ORIGINAL ARTICLE

Infant pain regulation as an early indicator of childhood temperament

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SA Stevens, N Racine, R Pillai Riddell, R Horton, H Garfield, S Greenberg. Infant pain regulation as an early indicator of childhood temperament. Pain Res Manag 2013;18(6):313-318.

BACKGROUND: There is considerable variability in infants' responses to painful stimuli, including facial and vocal expressions. This variability in pain-related distress response may be an indicator of temperament styles in childhood.
OBJECTIVE: To examine the relationships among immunization pain outcomes (pain reactivity, pain regulation and parent ratings of infant pain) over the first year of life and parent report of early temperament.
METHODS: A subset of parent-infant dyads in an ongoing Canadian longitudinal cohort was studied. Infant pain behaviours were coded using the Modified Behavior Pain Scale. Parental judgments of infant pain were recorded using the Numeric Rating Scale. Infant temperament was measured using the Infant Behaviour Questionnaire-Revised. Correlational analyses and multiple regressions were conducted.
RESULTS: Multiple regressions revealed that the 12-month regulatory pain scores predicted parent ratings of the Negative Affectivity temperament dimension at 14 months of age. Parent ratings of infant pain at 12 months of age predicted parent ratings of the Orienting/Affiliation temperament dimension, with sex differences observed in this substrate.
CONCLUSION: Pain-related distress regulation at one year of age appears to be a novel indicator of parent report of temperament ratings. Pain outcomes in the first six months of life were not related to parent temperament ratings.

Key Words: *Infant; Acute pain; Reactivity; Regulation; Temperament*

La régulation de la douleur du nourrisson comme indicateur précoce du tempérament pendant l'enfance

HISTORIQUE : On constate une variabilité considérable des réponses des nourrissons aux stimuli douloureux, y compris leurs expressions faciales et vocales. Cette variabilité de la réponse à la détresse liée à la douleur peut être un indicateur du type de tempérament pendant l'enfance.
OBJECTIF : Examiner les relations entre les conséquences de la douleur causée par la vaccination (réactivité à la douleur, régulation de la douleur et évaluation de la douleur du nourrisson par le parent) pendant la première année de vie et le compte rendu du tempérament précoce du nourrisson par le parent.
MÉTHODOLOGIE : Les chercheurs ont étudié un sous-groupe de dyades parent-nourrisson faisant partie d'une cohorte longitudinale canadienne en cours. Ils ont codé les comportements de douleur des nourrissons au moyen de l'échelle modifiée de comportement face à la douleur. Les parents ont évalué la douleur de leur nourrisson au moyen de l'échelle d'évaluation numérique. Les chercheurs ont mesuré le tempérament des nourrissons au moyen du questionnaire révisé sur le comportement du nourrisson. Ils ont effectué des analyses corrélationnelles et des régressions multiples.
RÉSULTATS : Les régressions multiples ont révélé que les indices de régulation de la douleur sur 12 mois étaient prédictifs de l'évaluation par le parent de la dimension du tempérament d'affectivité négative à 14 mois. L'évaluation de la douleur du nourrisson par le parent à 12 mois était prédictive de l'évaluation par le parent de la dimension du tempérament d'orientation et d'affiliation, mais on observait des différences selon les sexes dans ce substrat.
CONCLUSION : La régulation de la détresse liée à la douleur à un an semble être un nouvel indicateur du compte rendu de l'évaluation du tempérament par le parent. Les conséquences de la douleur au cours des six premiers mois de vie n'étaient pas liées à l'évaluation du tempérament par le parent.

There is a considerable amount of undefined variability in the pain responses of infants. While some infants show intense behavioural responses following painful stimuli, including facial and vocal expressions, others exhibit more diminished reactions (1-5). A greater understanding of the individual variability in response to pain may provide valuable insight into future behavioural regulation and mental health of infants and children. One aspect of development that may contribute to the inherent variability in response to pain is a child's temperament. Temperament, defined as early reactivity and regulation behaviours, is assumed to be influenced by both biological and social factors during childhood (6) and is often characterized by the duration, intensity and valence of emotional reactions, as well as the control of those reactions (6,7). Importantly, early individual differences in temperament are reported to impact the development of self-regulation (7,8) which, in turn, plays a vital role in social, behavioural, academic and health outcomes (9,10). Further investigation of the early indicators of temperament is, therefore, crucial in understanding both adaptive and maladaptive childhood mental health outcomes. Because reactivity to stressors has been proposed to be a critical basis for emotional temperament (6), understanding reactivity and regulation following painful procedures early in infancy may provide valuable insight into understanding the self-regulatory abilities of young children during painful experiences.

For preverbal infants, pain-related behaviours, including crying, facial expressions and body movements, represent direct ways to express emotions in response to environmental experiences (11,12). Researchers in infant pain are beginning to examine reactivity (ie, immediate onset of responses following a painful event) and regulatory (ie, period of control or recovery phase following a painful event) reactions to painful procedures, not only as indicators of pain responding, but also as indicators of temperamental predispositions (13-16). Indeed, neonatal crying has been interpreted as an early display of temperament style (17,18). Healthy neonates who show high crying intensity before a regulatory phase of a painful procedure displayed a positive mood quality at one month of age, and infants who displayed shorter breath intervals after the regulatory phase had high activity styles at one month of age (15). Additional studies have examined the association between infant pain response and temperament beyond

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one month of age; however, as infants age, this relationship becomes less clear. Whereas increased reactivity in healthy neonates following a painful procedure has been associated with lower levels of distress at six months of age (14), higher reactivity and increased distress in preterm newborns following a painful procedure experienced in the first 10 days of life was predictive of negative affect at 18 to 32 months of age (16). Interestingly, these findings suggest that infant pain responses have different outcomes depending on the stage of development (eg, age) and early experience (eg, prematurity). Overall, infant reactivity to stressors, including painful stimuli such as needles, appears to be a valuable predictor of later temperament to explore. However, there is limited research distinguishing between infant pain reactivity and regulation behaviours, and limited understanding of how these behaviours impact self-regulation and future mental health. Furthermore, the relationship between temperament, and pain-related reactivity and regulation, has not been fully investigated using multiple timepoints across the first year of life.

The present study investigated these relationships in more detail by examining infant pain behaviour at two, four, six and 12 months of age, and its association with parent report of temperament at 14 months of age. The main objective of the present study was to use objective indicators of infant pain reactivity and regulation as well as parental pain judgments across the first year of life to determine whether variability in early pain responding is associated with parent temperament ratings at 14 months of age.

METHODS

Participants

The data used in the current study were part of an ongoing longitudinal research cohort for which parent-infant dyads were recruited from three pediatric clinics in the greater Toronto (Ontario) area between 2007 and 2012. Infants were recruited at two, four or six months of age and were followed in a cohort-sequential design until their 12-month immunization. Parents able to speak and read English whose infants had no suspected developmental delays or impairments, no chronic illnesses, and had never been admitted to a neonatal intensive care unit were eligible to participate in the study. All infants included in the current study were considered to be healthy, from middle class families, low risk and developmentally typical. The withdrawal rate for the longitudinal study was 3%. The cross-sectional sample included data from 747 infants.

Between September 2009 and April 2012, every parent-infant dyad from the original cohort that was receiving their 12-month immunization (n=286) was invited to participate in a subsequent wave that measured attachment status and temperament (only temperament data will be discussed in the current study). Of the 286 dyads, 175 agreed to participate in the subsequent wave of the study (62%). However, due to scheduling difficulties and the age restrictions of the attachment measure procedure (which had to be conducted between 12 to 18 months of age at the local children's hospital), the final sample consisted of 130 parent-infant dyads.

The final sample of 130 dyads included 72 male and 58 female infants, and 116 mothers and 14 fathers. At the time of hospital follow-up, the mean (± SD) age of the infants was 13.74±1.35 months (range 12.06 to 20.70 months) and the mean age of parents was 34.70±5.05 years (range 22.59 to 58.08). All children lived with their biological parents, with the exception of one child who was adopted. Table 1 presents demographic variables for the parent-infant dyads included at two, four, six and 12 months of age.

TABLE 1
Demographic characteristics (n=130)

Characteristic	
Age of caregiver present, years, mean	33.56
Self-reported heritage culture, %	
European	43.8
Canadian/American	15.4
Asian	10.8
Central American/Caribbean	6.2
South Asian	6.2
African/Middle Eastern	5.4
Other	12.2
Education level, %	
Graduate/professional school	36.2
University/partial university	44.6
Trade school/college	16.2
High school or less	3.1

Procedure

Immunization appointments: The research ethics boards at the participating university and associated pediatric hospital approved the protocol for the study.

The overall procedure has been published elsewhere (19) and only an overview is provided here. Parents with infants receiving immunizations were provided a flyer by a medical receptionist and asked whether they would like to learn more about a longitudinal study. If interested, a research assistant obtained informed consent and the parent completed a demographic information form. Once in the examination room, two video cameras were set up to capture a close-up face shot of the infant, as well as a wide shot to obtain a full view of the parent and the child. For naturalistic observation, video recording was continuous from when the parent and child entered the examination room until 5 min postimmunization (or when the parent and infant left the clinic room). This footage was used to code all parent and infant behaviours.

Hospital research-based appointment: At the end of the 12-month immunization appointment, parents were asked if they would be interested in participating in a follow-up study examining parent-infant interactions. The procedures involved with the hospital-based assessment received separate ethics approval from the participating university and pediatric hospital, and separate consent was obtained from the parent-child dyads. The mean length of time between the 12-month immunization appointments and the hospital appointment was 42.88±38.48 days. To maintain consistency, the parent who brought his or her infant to the 12-month immunization appointment was the same as the parent who completed the temperament questionnaire at the hospital assessment. If more than one parent accompanied the infant to the 12-month appointment, the primary caregiver was invited to participate in temperament ratings. The primary caregiver was defined as the caregiver who spent the most amount of time with the infant or who was primarily responsible for his or her child's care and caretaking decisions.

Apparatus

Immunization appointments: Two high-definition camcorders (HV20, Canon Inc, Japan) were used to record parent and infant behaviour. One camera was hand-held by a research assistant to record the close-up image of both the infant's and the parent's facial expressions. The second camera was mounted on a tripod and fitted with a wide-angle lens to record parent-infant interactions from a distance.

Hospital research-based appointment: Two wall-mounted rotating video cameras were used to record infant behaviour during the attachment assessment procedure. The experimental room included a one-way mirror so that the researcher could unobtrusively observe the participants (the caregiver, infant and a research assistant who acted as the stranger) from an adjacent control room. Parents completed the temperament questionnaire after the attachment assessment. On completion of the visit, the infant's photograph was taken and tokens of appreciation were provided.

Measures

Demographic questionnaire: Parents were asked to complete a brief demographic questionnaire as part of the larger research study. The questionnaire asked about personal information, such as relation to

TABLE 2
Pearson correlations among variables at two months of age

Variable	n	Score*	1	2	3
1. IBQ Negative Affectivity	123	3.49±0.65	–	–	–
2. IBQ Orienting/Affiliation	123	4.76±0.53	–	–	–
3. IBQ Surgency/ Extraversion	123	5.32±0.54	–	–	–
4. MBPS immediate†	96	8.88±0.508	−0.045	0.072	−0.056
5. MBPS 1 min‡	91	6.21±2.15	0.031	0.146	0.169
6. Parent pain rating	96	6.55±2.29	0.066	0.194	0.154

**Mean ± SD; †Modified Behavior Pain Scale (MBPS) scores were coded for 15 s immediately after the needle; ‡MBPS scores were coded 1 min after the MBPS immediate epoch. IBQ Infant Behaviour Questionnaire*

TABLE 3
Pearson correlations among variables at four months of age

Variable	n	Score*	1	2	3
1. IBQ Negative Affectivity	123	3.49±0.65	–	–	–
2. IBQ Orienting/Affiliation	123	4.76±0.53	–	–	–
3. IBQ Surgency/ Extraversion	123	5.32±0.54	–	–	–
4. MBPS immediate†	110	8.41±1.01	−0.116	0.140	−0.040
5. MBPS 1 min‡	107	4.89±2.42	0.085	0.123	−0.001
6. Parent pain rating	110	5.18±2.23	0.077	0.110	0.037

**Mean ± SD; †Modified Behavior Pain Scale (MBPS) scores were coded for 15 s immediately after the needle; ‡MBPS scores were coded 1 min after the MBPS immediate epoch. IBQ Infant Behaviour Questionnaire*

TABLE 4
Pearson correlations among variables at six months of age

Variable	n	Score*	1	2	3
1. IBQ Negative Affectivity	123	3.49±0.65	–	–	–
2. IBQ Orienting/Affiliation	123	4.76±0.53	–	–	–
3. IBQ Surgency/ Extraversion	123	5.32±0.54	–	–	–
4. MBPS immediate†	117	8.07±1.65	0.081	0.097	0.080
5. MBPS 1 min‡	116	4.43±2.46	–0.078	0.056	0.046
6. Parent pain rating	116	4.78±2.63	0.096	0.191	0.110

**Mean ± SD; †Modified Behavior Pain Scale (MBPS) scores were coded for 15 s immediately after the needle; ‡MBPS scores were coded 1 min after the MBPS immediate epoch. IBQ Infant Behaviour Questionnaire*

TABLE 5
Pearson correlations among variables at 12 months of age

Variable	n	Score*	1	2	3
1. IBQ Negative Affectivity	123	3.49±0.65	–	–	–
2. IBQ Orienting/Affiliation	123	4.76±0.53	–	–	–
3. IBQ Surgency/ Extraversion	123	5.32±0.54	–	–	–
4. MBPS immediate†	128	8.20±0.95	0.058	0.045	−0.062
5. MBPS 1 min‡	125	5.46±2.51	0.235*	0.048	0.092
6. Parent pain rating	128	5.78±2.24	0.086	0.243*	0.111

**Mean ± SD; †Modified Behavior Pain Scale (MBPS) scores were coded for 15 s immediately after the needle; ‡MBPS scores were coded 1 min after the MBPS immediate epoch. IBQ Infant Behaviour Questionnaire*

the infant, parent age, cultural background, profession and education level, as well as information pertaining to the infant such as date of birth, age, sex and previous medical conditions.

Infant pain behaviour (immunization appointment): The Modified Behavior Pain Scale (MBPS) (20) was used to assess the degree of infant pain-related distress. This scale uses behavioural indexes to determine how much pain-related distress the infant is experiencing. There are three subsections of the scale (facial expression, cry and body movement), each requiring the coder to decide on a score based on overt infant behaviour during a 15 s epoch. All sections of the measure are summed to provide a score out of 10. The MBPS has been extensively validated as a pain measure within the context of immunization for children 12 months of age and younger (20-22).

In the current study, data for this scale were coded for 15 s immediately after the needle (MBPS immediate) and 1 min after that epoch (MBPS 1 min). For the current study, the pain reactivity score was defined as MBPS immediate, and the regulation score was defined as MBPS 1 min. Trained primary coders who were blind to the study hypotheses coded the MBPS. Twenty per cent of the total sample in the longitudinal study (including the sample for the current study) was double-coded to assess ongoing reliability. The inter-rater reliability was calculated using intraclass correlations, which ranged from 0.93 to 0.96. Reliability coding was conducted every two to four weeks by a reliability coder. Reliability codes were used in the final data set.

Parent pain judgments: The Numeric Rating Scale (23) was used for parental judgment of their infant's pain after the immunization appointments. In this scale, parental pain rating was obtained using a verbal numerical rating scale that ranged from 0 (no pain) to 10 (worst pain possible). This scale has demonstrated feasibility and validity (24).

Infant temperament (temperament rating): The Infant Behaviour Questionnaire – Revised (IBQ-R) (25) was used to measure temperament during the laboratory visit when infants were between 12 and 18 months of age. The IBQ-R was designed for infants three to 12 months of age and was subsequently recommended for infants up to 15 months of age. The questionnaire consists of 191 items rated on a seven-point Likert-type scale of frequency, on which a rating of 1 indicates that the behaviour never occurred in the past week and 7 indicates that it always occurred. Summary mean scores for the Negative Affectivity, Orienting/Affiliation and Extraversion dimensions were calculated and used in subsequent analyses. The Negative Affectivity dimension includes the mean of the distress to limitations, fear, sadness and reactivity (reversed scored) scales. The Orienting/Affiliation dimension includes the mean of duration orienting, low-intensity pleasure, soothability and cuddliness scales. The Surgency/Extraversion dimension includes the mean of the activity level, smiling and laughter, high intensity pleasure, approach and vocal reactivity scales. The IBQ-R has strong inter-rater, interitem and item-total reliability (25). Seven parents did not complete the IBQ-R due to not having sufficient time at the end of the visit or the infant becoming too fussy/hungry/tired at the end of the visit. In total, 123 IBQ-R questionnaires were completed.

RESULTS

Data screening, transformation and cleaning

After the data file was reviewed for any data entry errors, descriptive statistics were used to examine correlation and regression diagnostics. A family-wise error rate was not assigned due to the exploratory nature of the analyses. An alpha level of 0.01 was used for all correlations. All assumptions for the multivariate regression analyses were met. Nine correlation analyses were conducted at each of the four timepoints (36 in total).

Correlations among key variables

Relationships among key variables were examined to investigate the relationships between infant pain reactivity, the pain regulation score, parent pain ratings at 12 months of age and temperament at 14 months of age. As shown in Tables 2, 3 and 4, there were no significant relationships between infant pain behaviour at two, four or six months of age and parent-rated infant temperament at 14 months of age. There were also no significant relationships between parent ratings of the infant pain immediately following the immunization and infant temperament at approximately 14 months of age.

At 12 months of age, two significant relationships emerged. These results are presented in Table 5. First, infants who had higher pain

TABLE 6
Model one: Predicting infant Negative Affectivity at 14 months of age

Predictor	B	SE	B	t	P
Infant age	−0.001	0.044	−0.003	−0.030	0.976
Sex	0.155	0.119	0.118	1.300	0.196
MBPS 1 min*	0.064	0.024	0.245	2.716	0.008

**Modified Behavioural Pain Scale (MBPS) scores were coded 1 min after the MBPS immediate epoch. F(3, 115) = 2.839, P=0.04, R^2=0.069 (pairwise, two-tailed).*

TABLE 7
Model two: Predicting infant Orienting/Affiliation at 14 months of age

Predictor	B	SE	B	t	P
Infant age	0.020	0.035	0.052	0.590	0.557
Sex	−0.198	0.097	−0.187	−2.050	0.043
Parent pain rating	0.044	0.022	0.186	2.034	0.044

F(3, 118) = 4.126, P=0.008, R^2=0.10 (pairwise, two-tailed)

scores 1 min postneedle (ie, the pain regulation score) had higher infant Negative Affectivity temperament scores at 14 months of age (r=0.235; P=0.01). Second, infants of parents who rated them as having higher pain at 12 months were rated as having higher Orienting/Affiliation temperament scores at 14 months of age (r=0.243; P=0.007). These significant correlations, in addition to theoretical and empirical support, justify the inclusion of these variables in the regression models.

Predicting infant negative affectivity at 14 months of age

Using the significant correlations, and controlling for infant age and sex, multiple regression analyses were conducted to determine whether pain regulation at 12 months of age predicted Negative Affectivity at 14 months. Table 6 presents the results for the effect of infant age, sex and pain 1 min following the needle (MBPS 1 min, regulatory score) at 12 months of age on Negative Affectivity at 14 months of age. After controlling for infant age and sex, pain 1 min postneedle accounted for a significant portion of the variance in infant Negative Affectivity. Collectively, this model accounted for approximately 7% of the variance in infant Negative Affectivity.

Predicting orienting/affiliation at 14 months of age

Using the significant correlations, as well as infant age and sex, multiple regression analyses were conducted to determine whether parent ratings of infant pain at 12 months of age predicted Orienting/Affiliation at 14 months of age. Table 7 present results for the effect of infant age, sex and parent pain ratings at 12 months of age on the Orienting/Affiliation dimension. After controlling for infant age and sex, parent rating of infant pain at 12 months of age accounted for a significant portion of the variance in infant Orienting/Affiliation at 14 months of age. Sex also emerged as a significant predictor of infant Orienting/Affiliation. Collectively, this model accounted for approximately 10% of the variance in infant Orienting/Affiliation.

DISCUSSION

The present study examined infant pain behaviours at multiple timepoints across the first year of life to determine the relationship with parent ratings of early childhood temperament profiles. Over the first six months of life, pain outcomes (ie, objectively coded reactivity and regulation, and parent ratings of infant pain responding) did not relate to parental temperament ratings during the second year of life. However, by 12 months of age, both the regulatory pain-related distress response and parent ratings of infant pain response predicted the parental temperament rating.

By 12 months of age, increased infant distress behaviour during the regulation phase (ie, 1 min post-needle) was associated with increased scores on the Negative Affectivity temperament dimension at 14 months of age. In addition, higher parent ratings of infant pain at 12 months of age were related to higher scores on the Orienting/Affiliation temperament dimension at 14 months of age. Collectively, these findings suggest that infant regulatory behaviours following painful stimuli at 12 months of age may act as indicators of temperament in early toddlerhood. However, although these results are statistically significant, caution is warranted against overinterpretation of these relationships due to the small magnitude correlations (ie, r<0.25 or r^2 between 7% and 10%).

Greater distress during the regulation of a painful event predicted higher parent-rated scores on the Negative Affectivity temperament dimension, which includes scores from the distress to limitations, fear and sadness scales, at 14 months of age. These results are similar to those reported in preterm infants during the reactivity phase following painful events (16). Collectively, these findings suggest that infants who show lower levels of distress 1 min after a painful stimulus (needle) are rated as being less temperamentally negative later in toddlerhood. Indeed, low negative emotionality has been related to high effortful control (26) or regulation, which is associated with executive attention (27). These findings highlight the importance of supporting strong regulation abilities in early childhood to promote positive social, behavioural, academic and health outcomes (9,10). The current study provides evidence that early markers of temperament may be identified within the primary care environment, making the infant immunization context a largely untapped resource for better understanding infant development. Further research is needed, however, to support the link between infant pain responses and later developmental outcomes related to temperament and affect regulation.

The present study found that higher parent ratings of infant pain at 12 months of age were associated with higher parent-reported scores on the Orienting/Affiliation temperament dimension, which includes scores from the duration of orienting, low-intensity pleasure, soothability and cuddliness at 14 months of age. Notably, certain parent factors, such as personal experiences with needles, psychopathology, stress and empathy, have been shown to significantly influence parental perceptions of their child's pain experience (24,28,29). The influence of these personal experiences on parent judgments of infant pain may also contribute to parent ratings of their children's early temperament. For example, parental empathy may influence the sensitivity the parent has toward their child's pain, and in some cases may lead to under- or overestimations of the pain (28). When overestimations occur, parental reactions may cause the child to orient their attention to the pain and re-evaluate their pain as more serious than initially believed (28), resulting in an increased need to be soothed or distracted. When underestimations occur, the lack of parental reactions may result in the child feeling misunderstood and that they are not receiving adequate care (28), which could result in dysregulation and behavioural outbursts to obtain their parent's attention, or dysregulation and internalization of the pain. Parental underestimations of pain may also be a mechanism to cope with their own distress, similar to that observed in health care professionals (28,30). Because parenting behaviours and responses have critical influences on their children's development (31), the over- or underestimated rating of pain, as well as any parent-directed soothing or distraction behaviours, may contribute to the child's parent-rated temperament profile, specifically in the Orienting/Affiliation dimension. Indeed, young children rely heavily on parental regulation and scaffolding, and it is not until the children get older that they are then able to regulate their own behaviours more independently. In the current context, future research is necessarily to explore the mechanisms that underlie these relationships.

Sex was also found to significantly predict infant Orienting/Affiliation, with females having higher parent-rated scores on this dimension than males. Similar results have been reported previously (32,33), with females being better able to regulate their negative arousal within the first year of life, potentially enabling them to

behave more competently during stressful events (33). Of note, sex was not relevant in predicting negative affectivity. This finding is consistent with the original research investigating negative affectivity in infants up to 12 months of age (25). There are also reported differences in the presentation style of negative affectivity in males and females, with males more likely to externalize negative affect and females more likely to internalize negative affect (34,35). These differences may contribute to a less clear understanding of how negative affectivity develops in males versus females.

Despite the large sample size, the present study was limited by the sample on which the study is based. Given the low-risk, middle-class, educated participant composition of the overall research program, the generalizability of these findings to high-risk samples has yet to be determined. In addition, although the two significant relationships were significant at $P<0.01$, experimental error for the study was not controlled, opening the possibility of type 2 error. Temperament profiles were also based solely on parent ratings. Although parent ratings can provide comprehensive information to better categorize temperament, additional child temperament measures should be used in the future. While statistical significance was observed, the pain regulation scores accounted for a relatively small percentage of the variance in infant temperament. Further work is, therefore, needed to explore other factors that may influence the relationship between pain-related distress and infant temperament. For example, the quality of the caregiver-infant relationship has been shown to moderate associations between early ratings of temperament and infants' later responses to immunizations (36). Exploring the dynamic influences of biopsychosocial factors on temperament will lead to a more comprehensive understanding of infants' regulatory capacities.

Finally, the present study did not examine the implications of parental pain management techniques used during the immunizations. Based on descriptives from the larger Opportunities to Understand Childhood Hurt (OUCH) cohort (760 caregiver-infant dyads), physical comfort, rocking behaviour and verbal reassurance were the most commonly used nonpharmacological management techniques across each age of immunization, with breastfeeding and sucrose used less frequently. Nonpharmacologically based pain management, such as maternal holding, maternal vocalization, breastfeeding and pacifying behaviours, have been examined as evidence-based interventions for acute pain in infancy (37-39). The techniques parents used to manage their infant's pain during immunization may, therefore, contribute to their overall ratings of their infant's pain, as well as their temperament ratings. Future work would benefit from investigating the impact of nonpharmacological management on these outcomes.

Identifying early precursors of childhood temperament enables parents and caregivers to adopt specific strategies, including parent-related soothing and regulatory behaviours both inside and outside the immunization context, to foster positive developmental and mental health outcomes later in life. However, it is important to highlight that, although knowledge of the precursors of temperament are of great value to parents for supporting positive development and healthy childhood outcomes, consistent and effective pain management for all infants is an important means to end on its own. Providing parents and health care professionals with information on regulatory strategies that may reduce distress for both the pained infant and their parent is, therefore, essential (37-39).

SUMMARY

The current study provides critical and novel information regarding early predictors of child temperament. Higher levels of infant distress during regulation of a painful event at 12 months of age are related to higher parent-rated scores on the Negative Affectivity temperament dimension at 14 months of age, supporting the use of early regulatory behaviours as precursors to understand temperament substrates. In addition, higher parent ratings of pain at 12 months of age are related to the Orienting/Affiliation temperament dimension. By measuring reactivity and regulation following a painful stimulus at multiple timepoints across the first year of life, the present study contributes a comprehensive understanding of distress regulation in the context of early temperament profiles.

FUNDING: All four waves of this study were supported by a Canadian Institutes of Health Research (CIHR) New Investigator Award and Operating Grant (FRN: 84511) and an Early Career award from the Ontario Ministry of Research and Innovation (ER05-08-219) to Dr Pillai Riddell.

DISCLOSURES: The authors have no financial interest in the results of this research. None of the authors have any conflicts of interest with this work. The corresponding author had access to all data.

ACKNOWLEDGEMENTS: This research was supported by funds to Dr Pillai Riddell and Nicole Racine from CIHR (New Investigator Award; Operating Grant FRN: 84511; CIHR Canada Graduate Scholarship – Doctoral) and the Ontario Ministry of Research and Innovation (ER05-08-219) and Dr Stevens (Postdoctoral Training Award from CIHR Pain in Child Health). Dr Stevens, Nicole Racine and Rachel Horton were also funded by graduate fellowships from the Lillian Wright Foundation for maternal-child health (RH, NR), the CIHR-Pain in Child Health Strategic Training Initiatives (SS, NR, RH) and the Ontario Graduate Scholarship program (RH). Funders were not involved in the design or conduct of this study.

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