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Effects of maternal parity, depression and stress on two-month-old infant expression of pain

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Objective: This study investigates effects of maternal parity, mental health and frequency of touch on infant distress expressed during routine vaccination, as well as the ability of mothers to assess infant pain. Methods: 50 mothers (19 first-time mothers, 23 stressed, 8 depressed) and their 2-month-old infants (mean age 8.1 weeks, range 7–9 weeks) were videotaped during routine immunisation for off-line-analysis. Infant-related pain behaviours were coded before, during and after needle insertion. Maternal touch was coded throughout the immunisation procedure and maternal estimates of infant pain were established immediately after the procedure. Results: Infants of first-time mothers showed significantly more pain before the needle insertion as well as during the first vaccination, compared with infants of experienced mothers. In contrast to expectation, maternal mental health status and type of touch did not influence the level of pain expressed by infants. Mothers consistently overestimated infant pain and their assessments were poorly correlated with observed infant pain behaviours. Conclusion: These findings suggest that maternal parity may influence infant pain expression before vaccination. However, all mothers overestimate their infant’s pain. Further studies are required to resolve conflicting findings in this field of research, as findings may have policy implications in promoting adherence to the vaccination schedule.

Keywords: infant vaccination; pain; parity; stress; depression

Introduction

Background

Vaccinations are a common cause of pain and distress in healthy infants (Cohen, Bernard, McClellan & MacLaren, 2005; Ipp, Parkin, Lear, Goldbach, & Taddio, 2009; Reis, Roth, Syphan, Tarbell, & Holubkov, 2003; Taddio, Ilersich, Ipp, Kikuta, & Shah, 2009). Early experience with pain shapes infant responses to painful events later in life (e.g. Taddio et al., 1997; Young, 2005). In addition to the behavioural impact of painful procedures, long-term physiological effects have been observed in the central nervous system (Reis et al., 2003) affecting the neural circuitry responsible for processing and perceiving pain (Lidow, 2002). Consequentially, infant pain and coping with infant pain are important topics which have been discussed extensively in the context of infant immunisation (Cohen et al., 2008).
**Infant pain expression is mediated by the caregiver**

The current immunisation schedule in the UK requires otherwise healthy infants to be subjected to a routine painful experience of an immunisation at 2 months of age. Pre-verbal infants express pain by crying, facial and body behaviours which have to be interpreted by the caregiver. Maternal interpretation of behaviours in terms of infant pain experience influences the behavioural regulation of infant pain during immunisation (e.g. DeMore & Cohen, 2005; Din, Pillai Riddell, & Gordner, 2009; Pillai Riddell & Chambers, 2007; Pillai Riddell & Racine 2009). Hence, it is vital that mothers can identify and interpret infant pain behaviours accurately in order to respond appropriately (Taddio, Nulman, Koren, Steventts, & Koren, 1995). There are a number of ways in which caregivers try to relieve infant pain including touching their infant in a soothing manner. Maternal touch acts as a facilitator of emotional communication between a mother and her infant (e.g. Hertenstein, 2002; Moszkowski & Stack, 2007; Kisilevsky, Stack & Muir, 1991). Furthermore, Jahromi, Putnam and Stifter (2004) found that the duration and intensity of infant cry during immunisation decreased with affectionate touch and vocalisations by mothers.

**Effects of maternal psychological state on infant pain expression**

Maternal psychological state, namely maternal stress and depression have been found to influence early infant development, including their expression of pain. For example, Moscardino, Axia, and Altoe (2006) observed a stronger pain response during standard vaccination in infants of depressed mothers compared with infants of non-depressed mothers. Since anxiety is often comorbid with depression (Mineka, 1998), not only depression but also the effects of stress and anxiety have been considered (Frank, Blount, Smith, Manimala, & Martin, 1995; Matthey, Barnett, Howie, & Kavanagh, 2003). Two other studies reported that parental anxiety was positively correlated with infant procedural pain (Bernard & Cohen, 2006, Frank et al., 1995). Others found that infants showed variously fewer emotional reactions when the mother was anxious (Schmucker et al., 2005), or depressed (Reissland & Shepherd, 2006) or a stronger stress response (Ashman, Dawson, Panagiotides, Yamada, & Wilkinson, 2002). Hence, maternal depression may impair a mother’s ability to regulate her child’s emotions (Reck et al., 2004) particularly infant pain expression during vaccinations. Additionally, stressed mothers may overestimate the pain of their infants (Pillai Riddell & Chambers, 2007).

**Effects of parity on infant pain expression**

Being a first-time mother may also influence infant behaviour in terms of pain expression and emotion regulation. Especially in the first few weeks after birth, inexperienced mothers learn about their infants’ abilities (e.g. Mercer & Walker, 2006), including the capacity to cope with pain. Furthermore, depressed mothers with previous children appear better able to deal with their depression without affecting negatively their interaction with second or later born infants (e.g. Goldstein-Ferber, 2004). Hence, parity might be an important factor to consider when assessing infant expressions.
Limitations of previous research

A limitation of previous studies, encouraging heterogeneous findings, is the broad range of ages of infant participants observed. Many immunisation studies investigate the pain expression of infants undergoing immunisations ranging from 2 to 12 months of age (e.g. Craig et al., 1984; Taddio et al., 1995; Ipp et al., 2004; Ipp et al., 2009). One study of younger infants 6–16 weeks old (Reis et al., 2003) assessed cry duration but did not assess additional infant pain expression, such as infant facial expressions and body movements. A further study (e.g. Wolff et al., 2009), although investigating a homogeneous age range, focused on immunisations after the infant’s first birthday at 14 months of age. Hence, there is a lack of evidence from studies of 2-month-old infants measuring a range of pain behaviours.

Purpose of the present study

Several previous studies have found that maternal presence and caring behaviours shown towards infants during immunisation decrease infant distress (e.g. Cohen et al., 2005; Kohut & Pillai Riddell, 2009), whereas others have found maternal presence increases infant distress (e.g. Moscardino et al., 2006; Shaw & Routh, 1982), although these studies all have limitations. One key limitation is heterogeneity of the wide age range of infants that may confound findings. Another limitation is the lack of controlling for maternal experience with infant pain expressions. Although Reis et al. (2003) observed a homogenous sample of 2-month-olds in order to establish the effectiveness of sucrose on infant pain expressions, they did not control for maternal parity. In sum, it is unclear whether maternal experience with their baby’s pain expression has an effect on how infants react to the pain of an immunisation when their mother holds them during the procedure.

In the present study, in a well-defined homogeneous group of 2-month-old Caucasian infants, we explored whether there was a difference in infant pain behaviour between infants of primiparous compared with experienced mothers. Furthermore, we explored whether maternal stress and depression had an effect on infant pain expression. In addition, we investigated maternal estimates of their infant’s pain against observed behavioural expressions of infant pain.

Method

Design

A prospective observational study was conducted in Well-Baby clinics held in five medical groups in County Durham, UK from June 2010 to December 2010.

Participants

We recruited a convenience sample of 66 mother–infant dyads attending Well-Baby clinics. All infants were healthy according to assessment by the health visitor who saw them before the vaccination procedure. During the immunisation, 4 infants lay supine with the mother still touching the infant, and 45 were held on their mother’s lap. The intention was to recruit 60 patients, which in simple contrasts of pain scores provided approximately 80% power to find an absolute difference of 20% in pain between groups at conventional statistical significance.
of 5%. A 20% change in pain corresponded to a moderate effect size, \( d \) of 0.74. As the purpose of the research was hypothesis-generating, correction for multiple testing was not applied.

Sixteen mothers were excluded from the final sample: 13 mothers did not touch their infants during their vaccination. Instead, infants were held by their grandmother, father or a family friend during the vaccination. One mother was excluded because of insufficient English to fill out the questionnaires and two mothers withdrew consent following the procedure. Of the 50 mothers, 49 provided adequate data to contribute to the analysis; inadequate questionnaire data was collected for one mother meaning that the dyad could not be grouped by maternal psychological state or parity.

All mothers received information about the study by post prior to attending, and provided written and informed consent before participating. Ethical approval was obtained from Sunderland Ethics committee (Rec reference Number 07/H0904/75), the Department of Psychology at Durham University, and the Medical Groups that agreed to take part in the study.

### Measures

**Maternal psychological state**

Following the vaccination mothers also completed questionnaires on depression and stress. Frank et al. (1995) found that maternal Trait Anxiety did not contribute significantly to the prediction of child coping or distress in a study that examined the pain expression of 77 children aged between 4 and 7 years receiving routine immunisations. Therefore, in the present study we used an index of stress arising from parenting. The Parental Stress Index–Short Form (PSI-SF: Abidin, 1995) was used to assess maternal stress immediately following the vaccination procedure. In this validated test, parental stress is indicated when mothers score either over 91 on the total stress dimension or below 10 on the defensive responding subdimension. Defensive responses indicate that mothers, although stressed, minimise problems between themselves and their infant rather than giving an accurate assessment of normal interactions. The Edinburgh Postnatal Depression Scale (EPDS: Cox, Holden, & Sagovsky, 1987) was used to assess maternal depression; mothers who scored nine and above were classed as showing depressed mood (Lee et al., 1998).

**Maternal estimates of infant pain**

The Faces Pain Scale-Revised (FPS-R: Hicks, von Baeyer, Spafford, van Korlaar, & Goodenough, 2001) was used to assess maternal evaluation of infant pain immediately following completion of the vaccination procedure. The FPS-R is scored from 0: no perceived pain to 10: maximum perceived pain. In order to compare the percentage of infant pain expression and maternal estimates of infant pain, FPS-R scores were converted into percentages in this study. The FPS-R measure has been found to have good reliability and validity (Cohen et al., 2008; Stinson, Kavanagh, Yamada, Gill, & Stevens, 2006) when mothers make assessments about pain in their children although previous studies have not used the FPS-R in order to assess pain estimates in non-verbal infants.
Infant pain expression and maternal touching behaviour

The reference measure of infant pain was assessed using observed infant pain behaviours throughout the vaccination procedure. Given that blood pressure or respiratory rate do not provide an adequate description of infant pain (e.g. Huguet, Stinson, & McGrath, 2010), we opted for behavioural assessment of infant pain behaviours based on an adaptation of the Modified Behavioral Pain Scale (MBPS: Taddio et al., 1995) and Measure of Adult and Infant Soothing and Distress (MAISD: Cohen et al., 2005). The patterns of infant pain expression and maternal touching behaviour were analysed using frame-by-frame coding of the videotaped vaccination procedure using a single camera in HD format.

Frame-by-frame coding was performed for the following behaviours including the level of facially expressed pain (‘upper-lip-raiser’, lower lip depression, nasolabial furrow and eye creases), amount of crying and pain movements (based on the mean of arching, tensing, clenching limbs, flailing, avoidance of needle, finger splay and rigidity). A composite pain measure, total pain, was calculated using the mean sum percentage of facial, cry and bodily behaviours expressed in response to immunisation. The infant pain score varied from 0% (no pain behaviours) to 100% (all behaviours all the time). The format for observing the vaccination followed the approach of Johnston and Strada (1986).

In addition to the codes of general touch behaviours included in the MAISD, more specific maternal touching behaviours (e.g. touch by rubbing or patting, squeezing, kissing or rocking) were coded using elements of the Infant Touch Scale (ITS: Moszkowski & Stack, 2007).

Not all behaviours from the MAIDS were included. For example, the MAISD codes ‘distraction’ and ‘consume food’ were not included in the coding scheme, as they were never observed.

Method of behavioural analysis

Videorecordings were coded frame-by-frame, 30 frames per second, using a computer program (Observer XT 9.0: Noldus, Trienes, Hendriksen, Jansen, & Jansen, 2000). The following five phases of the procedure were scored: (1) 20 s before the first immunisation; (2) the first vaccination; (3) between the two vaccinations, from when the first needle had been withdrawn to when the second needle broke the skin; (4) the second vaccination; and (5) until 20 s after the second needle had been removed from the skin (see Table 1 for durations of each of the phases).

The total amount of pain expressed was calculated over the five phases and included percent of pain facial expression, percent of cry and percent of pain movements.

Table 1. Mean duration of phases in seconds analysed over the course of the immunisation procedure.

<table>
<thead>
<tr>
<th>Phase</th>
<th>Time (s)</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1</td>
<td>18.29</td>
<td>3.69</td>
</tr>
<tr>
<td>Phase 2</td>
<td>2.28</td>
<td>0.76</td>
</tr>
<tr>
<td>Phase 3</td>
<td>26.47</td>
<td>13.86</td>
</tr>
<tr>
<td>Phase 4</td>
<td>2.46</td>
<td>0.89</td>
</tr>
<tr>
<td>Phase 5</td>
<td>19.40</td>
<td>2.69</td>
</tr>
<tr>
<td>Total duration</td>
<td>68.91</td>
<td>15.80</td>
</tr>
</tbody>
</table>
The data were structured for repeated measures analysis of variance using the five assessments of pain recorded over time as the repeated measures, exploring simple contrasts due to maternal mental health, parity and touch. Greenhouse-Geisser corrected estimates were used to adjust for sphericity. Where the assumptions for the repeated measures analysis of factors could not be met (i.e. a varying contrast over time), an area-under-the-curve approach estimated the product of the level of pain and time in pain for each infant. Thus contrasts could be assessed using simple parametric methods on the pain time product.

Reliability
Ten percent of the videorecordings (five mother–infant interactions) were re-coded in the OBSERVER XT by an independent coder blind to maternal psychological state and the hypotheses of the study. A tolerance window of 1 s was defined for the Kappa calculation within the OBSERVER XT. Cohen’s Kappa was .77 (range = .73–.84) for infant pain behaviours, .80 (range = .56–.90) for maternal touch behaviours and .93 (range = .79–1.00) for procedural behaviours. The mean inter-rater reliability score for occurrence was Kappa = .86 (range = .84–.90).

Results
Descriptive findings
Forty-nine mothers (23 stressed, 7 depressed, 1 stressed and depressed; mean age 29.1 years, range 18–41 years with a mean of 1 child, range 0–5 previous children) and their infants (28 female, mean age = 8.10 weeks, range 7–9 weeks) took part in the study. Mothers had left full-time education at a mean of 18.6 years (range 15–27 years). Among mothers the mean score on the EPDS was 4.35 (SD 4.18). The mean total stress was 54.37 (SD 14.37) and the mean defensive responding score was 11.63 (SD 3.82).

Preliminary analysis
An independent t-test was carried out to examine total infant pain compared with holding (infant position held, supine) during immunisation (t(47) = .373, p = .711, ns). Hence holding position did not influence infant pain expression.

Maternal mental health and parity
We tested whether maternal mental health (stressed, depressed, not stressed or depressed) was related to the parity of the mother. Two separate t-tests were carried out to examine differences between parity and maternal mental state. There were no differences between first time and multiparous mothers on the PSI (stress: t(47) = .616, p = .541, ns) or EPDS (depression: t(47) = 1.837, p = .073, ns) measures.

Infant pain during vaccinations
Observed infant pain increased according to prior expectation during the vaccination procedure, with an increase following needle insertion and a decrease prior to the second vaccination (see Figure 1).
A within-subject repeated measures ANOVA found that pain increased significantly during the vaccination process ($F(1,48) = 37.987, p < 0.001, \text{partial } \eta^2 = .442$). Changes in pain level occurred at the time of first needle insertion, and following each needle insertion (Phase 2 – Phase 1: $1 95\% \text{CI}: 8–26, p < .001$; Phase 3 – Phase 2: $33 95\% \text{CI}: 22–45, p < .001$; Phase 5 – Phase 4: $24 95\% \text{CI}: 11–38, p = .001$). Crying (a subscore of overall pain) following an almost identical pattern to overall pain, replicating the pattern previously observed by Johnston and Strada (1986).

**Infant pain and maternal mental health**

There was no simple contrast between levels of maternal mental health and observed infant pain over the five phases. Consequently, differences in pain were analysed as the area under the curve (the product of pain in each phase and duration) and compared using ANOVA. The average product of pain score and time over all five phases in the healthy, stressed and depressed groups was 3289, 3821 and 3904 s, respectively (ANOVA, $F(2,46) = 0.668, p = 0.518$). Consequently, observed total pain in infants did not differ between non-stressed–non-depressed, and stressed or depressed mothers.

**Infant pain and maternal parity**

There was no simple contrast between parity and observed infant pain over the five phases (Figure 2).

Results indicated that infants of mothers with previous children demonstrated significantly less initial pain than mothers with their first child (Mann–Whitney $U$, $p = 0.035$).
However, pain levels had become comparable between groups by the end of the vaccination process. Overall differences in pain, analysed as the area under the curve, were similar (ANOVA, $F(1,47) = 1.712, p = 0.197$). It is possible that first-time mothers were more stressed due to the unfamiliarity of the process. However, comparing primiparous and multiparous parents, maternal stress (ANOVA, $F(1,47) = 0.379, p = 0.541$), depression (ANOVA, $F(1,46) = 2.752, p = 0.104$) and defensive response (ANOVA, $F(1,47) = 0.093, p = 0.761$) were not significantly different.

**Infant pain and total maternal touch**

Maternal total touch (as a composite of all forms of touching) increased steadily and significantly across the five phases of the vaccination process (within-subject repeated measures (ANOVA, $F(1,48) = 9.965, p < 0.001$, partial $\eta^2 = .172$). However, there was no significant difference in touching according to depressed or stressed status (between-subject repeated measures (ANOVA, $F(2,46) = 2.025, p = .144$) or parity (between-subject repeated measures (ANOVA, $F(1,47) = 2.158, p = .149$). In summary, all mothers used touch significantly more as the vaccination procedure progressed, although maternal touching behaviours were not significantly associated with maternal psychological state or parity.

**Maternal estimates of infant pain**

Maternal estimates of infant pain using faces scales such as the FPS-R have been reported previously as a consistent measure to assess infant pain (e.g. Chambers, Giesbrecht, Craig, Bennett, & Huntsman, 1999). However, Chambers et al. (1999) found that the level of agreement between children’s ratings and parental rating was
low. Specifically, they found that parents overestimate their children’s reported pain. However, it is not clear if parental rating of pain based on the FPS-R might correlate more with infant observed infant pain behaviours rather than child pain reports. We compared FPS-R maternal estimates with fine-grained coding of observed infant pain behaviour. No measure of infant pain behaviour (i.e. the individual phase scores, average over all phases or time-adjusted average over all phases) was correlated with the maternal FPS-R measure (Spearman $|\rho| < 0.3$, ns). There was no evidence that correlation improved when controlling for parity (see Figure 3). We concur with Chambers et al. (1999), whose findings in children indicate that maternal assessments reliably overestimate their child’s pain.

**Discussion**

Given that early experience with pain shapes infant responses to painful events later in life (Young, 2005), this study tested pain responses of healthy infants during their first vaccination at 2 months of age. We examined whether first-time mothers judged infant pain differently from experienced mothers, i.e. the mothers’ parenting abilities in coping would influence their infants’ behavioural reactions (e.g. Hsu & Sung, 2008). In the light of findings concerning the effects of parental anxiety on their infant’s pain experience (e.g. Guerra, 2007; Knutsson, Jansson, & Alm, 2006) we investigated whether parity might influence the expression of infant distress. Furthermore, given the results of previous studies (e.g. Moscardino et al., 2006; Pillai Ridell et al., 2007) which highlight the influence of maternal psychological state on infant behaviour, with infants being more distressed when their mothers were depressed (e.g. Moscardino et al. 2006) or anxious (e.g. Bernard & Cohen,
2006; Frank et al., 1995), we investigated these factors and tested whether we could identify variations in pain expression during the procedure: in anticipation of the vaccination, during the vaccination or after withdrawal of the needle.

The results showed that infant-observed pain increased progressively during the vaccination process, with augmented pain behaviours in response to the first vaccination, a lull after the first vaccination followed by a further increase following the second vaccination (see Figure 1). In response to infant pain, total maternal touching increased monotonically during the vaccination process with each phase. The results of this study suggest that the difference in immunisation pain behaviour between infants of experienced and inexperienced mothers is not a result of maternal mental health or maternal touch behaviours as measured in this study. Rather, the study found interesting evidence that infants of primiparous mothers displayed more pain initially in anticipation of the vaccination process, although pain levels asymptoted to pain levels displayed by infants of multiparous mothers. Hence, there is a link between being an inexperienced mother and increased infant distress specifically in anticipation of the vaccination. We suggest that other variables might be involved and should be investigated in future research. Specifically future research should consider that pain, as a concept comprises both physical and psychological facets (e.g. Derbyshire, 1999). In very young infants the concern is mostly for behavioural signs of pain and distress in relation to physical aspects of pain. One interpretation of the findings suggests that 2-month-olds are affected not only by physical but also psychological pain. We propose that they are affected psychologically via maternal distress and physically when experiencing the vaccination itself. We arguably demonstrate in this study that there is a difference between these two aspects of pain, which needs to be further examined.

However, the mechanism by which infants of primiparous mothers overestimate infant pain is unclear because, in contrast to our expectations and other research (e.g. Bernard & Cohen, 2006; Moscardino et al., 2006), we found no relationship between maternal assessments of infant pain and infant observed pain scores during vaccination in preverbal infants. The research conducted in this study, in which a precise estimate of infant pain expression was generated using fine-grained frame-by-frame coding, calls into question whether maternal estimates, controlling for maternal stress, depression and parity, are reliable measures of 2-month-old infants’ pain.

Both observed infant behavioural pain and maternal estimates of infant pain are proxies of pain: neither are a direct assessment of the pain experienced by the infant. As maternal and infant estimates used different methods and scales there is no appropriate way to compare them in absolute terms, only relative relationships can be interpreted. Nonetheless, it is interesting that maternal estimates often appear very high and not well matched with observed infant pain (see Figure 3). It seems specifically that young children’s (3–4 years old) rating of their pain compared with older children’s (6–7 years old) ratings of their pain differ more from parental ratings of their children’s pain experience. Interestingly in the study by von Baeyer, Uman, Chambers, and Gouthro (2011), younger children indicated being in pain before the procedure started. In a similar fashion, we found in our study that 2-month-old infants expressed their pain before the procedure started and this was significantly more pronounced in children of first-time mothers (see Figure 2). Furthermore, maternal estimates of infant pain may influence future adherence to recommended immunisations. Meyerhoff and Jacobs (2005), reporting that a survey
of 32 office-based paediatrics offices in the US found that up to 25% of all children do not complete their primary course of immunisations. An explanation for the sub-optimal compliance to vaccinate infants could be based on findings of the present study that all mothers, independent of psychological state overestimate the pain their 2-month-old infants feel during the vaccination.

**Strengths and limitations**

The findings of the current study provide an important step forward by incorporating a behavioural coding scheme of both infant pain expression and maternal touching behaviours in a highly homogeneous group of young infants experiencing a standard pain eliciting medical procedure. However, the findings need to be interpreted with caution because of the small sample size. Although the sample size obtained in the current study reflects the number of participants used in other studies (range = 25–200 participants in a meta-analysis carried out by Uman, Chambers, McGrath & Kisley, 2008), the study power was only sufficient to find moderate changes in infant pain score that were attributable to maternal factors. Because of under-recruitment of subjects with complete data (49 vs. 60), the original study design had 72% power to find an effect size of 0.74, or 80% power to find an effect size of 0.82. Furthermore, findings should be viewed with caution because of the unbalanced nature of the size of the maternal mental state groups. Hence, future research needs to replicate these findings in a balanced, larger sample and, in order to make generalisations outside the Caucasian sample, in other racial and ethnic groups.

**Conclusion**

The results of the present study suggest that prior maternal experience of child vaccinations somehow influences infant expression of pain before and during the first vaccination independent of maternal mental health. These findings may have implications for the number of infants fully immunised, therefore imposing important health risks to the child and society. Our findings that parity as a measure of experience with previous children’s vaccinations does influence infant pain reactions is supported by research demonstrating that nurses more accurately estimated infant pain (Shah, Taddio, Bennett, & Speidel, 1997) compared with mothers. These findings could be used in a future intervention study for new parents.

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