90 (Grunau et al., 1990). Facial action in general also shows

consistent relations with sensory and affective pain scales (Prkachin & Mercer, 1989).

With the NFCS in particular, Johnston, Stevens, Yang, and Horton (1995) found significant correlations (.3 to .6) between physiological measures of pain and facial action. Total facial activity was negatively correlated with latency to cry ($r = -.67$) and positively correlated with cry duration ($r = .44$) during injection (Grunau et al., 1990).

Latency to facial action was also significantly correlated with total facial action (Pearson $r = -.52$; Grunau & Craig, 1987).

The NFCS has been socially validated as signifying pain (Craig et al., 1988).

Adults' ratings of infants' sensation and discomfort during painful events were significantly related to facial action ($r = .65$), and 43% of the variance in ratings of discomfort were accounted for by the facial variables brow bulge, taut tongue, latency to facial movement, and vertical mouth stretch.

The NFCS also shows specificity to pain. For example, Grunau and Craig (1987) found that on the second day after birth, there was a significantly more facial action to heel lance than to heel rub. Grunau et al. (1990) found significant effects of procedure for total facial activity and latency to facial movement in full-term infants receiving either intramuscular injections, application of triple dye to the umbilical stub, and rubbing the thigh with alcohol. More facial action was present in the invasive versus the tactile procedures.

In the present study, a total of 30 continuous seconds of video tape, divided into 2-second segments, were scored on the NFCS for each subject. In order that the time periods coded were uniform, it was decided that the "baseline" interval would include the

10 second period immediately preceding the injection, the "injection" interval would include the 10 seconds beginning upon insertion of the needle, and the "recovery" interval would include the 10 second period immediately following the "injection" interval. Each interval was divided into five 2-second time periods, in which facial actions were scored as present or absent. Facial action was recorded using a Panasonic Camescope S-VHS AG-455P color camera and Super VHS T120 video tapes. A Panasonic Super VHS 4-head AG-1970 VCR and Panasonic CT-2084 19-inch viewable screen playback color monitor were used during video coding. Facial action coding using the NFCS system was carried out using slow motion and stop-frame feedback.

In addition to the NFCS, a Visual Analog Scale (VAS) was used to provide a global, unidimensional rating of the intensity of each child's pain during immunization. VAS most often consist of a 10 cm horizontal line with anchor words on each end defining the extreme limits of the pain experience. The person using the scale rates his or her pain by marking the line at the point which best corresponds to his or her level of perceived pain. VAS scales are simple to administer and score, practical, and frequently used (Carlsson, 1983). As VAS are continuous, they are preferable to discontinuous methods, such as numerical and verbal rating scales (Carlsson, 1983). VAS have shown evidence of providing ratio, rather than interval, level information, thereby allowing them to accurately estimate ratios of pain sensation intensity and percent changes in pain intensity (Price, Bush, Long, & Harkins, 1994).

Many studies have used VAS measures of pain with adults (e.g., De Conno et al., 1994; Doctor, Slater, & Atkinson, 1995; Price et al., 1994), and older children (e.g., Abu-

Saad & Holzemer, 1981; Adesman & Walco, 1992). In addition to their use as self-report measures of pain, VAS have also been used as proxy measures of pain in young children (e.g., Blount et al., 1997; Craig, Grunau, & Aquan Assee, 1988; Manne, Jacobsen, & Redd, 1992; O'Hara et al., 1987). Studies using VAS in this manner have found significant correlations between VAS proxy measures of pain and child self-reports of pain. For example, correlations in Manne, Jacobsen, and Redd (1992) were $r = .44$ (child-parent). Correlations in O'Hara et al. (1987) were $r = .70$ (child-parent). Finally, Blount et al. (1997) found that parental VAS report of pain to immunization was significantly positively related ($r = .25$) to child distress, and significantly negatively correlated ($r = -.23$) with child coping.

In this study, a 10 cm (100 mm) VAS scale was used to measure child pain (see Appendix I). Ten centimetres was chosen as generally VAS between 10 and 15 cm in length using anchors which clearly indicate extremes appear to have the greatest sensitivity and least susceptibility to bias or distortions in rating (Price & Harkins, 1992). The anchor points in this study were those used by parents to indicate their children's pain in O'Hara et al. (1987). The anchors were "no pain" and "pain as severe as it could be." VAS ratings were based on the observation of children's pain behavior, based on video-recordings of their immunizations. A VAS rating was made based on real time viewing of behavior during the "injection" time period.

Operationalization. As children's pain behavior was the single dependent variable of interest, two measures of pain were included in order that the appropriateness of the rating of pain in this study could be examined in greater detail. Because the VAS

provides a single metric to measure a very complex construct, it was intended to act as an adjunct to the NFCS. The NFCS, which rates pain based on multiple defined behaviors, rather than a global impression, was considered the primary measure of pain in this study and scores derived from the NFCS were used to represent sensitivity in all analyses. Child pain was therefore operationalized as children's summary scores on the NFCS, as rated by the primary coder. Three NFCS scores were calculated, one for each time period coded (baseline, injection, and recovery). Each of these scores was a summary score, representing the total sum of facial activity within that time period. As the total number of facial actions coded was 10, and they were coded within 5 two-second blocks during each 10 second time period, the total possible score during each time period ranged from 0 to 50, with higher scores indicating more facial activity, and therefore more pain. Analyses were replicated with children's pain scores based on their raw score VAS ratings (0 to 100), with no resulting changes in the patterns of significant and non-significant relations.

Reliability. Two coders, who were blind to the other variables for each infant-mother dyad, were trained on the NFCS. Before coding began, coders established reliability on a set of five training tapes provided by Craig. These tapes had previously been coded by persons experienced in the NFCS. Inter-rater reliability was calculated with the formula from Ekman and Friesen (1978), as recommended by Grunau and Craig (e.g., Grunau & Craig, 1987): $(\text{number of actions on which coder 1 and 2 agree}) \times 2 / \text{total number of actions scored by coders 1 and 2}$. This formula allows a conservative measure of agreement which does not take into account agreement of the absence of a facial

action. The inter-rater reliability on each facial action before coding began was as follows for the primary coder: brow bulge .914, eye squeeze .932, naso-labial furrow .940, open lips 1.00, vertical mouth stretch .970, horizontal mouth stretch .875, taut tongue .930, and tongue protrusion 1.00. The average agreement with the criterion tapes was .945. While no infant showed chin quiver or lip purse in the training tapes, there was 100% agreement between the coder and the criterion tapes that these facial actions never occurred. The inter-rater reliability on each facial action before coding began was as follows for the secondary coder: brow bulge .904, eye squeeze .924, naso-labial furrow .930, open lips .994, vertical mouth stretch .970, horizontal mouth stretch .900, taut tongue .865, and tongue protrusion 1.00. The average agreement with the criterion tapes was .935. While no infant showed chin quiver or lip purse in the training tapes, there was 100% agreement between the coder and the tapes that these facial actions never occurred. The inter-rater agreement between rater 1 and 2 on the training tapes was as follows: brow bulge .964, eye squeeze .952, naso-labial furrow .960, open lips .994, vertical mouth stretch .987, horizontal mouth stretch .880, taut tongue .933, and tongue protrusion 1.00. The average inter-rater agreement on the training tapes was .958. While no infant showed chin quiver or lip purse in the training tapes, there was 100% agreement between the coder and the tapes that these facial actions never occurred.

Twenty-five percent (15) of tapes were randomly selected and coded by a second rater to determine inter-rater reliability. The inter-rater reliability on the test tapes was: brow bulge .882, eye squeeze .879, naso-labial furrow .925, open lips .949, vertical mouth stretch 1.00, horizontal mouth stretch 1.00, taut tongue .923, and tongue protrusion

1.00. The average inter-rater agreement across facial actions on the test tapes was .945. While no infant showed chin quiver or lip purse in the tapes used for reliability, there was 100% agreement between the coders that these facial actions never occurred.

A separate pair of primary and secondary coders rated children's pain during immunization using the VAS. Before coding test tapes, coders achieved an inter-rater reliability intraclass correlation of .998 on a series of five training tapes. As in the case of the NFCS, the second rater completed the VAS in 25% (15) of randomly selected cases, so that inter-rater reliability might be assessed. Their inter-rater reliability, using an intraclass correlation, was .991.

In order to determine the comparability of these two measures in rating child pain during immunization, each child's score on the NFCS was compared to his or her score on the VAS. As mentioned, these two scores came from separate raters, blind to the other factors of interest in the study. For this comparison, Spearman's $r = .881$. This suggests that these two measures were capturing the same construct in this study.

Pain Stimulus

Needle pain was used as the pain stimulus in this study. Injections are a routine, necessary, frequently studied source of pain in children (e.g., Craig et al., 1984). Needle pain also has methodological advantages over other types of pain. It provides a uniform stimulus with a specific time of onset. It is also relatively easy to unobtrusively observe reactions to needle pain (Craig et al., 1984). Needle pain also causes a wide variety of pain responses in children (Craig et al., 1984). For example, Fradet et al. (1990) found that with venepuncture in children 3-6 years old, 36-64% of children experience moderate

to severe distress, while the other children displayed no distress or mild distress.

The particular needle which was administered in this study consisted of the following. The syringe was a B-D[®] 3cc Syringe by LUER LOK[®], manufactured by Becton Dickinson & Co., Franklin Lakes, NJ, 07417-1884, USA (Reorder #309585). The needle was a 25 Gauge 5/8" PrecisionGlide[®] Needle, manufactured by Becton Dickinson & Co., Franklin Lakes, NJ, 07417-1884, USA (Reorder # 305122). The bolus, which was given intramuscularly, consisted of .05 mL Haemophilus b Conjugate Vaccine (Tetanus Protein-Conjugate) Act-HIB[®] vaccine, and .05 mL of Diphtheria and Tetanus Toxoids Absorbed and Pertussis Vaccine and Inactivated Poliomyelitis vaccine. The vaccines were manufactured by Pasteur Mérieux Sérums & Vaccins, AS, Lyon, France, and distributed by Connaught Laboratories, Ltd., North York, Ontario, Canada. The syringe, needle, and bolus were identical for the 6- and 18-month-old groups.

Procedure

This study was conducted using a cross-sectional design. During the first section of the study, participants were asked to come to the Psychology Department at Dalhousie University. Even though a home visit is often recommended for sensitivity Q-sort coding, the visit was conducted in the laboratory due to the lack of portability of the EKG equipment. Some advantages are associated with using a controlled laboratory environment instead of individual home settings when rating maternal sensitivity. For example, this environment allows the experimenter to observe mother-child interaction within a standard environment, whereas home settings are varied and may introduce

uncontrolled variance when comparing individual differences (e.g., Matheny et al., 1985).

There are also advantages of placing competing demands on mothers' attention and observing how this division is dealt with. Pederson et al. (1990) say that "sensitivity is best examined under circumstances where the mother is unable to devote her attention solely to the demands of her infant" (p. 1981). Situations in which mothers' attention can be focused completely on their infants, such as free play, may mask most individual differences in sensitivity (Pederson et al., 1990). Situations in which mothers are distracted from infant cues, however, may be more effective in demonstrating individual differences, as more variability in behavior occurs under stress. Other studies have used similar paradigms successfully to elicit individual differences in maternal sensitivity (Smith & Pederson, 1988). In addition, as mothers are asked to complete several tasks in this study (e.g., EKG recording, interview, questionnaires), they had the opportunity to show a varied sample of mother-child interaction.

Upon their arrival, mothers were thanked for coming and shown into the test room, which was designed as a "living room" with two sections divided by a curtain. The "front" of the room was 9 ½ feet wide and 12 ½ feet long, and contained toys, a chesterfield, two chairs, a playpen, a coffee table, and a child-sized table with two chairs. The "back" of the room was 9 ½ feet wide and 9 feet long and contained the EKG equipment, computer, television, and VCR. If additional children, other than the child participating in the study, accompanied the mother, babysitting services were provided in a room adjacent to the test room. If fathers accompanied mothers, they were given the option of completing questionnaires about their child, or simply waiting for the study to

be completed in a separate room.

Once in the test room, the procedure was explained to mothers (in the same fashion as over the telephone) following a second standard script (see Appendix J). Mothers still wishing to be involved in the study at this time were asked to sign a consent form (see Appendix K) for their and their child's participation in the study, and they were informed of their right to discontinue the study at any time.

The first task consisted of recording the child's resting EKG. Children were asked to sit in their mothers' laps during recording, as in previous studies (Calkins & Fox, 1992; Porges et al., 1994; Richards, 1995; Stifter & Fox, 1990). Three electrodes (Thought Technology, Ltd., Montreal, Canada, MIEP02-00) were placed in a triangular pattern on the child's chest for recording: one active electrode above the right breast near the shoulder, another above the left breast, and the reference electrode under the right breast. Children were given a brief adjustment period to the presence of the electrodes before recording began, in an attempt to allow them to become comfortable with the apparatus. Since vagal tone is responsive to context and to changes in breathing rate and depth, efforts were made to reduce this variation as much as possible and to collect data under similar affective conditions (Field et al., 1995). In adults, training breathing to occur with a metronome has been used to control variation. As this is not possible with infants, efforts were made to test all infants while they were awake and quiet, so that while breathing was uncontrolled, it was quiet and spontaneous. Children were also presented with a segment of the children's television show *Sesame Street* during recording to help control contextual cues and psychological state during vagal tone assessment. This

methods has been used in previous studies of vagal tone (e.g., Fox, 1989; Healy, 1989).

For each child, a 5-minute (variable) segment of continuous stationary EKG was collected. This signal was visually monitored for artifact during recording. If there appeared to be large amounts of artifact present, the recording period was extended in an effort to collect a continuous 3-minute signal that was relatively clean.

Following EKG recording, mothers were asked to provide some basic background information during a standard interview. During this interview, they were also asked to respond to questions designed to tap information required by the MBQ which would not be observed in the laboratory. This interview was tape-recorded with each mother's permission, due to the difficulty in manually recording some of the broad responses to the background questions asked. No mother declined to be tape-recorded.

Following the interview, mothers were asked to fill out a series of questionnaires. Mothers first completed the Bates' temperament questionnaire appropriate for the age of their child (either the 6-month or 24-month version; Bates, Freeland, & Lounsbury, 1979). Mothers were then asked to complete the Parenting Stress Index (Abidin, 1995). Throughout this period, children were left free to play in the test room and mothers' reactions to their children's cues were observed.

When the questionnaires were completed, mothers were thanked for their participation. The time the child was scheduled to receive his or her needle at Dalhousie Health Services was noted and a time to meet at the clinic was arranged. Mothers were then informed about what would occur during the second visit. The entire session took approximately an hour and a half to two hours to complete.

Immediately following mothers' departures from the Psychology Department, the Maternal Behavior Q-sort (Pederson et al., 1990), and the Ainsworth et al. (1974) Sensitivity Scale were completed, while the rater was blind to the child's temperament status and vagal tone level.

The second section of the study occurred during the child's needle appointment at Dalhousie Health Services. This appointment was scheduled by mothers at their convenience during the same month as the first visit. Due to mothers' individual schedules, and child variables such as illness, the time between the first and second part of the study ranged from zero to 28 days ($M = 8.15$ days, $SD = 7.33$ days). Needles were given throughout the day, depending upon mother's individual schedules. The time of day at which needles occurred ranged from 9 a.m. to 8:30 p.m. During this visit, mothers were met in the waiting room of Dalhousie Health Services on the day of their child's regularly scheduled appointment. While waiting for their appointment, mothers were asked, using a standard scrip (see Appendix L), to fill out a rating scale for their own anxiety surrounding their child's needle. The experimenter accompanied mothers and children into the nursing office in order to record each child's height and weight. Then, the experimenter waited in the waiting room during children's appointments with their physicians.

When children were finished with the physician visit, and received permission to have their needle, the experimenter returned to the nursing office with mothers and children. During the needle, mothers were asked to sit in a standard chair which remained in the same location throughout the study. Mothers were asked to hold their

children in the manner in which the nurse requested, so as to expose their thigh or arm during the needle. Then, the experimenter positioned herself with the camera to record the best-possible view of children's faces. At this time, mothers were reminded of the importance of keeping children's faces unobstructed during the needle. Finally, recording began. Recordings were made from the time before children's legs or arms were swabbed until approximately one minute after the needle was withdrawn (approximately two minutes in total).

In order to standardize the conditions under which needles occurred, the doctors and nurses of the clinic conducted immunizations in a uniform manner. Most needles (75%) were given by the clinic's two regular full-time day nurses. Six other persons gave the remaining 15 (25%) needles. All 6-month-olds received their needle in their upper thigh. At 18 months, 19 children (63%) received their needle in their upper thigh, and 11 children (37%) received their needle in their upper arm, according to individual physician instructions and parental request.

After the recording was completed, the experimenter left the office and waited for mothers in the waiting room. When mothers returned with their children, they were thanked for their participation. Any questions were answered and mothers were asked permission to be contacted with information about future studies. No mother declined.

Following the second visit, video tapes were used to code child state prior to immunization, to code the infants' pain behavior during immunization using the NFCS (Grunau & Craig, 1987) and the VAS, and to code maternal verbalizations during the immunization using the CAMPIS-R (Blount et al., 1990).

CHAPTER 3. RESULTS

Overview

All primary and secondary hypotheses were examined using SPSS/PC for Windows, version 6.1.3. In accordance with Keppel, Saufley, and Tokunaga (1992), corrections for multiple hypothesis tests were not used with planned comparisons. Rather, the null hypotheses were rejected at the usual per comparison probability level ($p < .05$). However, with unplanned comparisons, corrected alpha levels were used on a familywise level, as recommended by Shaffer (1995). Refer to Appendix M for a summary of the main independent and dependent variables used in the analyses. As independent samples t-tests indicated that there was no difference in the pain behavior (NFCS summary score during injection) of 18-month-olds given their immunizations in their arm versus those their thigh, all 18-month-olds were grouped in data analyses.

Preliminary Analyses

Examination of Demographic Characteristics Between Age Groups

Prior to the main analyses, tests were conducted in order to determine the equivalence of demographic background variables across age groups. Independent samples t-tests were conducted for continuous variables, and chi-square analyses were conducted for categorical variables. Corrected p values were not used in this case, in order that the chance to uncover confounding variables be maximized. No differences were found in either maternal variables (maternal age, marital status, ethnic group, educational level, employment status), or paternal variables (ethnic group, educational

level, employment status) between the 6 and 18 month age groups, with one exception. Mothers of 6-month-olds were significantly more likely to be on maternity leave than were mothers of 18-month-olds, $\chi^2(1) = 8.333$, $p = .004$, which is hardly surprising given family leave provisions in Canada of 25 weeks. No differences were found between groups in demographic familial variables (SES, number of persons in the family, number of children in the family) or child variables (birth order, child sex, birth weight, gestational age, ethnic group). It appears that the two groups were equivalent, based on measures of background characteristics. Therefore, these factors should not serve as confounding variables in further analyses. See Appendixes N and O for a summary of scores on continuous and categorical demographic variables, respectively, at each age.

Examination of Major Variables Between Age Groups

Prior to the main analyses, tests were conducted in order to determine that the main predictors and dependent variable were equivalent across age groups. Several of the factors predicting children's pain behavior and children's pain behavior itself were expected to exhibit developmental changes. The characteristics of children's scores on the primary and secondary predictors, and independent samples t-tests for age-related changes in the predictors were examined (see Table 7). These tests revealed no age-related changes in the predictors of children's pain behavior ($p > .05$). Chi-square analyses were conducted for nursing status, and again, no age-related differences were found. Children were not more likely to have a regular clinic nurse at 6 months than at 18 months of age, $\chi^2(1) = .200$, $p = .655$, nor were they more likely to have a non-regular clinic nurse at 6 months than at 18 months of age, $\chi^2(1) = .600$, $p = .439$.

Insert Table 7 About Here

Therefore, according to these tests, mean child vagal tone level (the log-transformed score based on children's raw scores) did not significantly increase from 6 ($M = -.533$, $SD = .388$) to 18 months of age ($M = -.435$, $SD = .384$), $t(58) = .99$, $p = .325$, although changes were in the expected direction. Also contrary to hypotheses, maternal behavior did not significantly change with child age. Mothers were not less distracting (based on the proportion of Coping Promoting behavior coded on the CAMPIS-R) with their 6-month-olds ($M = .228$, $SD = .388$) than with their 18-month-olds ($M = .299$, $SD = .367$), $t(58) = .73$, $p = .468$, and they were not more reassuring (based on the proportion of Distress Promoting behavior coded on the CAMPIS-R) with their 6-month-olds ($M = .364$, $SD = .412$) than with their 18-month-olds ($M = .206$, $SD = .250$), $t(58) = 1.79$, $p = .078$. However, based on the mean number of comments mothers made across the time periods studied (baseline, injection, and recovery), they were significantly more interactive with their 18-month-olds ($M = 6.933$, $SD = 2.572$) than with their 6-month-olds ($M = 4.700$, $SD = 2.641$), $t(58) = 3.32$, $p = .002$.

The characteristics of children's pain scores on the NFCS (the dependent variable) as well as independent samples t-tests for age-related changes in children's pain behavior were examined (see Table 8). There were no significant changes in children's pain behavior (their summary scores reflecting their total facial activity based on the NFCS within each time period) from 6 to 18 months of age during the baseline, injection, or

recovery period ($p > .05$). Although there were no changes in pain behavior between groups, paired samples t-tests revealed an interesting age-related pattern in the mean levels of facial action within age periods (see Table 8). At 6 months of age, the total amount of facial action during the baseline period was significantly lower than the total amount of facial action during the injection, $t(29) = 5.12$, $p = .000$, while facial action during injection did not significantly differ from that during recovery, $t(29) = 1.34$, $p = .191$. At 18 months of age, facial action during the baseline period also was significantly lower than facial action during injection, $t(29) = 5.62$, $p = .000$. At this age period, however, the total amount of facial action during injection was significantly higher than that during recovery, $t(29) = 2.43$, $p = .022$.

Insert Table 8 About Here

Overall, the results of analyses examining age-related changes revealed few significant differences. It appears that within the age span examined, and with this particular type of pain, there were relatively few age-related differences in the factors influencing the pain experience, or in the behavioral expression of pain.

Examination of Relations Among Independent Variables

Prior to the main analyses, relations between the main predictor variables were examined using Pearson correlations, in order to determine that variables which were not theoretically related were indeed orthogonal. Relations were expected between variables representing child and maternal constructs, respectively. All predictor variables were

orthogonal ($p > .05$) at both 6 (see Table 9), and 18 months of age (see Table 10), respectively.

Insert Tables 9 and 10 About Here

Contrary to hypotheses, neither child nor maternal variables, respectively, were related. Children's vagal tone scores and mothers' ratings of child difficulty (based on their average difficulty scores on the ICQ) were not significantly correlated at either 6 ($r = -.182$, $p = .337$) or 18 months of age ($r = -.015$, $p = .937$). Further, measures of immediate maternal behavior (based on the ratio of the proportion of Coping Promoting to Distress Promoting maternal behavior on the CAMPIS-R) and measures of general maternal behavior (based on mothers' r scores on the MBQ) were also not significantly correlated at either 6 ($r = -.191$, $p = .312$) or 18 months of age ($r = -.227$, $p = .229$). Therefore, each variable entered into the main analysis was independent of each other variable entered into the main analysis.

Primary Analyses

Examination of Primary Predictors and Child Pain Behavior

It was predicted that at 6 months of age, children's individual levels of reactivity, as represented by child vagal tone and child temperamental difficulty, would be the strongest predictors of child pain response. At 18 months of age, however, parenting context, as represented by maternal behavior during child pain and maternal sensitivity,

was predicted to be the strongest predictor of child pain response. According to the literature, the direction of significant relations between the main predictors and child pain behavior (the sum of facial activity based on the NFCS occurring within the "injection" period) predicted was as follows: positive relations with child vagal tone level, maternal reports of child difficulty, and observer reports of maternal sensitivity, and negative relations with the observer ratings of the ratio of Coping Promoting to Distress Promoting maternal behavior during immunization.

In order to examine the main hypotheses, a stepwise regression model was employed. Although hierarchical regression is generally preferred over stepwise methods, as it requires the examiner to specify the order of variable entry into the regression equation based on theory (see Cohen & Cohen, 1983), a stepwise approach was used in this case in order to test the hypotheses concerning the relative importance of each variable at each age period. A stepwise approach allows identical sets of variables to be entered into the regression equation at each age period. Further, due to the equivalent sets of variables entered into the stepwise regressions, the possible amount of variance each variable can account for across age periods is also equivalent. This would not be the case with two separate hierarchical models (one for each age period) based on the hypotheses, as the variables predicted to be of importance (and therefore their orders of entry into the equation) differ between age periods.

The stepwise regression equation was set to select variables for acceptance into the model according to the following criteria. If the probability of the F test associated with each variable was less than or equal to 0.05, the variable was accepted into the

model. After its entry into the model, each variable was examined for removal, based on whether or not the probability of the associated F test was 0.10 or greater. This process was carried out beginning with the variable which accounted for the greatest proportion of variance, and continued for the remaining variable with the highest partial correlation, until no further variables were accepted into the model and the procedure terminated.

The following factors were entered into the stepwise regression predicting child pain at both 6 and 18 months of age: child vagal tone level, maternal report of child difficulty, the ratio of Coping Promoting to Distress Promoting maternal behavior during immunization, and observer ratings of maternal sensitivity. According to the hypotheses, it was expected that the stepwise regression equation would select child vagal tone and child difficulty into the regression model at 6 months, while at 18 months the model would select maternal behavior at the time of the needle and maternal sensitivity into the model. Finally, the direction of the relations between the main predictors and child pain behavior were examined using Pearson correlations.

The primary stepwise regression analyses indicated that at 6 months of age, maternal behavior during immunization and child difficulty met the criteria to be included in the regression model predicting child pain during immunization (see Table 11). Collectively, these variables accounted for 44% of the variability in child pain behavior. However, at 18 months of age, maternal sensitivity and child vagal tone met the criteria to be included in the regression model predicting child pain during immunization (see Table 11). Collectively these variables accounted for 35% of the variability in child pain behavior. Although these analyses do not support the primary hypotheses, based on

Pearson correlations between the predictor variables and child pain (see Table 12), all significant correlations were in the predicted directions.

Insert Tables 11 and 12 About Here

Examination of Interactions Between Child and Maternal Variables
in the Prediction of Child Pain Behavior

Following the primary analyses, interactions between maternal and child variables were investigated at both 6 and 18 months of age. Based on previous research, it was thought that children with more "vulnerable" reactional styles (i.e., children with higher vagal tone and difficulty scores) would be more susceptible to the effects of maternal behavior than would children with less "vulnerable" reactional styles. However, these analyses were considered exploratory.

Interactions between child and maternal variables were examined using regression models. In accordance with Cohen and Cohen's (1983) guideline that an interaction term cannot be examined in a regression model before each of its components have been entered into that model, in each model the child and maternal variable of interest were entered simultaneously into the first block of the regression, while the interaction term was entered into the second block. Further, following Cohen and Cohen's (1983) recommendation that the F test for a set of independent variables be significant before its constituent independent variables are t tested (the protected t test), the significance of interaction terms was only examined when the overall model was significant. The

following interactions were examined: Child Vagal Tone x Ratio of Maternal Coping/Distress Promoting Maternal Behavior, Child Vagal Tone x Maternal Sensitivity, Child Difficulty x Ratio of Maternal Coping/Distress Promoting Maternal Behavior, and Child Difficulty x Maternal Sensitivity. Because of the exploratory nature of these analyses, no attempts to correct for Type 1 error were made, in order that the number of possible directions for future research might be maximized. Refer to Appendixes P and Q for a summary of these analyses at 6 and 18 months, respectively.

There was only one case in which both the overall model predicting child pain and the interaction term were significant. At 6 months of age, the overall model including Child Vagal Tone, the Ratio of Coping to Distress Promoting Maternal Behavior, and the interaction term was significant ($R^2 = .375$), $F(3, 26) = 5.206$, $p = .006$. In this regression, the interaction term significantly contributed to the overall model $t(26) = 2.159$, $p = .040$, while the ratio of Coping to Distress Promoting Maternal Behavior was no longer significant [$t(26) = .009$, $p = .993$]. When this interaction was examined further, it was found that among children with higher vagal tone (based on a median split), maternal behavior at the time of the needle was unrelated to child pain response ($r = -.290$, $p = .294$). However, among children with lower vagal tone, the ratio of Coping/Distress Promoting Maternal Behavior was significantly negatively correlated with child pain ($r = -.623$, $p = .013$).

There was little support that children with more “vulnerable” reactional styles were more susceptible to parental influences during pain. In fact, the only significant interaction found was in the opposite direction of that which was predicted.

Secondary Analyses

Examination of Situational Confounds and Child Pain Behavior

After the primary analyses were completed, a second set of regression analyses was conducted, based on patterns of relations noted in the correlation matrices between secondary predictor variables and child pain behavior. Pearson correlations indicated that observer ratings of child state (on a 0 to 6 point scale, with higher scores indicating less aroused states) before the immunization were related to child pain at both 6 ($r = -.428$, $p = .018$) and 18 months of age ($r = -.543$, $p = .002$). Pearson correlations also indicated that whether or not the person administering the immunization was a regular daytime clinic nurse was related to child pain on the NFCS at 6 months ($r = .589$, $p = .001$), but not at 18 months of age ($r = .232$, $p = .217$). It was thought that these variables might represent "situational confounds" which could affect the relations between the other predictor variables and child pain behavior. Due to this concern, a second set of regression equations was calculated with these two variables entered simultaneously into the first block of a two-block model, in order that the variance they collectively accounted for might be controlled. In the second block, the initial stepwise regression with the primary predictors was repeated. At 6 months of age, the inclusion of nurse (regular or non-regular) and observer ratings of child state significantly increased the total amount of variance accounted for in child pain on the NFCS from 44% to 61%, $F(2, 26) = 7.188$, $p < .05$ (see Table 13). The pattern of variables selected as significant in the stepwise regression did not change with the entry of the "situational confounds" into the first step of the regression model. At 18 months of age, the inclusion of nurse (regular or non-

regular) and observer ratings of child state significantly increased the total amount of variance accounted for in child pain on the NFCS from 35% to 49%, $F(1, 26) = 13.05$, $p > .05$ (see Table 13). At this age, however, with nurse status and child state included in the regression equation, the log of child vagal tone level was no longer accepted into the model. Most likely, the relatively low proportion of variance in child pain behavior this variable accounted for was reduced substantially enough by the addition of nursing status and child state into the model that it no longer met the criteria necessary to be included in the model.

Insert Table 13 About Here

Based on the second set of regression analyses, an interesting developmental pattern emerged. At 6 months of age, both maternal report of child difficulty and whether or not the person administering the needle was a regular clinic nurse interacted in predicting observer ratings of child state prior to immunization. A regression equation including the average of maternal reported difficulty on the ICQ, nurse status, and the interaction term significantly predicted the variability in observer report of child state before immunization ($R^2 = .436$), $F(3, 26) = 6.707$, $p = .002$. Of these individual variables, only the interaction term contributed significantly to the overall model, $t(26) = 2.718$, $p = .012$. Further examination of the data revealed among children with regular clinic nurses, observer report of child state was not related to maternal report of child difficulty on the ICQ ($t = .176$, $p = .446$). However, among children with non-regular

nurses, observer report of child state (recall that more aroused states are indicated by lower scores on the 0 to 6 point scale) was significantly related to maternal report of child difficulty on the ICQ ($r = -.706$, $p = .033$). When identical analyses were conducted at 18 months of age, the overall model was not significant ($R^2 = .149$), $F(3, 26) = 1.518$, $p = .233$, and therefore the contributions of the individual variables were not examined.

Examination of the Role of Maternal Psychological Variables

After the primary analyses were completed, the roles of maternal stress and anxiety in child pain behavior were examined, in order to provide a more comprehensive picture of the complex interaction of variables involved in the pain experience. Previous research has suggested that maternal behavior during incidents of child pain may be affected by overall maternal stress level. Therefore, relations between the ratio of maternal Coping Promoting to Distress Promoting behavior during the injection and mothers' self-reports of stress (percentile rank on the PSI) were examined using Pearson correlations. Because parental reassurance (which should decrease) and parental agitation (which should increase) are both considered to be "Distress Promoting" behaviors on the CAMPIS-R, the direction of the overall relation between these factors was unknown. The results indicated no significant relation between the ratio of Coping/Distress Promoting maternal behavior and self-reported maternal stress at either 6 ($r = .053$, $p = .782$) or 18 months of age ($r = -.052$, $p = .785$).

These results were followed up with a second set of analyses, in order to determine whether or not stress moderated the relation between maternal pain response and child pain behavior. First, patterns of relations between maternal behavior and child

pain behavior were examined with the effects of maternal stress removed through the use of partial correlations. The patterns of relation between the ratio of Coping to Distress Promoting maternal behavior and child pain behavior during the injection did not change with stress partialled out. Maternal behavior was still significantly related to child pain at 6 months of age ($r = -.513$, $p = .004$), and still not significantly related to child pain at 18 months of age ($r = -.353$, $p = .060$).

Second, a multiple regression analysis was used to examine possible interactions between maternal behavior during immunization and maternal stress at each age period. Once again, maternal behavior and maternal stress were entered simultaneously in the first block of the regression, while the interaction term was entered in the second block. At 6 months of age, the overall model for stress and maternal behavior in predicting child pain was significant ($R^2 = .308$), [$F(3, 26) = 3.869$, $p = .021$]. However, the interaction term did not contribute significantly to the overall model [$t(26) = .898$, $p = .377$]. At 18 months of age, there was no significant effect of stress and maternal behavior ($R^2 = .230$), [$F(3, 26) = 2.588$, $p = .075$], and therefore the unique contributions of the individual variables in the regression model were not examined.

It was thought that if immediate maternal behavior at the time of the needle and general patterns of maternal behavior (sensitivity based on the MBQ) were not related, stress or anxiety would moderate this discrepancy. As these two predictor variables were not related, relations between maternal behavior and sensitivity were re-examined with anxiety or stress, respectively, controlled through the use of partial correlations, with no resulting change in the pattern of correlations. With maternal self-reports of stress

partialled out, there was still no significant relation between maternal behavior (the ratio of Coping to Distress Promoting maternal behavior) and maternal sensitivity at either 6 ($r = -.189$, $p = .327$) or 18 months of age ($r = -.221$, $p = .249$). With maternal self-reports of anxiety (on the 0 to 10 point scale) partialled out, the same pattern resulted. There were still no significant relations between the two predictor variables at either 6 ($r = -.207$, $p = .249$) or 18 months of age ($r = -.246$, $p = .198$).

Finally, maternal anxiety has been proposed to play a role in children's pain responses. Therefore, relations between maternal self-reports of anxiety and children's pain during immunization were examined. It was expected that maternal anxiety (mothers' self-reports on the 0-10 point scale) prior to immunization would be positively related to child pain behavior during immunization. Pearson correlations revealed no significant relations between maternal anxiety prior to child immunization and child pain behavior during immunization at either 6 ($r = -.116$, $p = .540$) or 18 months of age ($r = .178$, $p = .347$).

In this study, the inclusion of maternal psychological variables did not enhance the understanding of children's pain experiences. Maternal stress and anxiety played neither a primary nor a moderating role in influencing the factors involved in this particular type of pain experience (immunization pain) at these particular age periods (6 or 18 months).

CHAPTER 4. DISCUSSION

Overview

Based on the findings of this study, the primary hypotheses were not supported, although the data did suggest developmental shifts in the factors predicting children's pain behavior, within the confines of the design. Each of the proposed hypotheses will be examined, the findings will be reviewed, and possible explanations for the pattern of findings will be discussed.

Review of Preliminary Analyses and Discussion of Findings

Age-related Changes Between Groups

Contrary to hypotheses, few age-related changes were found in the factors predicting children's pain behavior, or in children's behavioral expressions of pain. Specifically, mean vagal tone level did not significantly increase from 6 to 18 months of age, although means levels did change in the expected direction. In general, maternal behaviors also did not change with child age. Mothers were not significantly more reassuring with 6-month-olds than with 18-month-olds, and they were not significantly more distracting with 18-month-olds than with 6-month-olds, based on the proportion of their verbalizations during immunization which was Distress Promoting or Coping Promoting, respectively, according to the CAMPIS-R. Finally, children's behavioral expression of pain, based on their facial activity during immunization, did not significantly decrease from 6 to 18 months of age.

Several factors may have been involved in the general lack of age-related changes

in this study. First, the age groups examined may have been too narrow to capture age-related changes in the factors predicting pain, or in children's pain behavior. Indeed, studies reporting age-related changes in vagal tone level examined wider age-ranges (9 months versus 3 years in Porges et al. 1994), as did studies reporting age-related changes in maternal behavior during pain (2-12 months vs. 13-24 months in Craig et al., 1984).

Studies reporting age-related changes in pain behavior also examined older age groups, and compared wider age-ranges (e.g., 3-9 years in Blount et al., 1991; 4-7 years in Dahlquist et al., 1995; 2-7 years in Dahlquist et al., 1994; 4-6 years in Fowler-Kerry & Lander, 1987; 13 months-7 years in Gonzalez et al., 1989; 3-10 years in Jacobsen et al., 1990; 36-112 months in Manne et al., 1993). The only study reporting age-related changes in pain behavior which included infants under one year of age was Craig et al. (1984). In this study, the participants were broadly grouped into "younger" children (ages 2-12 months) and "older" children (13-24 months). Craig et al. (1984) found that during immunization, "younger" children vocalized (screamed) more and exhibited more torso rigidity than did "older" children. These age-related changes may have resulted from the children at the extreme age-ranges of each group. With the inclusion of a wider age-range in this study, the predicted differences in vagal tone, maternal behavior, and child pain behavior may have been found.

Second, the nature of the pain stimulus in this study (short, sharp, medically-related pain) may have played a role in the lack of age-related changes found. Although the type of pain could not have affected children's resting vagal tone levels, it may have affected parental behavior during child pain, and child pain expression. For example,

perhaps mothers' behavior during such short, quick incidents of pain does not display as much age-related variability as it does during longer-lasting, more distressing procedures, such as bone marrow aspirations or lumbar punctures. Further, child pain behavior to this type of stimulus may also not exhibit the same age-related changes as it does during longer lasting procedures, where children would presumably have to endure more pain and therefore be asked to exhibit greater pain tolerance and self-control. However, as Craig et al. (1984) found age-related changes in maternal behavior and in child pain expression in their study of immunization pain, alternative explanations are more likely.

Third, the particular measures used in this study may have played a role in the lack of age-related changes found, as they differed from those used in previous studies reporting age-related changes in vagal tone, maternal behavior, and child pain. For example, Porges et al. (1994), who found age-related changes in child vagal tone level, did not use the method of vagal tone calculation used in this study. Instead, they used Porges' method of vagal tone calculation. However, as previously mentioned, Porges' method correlates well with spectral methods of vagal tone calculation (e.g., Grossman et al., 1990; Litvack et al., 1995). Despite these previous studies showing the overlap of findings with Porges' method and other techniques, further study is needed to explore relations in further detail (e.g., across a variety of sampling epochs, sample ages, and pain stimuli). Craig et al. (1984), who found age-related changes in both maternal behavior and child pain expression during immunization, did not use the measures of maternal behavior and child pain used in this study. Instead of the CAMPIS-R, Craig et al. (1984) used real-time observation of parental behavior, coding the category occurrence

of verbal actions to the child (e.g., praise, criticism, distraction, soothing, procedural statement, other), verbal actions to another person (about child, procedural statements, unrelated to child, no verbalization), or nonverbal behavior (pain expression, vocal pain, physical distortion, soothing, physical restraint). The age-related changes which Craig et al. (1984) reported in children's pain behavior were based on measures of vocalization (screaming) and torso rigidity, neither of which was used to measure child pain behavior in this study. It may be that certain maternal and child behaviors (e.g., screaming) are sensitive to age-related changes early in life, while others (e.g., facial activity) are not. Age-related changes may not be uniform across all measures used to assess maternal and child behavior during incidents of child pain.

Despite the preponderance of null findings, data analyses did reveal two age-related changes. First, mothers were found to be significantly more interactive with their 18-month-olds than with their 6-month-olds during immunization, based on the mean number of comments they made across the time periods studied (baseline, injection, and recovery), as was found in previous studies (e.g., Dahlquist et al., 1995). This may reflect the developmental changes which occur in language between 6 and 18 months of age. By 18 months, children are much more verbally interactive with their parents than they are at 6 months. Parents, in turn, may respond to children's language levels, and attempt to interact with 18-month-olds during periods of stress through verbal means, while interactions with younger child may involve more non-verbal communication (e.g., rocking or stroking the child).

Second, while there were no age-related changes in pain behavior within any

phase of the procedure, there were age-related changes in the patterns of relation between phases of the procedure. At 6 months, infants showed significantly more facial activity during injection than during baseline, which was expected. However, there was no difference between their facial activity during the injection and recovery period, indicating that they were not able to calm themselves within the relatively short time period measured. At 18 months of age, children also showed more pain behavior during injection than during baseline. At this time, however, they also showed significantly more facial activity during injection than recovery, indicating that they were able to calm within the time period measured, unlike the 6-month-olds. This pattern may be interpreted in terms of emotion regulation.

Emotion regulation is an individual difference variable which indexes "the processes and the characteristics involved in coping with heightened levels of positive and negative emotions including joy, pleasure, distress, anger, fear, and other emotions" (Kopp, 1989, p. 343). Emotion regulation may underlie the degree of behavioral expression accompanying negative emotions, including those surrounding pain. Emotions have, in fact, been reported to play an integral role in both the subjective experience of pain and in the behavioral expression of pain, and emotional distress may be the best indicator of the presence of pain (Craig, 1994).

In addition to influencing children's pain expressions, emotion regulation may also influence children's abilities to self-calm and cease emotional displays following periods of distress. According to theories of emotion regulation, the skills involved in self-calming should change with development. Children should move from an inability to

regulate their emotions and restrain their behavior (Kagan, 1994) to an ability to regulate and organize their emotions (Spangler et al., 1994). Therefore, the 6-month-old group may have continued to display significant facial activity during the recovery period as they were not able to calm themselves as quickly after the distressing incident (immunization) as the 18-month-olds, due to their weaker skills in regulating their emotions and regaining emotional control after a period of disorganization.

Despite these findings, the fact remains that age-related changes were not generally found in the factors predicting child pain, or in child pain expression. The most important thing this lack of age-related findings indicates is that we should not expect uniform patterns with regard to the factors involved in children's pain, or in children's behavioral expressions of their pain. Pain is an extremely complex phenomenon, and it appears that the factors predicting its behavioral expression are equally complex. While some age-related changes may be uniform across many age periods, types of pain, and measurement strategies, others may not. It is therefore of primary importance in assessing and managing children's pain to take the age of the child, source of the pain, and measures involved into consideration.

Relations Among Predictor Variables

It was expected that variables which were proposed to represent biologically-based child reactivity level and maternal behavior, respectively, would be related. However, no patterns of relation were found between child vagal tone level and child temperamental difficulty, or between immediate maternal behavior (the ratio of the proportion of Coping to Distress Promoting maternal vocalizations) and maternal

sensitivity. The patterns of results expected and possible reasons for the lack of relations found will be discussed for child and maternal variables, in turn.

Child Vagal Tone and Child Temperament

It was hypothesized that child vagal tone would be positively related to child difficulty. It was found, however, that contrary to previous studies (e.g., Healy, 1989; Porges et al., 1994; Stifter & Fox, 1990), measures of child reactivity were unrelated. It appears that, based on the measures used in this study, child vagal tone and child difficultness represented different components of reactivity.

The particular measures chosen to represent child temperament in this study may have played a role in the lack of relation between child vagal tone and child difficulty, as the measures differed from those used in previous studies which did find relations. Only one previous study finding relations between child vagal tone and child temperament used the ICQ to assess child temperament (Porges et al. 1994), and, in fact, many of the studies used observational measures of child temperament (e.g., vocalization in Field et al., 1995; reaction to peek-a-boo and arm restraint in Fox, 1989; observation of child with toys and unfamiliar person in Healy, 1989; reaction to peek-a-boo and arm restraint in Stifter & Fox, 1990), in addition to or instead of maternal report via questionnaire. Not all behavioral and pencil-and-paper methods of measuring child temperament may represent reactivity in a similar manner.

One important difference between the measures used to represent child vagal tone and child difficulty in this study which may have affected the results was their source. Vagal tone was a physiologically-based variable, whose measurement was relatively

independent. Child difficultness, however, was not objective, and instead was based on maternal reports of infant temperament. As a result of the source, the time period assessed by each measure also differed. Maternal reports of child temperament were presumably based on patterns of behavior displayed on a daily basis, over many occasions. The measure of vagal tone, although intended to reflect general resting vagal tone level, was based on a single occasion. Perhaps a composite measure of child vagal tone based on several assessments of vagal tone over several time periods would have provided a better estimate of general vagal tone level, which would then have been related to child temperament. Conversely, perhaps an observer report of child temperament on a single occasion would have been related to the single measure of child vagal tone level used in this study.

In addition to the majority of studies which reported relations between child vagal tone and child temperament, a few studies, in addition to the present study, did not find relations (see Table 2). In these studies, whether or not vagal tone was related to child temperament seemed to be a factor of the age-period under study. For example, Fox (1989) found that vagal tone at 5 months predicted temperamental characteristics at 14 months, but vagal tone at 2 days did not. Stifter and Fox (1990) also found relations between vagal tone and temperamental characteristics at 5 months, but not at 2 days, and Porges et al. (1994) found relations at 9 months, but not at 3 years. Relations between vagal tone and some temperamental characteristics also changed over time. For example, while vagal tone and approach/fearfulness were reported to show positive relations at some age periods (e.g., 14 months in Fox, 1989), they were reported to show negative

relations at other age periods (e.g., 11-35 months in Healy, 1989; 5 months in Stifter & Fox, 1990). Patterns of relation between temperamental characteristics and vagal tone appear to both age-dependent and unstable.

Despite this, the fact that vagal tone and child difficulty were not related in this study was relatively surprising and deserves further study. Particular emphasis in future studies should be placed on the age-related changes in relations between vagal tone and temperament characteristics, and possible explanations for the changing pattern of relations found over time.

Immediate Maternal Behavior and Maternal Sensitivity

It was hypothesized that immediate maternal behavior during child pain and maternal sensitivity would be related. It was found that, contrary to prediction, measures of maternal behavior were unrelated.

There are several possible explanations for the lack of relations found. First, there was no direct empirical data in the literature on which to base the prediction that these two measures would be related; rather, predictions were based on the theoretical similarity between these measures. It may well be the case that maternal behavior during relatively rare events (e.g., immunization) does not represent maternal behavior during the routine events of daily life. During the immunization, most mothers' attention was focused fully on their children. Therefore, individual differences in mothers' daily patterns of sensitivity would not be expected to surface in their behavior on this particular occasion.

In contrast, perhaps relations between mothers' immediate behavior and maternal

sensitivity were present, but the measures of maternal behavior chosen were inadequate to uncover them. In particular, the nature of the "Distress Promoting" and "Coping Promoting" categories of the CAMPIS-R (see Blount et al., 1989) may have been problematic. On the CAMPIS-R, reassurance and empathy are both coded as Distress Promoting behaviors. These behaviors would typically be consistent with high sensitivity. On the CAMPIS-R, distraction is coded as Coping Promoting behavior. This behavior may also be consistent with sensitivity in mothers who know their infants respond well to this tactic. Therefore, mothers rated as high in sensitivity on the MBQ may have exhibited behaviors consistent with both the Distress Promoting and Coping Promoting categories of the CAMPIS-R, allowing no clear pattern of relation between these two measures.

It seems likely, however, that, based on the measures used in this study, specific maternal behaviors will not always be representative of general patterns of maternal behavior. In particular, maternal behaviors exhibited during periods of stress (such as when managing child pain) should not be expected to be representative of general patterns of maternal behavior during non-stressed, everyday situations.

Review of Analyses Examining Primary Hypotheses

Based on the data analyses, the primary hypotheses in this study were not supported. However, the pattern of findings did suggest developmental changes in the factors predicting child pain behavior, within the confines of the design. The pattern of factors expected to predict child pain at 6 and 18 months of age, and the actual pattern of

factors found to predict child pain at each age-period will be discussed, in turn.

Pattern of Variables Predicting Pain at 6 Months of Age

It was predicted that at 6 months of age, children's individual levels of reactivity, as represented by child vagal tone and child temperamental difficulty, would be the strongest predictors of child pain response during immunization. However, it was found that contrary to prediction, there was no main effect of child vagal tone in the prediction of children's pain responses to immunization. Child difficultness, however, was significantly related to children's pain responses. Children with more difficult temperaments were more behaviorally reactive (displayed more facial activity) to their immunizations than were children with less difficult temperaments. This was expected, based on the relations between difficulty and pain behavior reported in older children (e.g., Davison et al., 1986; Schechter et al., 1991), and these relations may now be extended to children at 6 months of age.

As predicted, maternal sensitivity was not related to child pain behavior at 6 months of age. Children's pain expressions were not yet influenced by general patterns of mother-child interaction. Unexpectedly, however, immediate maternal behavior during the painful experience was significantly predictive of child pain behavior during the same time period. Although relations were not predicted at this age, the pattern found did parallel the findings of previous studies. That is, maternal "Distress Promoting" behavior (e.g., reassurance, apologizing, criticizing) was related to increased child pain behavior, while maternal "Coping Promoting" behavior (e.g., distraction) was related to decreased child pain behavior (e.g., Blount et al., 1991; Blount et al., 1989; Dahlquist et al., 1995).

Upon further examination, it was found that it was actually the interaction between maternal behavior at the time of the needle with child vagal tone level which predicted child distress to immunization. However, the interaction found was in the opposite direction of that predicted. It was thought that children with more “vulnerable” reactional styles would be more susceptible to the effects of maternal behavior during times of distress than would children with less “vulnerable” reactional styles. Further, it was thought that children with higher vagal tone levels would be more “vulnerable” than would children with lower vagal tone levels, as they were proposed to be the most behaviorally reactive to pain. The findings indicated, however, that among children with higher vagal tone, maternal behavior was unrelated to child pain behavior, and that among children with lower vagal tone, maternal "Distress Promoting" behavior was related to more child pain, while maternal "Coping Promoting" behavior was related to less child pain.

Characteristics reflected by vagal tone level other than behavioral reactivity, may be involved in children's susceptibility to the effects of maternal behavior during times of distress. Children with higher vagal tone levels are proposed to have more optimal patterns of organization and regulation, while children with lower vagal tone levels are proposed to be more poorly organized and regulated (Izard et al., 1991). It may be that these characteristics of vagal tone make children higher in vagal tone (although more reactive) actually less vulnerable during distress than children with lower vagal tone.

The findings at 6 months of age present a very "in the moment" based picture of early infant pain behavior, in which children rely heavily on biologically-based child

variables and the immediate context, and relatively little on experience. At 6 months of age, children reacted to the pain of immunization based on their biologically-based temperamental styles (child difficulty) and the interaction between mothers' immediate behavior and children's physiology (vagal tone).

Pattern of Variables Predicting Pain at 18 Months of Age

It was predicted that at 18 months of age, children's individual parenting contexts, as represented by maternal behavior during child pain and maternal sensitivity, would be the strongest predictors of child pain response during immunization. However, it was found that contrary to prediction, maternal behavior immediately at the time of the immunization was not a significant predictor of child pain behavior, although the correlation was in the expected direction and approached significance. Maternal sensitivity, however, significantly predicted child pain behavior. Children of mothers who were relatively high in sensitivity reacted with more distress to immunization than did children of mothers who were relatively low in sensitivity, as predicted (e.g., Cassidy, 1994).

Unexpectedly, child vagal tone level was also predictive of child pain response at 18 months of age. Although vagal tone was not expected to predict child pain behavior at 18 months, the pattern of relations was in accord with those predicted in the literature (e.g., Porter et al., 1988); children with higher vagal tone levels reacted with more pain behavior than did children with lower vagal tone levels. As expected, child difficulty was not a significant predictor of child pain behavior at this age.

At 18 months of age, there were no interactions between child and maternal

variables in the prediction of child pain, indicating that even though both child characteristics and maternal behavior influenced pain behavior, their effects were relatively independent. The lack of interaction found at this age period is not surprising, considering the relatively small amount of variance accounted for by interactions in previous studies (e.g., 6.5 to 11.4% in Lumley et al., 1990).

The findings at 18 months of age present a picture in which child pain behavior is more heavily related to well-established patterns of mother-child interaction built up over many occasions than to maternal behavior on a specific occasion. Further, children's biologically determined capacities to react (vagal tone levels) also predicted their pain reactions. Pain behavior at this age appears to be a combination of both physiological child factors, and experientially-based environmental factors.

Discussion of Pattern of Findings in Each Predictor Variable

The pattern of findings supports the presence of developmental shifts in the predictors of infant pain behavior, within the confines of the study. However, the changes found were not in agreement with the developmental patterns predicted. Specifically (and in accord with their orthogonal nature in previous analyses), variables proposed to reflect child reactivity did not behave in a similar manner in the prediction of child pain behavior, nor did variables proposed to represent maternal behavior.

Possible explanations for the pattern of results for both biologically-based child variables and maternal behavior, in turn, will be discussed. First, a more detailed overview of emotion regulation and socialization will be presented. This will be

followed by a discussion of possible explanations for the pattern of variables predicting child pain behavior at each age period, with particular emphasis on the roles which emotion regulation and socialization may have played in the pattern of findings.

Overview of Emotion Regulation

As previously noted, individual differences in emotion regulation may influence individual variability in the degree of behavioral expression associated with emotions, including pain-related distress. In fact, emotions play an integral role in the pain experience (Craig, 1994).

Individual differences in children's emotion regulation skills are proposed to be related to several factors. According to Calkins (1994), the factors unique to each child which are proposed to play a role in emotion regulation include: 1) neuroregulatory or biological systems (e.g., endocrine activity, heart rate/vagal tone, brain activity), 2) behavioral traits (e.g., temperamental disposition), and 3) cognition (e.g., social referencing, beliefs about others, internal working models, ability to apply strategies, learning when to regulate displays of affect). The environmental factors which are proposed to play a role in emotion regulation typically involve parents, especially the mother, who is usually the primary caregiver (Calkins, 1994). It is largely within the parent-child relationship that children are believed to learn about emotion regulation through socialization (Calkins, 1994; Cassidy, 1994; Cole, Michel, & Teti, 1994).

There are proposed to be two components of emotion regulation, each of which may influence children's behavioral displays of emotion. "Reactivity" (or what the child actually feels) is proposed to be directly related to children's biologically-based

physiology and temperament, with only weak links to caregiving (Cassidy, 1994).

"Expressivity" (or the level at which feelings are demonstrated), however, is proposed to be related to both feeling states and environmental variables, including parental influences (Cassidy, 1994). Therefore, children may appear to be well regulated if they have less intense feeling states (reactivity) to begin with, or if their expressivity has been successfully socialized by parents (Kagan, 1994). Children may appear to be dysregulated if they have more intense feeling states to begin with, or if their parents have not been successful in socializing them to control their emotional expressions.

The factors involved in children's skills in emotion regulation are not believed to remain stable throughout childhood. Rather, developmental changes in the factors underlying emotion regulation, and therefore in children's abilities to control their emotional displays, are believed to occur. According to theories of emotion regulation, children should move from an inability to regulate their emotions and restrain their behavior (Kagan, 1994), to an ability to regulate and organize their emotions (Spangler et al., 1994). These changes may stem from both children's maturation and growth, and from the increasing influence of socialization on their behavior. The specific mechanisms whereby children become socialized with respect to emotion regulation are not well understood (Cole et al., 1994). In general, socialization is believed to occur through children's exposure to their parents' interactive care-giving styles, through explicit training (e.g., modelling, reinforcement, discipline; Calkins, 1994) and through the attachment relationship (Cassidy, 1994), as in the socialization of other behaviors (see Maccoby, 1992).

Overview of Socialization

Socialization is believed to be an important process involved in shaping children's behaviors, including their expressions of pain-related distress. Further, socialization is noted to play an important role in the development of children's emotion regulation skills (e.g., Calkins, 1994; Cassidy, 1994).

There are several proposed methods of socialization, which may explain the ways in which, over time, children's pain-related behaviors are modified by their environmental experiences. Common to these different theories is the acknowledgement of parents as the chief socializing agents of young children (Maccoby, 1992). Through socialization, children may increasingly internalize the expectations their parents, and mothers in particular, have for their pain expression.

Reinforcement is an important component of many theories of socialization (see review by Maccoby, 1992). In such theories, children are seen as learners and parents as teachers. Through both instrumental and classical conditioning, children are believed to acquire the forms of behavior desired by their parents. Behaviors (e.g., emotional displays) which are reinforced continue to be exhibited, while behaviors which are not reinforced or punished are removed from children's behavioral repertoires.

The attachment relationship (see Ainsworth & Bowlby, 1991) is also considered important in the process of socialization (see Bowlby, 1982), and in emotional behavior. Based on their histories of parent-child interaction, and on the outcome of their efforts to gain proximity to their parents (the goal of attachment behavior), children are believed to develop a mental representation or internal working model of attachment (see Main,

Kaplan, & Cassidy, 1985). This working model comprises a set of conscious and/or unconscious rules for organizing information regarding attachment, which is then believed to direct feelings, behavior, memory, attention, and cognition, as they relate to attachment (Main et al., 1985).

Based on their working models, children may possess several automatic, unconscious "strategies" (Main, 1990; Main et al., 1985). A "strategy" refers to the way in which infants tailor their behavior to accommodate it to the particular style of care they receive, and to regulate their emotions accordingly (Main, 1990). It is important to note that the strategy or response which is adaptive at any particular time depends upon children's individual environments and situational demands (Cassidy, 1994; Cole et al., 1994; Kagan, 1994). Indeed, even dysregulation may be adaptive under some circumstances (Cole et al., 1994).

Although these processes sound similar to those proposed in models of reinforcement (i.e., children develop behaviors which stem from the responsiveness of their parents), this is not the case. Biological, as opposed to learned, mechanisms are thought to be at work in this model (see review by Maccoby, 1992). Moreover, some of the proposed relations between parent-child behavior are in direct opposition to those of reinforcement. For example, in attachment theory, "dependent" behaviors (such as crying and signalling distress) are seen as part of attachment behavior and parental responsiveness to such behaviors is not seen as reinforcing further dependency. Rather, parental responsiveness to children's dependency signals (such as crying) is proposed to lead to subsequent child behavior which is actually less dependent (less crying; see

Sroufe & Waters, 1977).

Finally, observational learning and modelling are also proposed to be important in the process of socialization. Bandura proposes that learning is not controlled by external contingencies, and that learning through observation is an important mode of acquiring new patterns of behavior (Bandura, 1977). These processes may be particularly valuable in the case of pain, as they allow children to learn about pain without having to directly experience it. Modelling processes may be "central to the development of pain behavior, the manner in which pain is experienced, and whether individuals display self-control or uninhibited distress when in pain" (Craig, 1986, p. 75).

Regardless of the particular method, the effects of socialization on children's behavior are not believed to remain stable throughout childhood. Rather, developmental changes in the effects of parental behaviors on child behaviors are expected. Children should become more susceptible to the effects of socialization over time (Calkins, 1994; Kopp, 1982). While early in development, children have not been exposed to substantial amounts of socialization (Matheny et al., 1985), by the second year of life, "communications and interactions with the caregiver teach the child to manage distress, control impulses, and delay gratification" (Calkins, 1994, p. 53). Therefore, general patterns of parental behavior should become increasingly influential in shaping children's behavior over time.

Discussion of Age-Related Changes in Each Predictor

Age-Related Changes in Child Vagal Tone

While it was expected that vagal tone level would predict child pain behavior at 6

months, but not at 18 months of age, the opposite pattern of relations was found. At 6 months of age there was no main effect of child vagal tone level on child pain. At 18 months of age, however, there was a main effect of vagal tone in the prediction of child pain.

At 6 months of age, while there was no main effect of vagal tone on child pain, vagal tone did predict child pain behavior through its interaction with maternal behavior. Among children with higher vagal tone, maternal behavior during pain was not predictive of children's pain behavior. However, among children with lower vagal tone, maternal behavior during pain was predictive of children's pain behavior. At this age, rather than purely reflecting reactivity, vagal tone may reflect vulnerability to dysregulation, and the subsequent dependence upon the immediate context (maternal behaviors) for aid in behavior regulation during pain. In this case, reactivity level would be determined by the particular maternal behaviors present in the immediate context during pain. If maternal behaviors which are "regulating" are present, pain reactivity may be low. However, if maternal behaviors which are "dysregulating" are present, pain reactivity may be high.

Children with higher vagal tone levels, who are proposed to have more optimal patterns of organization and regulation (Izard et al., 1991), may be less dependent upon immediate maternal behaviors for aid in emotion regulation. In these children, pain behavior was unrelated to maternal behaviors. Children with lower vagal tone levels, who are proposed to be more poorly organized and regulated, may be more dependent upon their mothers as external sources of regulation. In these children, maternal behaviors which were proposed to be more regulating (Coping Promoting) were related to

decreased pain behavior, while maternal behaviors which were proposed to be less regulating (Distress Promoting) were related to increased pain behavior. Therefore, at 6 months of age, vagal tone may represent children's need for external emotion regulation during stress.

Contrary to prediction, at 18 months of age, children's reactivity during pain was predicted by their vagal tone levels. In accordance with the literature (e.g., Porter et al., 1988), higher vagal tone was related to more pain behavior, while lower vagal tone was related to less pain behavior. It is unclear why vagal tone predicted pain behavior at this age period.

The importance of vagal tone at 18 months of age is not likely due to the increasing importance of socialization over time. Although relations have been found between vagal tone and environmental variables (e.g., attachment status in Izard et al., 1991), and there is some evidence to suggest that vagal tone may be modified by environmental factors, the changes reported have been short-term responses to immediate environmental stressors (e.g., pain in Gunnar et al., 1995). Studies have not examined changes in tonic vagal tone levels in relation to environmental variables. However, studies suggest that it is vagal tone which leads to environmental change, rather than vice versa. For example, Katz and Gottman (1995) found that vagal tone measured at five years of age was predictive of children's reactions (externalizing behavior) to exposure to marital hostility three years later. Children with high vagal tone levels showed no link between marital hostility and externalizing behavior, while among children with lower vagal tone levels (who again may be more vulnerable), there was a strong link ($r = .65$).

To date, the only evidence of the modification of slightly longer-term changes in vagal tone level is in relation to changes in physiology. For example, diminished tonic respiratory sinus arrhythmia has been found in asphyxiated term infants tested within 24 hours of delivery (Divon, Winkler, Yeh, Platt, Langer, & Merkatz, 1986).

The importance of vagal tone in pain prediction at 18 months of age may be due to the physiological changes which occur in vagal tone over time. With age, vagal control of the autonomic nervous system increases, due to the increasing myelination and maturation of the nervous system (Porges, 1991). Further, the physiological stability of vagal tone increases with age. The comparatively lower stability present in vagal tone at 6 months of age might have contributed to the lack of relations seen at this age period. The increase in level and stability at 18 months of age leads to an increase in the organization of behavior, the ability to regulate affective states, the ability to display appropriate facial expressions, and the range of expressivity possible. This suggests that, over time, children may be increasingly able to regulate their own emotions independently of their caregivers, and there may be an increasing correlation between children's vagal tone levels and their emotional expressions. Moreover, due to the increases in vagal tone over time, by 18 months of age, vagal tone levels may be high enough in all children to make its effects on pain independent of immediate maternal behaviors, accounting for the lack of interaction between these two variables at this age period. Although the change in vagal tone from 6 to 18 months was not significant in this study, there was a trend toward higher vagal tone at 18, as opposed to 6 months of age.

A final possibility for the main effect of vagal tone at 18 but not at 6 months of

age is that this was a spurious result. As in the case of studies relating vagal tone and temperament (which did not find relations in very young infants, but did at later age periods, e.g., Fox, 1989; Stifter & Fox, 1990), relations between vagal tone and child pain may not be stable across development. For example, in the previous studies examining relations between vagal tone and child pain, relations were found in newborns (e.g., Gunnar et al., 1995; Porter et al., 1988), while this study did not find relations at 6 months of age, relations were again present at 18 months of age. At this time, there are not enough studies to determine whether or not patterns of relation between child pain behavior and vagal tone continue to show instability over time, and therefore whether or not this measure will be of use in assessing and managing child pain.

Age-Related Changes in Child Temperament

Temperamental difficulty exhibited the pattern of age-related changes predicted. Specifically, maternal reports of child temperamental difficulty predicted children's pain behavior at 6 months of age. At 18 months of age, child temperamental difficulty no longer predicted child pain behavior.

At 6 months of age, children with more difficult temperaments reacted with more pain behavior to immunization than did children with less difficult temperaments. Temperamental difficulty may reflect children's susceptibility to dysregulation, which in turn, may underlie their reactional styles. Children with difficult temperaments in this study may have been more easily dysregulated during stress than children with less difficult temperaments. This dysregulation may have been demonstrated as their subsequent greater reactivity to the distressing event (pain).

While temperamental difficulty may continue to reflect susceptibility to dysregulation at 18 months of age, the relation may not be as clean as it was at 6 months of age. Temperament is relatively, but not absolutely stable over time (see Goldsmith et al. 1987). It may be modified to some degree across development, due its interaction with other psychological attributes and environmental influences, and due to maturational transitions (such as the development of new motoric and cognitive coping responses). Therefore, while temperamental tendencies may remain similar over time (and mothers may still be able to perceive these tendencies), the expression of temperament may change. As emotional expressions become socialized, they may be less well coordinated with feeling states (see Goldsmith et al. 1987). For example, while certain situations may continue to present challenges for difficult children (e.g., going to a new place), over time, they may be better able to suppress behavioral signs of their distress on such occasions. Therefore, over time children's behavioral expressions of their feeling states may be "diluted" by the effects of socialization. At 6 months of age, when children have not experienced substantial amounts of socialization (Matheny et al., 1985), their pain reactions may reflect their innate temperamental dispositions. By 18 months of age, however, children's temperamental behaviors may be socialized and children may suppress their temperamental tendencies during periods of stress in accordance with their environmental demands.

Age-Related Changes Immediate Maternal Behavior

While it was expected that mothers' immediate behavior during child pain would predict child pain behavior at 18 months, but not at 6 months of age, the opposite pattern

of relations was found. At 6 months of age, mothers' behavior during child pain significantly predicted child pain behavior. At 18 months of age, however, mothers' immediate behavior did not predict child pain behavior.

At 6 months of age, maternal Coping Promoting behaviors were related to decreased child pain, while maternal Distress Promoting behaviors were related to increased child pain. The importance of immediate maternal behavior in the prediction of child pain may be explained by emotion regulation. According to theories of emotion regulation, the immediate behavior of parents in children's emotion regulation is expected to be particularly important in early infancy, when children are not believed to be mature enough or to have developed the skills necessary to regulate their own emotions and to restrain their behavior (Kagan, 1994). As mentioned, when dysregulation occurs, children at this age may depend upon their parents to regulate their arousal and to manage their emotional displays (Calkins, 1994; Cole et al., 1994; Kopp, 1989). Studies support the role of mothers as regulators of emotion during infancy. For example, Spangler et al. (1994) found relations between maternal behavior directly at the time of a child stressor and child distress, as measured by cortisol level. At 6 months of age, infants whose mothers were less responsive to them had higher cortisol change scores during stress than did infants whose mothers were more responsive.

Therefore, at 6 months of age, mothers may have served as external regulators of their children's emotions during pain. Behaviors which are proposed to be more regulating (Coping Promoting) were related to decreased child distress, while behaviors which are proposed to be less regulating (Distress Promoting) were related to increased

child distress. Again, it should be noted that the need for external regulation of emotion varied with the physiological vulnerability of the child. Children who were more physiologically vulnerable (had lower vagal tone) relied more heavily on mothers to regulate their emotions during pain than did children who were less vulnerable (had higher vagal tone).

At 18 months of age, immediate maternal behavior no longer predicted child pain behavior. This may reflect the decreasing reliance of children on their parents as external regulators of emotion with development. By the second year of life, gross motor and cognitive advancements have occurred and "infants have become skilled at monitoring their own behaviours, interpreting the behaviours of others, and responding to social demands" (Calkins, 1994, p. 54). Although some co-regulation between parents and children may be seen at this time (Cole et al., 1994), children at this age are increasingly capable of organizing and regulating their own emotions separately from their caregivers (Spangler et al., 1994). Therefore, the 18-month-olds in this study may have been skilled enough to regulate their own arousal levels (pain behavior) during immunization and maternal behavior was no longer needed to externally regulate their emotions.

Age-Related Changes Maternal Sensitivity

Maternal sensitivity exhibited the pattern of age-related changes predicted. Specifically, at 6 months of age, children's pain reactions were not predicted by the patterns of maternal sensitivity to which they had been exposed. By 18 months of age, however, general patterns of mother-child interaction over time were related to children's expressivity during pain. This pattern supports the socialization of children's pain

behavior. Over the period from 6 to 18 months of age, children's pain behavior may be socialized by the patterns of maternal behavior to which they are subject on a daily basis.

At 6 months of age, general patterns of maternal responsivity to child cues did not predict children's pain behavior. This may reflect a lack of socialization of pain behavior at this age period. Indeed, children at 6 months of age have not yet been exposed to substantial amounts of socialization (Matheny et al., 1985), as they are not developmentally ready for its effects.

At 18 months of age, however, general patterns of maternal responsivity to child cues significantly predicted children's pain behavior. Specifically, higher maternal sensitivity was related to more pain behavior, while lower maternal sensitivity was related to higher pain behavior, and children were less dependent upon the immediate behaviors of their parents. This may reflect the increasing susceptibility of children's behavior to the effects of socialization. Over the time period from 6 to 18 months of age, children's pain behavior may be socialized with respect to the patterns of maternal behavior to which children are subject on a daily basis.

The particular mechanism of socialization responsible for the patterns found was not directly examined, and therefore may only be speculated upon. Operant models of behavioral reinforcement fit well with the pattern of results found. Children who were used to having their signals responded to, and who learned that their attempts to attract their caregivers' attention would be successful (positive reinforcement), may have continued to display signals indicating their emotions during times of stress, while children who were not responded to on a regular basis may have diminished their

attempts to elicit caregiver comfort.

Although attachment theory would seem to be at odds with the results of this study, in that it indicates children who are responded to should subsequently show less distress than should other children, this may not be the case. Cassidy (1994) agrees that overall, children of sensitive parents will show less negative affect than will children of insensitive parents. However, on those occasions on which they do experience negative affect, she reports that they will be more open about their distress and more willing to signal caregivers for help than will other children. In this study, children whose mothers responded to their cues more regularly were more expressive of their pain than were children whose mothers responded to their cues less regularly. It may be that these children had templates of maternal responsiveness to their signals which lead them to openly express their pain, as they knew that their attempts to gain proximity to their caregivers would be successful.

Observational learning and modelling may also have played a role in the socialization of children's pain behavior. In agreement with the lack of socialization found at 6 months of age, studies show that there is little evidence of selective matching to models, or of differential responsiveness to models in infants at 6 months of age (Lewis & Sullivan, 1985). Although there are some reports that infants may imitate simple facial gestures (e.g., tongue protrusion) at 6 months of age (and even this is contentious; see Anisfeld, 1991), the literature clearly distinguishes between this type of early spontaneous imitative behavior and later deliberate imitative behavior (see Anisfeld, 1991). By 18 months of age, some genuine imitation may be developing (see Anisfeld,

1991). Imitation, however, increases and becomes more exact with age, especially in the case of complex actions (McCabe & Uzgiris, 1983). Further, age estimates for the emergence of deferred imitation (imitation which occurs after both modelling and a subsequent time period during which other events occur, necessitating long-term memory and representational capacities) are generally around 18-24 months of age (McCall, Parke, & Kavanaugh, 1977), putting the older children in this study at the early stages of more advanced types of modelling and imitation. The clinical and experimental research showing relations between social modelling and subsequent pain behavior have also generally focused on older children (see review by Craig, 1986). Therefore, although modelling and imitation may influence children's pain reactions, their effects are unlikely to be strongly established in children as young as those tested in this study.

Among the mechanisms of socialization reviewed, reinforcement and attachment models may best fit with the pattern of results found. Further studies are needed, however, before the specific mechanisms involved in the socialization of young children's pain behavior can be delineated.

Summary of Major Findings

Based on the results of this study, it appears that 6-month-olds were reacting to pain based on their skills in emotion regulation, rather than their socialization histories. At this time, general patterns of maternal responsivity over time (maternal sensitivity) did not predict their pain behavior. Rather, their temperamental difficulty (susceptibility to dysregulation) predicted their pain, as did immediate maternal behavior during immunization. Based on the relation between children's pain behavior and their mothers'

immediate behavior, mothers were necessary as external regulators of emotion. This need, however, varied based on children's physiological vulnerability (vagal tone level).

At 18 months of age, children were reacting to pain based on their socialization histories (maternal sensitivity), which may have influenced their emotion regulation strategies. At this time, children's temperamental dispositions (difficulty) were suppressed by their experience. Further, mothers were no longer necessary as external regulators of emotion, based on the lack of relation between their immediate behavior and children's pain; this may reflect children's increasing abilities to regulate their own emotions, independently of their caregivers. The additional finding that vagal tone predicted children's pain behavior at this age period was relatively surprising. Its importance may be related to the increasing vagal control of the ANS with age, or to its relative independence of socialization. Further study of the age-related patterns of relation between vagal tone and child pain are warranted.

Review of Secondary Analyses and Discussion of Findings

In addition to the primary analyses, secondary analyses were carried out, in order to provide a more comprehensive picture of the factors involved in children's pain. These analyses centered around situational confounding variables, which might affect the relations between the predictors and children's pain behavior, and maternal psychological variables, which might also affect the relations between the predictors and children's pain behavior. The findings of each of these analyses will be discussed, in turn.

Situational Confounding Variables and Child Pain

In addition to the primary predictors, two situational variables representing the immediate context in which pain occurred were also important in the prediction of children's pain. Both nurse status (whether or not the person administering the needle was a regular clinic nurse) and child state (on a 0 to 6 point scale, from more aroused to less aroused states) prior to immunization predicted child pain behavior. Whether or not the person administering the needle was a regular clinic nurse was significantly related to children's pain behavior at 6 months of age; children with regular clinic nurses demonstrated less pain during immunization than did children with other nurses or physicians. At 18 months of age, however, nurse status did not affect children's pain behavior.

There are several possible explanations for this pattern. In addition to mothers, medical staff may have served as external regulators of emotion. Again, according to theories of emotion regulation, persons present in the immediate context during dysregulation may serve as external regulators of emotion at earlier, rather than later age periods (e.g., Spangler et al., 1994). This fits with the pattern of finding in that it was only at 6 months of age (and not at 18 months of age) when medical staff were found to be related to children's pain behavior.

A second possibility for the relation is that there were differences in nurses' techniques and the subsequent painful sensation produced by the administration of the needle which children reacted to at 6 month, but not at 18 months of age. According to theories of emotion regulation and socialization, children at earlier ages should be more

expressive of what they are actually feeling (the pain sensation) than should older children, as older children's behavior is also colored by their individual socialization histories (Cassidy, 1994).

Both of these explanations depend upon children at 6 months of age being more responsive to variants in their immediate environments than children at 18 months of age. Again, this is predicted by theories of emotion regulation (e.g., Cassidy, 1994). Previous studies finding relations between medical staff and child pain behavior also reported relations in young children. For example, Grunau and Craig (1987) found that in newborns, facial activity during the latter phase of blood collection (squeezing, not lancing) for PKU screening varied as a function of the laboratory technician. Although relations would not be expected to be as strong in older children, studies to date have not examined such relations.

Child state prior to immunization significantly predicted child pain behavior at both 6 and 18 months of age. Specifically, the more awake and aroused children were prior to immunization, the more pain behavior they demonstrated during immunization. Previous studies have also found this relation (Grunau & Craig, 1987; Gunnar et al., 1985). Children's state prior to immunization may reflect their ongoing levels of internal organization, and their receptivity to emotional input at that time (Grunau & Craig, 1987). Children who were more disorganized and open to emotional input to begin with (more aroused prior to immunization) did indeed show greater behavioral reactions to pain than did children who were more organized and less open to emotion input (less aroused prior to immunization). Children's levels of dysregulation at the time at which they are

exposed to a stressor (immunization) may predict their subsequent ability to regulate their emotions. Children who are disorganized to begin with may be hampered in their attempts to exercise their emotion regulation skills, while children who are organized at the time of a stressor may be facilitated in this process.

Interestingly, at 6 months of age, both child difficulty and whether or not the person administering the needle was a regular clinic nurse interacted in predicting child state prior to immunization. Among children with regular clinic nurses, child state and temperament were unrelated. However, among children with non-regular nurses or physicians, child state was related to child temperament. The more difficult the child's temperament was, the more aroused and upset he or she was prior to immunization. It is unknown why the relations found varied with nursing status. The general lack of variability in state among children with regular nurses may have been responsible for the different patterns found.

When identical analyses were conducted at 18 months of age, the same interaction was not found. Although the magnitude of the correlation between child state and child difficulty was similar at 6 ($r = -.36$) and 18 months ($r = -.35$), nurse status was not related to child state at 18 months of age, as previously mentioned. This indicates that at this age period, child state was more solely linked to internal child variables. This may reflect children's increasing abilities to regulate their own emotional states, independently of their immediate contexts. Further, vagal tone, which was more predictive of pain behavior at 18 than 6 months of age, may also have been involved in children's increasing internal control over their states. Porges (1991) reports that with age, the increasing vagal

control of the autonomic nervous system is related to increased state regulation, enabling children more control over their own emotional states over time.

Once again, interactions were found between biologically-based child factors and immediate environmental contextual factors at 6 months of age, but not at 18 months of age. At 6 months of age, vagal tone and immediate maternal behavior interacted in the prediction of child pain, and nursing status and child difficulty interacted in the prediction of infant state. Neither of these patterns of relation were present at 18 months of age. Moreover, neither of the immediate contextual variables (immediate maternal behavior or nursing status) played any role in children's behavior, perhaps due to children's increased skills in self-regulation at 18 months of age.

Based on the examination of the situational factors carried out, it is important to note that with the inclusion of the situational factors in the model predicting child pain, the major pattern of predictors did not change at 6 months of age. Child temperament (difficulty) and immediate maternal behavior predicted child pain, irrespective of situational factors. However, at 18 month of age, child vagal tone level no longer predicted children's pain behavior with the addition of the situational factors to the model predicting child pain. At this age period, child vagal tone was not a strong enough predictor of children's pain behavior to withstand the reduction in variance in pain behavior caused by the situational factors. Maternal sensitivity, however, continued to be an important predictor of children's pain, irrespective of the situational factors.

Maternal Psychological Variables and Child Pain

Two measures of mothers' psychological states were included in this study:

maternal stress and maternal anxiety. Although maternal anxiety and stress were not central to the model of pain tested, there was evidence that they might play a role in the pain experience (e.g., Bennett-Branson & Craig, 1993; Dahlquist et al., 1984; Jacobsen et al., 1990; Jay et al., 1983). Therefore, in order to provide a more comprehensive picture of the complex nature of the factors involved in the pain experience, primary analyses were supplemented with additional tests to examine whether or not maternal psychological state influenced maternal behaviors or child pain, or if they played mediating roles in the pain experience. It was expected that: a) the ratio of maternal Coping Promoting to Distress Promoting behavior during the needle would be related to mothers' general stress levels; b) if maternal behavior at the time of the needle and maternal sensitivity were not related, stress or anxiety would moderate this discrepancy; c) stress would moderate the relation between maternal pain response and child pain behavior; and d) maternal anxiety prior to immunization would be positively related to child pain behavior during immunization.

The results of the analyses indicated that, in all cases, maternal psychological variables were not involved in the pain experience, within the confines of this study. There are several possible explanations for the lack of relations found.

First, the backgrounds of the children and mothers studied may have been important in the lack of effect which maternal psychological variables had on the pain experience. Mothers in this study were generally well-educated and from two-parent, high SES families. This may have affected their levels of self-reported stress and anxiety, which were generally low. They may, in fact, have been too low to affect their behavior,

or their children's pain. In addition, many of the previous studies finding relations between maternal psychological variables and maternal or child behavior studied children with cancer (e.g., Dahlquist et al., 1994; Jacobsen et al., 1990; Jay et al., 1983), unlike the healthy infants in this study. Having a child with a serious illness may drastically increase the role maternal psychological variables play in the pain experience.

Second, the age of the children in the study may have been involved. Studies finding relations between maternal psychological variables and parental behavior or child pain, respectively, have examined children who were older than those in this study (e.g., 7- to 16-year-olds in Bennett-Branson & Craig, 1993; 2- to 17-year-olds in Dahlquist et al., 1984; 3- to 10-year-olds in Jacobsen et al., 1990; 2- to 20-year-olds in Jay et al., 1983). The impact of maternal psychological variables on child pain may increase with child age. For example, perhaps older children are more attuned to their mothers' anxiety levels than are younger children, and therefore maternal anxiety may affect their pain behavior to a greater extent than younger children.

Third, the type of medical procedure and pain studied may also have affected the relations found. The routine, fairly quick pain in this study (immunization) may not have been sufficient to elicit high enough levels of anxiety to be detected by children. Most of the studies finding relations between maternal psychological variables (e.g., anxiety) and child pain examined more serious, less common types of medical procedures (e.g., post-surgical pain in Bennett-Branson & Craig, 1993; BMA/LP in Dahlquist et al., 1994; venipuncture in Jacobsen et al., 1990; BMA in Jay et al., 1983). Such procedures may be associated with higher levels of anxiety than is immunization, which may then be

perceived more easily by children, causing increased child distress. It may also be that this type of pain experience did not pull psychological variables into play, while experiences which are much more distressing for most parents (e.g., observing a lumbar puncture) involve psychological processes to a greater degree. Medical procedures which are relatively uncommon, longer lasting, and related to higher levels of child distress may involve maternal psychological variables to a greater extent than does immunization.

A fourth possibility is that discrepancies resulted from differences in the measures used to assess maternal anxiety, maternal stress, and maternal behavior during pain between this study and studies which did find relations between maternal psychological variables and maternal behavior or child pain. The measures used in this study may not have been adequate to assess such relations. For example, it was expected that the ratio of maternal Coping Promoting to Distress Promoting behavior during the needle would be related to mothers' general stress levels. However, because parental reassurance (which should decrease with stress) and parental agitation (which should increase with stress) are grouped as "Distress Promoting" behaviors on the CAMPIS-R, any changes present may have balanced out, resulting in the appearance of an overall lack of relations. A measure examining each maternal behavior individually may have shown some patterns of relation. Most previous studies examining relations between maternal stress or anxiety and maternal behavior or child pain used the State and Trait scales of the State-Trait Anxiety Inventory (e.g., Bennett-Branson & Craig, 1993; Dahlquist et al., 1994; Jacobsen et al., 1990; Jay et al., 1983). The 0 to 10 point scale of maternal anxiety in this study may not have been sensitive enough to discriminate between levels of anxiety,

although Jacobsen et al. (1990) found significant positive relations between parental self-reported anxiety prior to child venipuncture on a 10 cm VAS and child distress during venipuncture. Representation of maternal stress with only the Parental Stress subscale of the PSI, rather than using a measure of total stress (for reasons previously explained) may also have provided too narrow a picture of maternal stress to be of use. Finally, the timing of the measure of maternal anxiety may have been problematic. Mothers' self-reported anxiety was measured in the waiting room, prior to examination with physicians, which preceded the needle. Maternal distress at this time may not have been reflective of maternal distress directly at the time of the immunization. Had maternal anxiety been measured immediately prior to the needle, it may have been found to play a role in the pain experience. In general, some measures of maternal behavior may be sensitive to the effects of maternal psychological variables, while other measure may not.

In addition to differences in the methods used to assess maternal variables between this study and previous studies, the measures of child pain behavior and coping also differed between this study and studies finding relations between maternal psychological variables and child pain. For example, Bennett-Branson and Craig (1993) assessed child coping using open-ended and forced choice questions about coping strategies and catastrophizing, a checklist of coping methods, and an interview of parental perceptions child coping; Jay et al. (1983) assessed child pain using the Observational Scale of Behavioral Distress (OSBD; Jay et al., 1983); Jacobsen et al. (1990) assessed child pain using a modified version of the Procedure Behavior Rating Scale (PBRs; Katz et al., 1980); and Dahlquist et al (1994) assessed child pain using the OSBD and a self-

report VAS measure for older children. As in the case of maternal variables, some measures of child pain may be sensitive to the effects of maternal psychological variables, while other measures may not.

It appears that maternal stress and anxiety below certain levels may not affect maternal behavior or child pain expression during incidents of child pain. Alternatively, maternal psychological variables may not be universally involved in the pain experience, irrespective of their levels. Their impact may vary with factors such as child age, maternal and child background, the type of pain procedure under study, and the measures used to assess maternal psychological variables, maternal behavior, and child pain.

Limitations of this Study and Suggestions for Future Studies

One of the main drawbacks of this study was its cross-sectional design. Although capable of elucidating changes in the factors predicting children's pain behavior between developmental periods, it did not allow for comparison of the relative changes within children over time. A much stronger test of age-related changes in the factors predicting children's pain and in children's pain behavior would be a replication of this study using a longitudinal design. This would allow the comparison of the relative weights of child versus parental factors over time, and provide some information as to the set of circumstances under which the factors predicting children's pain, and children's pain expression itself, are most likely to change.

Within a longitudinal study, measurement of the relations between predictor variables and pain behavior at more frequent intervals and extending over a longer time

period would also be of valuable. The inclusion of only two age periods limited the ability of this study to uncover the full spectrum of age-related changes in the pattern of factors predicting children's pain which may exist. Examination of patterns in pain predictors at time periods beyond 18 months of age might also indicate whether or not children maintain the patterns of pain behavior which they develop based on their early formative experiences, or whether their pain behavior continues to be modified by their ongoing experiences. The constraints of this study due to the ages at which immunizations are administered might also have prevented the revealing of changes and transitions that actually occur. Further, due to the short sharp type of pain examined (immunization) the time period of observation was necessarily brief. Different findings may occur with longer-lasting types of pain.

In addition to the examination of developmental changes in children's pain, the universality of children's pain behavior at a single point in time should also be investigated. The findings of this study suggest that both the factors predicting children's pain, and children's pain expression may change as a result of measurement strategies, the type of pain, the background of the persons involved, and the situational circumstances surrounding the pain. The literature on emotion regulation also notes that children possess a variety of emotion regulation strategies, and that they may choose among these strategies based upon their immediate goals (Thompson, 1994). Their pain behavior may therefore be situation-specific, depending upon the effectiveness of each strategy according to the setting and social circumstances. For example, Garner (1995) found that toddlers were more emotionally regulated (more self-soothing) when with their older

siblings and a stranger than when with their siblings only (more emotional lability, shorter latency to distress). Differences have also been found specifically in children's pain related behavior when mothers are present versus absent (e.g., Gonzalez et al., 1989; Ross & Ross, 1984). Examining children's pain-related behavior in different contexts with different measurement tools might help to indicate the variety of responses children are capable of, and the environmental factors are involved in determining their pain expression on a particular occasion.

This study provided evidence of the socialization of children's pain behavior. However, the method of socialization whereby children's pain-related behavior was modified was not directly examined and could only be speculated upon. It would be useful in future studies to focus more specifically on the different mechanisms involved in the socialization of pain, in order to better understand the development of pain behavior. For example, at what age does modelling begin to influence children's pain behavior? If patterns of reinforcement and pain modelling are at odds, how much weight does each carry in influencing children's pain behavior? Further, examination of the specific mechanisms underlying the influence of immediate parental behavior on child pain should also be examined. For example, does attention mediate the effect of immediate maternal behavior on child pain? Are children's eye gaze patterns during pain related to the effect which maternal behaviors may have on child pain expression?

An area which was not examined in this study and which is currently emerging as an important factor in children's pain is that of acquired reactivity. There is a growing body of literature suggesting that the physiology underlying reactivity may be modified

through experience. For example, Taddio, Goldbach, Ipp, Stevens, and Koren (1995) and Taddio, Katz, Ilersich, and Koren (1997) found that circumcised infants showed larger pain responses to a subsequent vaccination at 4 or 6 months of age than did uncircumcised infants. Further, in Taddio et al. (1997) the use of EMLA cream during circumcision attenuated the pain response (based on VAS but not on facial action or cry duration) to subsequent vaccination. The authors suggest that the increases seen in response to immunization after circumcision were due to alterations in the central neural processing of painful stimuli, resulting in central neural sensitization or hyper-excitability which amplified subsequent pain input. This suggests that early painful experiences may alter children's sensitivity to later painful stimulation. Future studies examining children's pain histories in relation to their reactions to further painful stimuli are necessary to determine the conditions under which past pain may modify children's reactions to current pain.

Summary and Conclusions

Overall, the results of this study suggest developmental shifts in the factors predicting children's pain behavior, within the confines of the design. However, the pattern of results was not in accord with the hypotheses. At 6 months of age children's pain behavior was predicted by maternal reports of temperamental difficulty, and by mothers' immediate behavior (vocalizations) during immunization, but not by child vagal tone or maternal sensitivity. Although vagal tone did not predict child pain response at this age, there was an interaction between vagal tone and immediate maternal behavior in

the prediction of child pain. At 18 months of age, maternal sensitivity predicted child pain behavior. Unexpectedly, children's vagal tone levels also predicted their pain behavior, but child temperamental difficulty and immediate maternal behavior did not.

The pattern of predictors of children's pain behavior at each age period may be best explained by theories of emotion regulation and socialization. At 6 months of age, children had not experienced substantial amounts of socialization, as they were not yet developmentally prepared for its effects. Therefore, at this time their pain was not predicted by the general patterns of maternal behavior to which they had been exposed on a daily basis (maternal sensitivity). Rather, their pain behavior was predicted by their biologically-based reactional styles (temperamental difficulty). At this age, children also had not developed the skills necessary to regulate their own emotions. Therefore, they were dependent upon the immediate context to aid in their emotion regulation and mothers were necessary to act as external regulators of emotion at this time. Further, the need for mothers as external regulators of emotion was based on children's physiological vulnerability (vagal tone levels).

By 18 months of age, there was evidence that children's pain behavior had been socialized. Rather than continuing to react to pain based on their temperamental dispositions (difficultness), children now reacted to pain based on the general patterns of maternal behavior to which they had been exposed over time. In addition, mothers' immediate behaviors during pain were no longer necessary to externally regulate children's emotions during distress, as children had developed sufficient skills to regulate their own emotional states. Vagal tone, however, now predicted children's pain behavior,

perhaps due to the increasing vagal control of the ANS over time, and to its relative independence of the effects of socialization. However, at this age the effects of vagal tone were not as strong as were those of experience, as they could not withstand the addition of additional situational factors to the model predicting children's pain. Unlike the results at 6 months, the results at 18 months revealed no interactions between biological and immediate contextual factors, as no immediate contextual factors were involved in children's behavior at this age.

In summary, the data presented in this study support emotion regulation as an important determinant of the age-related changes in factors predicting children's pain behavior. Further, the data provide clear evidence of the socialization of children's pain behavior over time.

Based on analyses conducted in addition to the primary analyses, few hypotheses were supported. There were few age-related changes in the variables tested (e.g., vagal tone level, maternal behavior during immunization, or child pain behavior). Further, the four main predictor variables tested (child vagal tone level, child difficultness, maternal sensitivity, and maternal behavior during child immunization) were independent and behaved quite differently in their relations to child pain. Finally, maternal anxiety and stress played little role in either maternal behavior or child pain behavior in this study.

The results of these analyses indicate the extreme complexity of the factors involved in children's pain, and the danger of making sweeping statements regarding relations between children's pain behavior and other variables. Based on the results, it would be incorrect to expect uniform patterns with regard to the factors involved in

children's pain, or in children's behavioral expressions of their pain, or to try to generalize the results of studies carried out under one set of circumstances to pain occurring under a different set of circumstances. Pain is an extremely complex phenomenon, and it appears that the factors predicting it and its behavioral expression are equally complex. While some age-related changes may be uniform across many age periods, types of pain, and measurement strategies, others may not. It is therefore of primary importance in assessing and managing children's pain to take the age of the child, the background of those involved, the source of the pain, and the measures involved into consideration. An examination of the individual context in which pain occurs is necessary if any assessment of children's pain is to be accurate. Much more study is necessary before we will be able to accurately predict children's pain within the variety of contexts in which it may occur.

Appendix A

Script for Initial Telephone Contact with Mothers

Hello Ms. _____,

I am calling from the Dalhousie Pain Research Lab about the immunization study Dalhousie Health Services contacted you about. Is now a good time to tell you a bit more about the study? (If “yes” continue, if “no” arrange another time to call.)

This study is being conducted by (*Susan Sweet*), who is doing her Ph.D. in Clinical Psychology under the supervision of Dr. Patrick McGrath. We are trying to figure out why some infants seem to mind their immunizations so much while other infants don't seem to mind them at all. Our study is trying to look at what these differences might be related to.

If you agreed to participate in the study, you will be asked to take part in two different visits. The **first visit** will be here in the psychology department at Dalhousie. During this visit, you will be asked to bring your baby to the department about two hours. We can provide child care for any other children you have during your visit, if needed. While you are here, you will be asked to tell us about you and your child during an interview and through questionnaires. You can choose not to answer any questions you are uncomfortable with. In addition to this, your baby's resting heart-rate will be recorded for about 5 minutes and stored on a computer. This is not at all dangerous or painful for your child.

The **second visit** is much shorter. It involves (*Susan*) meeting you at Dalhousie Health Services on the day your baby is normally scheduled to receive his or her needle. (*Susan*) will meet you in the waiting room and ask you to fill out a short rating scale. Then (*Susan*) will come into the nurses' office during the needle to record your baby's reaction to the needle for about 2-3 minutes. (*Susan*) will not be involved at all in your visit with your doctor, and you are free to use whatever methods of pain management you normally use (e.g., Tylenol).

If you participate, all the information you provide us with will be identified only with a number, not your name, and it will be kept locked in the lab at Dalhousie. Only those persons helping in the study will have access to it. We will also be providing all participants with a \$20 honorarium in order to help cover their transportation costs, and we will send any interested participants a copy of the results of the study when it is finished. If you agree to participate, you can discontinue the study at any time. Do you have any questions or concerns about the study? Would you like to participate?

- NO** - Thank you for your interest. This won't affect the care you receive at Dalhousie Health Services in any way.
YES - complete background questions

Family Information:

Mother's name: _____ Child's name: _____
 Phone number: _____ Date of initial contact: _____
 Wants copy of results: yes no Sent on: _____
 Mailing address: _____
 Child's date of birth: _____ Child's age in months at Psych appt: _____

Prenatal Information:

Mother's pregnancy non-eventful? yes no _____
 Baby's gestation: (37 - 42) _____ Birth weight (2500 / 5.55lbs): _____
 Complications at birth? yes no _____
 Re-admitted to hospital? yes no _____
 Invasive Procedures? yes no _____
 Baby in good health now? yes no _____
 Other concerns (ie. language): _____

Needle Information:

Dal Health appointment: _____
 Doctor: _____
 Does health services know that you are part of this study? Yes No (*If not, please tell them*)
 We would like you to have your visit to Dalhousie within 10 days before your needle appointment. Is there anytime before then that you would be able to come?

Appointment Information:

Psychology appointment: _____
 Reminder call on: _____ by: _____
 Babysitter needed? yes no name: _____ age: _____
 Babysitting will be done by: _____
 Give directions and parking instructions.

Thank you for your interest and we will see you _____.

Appendix B

Recruitment Demographics

Participants:

- 116 mothers were informed about the study
- 91 mother-child dyads were eligible to participate

Reasons mothers were ineligible:

- they had the needle by the time they were contacted (7)
- they were no longer patients of Dalhousie Health Services (7)
- they were using EMLA during the needle (3)
- they were moving out of province (2)
- they could not understand the questionnaires (ESL - 1)
- they were unable to attend their child's needle (1)
- their child was off schedule for needles (1)
- they refused to hold their children during the needle (2)

Of the eligible parents, 72 (79%) agreed to participate and 19 (21%) declined.

Reasons for declining:

- not having enough time (9)
- not being interested in the study (5)
- having other young children (1)
- not wanting to travel to Dalhousie (1)
- objections of their husbands (1)
- illness in the family (1)
- extreme child shyness (1)

Reasons for excluding 12 participants:

6-month-olds

- one child's EKG was not usable
- one mother was not present during the needle
- one child completed only half the study

18-month-olds

- one child had a wart treated before his needle
- two children's mothers were not present during the needle
- three children's EKG's were not usable
- two children's videotapes were not usable
- one child completed only half the study

Appendix C

Demographic Interview Completed with Mother

Mother's Participation Number _____

Today's Date _____

Time _____

PARENT INFORMATION:

You relationship to the child:

1. mother 2. stepmother 3. other _____

Mother's Date of Birth: Year _____ Month _____ Day _____

Marital Status: married _____
 single _____
 divorced _____
 separated _____
 remarried _____
 common law _____
 widow _____
 other _____

Which ethnic group do you feel you belong to? French Canadian _____
 English Canadian _____
 African Canadian _____
 Asian Canadian _____
 First Nations _____
 Other (please specify) _____

For participant: How far did you go in school?

less than grade 7 _____
junior high: completed _____ partial _____
high school: completed _____ partial _____
community college/trade school: completed _____ partial _____
university: completed _____ partial _____
professional/graduate training: completed _____ partial _____

What is your occupation? _____

If not presently working, what was your previous occupation (if applicable)?
Maternity leave? How long ago were you working?

For your partner (if applicable):

Which ethnic group do you feel he/she belongs to? French Canadian _____
English Canadian _____
African Canadian _____
Asian Canadian _____
First Nations _____
Other (please specify) _____

For your partner (if applicable): How far did he/she go in school?

less than grade 7 _____
junior high: completed _____ partial _____
high school: completed _____ partial _____
community college/trade school: completed _____ partial _____
university: completed _____ partial _____
professional/graduate training: completed _____ partial _____

What is his or her occupation? _____

If not presently working, what was his or her previous occupation (if applicable)?
How long ago was this?

Number of family members: _____ Adults _____ Children

For each child in your family, please list their age, sex, and whether or not they currently reside in your home.

Age: _____ Sex (circle one): Male Female Living at home? (circle one): No Yes
Age: _____ Sex (circle one): Male Female Living at home? (circle one): No Yes
Age: _____ Sex (circle one): Male Female Living at home? (circle one): No Yes
Age: _____ Sex (circle one): Male Female Living at home? (circle one): No Yes
Age: _____ Sex (circle one): Male Female Living at home? (circle one): No Yes

CHILD INFORMATION:

Sex of child here today: Female Male

Child's date of birth: Year _____ Month _____ Day _____

Which ethnic group do you feel your child belongs to?

French Canadian _____
 English Canadian _____
 African Canadian _____
 Asian Canadian _____
 First Nations _____
 Other (please specify) _____

Who presently lives with your child? (list all persons, adult or child):

Who takes care of your child during the day?

mother _____
 father _____
 sibling _____
 family member _____
 daycare _____
 babysitter _____
 other (please specify) _____

On average, how many hours/day do you spend with your child during a week day?
 _____ hours

On average, how many hours/day do you spend with your child during a week-end day?
 _____ hours

Please make an overall estimation of your child's general health:

very poor _____
 poor _____
 fair _____
 good _____
 very good _____
 excellent _____

How many needles has (have) your child (children) had at which you have been present?
 _____ needles

Does your child experience any type of pain that occurs regularly? YES NO

If "yes," what kind of pain? _____

If "yes," on average, how often do these pains occur?

constantly _____
 hourly _____
 daily _____
 weekly _____
 monthly _____
 other (please specify) _____

Does your child have a chronic illness? yes no

If yes, what is the illness _____

How often does your child experience everyday pain (bumps, falls, scrapes)?

5+ times a day _____
 1-4 times a day _____
 once a day _____
 every couple of days _____
 once a week _____
 less than once a week _____
 other (please specify) _____

What does your child do to indicate to you that he or she is in pain?

What seems to comfort your child when he or she is in pain (everyday pain)?

Appendix D

Comparison of Items Composing the Difficultness Scale of the ICQ (Bates, Freeland, & Lounsbury, 1979) Across Age Versions

“Fussy - Difficult” items in 6-month-old version:

How easy or difficult is it for you to calm or soothe your baby when he/she is upset?

How many times per day, on the average, does your baby get fussy and irritable--for either short or long periods of time?

How much does your baby cry and fuss in general?

When your baby gets upset (e.g., before feeding, during diapering, etc.), how vigorously or loudly does he/she cry and fuss?

How changeable is your baby's mood?

Please rate the overall degree of difficulty your baby would present for the average mother.

“Fussy-Difficult-Demanding” items in 13-month-old version:

How consistent is your baby in sticking to his/her sleeping routine?

* How many times per day, on the average, does your baby get fussy and irritable--for either short or long periods of time?

* How much does your baby cry and fuss in general?

How easily does your infant get upset?

* How changeable is your baby's mood?

On the average, how much attention does your baby require, other than for care giving (feeding, diaper changes, etc.)?

When left alone, your baby plays well by himself/herself.

How persistent is your baby in trying to get your attention when you are busy?

* Please rate the overall degree of difficulty your baby would present for the average mother.

“Difficult” items in 24-month-old version:

◇ How easy or difficult is it for you to calm or soothe your child when he or she is upset?

◇ How many times per day, on the average, does your child get fussy and irritable--for either short or long periods of time?

◇ How much does your child cry and fuss in general?

How easily does your child get upset?

◇ When your child gets upset, how vigorously or loudly does he/she cry and fuss?

◇ How changeable is your child's mood?

◇ Please rate the overall degree of difficulty your child would present for the average mother.

Note: * = in both the 6- and 13-month ICQs; ◇ = in both the 6- and 24-month ICQs

Appendix E

Questions Added to Demographic Interview to Investigate MBQ (Pederson et al., 1990) Items Not Observable in a Lab Situation

Please answer the following questions about your child.

1. What is mealtime like with your child? (How do you know that your child is full or hungry? Does he or she say or do something to tell/signal you?)
2. What is your child's activity level like during feeding? (Is he or she usually very focused on eating, or distracted? Does this activity level interfere with eating? What do you do when this happens?)
3. What does your child like to eat?
4. How do you feel about leaving your child with someone other than a relative or your partner? How well does your child deal with strangers taking care of him or her? What does he or she do when this happens?
5. Compared to other infants, how much care and attention do you think your child demands/enjoys? (Will your child play alone for a little while, or does he or she always require you to be there?)
6. Does your child like to go on outings? Where do you go? How often?
7. What is naptime like with your child? What does your child do to let you know that he or she is tired? When does your child usually take naps?
8. Where does your child spend most of his or her time? Describe this place (with whom, what is in the room, etc.).
9. What do you think your child finds interesting about this place? What does your child like to have around him or her?
10. How have you baby proofed your home? (6 months - not usually mobile)
11. Does your child like to stay in a playpen?
12. What does your child like to watch on TV or on video? How often does your child watch these programs/movies?
13. Tell me about your child's favourite toys.

Appendix F

Cards and Loadings Which Parallel MBQ (Pederson et al., 1990) Questions Added to Demographic Interview

<i>Item #</i>	<i>Loading</i>	<i>Actual Q-sort Item</i>
13	2.75	Is irritated by demands of baby (note information from interview including comments on care giving demands).
31	5.58	Makes an effort to take baby on "outings" such as shopping, visiting friends.
32	5.83	Provides age appropriate toys.
33	6.00	Creates interesting environment.
44	7.42	Balances task and baby's activities when changing diapers.
45	7.58	Encourages baby's initiatives in feeding.
46	8.17	Cues baby and waits for response in feeding.
47	7.67	Balances task and baby's activities in feeding.
48	5.08	Provides nutritional snacks.
49	6.17	Environment is safe, "baby proofed."
51	3.58	Disturbed by baby becoming messy during feeding, these concerns sometimes interfere with feeding.
71	2.08	When baby is in a bad mood or cranky, mother often will place baby in another room so that she will not be disturbed.
72	4.33	At first glance, home shows little evidence of presence of infant.
77	3.42	Often "parks" the baby in front of the television in an attempt to keep her entertained.
78	2.42	Naptimes are determined by mother's convenience rather than the immediate needs of the baby, (determined from interview).
81	4.25	Makes frequent use of playpen in order to permit carrying out normal household chores.
82	5.50	Feels at ease leaving the child with a baby sitter in the evening.
85	5.08	Is very reluctant to leave the baby with anyone other than husband or close relative (determined from interview).
89	5.75	Very alert to "dirty diaper"; seems to change diapers as soon as any indication of need.

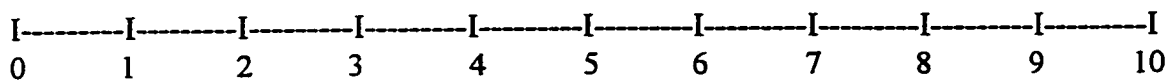
Note: Item loading range from 1 (most unlike a sensitive mother) to 9 (most like a sensitive mother). Items in the middle range (4-6) are least discriminative. Bold items are not represented by a question in the interview.

Appendix G

Maternal Anxiety Self-Report Rating Scale

Please rate on the following scale how anxious you feel about your child's needle:

(Please circle one)



very calm,
very relaxed

very upset,
very distressed

Appendix H

Observer Rating of Infant State Prior to Immunization

Participant Number: _____

Date: _____

Time of Needle: _____

- State 1** **crying:** cry bursts, with vigorous body activity
- State 2** **fussing:** either continuous mild agitated vocalization, or one cry burst
- State 3** **alert activity:** eyes open or closed, motor activity accompanied by grimacing or brief vocalization
- State 4** **alert inactivity:** eyes open, minimal movement
- State 5** **drowsy:** eyes slowly open and close, minimal movement, regular respirations
- State 6** **quiet sleep:** little motor activity, occasional startles, no REM facial movements
- State 7** **active sleep:** REM, frowns, or sucking may be present, eyes closed, minimal movement

Appendix I

Visual Analogue Scale Observer Rating of Child Pain During Immunization

Please place a mark along the following line where you feel it best reflects the child's pain response to the immunization:

No Pain |-----| Pain As
Severe As It
Could Be

Appendix J

Script for First Visit in Study at Dalhousie University

Hello Ms. _____. Thank-you so much for coming today. Maybe first I could just review the purpose of the study with you. I am trying to understand more about why some babies seem to mind their immunization shots quite a bit while other children do not seem to react to them at all. I am going to look at two groups of things these differences might be related to. The first is differences in the children themselves, so I will be asking you about your child's temperament and measuring his or her heart rate. The second is differences in more environmental things, such as how you tend to react to your child when he or she experiences pain. As I mentioned before, today I will be asking you to complete an interview with me and to fill out some questionnaires. I would also like to record your child's resting heart rate for a few minutes. Before we start, I will ask you to read this consent form saying that you agree for you and your child to participate in the study, and to sign it if you are comfortable with everything in the study. If you have any questions about the form or the study, please ask me.

First, I would like to measure your child's heart rate. This tells me about your child's resting level of physiological arousal, which can be important in pain response. This will be done using an EKG. To take an EKG, I have to put three of these little electrodes on your child's chest and the computer will read the electrical activity from your child's heart for a few minutes. What is really important during this time is that children are *as still as possible*. I thought the best way to do this was to have you hold your child on your lap during recording, and for them to watch a few minutes of Sesame Street. I'll get everything ready, start the tape, and then give your child a few minutes to adjust to it before starting to record. Then I'll record for about 5 minutes.

Complete Demographic Interview

Now I am going to ask you for some background information about you and your child, and about his or her routines. While we are doing this, your child can play with any of the toys in the room. During this section, you may notice that some of the questions are not really suited to your child. This is because the same questions are being asked to mothers with children of various ages. If a question does not really fit you, please answer as best you can.

Complete Questionnaires

Now I would like you to fill out some questionnaires about your child and yourself. Please don't put your name on any of them. They will be coded by number. While you are filling them out, please ask me if you have any questions. And remember, you do not have to answer any questions you are uncomfortable with. You will notice here that again some of the questions are not suited to children of all ages.

1) Administer the Infant Characteristics Questionnaire.

The first questionnaire asks you to report about your baby's temperament. Please do not fill out the Part I. Please start at Part II and circle the number of the item which you think best describes your baby. Please ask me if you have any questions.

2) Administer the Parenting Stress Index.

The second questionnaire asks about your stress level. This questionnaire includes an question booklet, which I will ask you not to write on, and an answer sheet where you can mark your responses. Again, please ignore the instructions to list personal information on the form. This questionnaire also asks you to circle the response you most agree with. This time they range from strongly agreeing with the statement to strongly disagreeing with the statement. When answering the section on children, please answer thinking about the child who is here with you today. Please don't erase on the form, as it copies onto the second page. If you wish to change an answer, just cross it out and circle another response. Please ask me if you have any questions.

When Mother has Finished Questionnaires

We are finished for today. Thank you for helping us with the study. When is your visit to Dal Health Services scheduled to occur? I will meet you there in the waiting room. I'll ask you to be there about 5 minutes early as I'll get you to fill out two quick rating scales in the waiting room. Then I'll wait in the waiting room until the nurse calls me in for the needle. I won't be involved at all in your visit with your doctor. I'll just come in to the nursing office, video-tape the needle, and then that will be the end of the study. Do you have any questions? Okay, I will see you _____.

Appendix K

Consent Form

Different children can have very different responses to the same types of pain. We are interested in learning more about the factors which may be important in influencing these different responses to pain. To do this, a study is being conducted by Susan Sweet (B.A. Hons) under the supervision of Dr. Patrick McGrath (Ph.D.). We would like to look at characteristics of your child, such as his or her age, sex, and typical levels of activity and reactivity. We would also like to look at characteristics of your relationship with your child, such as what you typically do when your child experiences pain. Studying these things may help us to determine whether children's pain behavior is more strongly related to their traits, or to their relationships with other people and things in the environment.

If you agree to help in this study, you will be asked to visit Dalhousie University for approximately two hours. During this time, you will be asked to fill out several questionnaires about your child and your relationship with your child. A measure of your child's heart rate will also be taken. Finally, we would like to observe and video-tape your child receiving his or her medically indicated inoculation shot at Dalhousie Health Services. This will be the *only* pain involved in the study. No additional pain will be studied.

If you agree to participate, you may change your mind at any time during the study. In addition, you may also refrain from answering any questions you are uncomfortable with. Your decision about participating or not participating will in no way influence the care you and your child will receive at Dalhousie Medical Services. If you participate, any information collected will be strictly confidential. All personal information will remain private and only the persons involved in this study will have access to it. It will be coded by number, and your name will not be recorded on any of the information you give us. Video tapes of needle procedures will be stored in locked cabinets in the psychology department of Dalhousie, and they too will be identified only by code number. Only those persons involved in this study will have access to them. When they are of no further scientific use, they will be destroyed. If you have any problems or questions about this study, please feel free to contact Susan Sweet (494-1938) or Dr. Pat McGrath (494-1580).

I hereby consent to participate in this study, and I consent for my child to participate:

(Signature)

(Witness)

(Date)

Appendix L

Script for Second Visit in Study at Dalhousie Health Services

Hello _____. Before you go in to the doctor, I'd like you to have a look at the scale I mentioned to you when you were at Dalhousie. I would like you to rate your own anxiety surrounding the needle from 0 (none at all) to 10 (as anxious as you can imagine).

(When the mother goes in to doctor) I'll wait here until you return for the needle.

(When mother returns to nursing office for needle) It's important for me to have a clear view of your child's face during the needle, because I'll use changes in facial expression to code each baby's response. Because of this, I'll ask you to try not to block your baby's face during and just after the needle. I will tape for about 30 seconds before the needle, and about a minute after the needle, so I'll also ask you not to get up right away after the needle. It won't be more than a couple of minutes all together.

Thank you for helping me with the study. I appreciate your time and effort. As you know, your participation is part of a larger study. I will be sending all interested participants a summary of the results, when one becomes available. That should be in about 6 months or so. Thank you again for your participation. We may be doing other studies in the future; would you like to hear about any other studies going on in the lab? If you agree to be contacted, you are still free to decide not to participate at a later time. **(If "yes" record name and phone number on a participant list, if "no" ask why not).** Do you have any questions before you go?

Appendix M

Summary of Independent and Dependent Variables in Analyses

Independent Variables:

Child Age

- 6 months (dummy coded as 1) or 18 months (dummy coded as 2)

Child Vagal tone

- vagal tone was operationalized as a log-transformation of each child's continuous individual raw score
- the range of vagal tone scores was unlimited, due to its continuous nature
- based on the participants in this study, scores ranged from -1.393 to .306, with higher scores indicating higher vagal tone levels

Child Difficulty

- coded as mothers' impressions of their children's difficulty, based on their ratings of their children on the "Fussy-Difficult" scale of the 6-month ICQ, or the "Difficulty" scale of the 24-month ICQ, respectively
- as the 6-month scale is composed of six items, and the 24-month scale is composed of seven items, mothers' raw ratings were converted into average scores on each age-version, in order scores might be compared across age periods
- possible range of average scores was 1 to 7, across age periods, with higher scores indicating higher perceived child difficultness

Maternal Behavior During Immunization

- maternal behavior during immunization was operationalized as the ratio of mothers' Coping Promoting to Distress Promoting vocalizations, according to the CAMPIS-R
- mothers' raw scores on the Coping Promoting and Distress Promoting subscales of the CAMPIS-R, based on the primary coder, were made continuous by calculating the proportion of each type of verbalization within each time period (the total number of instances that a given CAMPIS-R code category was designated as occurring was divided by the total number of coded behaviors for that person)
- the proportions ranged from 0 to 1.0
- to create the final summary score (ratio) used in analyses, the proportion of Coping Promoting verbalizations within each time period was divided by the proportion of Distress Promoting verbalizations within the same time period
- before division occurred, a constant of one was added to all scores, in order to correct for divisions by zero
- final scores had a possible range of .5 to 2, with higher scores indicating more Coping Promoting relative to Distress Promoting verbalizations.

Maternal Sensitivity

- because the Ainsworth, Bell, and Stayton (1974) Sensitivity Scale provides a single metric to measure a very complex construct, it was intended to act as an adjunct to the MBQ, and scores derived from the MBQ were used to represent sensitivity in all analyses
- maternal sensitivity was operationalized as each mother's r score (the correlation between her sort and the criterion sort)
- scores were correlations, and therefore ranged from -1 to +1, with higher scores indicating more sensitive behavior

Maternal Stress

- maternal stress was operationalized as mothers' scores on the Parental Stress scale of the PSI, based on their self-reports
- each mother's raw score on the Parental Stress scale was converted to a percentile rank, based on tables provided in the PSI manual
- the possible range of score was 0 to 100%, with higher scores indicating greater maternal stress

Mothers' Ratings of Their Own Anxiety Before Needle

- anxiety was operationalized as mothers' self-reported raw scores on the 0 to 10 point scale, with higher scores indicating greater anxiety levels

Child State

- infants' raw scores on the 0-6 point rating scale, with higher scores indicating less aroused states (0 = crying, 1 = fussing, 2 = alert activity, 3 = alert inactivity, 4 = drowsy, 5 = quiet sleep, 6 = active sleep)

Nurse:

- this variable was dummy coded 1 (the person administering the needle was one of the regular two daytime nurses) or 2 (the person administering the needle was someone other than the two regular daytime nurses)

Dependent Variable:

Pain

- as the VAS provided a single metric to measure a very complex construct, it was intended to act as an adjunct to the NFCS, and scores derived from the NFCS were used to represent sensitivity in all analyses
- 3 summary scores representing the total amount of facial activity within a given time period were calculated, one each for the baseline, injection, and recovery in each period, 10 facial actions were coded in five 2-second time blocks
- the total possible score during each time period ranged from 0-50, with higher scores indicating more facial activity and therefore more pain

Appendix N

Summary of Continuous Demographic Variables in 6- and 18-month-old Groups

Variable	6 Months		18 Months	
	<u>M</u>	<u>SD</u>	<u>M</u>	<u>SD</u>
Maternal Age	32.028	5.099	31.169	4.596
Number in Family	3.800	.805	3.833	1.020
Number of Children	1.800	.805	1.900	.923
Child Birth Weight	7.929	1.004	7.860	.789
Child Gestational Age	39.264	1.514	38.817	1.573

Appendix O

Summary of Categorical Demographic Variables in 6- and 18-month-old Groups

Child's Sex		Male	Female				
6 months		40% (12)	60% (18)				
18 months		36.7% (11)	63.3% (19)				
Child's Birth Order		First Born	Second Born	Third Born	Fourth Born		
6 months		40% (12)	43.3% (13)	13.3% (4)	3.3% (1)		
18 months		43.3% (13)	36.7% (11)	13.3% (4)	6.7% (2)		
Child's Ethnic Group		English Can.	French Can.	Bi-racial Can.	Italian Can.	Arabic Can.	African Can.
6 months		86.7% (26)	3.3% (1)	3.3% (1)	3.3% (1)	3.3% (1)	0
18 months		86.7% (26)	0	6.7% (2)	0	0	6.7% (2)
Mother's Ethnic Group		English Can.	French Can.	Hungarian			
6 months		86.7% (26)	13.3% (4)	0			
18 months		96.7% (29)	0	3.3% (1)			
Father's Ethnic Group		English Can.	French Can.	African	Arab	Russian	Italian
6 months		83.3% (25)	3.3% (1)	3.3% (1)	3.3% (1)	3.3% (1)	3.3% (1)
18 months		73.3% (22)	10% (3)	10% (3)	0	3.3% (1)	3.3% (1)
Mother's Marital Status		Married	Common Law	Single	Separated	Widowed	
6 months		93.3% (28)	6.7% (2)	0	0	0	
18 months		76.7% (23)	10% (3)	6.7% (2)	3.3% (1)	3.3% (1)	
							Guatemalan
							0
							3.3% (1)

Mother's Employment Status

	<u>Full Time</u>	<u>Part Time</u>	<u>Maternity Leave Regular Full Time</u>	<u>Maternity Leave Regular Part Time</u>	<u>Not Working</u>
6 months	13.3% (4)	6.7% (2)	36.7% (11)	6.7% (2)	36.7% (11)
18 months	33.3% (10)	20% (6)	3.3% (1)	3.3% (1)	40% (12)

Father's Employment Status

	<u>Full Time</u>	<u>Part Time</u>	<u>Not Working</u>	<u>Student</u>
6 months	96.7% (29)	0	3.3% (1)	0
18 months	76.6% (23)	3.3% (1)	3.3% (1)	16.7% (5)

Mother's Educational Level

	<u>Graduate/Professional</u>	<u>University</u>	<u>Partial University/College</u>	<u>High School</u>	<u>Partial High School</u>	<u>Junior High</u>
6 months	23.3% (7)	30% (9)	43.4% (13)	0	3.3% (1)	0
18 months	20% (6)	36.7% (11)	33.3 (10)	6.7% (2)	0	3.3% (1)

Father's Educational Level

	<u>Graduate/Professional</u>	<u>University</u>	<u>Partial University/College</u>	<u>High School</u>	<u>Partial High School</u>
6 months	33.3% (10)	20% (6)	20% (6)	23.3% (7)	3.3% (1)
18 months	36.7% (11)	23.3% (7)	23.3% (7)	13.3% (4)	3.3% (1)

Household SES

	<u>Level 1</u>	<u>Level 2</u>	<u>Level 3</u>	<u>Level 4</u>	<u>Level 5</u>
6 months	20% (6)	40% (12)	30% (9)	10% (3)	0
18 months	10% (3)	43.3% (13)	23.3% (7)	20% (6)	3.3% (1)

Appendix P

Summary of Regression Analyses for Interactions Between Child and Maternal Variables at 6 Months of Age

Variables in Total Model	R ²	F	p	t	β	p
Maternal Sensitivity	.132	1.313	.291	1.656	-.711	.110
Child Vagal Tone				1.773	1.064	.088
Sensitivity x Vagal Tone				1.951	-1.359	.062
Ratio of Coping/Distress Promoting	.375	5.206	.006	.009	.003	.993
Child Vagal Tone				2.001	-.731	.056
Ratio x Vagal Tone				2.159	.917	.040
Maternal Sensitivity	.207	2.266	.105	.571	.303	.573
Child Difficulty				1.753	.574	.091
Sensitivity x Difficulty				.459	-.267	.650
Ratio of Coping/Distress Promoting	.481	8.031	.001	.437	.213	.666
Child Difficulty				2.634	.859	.014
Ratio x Difficulty				1.507	-.839	.144

Appendix Q

Summary of Regression Analyses for Interactions Between Child and Maternal Variables at 18 Months of Age

Variables in Total Model	R ²	F	p	t	β	p
Maternal Sensitivity	.382	5.355	.005	3.147	.633	.004
Child Vagal Tone				.091	.030	.928
Sensitivity x Vagal Tone				1.129	.399	.269
Ratio of Coping/Distress Promoting	.223	2.494	.082	.922	-.229	.365
Child Vagal Tone				.107	.054	.916
Ratio x Vagal Tone				.512	.286	.613
Maternal Sensitivity	.261	3.059	.046	.529	.454	.601
Child Difficulty				.269	.168	.790
Sensitivity x Difficulty				.029	.030	.977
Ratio of Coping/Distress Promoting	.175	1.836	.165	.925	-.586	.364
Child Difficulty				.161	.070	.874
Ratio x Difficulty				.346	.270	.732

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Table 1

Relations Between Child Temperament and Child Pain.

Study	Participants	Measure of Temperament	Pain Source	Results
Crunau, Whitfield, & Petrie, 1994	<p>at 18 months corrected age, extremely low birth-weight (ELBW) infants (<1001 g) were assessed in 2 groups: 49 birth weight 480-800g, 75 birth weight 801-1000g</p> <p>2 control groups were assessed: 42 heavier preterm (1500-2499 g) and 29 full birth weight (FBW) (>2500g)</p>	<p>Buss and Plomin's 1984 Temperament Questionnaire, all parental report (over 90% were mothers), parents also rated pain sensitivity on a 5-point scale</p>	<p>none, parents were asked to rate their children's sensitivity to pain on a 1- to 5-point scale ("Child is very sensitive to pain of bumps and cuts or other common hurts")</p>	<p>both groups of ELBW children rated by parents as significantly less sensitive to pain than control groups, temperament strongly related to rated pain sensitivity in the FBW group ($R = .80$), moderately in heavier preterm ($R = .51$) and 801-1000g ($R = .48$) groups, and not related in lowest group. trend for FBW: most emotionally reactive most responsive to everyday pain</p>
Schechter et al., 1991	<p>5 year old children and their families, 35 females and 30 males, mean age 60 months</p>	<p>Behavioral Style Questionnaire and a standardized measure of child temperament, all parental report (in most cases both parents), child distress was measured by a version of the Procedure Rating Scale Revised and a global assessment by a research assistant, Oucher completed by child, parents predicted child distress at needle</p>	<p>immunization</p>	<p>distressed behavior correlated with child difficulty and adaptability (mother $r = -.43$, father $r = -.22$)</p>
Davison, Fauli, & Nicol, 1986	<p>30 children with recurrent abdominal pain (about 6 years of age) and their mothers, 30 children without pain, half of children were male and half female</p>	<p>mothers were interviewed with the Newcastle Inventory of Temperamental Characteristics</p>	<p>abdominal pain</p>	<p>those with abdominal pain tended to be more active and more difficult (especially the males), females were more likely to be irregular, males more likely to withdraw in new situations</p>

Williams et al., 1985	25 children aged 8-14 years, 11 refusers of dental treatment (8 females, 3 males) and 14 controls (6 females and 8 males)	parent rating on nine 3-point scales based on 9 scales of temperament from Thomas & Chess (1968), parents also predicted reaction of child and child's anxiety level	most were check-ups, one refuser received a filling	parents of refusers expected them to react badly in dentist's chair and rated their children's current level of anxiety as higher, refusers were more distressed before the procedure but all felt the same in treatment, refusers more likely to find it difficult to play with unfamiliar children, and were rated by parents as having difficulty tolerating any pain/discomfort, difficulty approaching novel situations, and difficulty adapting to change
Young & Fu, 1988	80 children aged 48 to 83 months	Parent Temperament Questionnaire (parental report)	64 had finger sticks and 16 had venipunctures	rhythmicity explained 4% of variance in child's self-report of pain 5 minutes after the test ($r = .22$), approach explained 7.5% of variance in Body Movement/Posture scores right after the test ($r = -.27$)
Ruddy-Wallace, 1989	thirty-one 3-7 year olds	Behavioral Style Questionnaire (parent report)	elective surgery involving the urinary system	temperament and number of post-operative analgesic medications were related, intensity was a significant predictor of more analgesic use, those who were more intense used more medication, there were no sex differences
Lee & White-Traut, 1996	137 parent-child dyads, children 3-7 years old, all were scheduled for outpatient surgery within the next 5 days	Behavioral Style Questionnaire (parent report)	venipuncture	difficult children displayed more distress both physiologically and behaviorally when in pain, children with lower threshold self-reported more pain during venipuncture

Table 2

Relations Between Child Vagal Tone and Child Temperamental Behaviors.

Study	Participants	Assessment of Vagal Tone	Assessment of Temperamental Behaviors	Results
Field et al., 1995	22 three-month-olds, 22 six-month-olds (children of depressed mothers not included here)	EKG - 3 minutes while sitting still during mother-child play, used Porges' method	used the IRS (Field, 1980), 7 item rating system for vocalization	higher vagal tone related to more vocalizing (a form of expressivity)
Fox & Field, 1989	28 children ages 3-4 years old	recorded resting EKG for 5 min, child sat in a chair, used Porges' method	mothers were given the Dimensions of Temperament questionnaire at the onset of school and again 6 months after it began, they also completed a behavior problems questionnaire before school and at the end of the first, third, and sixth week of school, children were also observed during free play	more difficult temperament was related to lower vagal tone (DOTS composite negatively correlated with vagal tone, $r = .40$), children with high vagal tone, high activity level, and low distractibility evidenced more sleeping disturbances prior to school entry and more solitary behavior during the first two weeks of school
Fox, 1989	88 healthy term newborns assessed at 2 days, 63 again at 5 months, and 52 again at 14 months	2 days - tonic EKG recorded while infant lying in bassinet asleep 5 months - 5 minutes of EKG recorded while infant sitting with mother 14 months - EKG recorded while infant sitting, watching TV, and manipulating an object, used Porges' method	2 days - reactivity to pacifier withdrawal 5 months - reaction to peek-a-boo (smiling and laughter) and arm restraint (distress) observed 14 months - free play, reaction to unfamiliar adult and to novel object, and Strange Situation observed	2 days - vagal tone grouping not related to differences in reactivity at 14 months 5 months - those with high vagal tone were more reactive at 14 months, also showed more negative reactivity, more positive reactivity, more crying to arm restraint, and greater regulation of distress at 5 months 14 months - those with higher vagal tone showed more approach behavior to the object and adult *consistency in vagal tone was found over the 5 to 14 month period, but not the 2 day to 14 month period
Stifter & Fox, 1990	88 healthy term newborn infants tested at 2 days, 63 tested again at 5 months	2 days - EKG recorded while infant lying in bassinet 5 months - EKG while infant sitting on mother's lap, used Porges' method	2 days - reaction to pacifier withdrawal observed 5 months - mothers filled out the IBQ (Kothbart, 1981), reaction to peek-a-boo (smiling and laughter) and arm restraint (distress) observed	2 days - no significant relations between vagal tone and other measures 5 months - infants with higher vagal tone were more reactive, less smiling and laughter, more active those with higher vagal tone at 2 days were rated as more frustrated and fearful at 5 months

DiPietro, Larson, & Porges, 1987	100 healthy newborns, 40 males and 60 females, mean age 36.8 hours	while infant was asleep, 10 min of EKG and respiration were recorded (some were in active sleep and others were not), used Porges' method	Neonatal Behavioral Assessment Scale administered by examiners	breast-fed babies had significantly higher vagal tone than did bottle-fed babies, they were also more irritable and less consolable than were bottle-fed babies
Porges et al., 1994	35 infants assessed at 9 months of age, and again at 3 years	9 months - EKG recorded for 3 minutes while child sat on mother's lap 3 years - 3 minutes recorded while child watched cartoons, used Porges' method	9 months - mothers filled out ICQ (Bates) 3 years - mothers filled out Finegan's age appropriate version of the ICQ	9 months - difficulty was related to higher vagal tone, 9 month vagal tone predicted 3 year difficulty (negative correlation), difficulty at 3 years was not related to physiological measures
Healy, 1989	45 twin pairs between 11 and 35 months of age (mean = 19.6 months) were assessed	recorded EKG, 3-5 minutes baseline, 3-5 minutes during a TV show, after free play and lab tasks were completed, 3-5 more minutes were recorded during a TV show, used Porges' method	mothers were given the Toddler Temperament Scale (Fullard, McDevitt, & Carey), lab tasks used for behavioral observation - child and unfamiliar person with age appropriate toys (coded affective and adaptive response), coded behavior toward stranger, latency to cry when mother left, latency to touch novel toy	correlation between composite measures and vagal tone were nonsignificant, latency to cry showed no relation to vagal tone, children with higher vagal tone were slower to approach novel object, higher vagal tone correlated with maternal ratings of more negative mood and more distractibility, children rated as difficult were higher in vagal tone

Table 3
 Relations Between Parental Behavior and Child Pain.

Study	Participants	Measures	Pain Source	Results
Schechter et al., 1991	5 year old children and their families, 35 males and 30 females, mean age 60 months	Behavioral Style Questionnaire and a standardized measure of child temperament, all parents (in most cases both parents), child distress measured by version of Procedure Rating Scale Revised and a global assessment by research assistant, Oucher completed by child, parental self-report of pain-related attributes and attitudes, medically related attributes, and role of parents in comforting children in pain, parental prediction of child distress at needle	immunization	no relations between parent and child behavior, distressed behavior correlated with parents' prediction of distress (mother $r = .26$, father $r = .46$)
Broome & Endsley, 1989b	83 preschool children aged 4-6 years and their mothers	mothers rated their own and their child's anxiety on a 4-point scale prior to needle, observer rated parental behavior to child during needle on a 5-point scale from very positive to very negative, used Child Behaviour Scale for child adapted from Frankl et al. (1962)	immunization	most mothers reassured and very few admonished their children during the needle trends: of extremely reassuring parents, half had distressed children, half were non-distressed; if parents neutral or slightly positive, children not very distressed; if parents negative, child distressed mother's ratings of child's anxiety significantly correlated with child's observed behavior ($r = -.30$), if child rated highly anxious, child most likely to be observed to be distressed during the procedure
Gonzalez et al., 1989	47 children aged 13 months to 7 years, 10 females and 13 males had parents present, 14 females and 24 males had parents absent	child's reaction to needle recorded via videotape, behaviorally coded Observational Scale of Behavioral Distress, rating of child's reaction on Frankl Behaviour Rating Scale, parents present or absent	injection	when parents left, children showed more immediate distress on the OSBD than did other children, when parents absent the relation between age and distress significant ($r = -.52$), during injection age significantly correlated with distress behavior ($r = -.53$), all children preferred parent present
Broome & Endsley, 1989a	138 mother and child pairs, children aged 3-9 years old (89% were 4-6 years)	Child-rearing Practice Questionnaire (warmth and control subscales) and Child Behaviour Observation Rating Scale	immunization	maternal presence associated with more child distress during interview, but not during immunization, parents with high control/high warmth had less distressed children than parents low control/low warmth, high control/low warmth, or low control/high warmth

Blount et al., 1989	14 males and 9 females aged 5-13 years, all were leukemia patients	Child-Adult Medical Procedure Interaction Scale used to code transcription and audiotape of procedure (Sackett's Lag Analysis)	bone marrow aspirations and lumbar punctures	adults' reassuring comments, apologies to child, giving control to child, and criticisms of child typically preceded child distress, coping was preceded by nonprocedural talk and humor and adult commands to engage in coping behavior
Blount et al., 1991	13 males and 9 females aged 5-13 years, all were leukemia patients	Child-Adult Medical Procedure Interaction Scale - Revised used to code transcription and audiotape of procedure	bone marrow aspirations and lumbar punctures	children were grouped as high or low copers, adults with high coping children were more likely to distract and coach children in the use of coping skills; there was also a trend towards lower Distress Promoting behaviors by these parents
Blount, Sturges, & Powers (1990)	13 males and 9 females aged 5-13 years, all were leukemia patients	Child-Adult Medical Procedure Interaction Scale - Revised used to code transcription and audiotape of procedure	bone marrow aspirations and lumbar punctures	adult nonprocedural talk and humor to child before BMA were positively related to child verbal coping, negatively related to child distress before BMA, and not related to behavior during BMA; adult commands to use coping strategies during BMA were positively related to deep breathing by child during BMA and negatively related to child distress during BMA; adult Distress Promoting behavior was related to child distress before and during BMA

Table 4

Comparison of Difficultness Scores with Normative Difficultness Means and Standard Deviations.

Age	Source	N	M	SD
6 months	norms ¹	345	17.77	5.88
6 months	present study	30	17.17	6.44
24 months	norms ¹	127	21.86	6.51
18 months	present study	30	21.10	5.73

¹ See Bates (1986)

Table 5

Pearson Correlations Between Child Difficultness and Maternal Demographic Variables.

Variable	Child Difficulty			
	6 months		18 months	
	r	p	r	p
Maternal SES	.023	.905	.080	.674
Maternal Education	-.044	.818	.043	.823
Maternal Employment	.111	.561	.064	.739
Maternal Age	.048	.801	-.176	.353

Table 6

Pearson Correlations Between Child Difficultness and Maternal Psychological Variables.

Variable	Child Difficulty			
	6 months		18 months	
	r	p	r	p
Maternal Sensitivity	-.066	.728	-.018	.925
Maternal Anxiety	-.076	.690	.536	.002 *
Maternal Stress	.395	.031*	.493	.006 *

* $p < .05$

Table 7

Comparison of Scores on Predictor Variables Between 6 and 18 Months of Age.

Variable	Score										
	6 Months					18 Months					t test
	M	SD	Range	M	SD	Range	t	df	p		
Child Vagal Tone	-.533	.388	-1.393 to .306	-.435	.384	-1.231 to .304	.99	58	.325		
Child Difficultness	2.917	1.034	1.000 to 5.167	3.014	.818	1.714 to 4.857	.41	58	.686		
Maternal Sensitivity	.644	.375	-.593 to .946	.671	.297	-.065 to .916	.31	58	.759		
Ratio of Maternal Coping/Distress Promoting	1.008	.512	.500 to 2.000	1.138	.446	.667 to 2.000	1.05	58	.298		
Nurse Status	1.300	.466	1 to 2	1.200	.407	1 to 2					
Child State	3.367	.718	2 to 4	3.067	.907	1 to 4	1.42	58	.161		

Maternal Anxiety	3.133	2.417	0 to 7	3.033	3.000	0 to 10	.14	58	.887
Maternal Stress	37.233	29.257	1 to 93	33.900	24.542	3 to 82	.48	58	.634

Note: Possible ranges are as follows
 Child Vagal Tone = unlimited
 Child Difficultness = 1 to 7
 Maternal Sensitivity = -1.000 to 1.000
 Ratio of Maternal Coping/Distress Promoting Behavior = .500 to 2.000
 Nurse Status = 1 (regular nurse) to 2 (non-regular nurse)
 Child State = 0 to 6
 Maternal Anxiety = 0 to 10
 Maternal Stress = 0 to 100

Table 8

Independent Samples t-tests for Differences in Facial Action Across Age Groups.

Phase	NFCS Score									
	6 Months			18 Months			t test			
	M	SD	Range	M	SD	Range	t	df	p	
Baseline	5.433	4.415	0 to 19	5.533	6.479	0 to 23	.07	58	.945	
Injection	12.900	8.281	0 to 28	13.200	9.415	0 to 30	.13	58	.896	
Recovery	11.633	8.198	0 to 32	10.267	9.214	0 to 30	.61	58	.546	

Note: Possible range = 0 to 50.

Table 9

Correlation Matrix of Pearson Correlations Between Main Predictor Variables at 6 Months of Age.

Variable	Child Vagal Tone	Child Difficulty	Ratio of Maternal Coping/Distress Promoting	Maternal Sensitivity
Child Vagal Tone	--			
Child Difficulty	$r = -.181$ $p = .337$	--		
Ratio of Maternal Coping/Distress Promoting	$r = .060$ $p = .751$	$r = -.053$ $p = .781$	--	
Maternal Sensitivity	$r = .058$ $p = .763$	$r = -.066$ $p = .728$	$r = -.191$ $p = .312$	--

Table 10

Correlation Matrix of Pearson Correlations Between Main Predictor Variables at 18 Months of Age.

Variable	Child Vagal Tone	Child Difficulty	Ratio of Maternal Coping/Distress Promoting	Maternal Sensitivity
Child Vagal Tone	--			
Child Difficulty	$r = -.015$ $p = .937$	--		
Ratio of Maternal Coping/Distress Promoting	$r = -.121$ $p = .525$	$r = .090$ $p = .637$	--	
Maternal Sensitivity	$r = -.032$ $p = .868$	$r = -.018$ $p = .925$	$r = -.227$ $p = .229$	--

Table 11

Summary of Primary Stepwise Regression Analyses for Variables Predicting Child Pain Behavior by Age Group (N = 60).

Variable	Results at each step in the regression analyses					Results in the final step		
	Total R ²	df	F	p	R ² Change	t	β	p
6 months								
Step 1								
Maternal Coping/ Distress Promoting	.263	1, 28	9.989	.004		3.390	-.491	.002
Step 2								
Child Difficulty	.436	2, 27	10.422	.000	.173	2.875	.416	.008
18 months								
Step 1								
Maternal Sensitivity	.227	1, 28	8.199	.008		3.142	.487	.004
Step 2								
Child Vagal Tone	.352	2, 27	7.321	.003	.125	3.803	.354	.031

Table 12

Pearson Correlations Between Child Pain Behavior and Predictor Variables.

Variable	Correlation			
	6 months		18 months	
	r	p	r	p
Child Vagal Tone	-.048	.801	.339	.067
Child Difficulty	.442	.014 *	.117	.350
Maternal Sensitivity	.044	.818	.476	.008 *
Ratio of Maternal Coping/Distress Promoting	-.513	.004 *	-.357	.053

*p < .05

Table 13

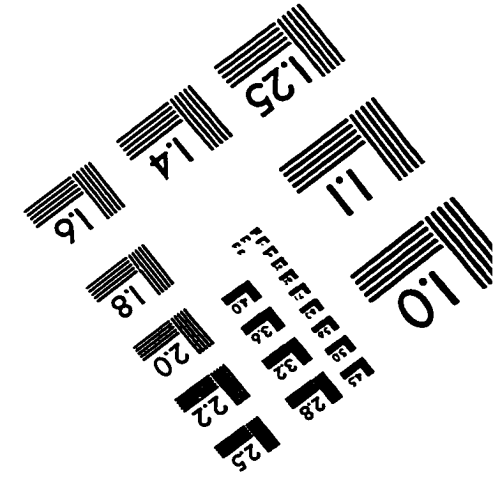
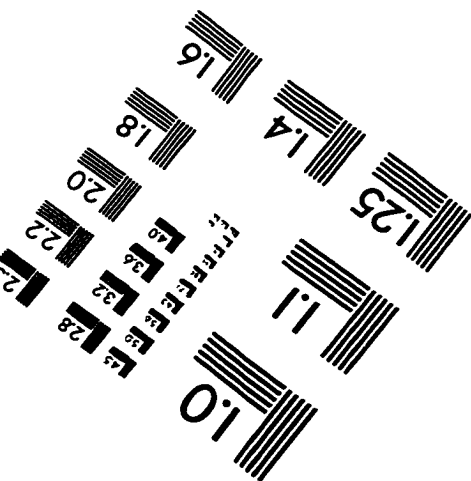
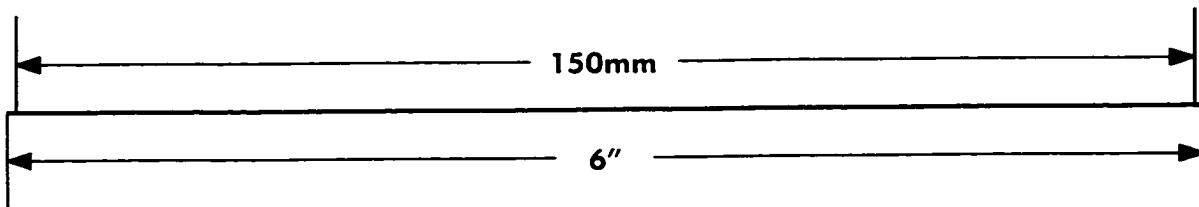
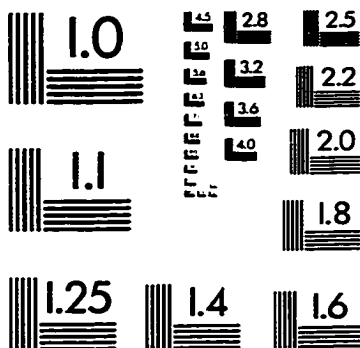
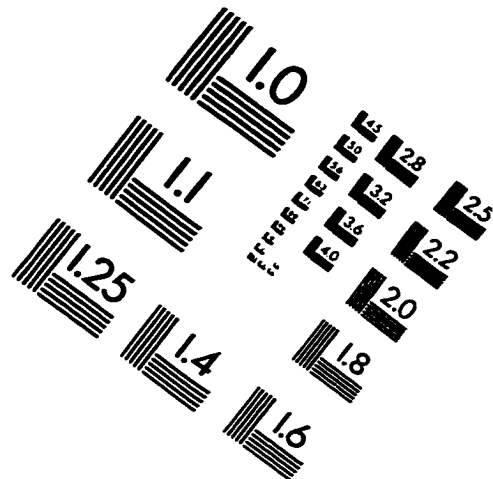
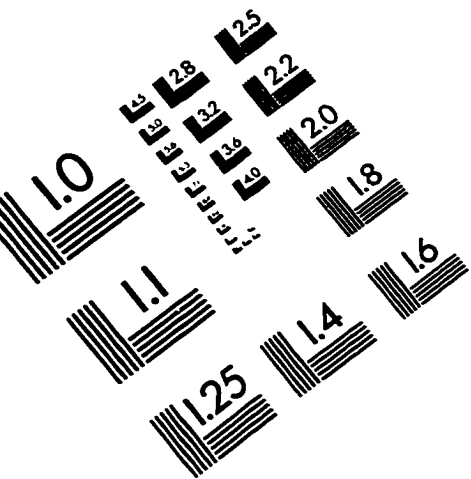
Summary of Secondary Stepwise Regression Analyses for Variables Predicting Child Pain Behavior by Age Group (N = 60).

Variable	Results at each step in the regression analyses				Results in the final step			
	Total R ²	df	F	p	R ² Change	t	β	p
6 months								
Step 1								
Nurse Status & Child State	.382	2, 27	8.330	.002		2.920 .397	.413 -.058	.007 .001
Step 2								
Maternal Coping/ Distress Promoting	.520	3, 26	9.374	.000	.138	3.023	-.389	.006
Step 3								
Child Difficulty	.611	4, 25	9.816	.000	.091	2.423	.324	.023

18 months

Step 1									
Nurse Status &	.395	2, 27	8.808	.001	3.533	-.516	.002		
Child State					1.570	.232	.129		
Step 2									
Maternal Sensitivity	.487	3, 26	8.241	.001	2.167	.322	.040		

IMAGE EVALUATION TEST TARGET (QA-3)



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