Children's Memory for Pain: Overview and Implications for Practice

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Abstract: **Children's memories of painful experiences can have long-term consequences for their reaction to later painful events and their acceptance of later health care interventions. This review surveys research on children's memory for pain, emphasizing implications for clinical practice. Topics reviewed include consequences of children's memories of pain; the development of memory; differences between explicit (declarative, verbal, autobiographic) memory and implicit (nondeclarative, nonverbal) memory; and individual differences, situational, and methodologic factors affecting memories of pain. Methods to prevent the adverse consequences of remembered pain are addressed with reference to current research on editing or reframing memories.**

Perspective: ***This review covers topics of value to clinicians providing care to children undergoing painful procedures. Specific recommendations are offered regarding the importance of acknowledging and assessing children's previous memories of painful experiences, the type of information that benefits children before and after procedures, and the most appropriate questioning strategies. It might be possible to prevent or reduce the adverse effects of memories of pain.***

Key words: *Pediatric pain, child, memory, recall, procedural pain.*

What one remembers about previous painful events plays a vital role in the anticipation of, and response to, future pains. Recent research, to be reviewed below, suggests that memories of procedures can be edited or altered, making subsequent procedures less painful. Our goal is to provide a nontechnical overview of this complex domain of research, emphasizing implications for clinical practice. We begin with 2 noteworthy examples of research on children's memory for pain. We briefly trace the development of memory in infancy and early childhood, with particular reference to implicit and explicit memory for pain. We then survey what is known about the consequences of such memories. We discuss the effects of individual differences such as temperament, as well as situational influences. Recent approaches to prevention of the negative consequences of adverse memories of pain will be reviewed. Finally, we close with some ideas on directions for future research and some recommendations for clinical practice that can be justified on the basis of available evidence. Of note, this literature was previously surveyed in a 1999 review[47]; rather than repeating material covered in that article, we emphasize and integrate recent developments.

Circumcision of newborns can lead to changes in behavioral reactions to immunization injection several months later. Taddio et al[62] studied the effects of circumcision of neonates with and without anesthesia on reaction to immunization injection at age 4 to 6 months. As a control, they also included a group of uncircumcised infants. The baby boys who were circumcised without local anesthetic cried significantly more and exhibited greater behavioral and physiological distress to the injection than the boys who were circumcised with anesthesia and those who were not circumcised. In a separate study, the same research group observed newborn infants of mothers with diabetes.[63] These infants had repeated heel lances during the first 24 to 36 hours and underwent a venipuncture the following day. Compared with control subjects, the babies displayed more intense pain re-

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sponses during skin preparation and cleansing as well as during the procedure. These findings suggest that the infants were sensitized to pain, perhaps both in the sites of the heel lances and beyond. The findings also raise the possibility that the infants had learned to anticipate pain from nonpainful cues occurring with handling and skin preparation; indeed, consistent with this possibility, a body of recent research highlights that some form of long-term memory is operational even before birth.[34]

Another dramatic demonstration of the role of memory for pain is provided in a study by Weisman et al.[66] The study was a randomized controlled trial of transmucosal fentanyl versus placebo for lumbar punctures and bone marrow aspirations. For the first procedure half of the children received the active analgesic, and the other half received a placebo. For all procedures after the first one, all the children in both groups got the active drug. The treated group, who received the fentanyl throughout, had low to moderate pain for all of the procedures. The group who got the placebo the first time, on the other hand, continued to have moderate to high levels of pain, even when they were getting the effective drug. Their memory of the first experience with unrelieved pain made it difficult for them to experience the pain relief provided by the fentanyl.

These studies show that a painful experience might be "remembered" from earliest infancy and that it can cause changes in the reaction to later painful events. We now turn to a brief overview of the development of memory in childhood.

The Development of Memory

Biological mechanisms that might underlie memory have been demonstrated in the long-term sensitization shown after tissue damage in invertebrates such as sea slugs and in isolated spinal cord circuits.[37,61] Sensitization at a cellular, peripheral, and spinal level is demonstrated in a lowered threshold, increased amplitude of neural response, and increased skin area sensitive to previously nonaversive stimuli. Although it is acknowledged that physiological sensitization to painful stimuli is an important substrate for memory of pain, the main focus of the present review is on the kinds of memory that require storage and retrieval of information in an intact central nervous system such that recalling this information (whether implicitly or explicitly) influences behavior. These forms of memory can be demonstrated in young humans at the time of birth or earlier.[21,34]

Along with motor skills, infants and young children quickly acquire a number of cognitive skills such as recognizing their parents, recognizing voices of different people, noticing changes made to their rooms, and remembering objects that are missing.[32] In fact, several studies have shown that newborns recognize voices, music, and spoken passages that occurred before birth. For example, DeCasper and Spence[21] found that newborns preferred to listen to a passage that their mothers had recited during the last 6 weeks of their pregnancy rather than to a novel passage. With an operant-choice procedure, the babies heard either the familiar or a novel passage as a function of the rate of their sucking on a pacifier. They learned to suck more rapidly to hear the familiar passage.

With younger children, memory is expressed and measured through changes in performance or behavior after prior exposure rather than through recall using words. It is displayed, for example, in the toddler who "remembers" to be hypervigilant about white coats and other strangers after 1 or 2 painful experiences in hospital. This type of memory is called procedural (or implicit or nondeclarative) memory; it is demonstrated when performance on a task is facilitated without deliberate recollection from a prior learning episode. But there is also increasing evidence of explicit (or declarative) memory from very early in life. For example, studies have shown that 13-month-olds exhibited memory for actions that were performed several months earlier.[5] This is considered to be the nonverbal equivalent to verbal recall because the infant is required to bring information about the past to conscious awareness, in this instance, the actions. Indeed, even 6-month-olds show evidence of explicit memory, albeit over short delays.[17]

As their cognitive skills develop, young children gradually become capable of expressing in words what they know and what they remember.[35] As they get older, children acquire (1) more content knowledge (knowledge of their social and physical environment), (2) better capacity to express this knowledge in words, (3) better metamemory (knowledge of memory and the use of memory-enhancing strategies), and (4) greater cognitive resources (ie, mental capacities such as working memory). Such developmental advances have consequences for the way in which children form memories and for the way in which they can recall them.

The development of the explicit memory system is tied to the development of autobiographic memory. Autobiographic memories involve a special set of experiences that are specific to time and place, tied to the self, and influenced by emotion. Preschool children easily recount the gist of routine events such as going to a restaurant. However, the mental representations for these routines tend to be simplified, and younger children need extensive prompting to report event details. Event description becomes more specific with age.

Children's recall can be very accurate, even over multiple interviews and across time.[25] However, younger children, especially preschoolers, are susceptible to memory distortion. Memory is not like a tape recorder; it is constructive and reconstructive. Like adults, children might introduce things that did not happen into a retrospective account and retain this false information. They readily incorporate into their memories and retrieve from their memories misleading suggestions concerning events that were not experienced. In the context of medical procedures, this could be helpful and adaptive (if the misleading information directs the child's attention away from distress) or maladaptive (if it emphasizes further negative aspects of the situation).[13,56]

The completeness and consistency of children's autobiographic recall depend on several individual difference

factors and several methodologic or situational factors. We will address these in later sections after first considering the changes brought about by recalled pain.

Consequences of Remembered Pain

When a painful stimulus is repeated over time, a person might adapt in 1 of the following 4 ways[33]:

Habituation

Habituation is getting accustomed to the stimulus and showing a lessened reaction over time.[18,22,33] This is likely to occur with milder pain stimuli and with more mature persons who can cope better with the event. For example, clinicians report that adolescents with diabetes generally get accustomed to their insulin injections over time, rating the pain intensity as low. Athletes learn to understand, tolerate, and respond adaptively to pain associated with their sport.

Sensitization

Sensitization is an increased reaction to the pain over time and/or a reduced threshold for reaction to painful stimuli. Sensitization might occur both at a physiological level (in the peripheral and central nervous system) and at a psychological level (by inducing the development of a behavioral fear-avoidance response). Behavioral changes include lower tolerance for pain, greater emotional distress, and greater avoidance of further painful stimulation. Although no longitudinal studies of sensitization have been done in young humans, data available to date suggest that sensitization is more likely to occur with more severe pain[42] and with younger children, particularly neonates.[1] Sensitization can apparently be elicited by a single strong painful event, as seen in the study by Taddio et al[62] of circumcision.

No Change

No change means the reaction to the stimulus remains the same over time. For example, some children report the same pain intensity for each in a series of painful procedures.[33]

No Pattern

No pattern means that all or none of the above patterns can be observed within an individual. The majority of children getting repeated lumbar punctures and bone marrow aspirations exhibit neither habituation nor sensitization; instead their reaction to the procedure varies unpredictably over time.[33]

In other words, one cannot assume that children will just get used to a repeated painful procedure. For anything more severe than mild pain, most will not. For some, the pain becomes worse with each repetition. There is a dearth of experimental data on habituation for pain in children, presumably because of the ethical difficulties in administering repeated painful stimuli to minors. However, on the basis of the limited evidence cited above, it would be reasonable to speculate that a sensitizing reaction is more likely to occur in younger children, in whom the initial pain is more severe and less well understood by the child, and in whom resources to modulate or cope with the pain are less developed. Under the latter conditions of sensitization, the painful event is likely to be remembered as more severe, unmanageable, or frightening than in conditions in which habituation occurs.

Over what periods of time is pain remembered in childhood? What is the consequence of recalling painful experiences on management of subsequent medical experiences in childhood and adulthood? With respect to children, much of what we know concerns recall of stressful experiences, rather than recall of the experience of pain itself (with a few exceptions[3,43,69]). A body of evidence shows that stressful invasive procedures are recalled quite accurately over delays of between 6 weeks and many years. The memory reports of such experiences are influenced by similar factors as those of nonstressful experiences; for example, older children typically report more information than do younger children, and recall of unique and distinctive experiences is superior to recall of single instances of recurrent events.[4,15,31,45,49,53]

If distress during a medical procedure adversely affects recall of procedural details, it might also interfere with understanding of, and coping with, subsequent procedures. This effect might be particularly noticeable in instances in which a young child cries, resulting in a withdrawal of attention from the central aspects of the procedure and a failure to learn a "script" for the event in which coping occurs. Evidence on this point is mixed. Some researchers have found a negative relationship between high levels of distress and the accuracy of children's recall, whereas others have found no relationship between pain or distress and recall of procedural detail.[9,45,46,56]

Experiencing a specific painful condition might influence memory for concepts related to pain in general. Two studies with different experimental methods have demonstrated enhanced recall for pain-related words in children with acute postoperative pain and chronic pain, in comparison with pain-free clinical samples and healthy schoolchildren.[38,41] The opposite pattern was found for non–pain-related words.

Chen et al[15] investigated 3- to 18-year-old children's recall of consecutive lumbar punctures (LPs) over a short (1 week) delay. A strong association was found between memory and pain/distress during the subsequent LP. Specifically, greater exaggeration in children's memories of anxiety and pain (compared with their original reports) was associated with higher distress (self-report and behavioral observations) during the subsequent LP. In other words, pain and distress negatively influenced explicit memory of the procedure, and distorted memory influenced subsequent distress and pain ratings. Notably, children with higher scores on a questionnaire measure of pain sensitivity displayed greater anxiety and pain, suggesting that these children might be particularly vulnerable to developing negatively exaggerated memories.[15]

Other research provides evidence, albeit less direct, that remembered distress and pain might influence anticipatory anxiety and/or coping with subsequent procedures. For example, children who have had painful dental procedures are more likely to become anxious about future dental procedures.[20] Children who have had several previous experiences with a voiding cystourethogram (VCUG) are rated as less cooperative than children with fewer or no VCUG experiences.[67]

What is the influence of negative childhood memories on adults' health care behavior? Research findings are equivocal. In a study of 147 young adults, Pate et al[48] investigated the effects of childhood medical experiences and temperament on adults' medical fear, pain, coping, and avoidance of medical situations. Results showed that adult reports of their pain, fear, and effectiveness of coping with pain were predicted by their reports of their own childhood pain, fear, and effectiveness of coping. Interpretation of these data is difficult, however, because it is unclear to what extent the adults' current psychological functioning influenced their memory reports. For example, memories of previous pain can be distorted when intense pain is experienced during recall testing,[23] and current anxiety can also influence memories of dental pain.[40]

In summary, several studies show that children can often recall stressful and painful procedural details, or even exaggerated negative aspects of such situations, over long delays.[4,30,45,53,56,60] Although the evidence is mixed, it appears likely that these memories can, under some circumstances, have a significant impact on future coping.[15,20,56,67] More research remains to be done on the longer-term effects of remembered pain and distress.

It is important to recognize that a limitation in the studies presented here is that memory for pain experience is generally confounded with memory for pain expression. What might be remembered is not the experience itself, but rather the child's pain rating or pain behavior or even, as we note below, the child's previous expectations of pain. This limitation is particularly salient in research that relies on self-report measures.

We now turn to individual and situational factors that might reciprocally influence memory and pain.

Individual Differences in Memory for Pain

A number of individual differences affect children's reports of painful events, for example, age, anxiety, temperament, pain response, and prior experience. There is much evidence showing that younger children remember and report more pain than older children for similar procedures such as venipuncture.[7,26-29,36]

Pain reports are also influenced by individual differences in temperament.[54,57] Temperament refers to stable individual differences in the quality and intensity of activity level, attention, and emotional reactivity. An "easy" temperament denotes easygoing children who can adapt to new experiences and establish regular routines. A minority of children who are described as having a "difficult" temperament, by contrast, tend to react warily and intensely to new experiences and to have irregular daily routines. A temperamental dimension of particular relevance to pain is termed *threshold*, that is, the minimum intensity of a stimulus to which a child will typically react. Children who are described by their parents as typically reacting to low threshold stimuli generally appear to be more sensitive to pain stimuli in particular.[7] Schechter et al[57] correlated ratings on a parent report of temperament with observed distress during immunization injections in 65 children aged 4 to 5 years. Children categorized as difficult on the basis of the mother's temperament rating had distress scores 2 to 3 times the means of the children in the other temperament clusters.

Several investigators suggest that preparation of children for painful procedures might need to be individualized on the basis of temperamental characteristics.[7,8,48,54,57] In a study of the "pain-sensitive temperament" in children with cancer, higher levels of pain sensitivity were associated with greater anxiety and pain, both during and after an LP.[15] The authors suggested targeting pain-sensitive children for special psychological preventative intervention before painful procedures. Again, in the pediatric oncology context, Broome et al[8] found the temperamental dimension of positive mood to be associated with improvement in pain reports during a 5-month period after cognitive-behavioral intervention for procedural distress.

Another individual difference that might be related to pain memory is anxiety.[2,40] These authors suggested that anxious people remember their negative expectations of dental treatment better than they remember their actual experiences. The subtitle of the article by Arntz et al[2] reads, "The fear of any expected evil, is worse than the evil itself"; one might add, "and the fear is better remembered."

Shame or embarrassment has also been shown to alter children's reports of pain.[60] Eight of 12 children aged 37 to 77 months who did not report pain from needle punctures and bone marrow aspirations exhibited behavioral signs of shame or embarrassment, whereas none of 12 children who did report pain exhibited shame. This might be understood in terms of "display rules"[68]; children develop an understanding that displaying pain under some circumstances, eg, with strangers, is socially undesirable, so those who feel embarrassed might suppress their report of pain.

Does the amount of previous experience with medical procedures affect the report of subsequent pain? It appears that it is not the amount of experience per se but rather the valence or quality of the previous experience that has an important effect. In 2 separate studies of medical procedures,[6,19] children who had more distressing previous experiences were found to be more anxious and distressed than children who had primarily positive or neutral experience with procedures. Thus, negative past experiences are likely to sensitize the child to such situations, making them more distressing in the future.[6]

Situational and Methodologic Influences

A number of situational factors might influence the way children remember and report distressing events. These include immediate versus retrospective questioning, repeated interviews, repeated questions, type of questions and prompts provided, and rapport developed in the interview.

The primary situational factor that has been explored in relation to children's recollection of pain is the delay, that is, the time passing between the painful event and the interview.[3,43,44,69] This research indicates that children can accurately recall previously experienced pain over a period of months or even years. For example, Badali et al[3] examined 5- to 12-year-old children's memory of reported pain intensity for pain from a cold pressor task, which requires children to immerse their hand in cold water for as long as they can. Ratings of pain were made on the 7-point Bieri Faces Pain Scale immediately and 1 year later. The children reliably recalled their pain intensity ratings over time. Of course, it is not clear whether they were really remembering their pain or only their own ratings.

On the other hand, the passage of time can change ratings of pain. Van den Brink et al[65] compared children's reports of headache frequency, intensity, and duration collected by using a prospective 4-week diary and a retrospective headache questionnaire. Results showed that headache intensity and duration were overestimated on the retrospective questionnaire compared with the diary. Thus, children with recurrent pain tend to evaluate their painful experiences more negatively when they are asked to recall them later than when they record the pain at the time it is experienced. Similarly, children in a study by Cohen et al[16] reported more pain for an earlier painful procedure than they had reported at the time it had occurred. To minimize bias, the use of prospective rather than retrospective reports when studying pain in children with recurrent or chronic pain seems appropriate.

When children are questioned about their recollections of painful events or procedures, several other methodologic and contextual factors might influence their reports. In particular, memory researchers have shown that the format of questions posed and the use of materials such as drawings and toys influence how children respond to questions regarding experienced events. These factors will be discussed in turn.

To gain access to children's underlying memory representations of their painful experiences we must ask about them. As described in memory research, these questions can be asked in 3 general formats. Open-ended questions can be used (eg, "How are you feeling?"). However, it is well established that young children do not provide much information in response to open-ended questions. Therefore, the 2 forms of questions commonly used with children are "yes-no" questions and "wh-" questions like "*What* happened when the nurse gave you the poke? *Where* did it hurt?" "*When* did the hurt go away?" "*Who* hurt you?" These question formats are different syntactically, and they produce different rates of accuracy.[49]

Wh- questions tend to increase the completeness of children's reports when compared to yes-no questions.[49] In research on children's memories of salient personal events, yes-no questions have been found to elicit unreliable information from children, particularly preschool-age children. Young children exhibit a bias toward responding with "yes" to questions in which the correct answer is either yes or no (eg, "Does your tummy hurt?") and to seemingly inappropriate questions such as "Is red heavier than yellow?" Such biases might be due to conversational norms that suggest that children should try to be positive and cooperative. Furthermore, repeating yes-no questions might suggest to the child that her first answer was incorrect and therefore lead to increased errors.

Such high error rates for yes responses suggest that researchers should avoid relying solely on children's answers to yes-no questions. Researchers have found that one can repeat wh- questions without increasing errors.[51] In interviews, it is also important to inform children that if they do not remember a detail, it is okay to say so. When children are instructed that "I don't know" is an acceptable response, they make fewer mistakes than when they do not receive these instructions.[49]

Prompts or reminders of details by the interviewer also affect accuracy of recall. Salmon et al[56] interviewed 2- to 7-year-olds 6 months after a VCUG. They found that both younger and older children remembered about twice as much information when they were prompted, compared with free, unprompted recall, but the proportion of accurate answers decreased from 86% to 62% for children 4 years of age and younger and from 97% to 88% for children 5 to 7 years. In other words, with prompting, children produced more information about the VCUG, both accurate and inaccurate.

Another factor that influences children's reporting of events is the use of extra cues, such as drawings or toys. When interviewing children, these materials are sometimes used to facilitate memory, to provide comfort, or as an icebreaker. The use of cues has not been well studied for feasibility in medical settings. From basic memory research, it is known that the completeness and consistency of a child's recall of an event are facilitated by the availability of cues.[24,50] Younger children and children who are recalling more distant events rely more on external and specific cues.[4] It stands to reason, therefore, that visual cues or hands-on materials might also be helpful to aid children in remembering and/or describing previous distress. For example, having children create images of their pain has been shown to be helpful in the diagnosis of headaches. Stafstrom et al[59] had patients aged 4 to 19 years who were referred for headaches to a neurology clinic draw pictures to describe their pain. Neurologists then scored the pictures as migraine or nonmigraine, and the results were compared with a standard clinical diagnosis provided from a different physician. Results showed that the categorization based on children's drawings matched the clinical diagnosis 87%

of the time for migraine and 91% of the time for tension headache. This shows that children were able to remember and represent their pain by using drawings. In the eyewitness testimony literature, in which accuracy is paramount, research on the utility of drawing for enhancing memory has been mixed. One study demonstrated that having children draw what happened during a particular event, combined with examination of the spontaneous narratives while they are drawing, was associated with increases in children's recall performance.[11] The beneficial effects of drawing by 5- and 6-year-olds on memory were evident up to 6 months after the event for both positive and negative experiences; however, similar beneficial effects of drawing were not evident among 3- and 4-year-olds. Steward and Steward[60] also found that drawings were effective in eliciting slightly more information from children about body touch when compared to unassisted or verbal techniques only. On the other hand, drawing has also been shown to introduce additional errors into children's event accounts[10] and does not always enhance their memory reports of medical experiences.[55] Thus, at present, there is limited research on drawing, and the specific circumstances under which it might be helpful in recall of pain are yet to be clarified.

The skill of the interviewer in talking with young children and the rapport established would also be key factors. The research is slim on these questions. There is little documented research on the effects of time spent developing rapport before interviewing children. It seems likely that greater rapport could lead to greater trust and therefore facilitate less reluctance and more accurate recall of previous painful experiences.

Preventing the Adverse Consequences of Remembered Pain

How can we intervene to help children remember invasive medical procedures in such a way that future coping is enhanced? In this section, we consider the use of information (coaching, psychological preparation, suggestion) and of amnestic medications in preventing the adverse consequences of memories of pain.

Salmon et al are currently investigating whether providing children with a developmentally appropriate description of a complex and invasive medical procedure (a VCUG) improves memory for the procedural (nonpainful) details of that experience, making it less mysterious and threatening. This research derives from a body of work showing that how adults talk with children as an event takes place influences how the children remember the experience, serving to compensate for immature knowledge and understanding.[64] In this instance, adult narration of the VCUG as it unfolds might reduce the incomprehensible and unfamiliar nature of the procedure, making it less frightening for the child[60] and enabling the experience to be encoded in an organized and accurate form in memory. Moreover, simply informing children that a procedure will hurt to some extent might reduce subsequent reports of how painful it was.[58]

Several studies on advance preparation for anesthesia and surgery show that preoperative anxiety is reduced for children and parents by a routine preanesthetic activity such as a hospital visit and an educational video.[12] These results demonstrate that children can remember information that will help them to understand their subsequent hospital experiences and to construe them as less threatening than children not given the advance preparation. Thus, memory for a suggested reinterpretation of a frightening or painful experience might be relevant to children's memory of the later experience itself.

The preceding paragraphs dealt with information given before or concurrent with procedures. Can memories of distress be altered after the distressing events are over? Although suggestion is known to influence children's memories, little of this knowledge has been applied to determine whether memories concerning painful events can be reframed so as to reduce pain and distress experienced during subsequent medical procedures. Chen et al[13,14] found that children who are very anxious about medical procedures remember and exaggerate negative details of their previous medical procedures, which results in increased anxiety and pain during future procedures. They reduced children's distress caused by an LP by using an intervention designed to reframe memory of a previous LP. They tested for biases in children's recall of threatening details, anxiety, and pain and then helped them reevaluate reactions to their last LP. They encouraged the children to believe in the efficacy of their own coping strategies and to remember positive aspects such as moments when they did not cry rather than the times they did cry. The results are promising, but as Chen et al argued, it is not known whether memory changes truly drive this intervention, and whether memory reframing and reductions in distress can be maintained long-term.

In a similar study, Bruck et al[9] told children after an immunization injection that they were very brave and had not cried and had not had much pain. A randomly selected half of the children were not given this information. The manipulation reduced the children's distress the next time they got an injection.

Marche and her students are currently investigating methods by which pain memory can be changed by suggestions from others. A memory-based intervention that coaches children to edit exaggerated memories, especially negative ones, and teaches them to focus less on unpleasant aspects of their experiences should enhance their pain coping abilities. A recent study by Cohen et al[16] found that certain interventions (ie, distraction with a movie or local anesthetics) prevented children who were undergoing a hepatitis B vaccination from developing negative memories that occur with typical care. Thus, reducing pain through distraction also reduces pain memories.

Several studies have examined the effects of midazolam (Versed) on memory for painful medical procedures in oncology/hematology and general surgery. In one study with a very small sample,[15] recall of the procedure was similar for the medicated and unmedicated groups. In other words, the midazolam did not have the expected amnestic effect. (The latter study, however, as the

authors point out, confounded a psychological intervention with the memory interview.) In the other 2 studies, the researchers did not assess the impact of midazolam on children's memory for the medical procedure itself, but rather on their memory of stimuli unrelated to the experience.[39,52] The findings of one study[39] showed that midazolam impaired recognition memory (an explicit memory task) as little as 10 minutes after administration, that is, to the extent that amnesia for the procedure is a desired outcome, midazolam can be administered as late as 10 minutes before surgery. Although midazolam might negatively affect recognition memory, however, other aspects of memory are not necessarily also impaired. Thus, the authors of a second study that also included a test of implicit memory[52] concluded that "the sedative midazolam had a significant anterograde amnesic effect on participants' performance on a visual recognition (explicit) memory task but not on a visual perceptual facilitation (implicit) memory task. That implicit memory scores were relatively unaffected while explicit memory scores deteriorated significantly indicates that learning occurred while participants were sedated, even when participants did not recollect the learning event."

It is commonly assumed that amnestic medications should prevent fear of future procedures; if children can't remember the pain they experienced last time, they won't fear the next time. The latter 2 studies make it clear that the picture is somewhat more complicated than that, with differential effects on different types of memory. A child who expresses no verbal or explicit memory of a painful event experienced under midazolam might nevertheless have implicit, nonverbal memories (like those of a baby) that could affect reactions to later procedures. The effects of amnestic medications might differ for the psychological and physiological aspects of sensitization referred to above. It should also be pointed out that forgetting pain might also entail forgetting successful coping with pain, but there is no research on that proposition.

Conclusion

Directions for future research have been mentioned throughout this review. Of these, perhaps the most immediately significant would be to evaluate further the effectiveness of methods for altering memory for pain (prospectively or retrospectively) to avert the negative consequences of such memories on future coping with painful and stressful events. Another useful research direction would be to examine the relationship between physiological sensitization (facilitation of synaptic function by a prior event, occurring at a peripheral or central level) and implicit memory (facilitation of task performance by a prior experience, requiring cognitive processing) in infants.

Some recommendations can also be offered for clinical care. Each of the following points is based on some evidence, although the research is not always unequivocal.

1. In treating children, clinicians should consider what they will remember. A procedure might seem minor to an adult, but a child might remember it as terrible. An investment in proper preparation and pain management today is likely to pay off tomorrow — for the child in reduced fear and avoidance of future care, and for the health professional in reduced time required to complete procedures.
2. Clinicians can assess memories of earlier painful experiences (by asking parents) so that children who have had exceptionally negative experiences can receive effective intervention for pain and fear. For example, most children can endure minor procedures with only local anesthesia, but the minority of patients who have had very negative previous experiences might need stronger medications or special psychological attention.
3. Children can be prepared for painful experiences by giving them accurate, credible information at their own level of understanding. Familiarity with a situation increases the child's sense of control. Remembering this information as they undergo a procedure can make it less distressing.
4. Wh- questions should be used before resorting to yes-no questions in finding out what children remember and expect. The open form of questions elicits more accurate information.
5. Distressing experiences should be discussed afterward, emphasizing positive aspects. This might help in reframing memories, reducing fear and expected pain for future painful events.

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References

1. Andrews K, Fitzgerald M: The cutaneous withdrawal reflex in human neonates: Sensitization, receptive fields, and the effects of contralateral stimulation. Pain 56:95-101, 1994

2. Arntz A, van Eck M, Heijmans M: Predictions of dental pain: the fear of any expected evil, is worse than the evil itself. Behav Res Ther 28:29-41, 1990

3. Badali M, Pillai R, Craig K, Giesbrecht K, Chambers C: Accuracy of children's and parents' memory for a novel painful experience. Pain Res Manage 5:161-168, 2000

4. Baker-Ward L, Gordon BN, Ornstein PA, Larus DM, Clubb PA: Young children's long-term retention of a pediatric examination. Child Dev 64:1519-1533, 1993

5. Bauer PJ: What do infants recall of their lives? Memory for specific events by one- to two-year-olds. Am Psychol 51:29-41, 1996

6. Bijttebier P, Vertommen H: The impact of previous expe-

rience on children's reactions to venipunctures. J Health Psychol 3:39-46, 1998

7. Bournaki M-C: Correlates of pain-related responses to venipunctures in school-age children. Nurs Res 46:147-154, 1997

8. Broome ME, Rehwaldt M, Fogg L: Relationships between cognitive behavioral techniques, temperament, observed distress, and pain reports in children and adolescents during lumbar puncture. J Pediatr Nurs 13:48-54, 1998

9. Bruck M, Ceci SJ, Francoeur E, Barr R: "I hardly cried when I got my shot!" Influencing children's reports about a visit to their pediatrician. Child Dev 66:193-208, 1995

10. Bruck M, Melnyk L, Ceci SJ: Draw it again, Sam: The effect of drawing on children's suggestibility and source monitoring. J Exp Child Psychol 77:169-196, 2000

11. Butler S, Gross J, Hayne H: The effect of drawing on memory performance in young children. Dev Psychol 31: 597-608, 1995

12. Cassady JF Jr, Wysocki TT, Miller KM, Cancel DD, Izenberg N: Use of a preanesthetic video for facilitation of parental education and anxiolysis before pediatric ambulatory surgery. Anesth Analg 88:246-250, 1999

13. Chen E: Painful medical procedures in children with cancer: The impact of reframing previous experiences in distress. Dissertation, University of California, Los Angeles, 1999

14. Chen E, Zeltzer LK, Craske MG, Katz ER: Alteration of memory in the reduction of children's distress during repeated aversive medical procedures. J Consult Clin Psychol 67:481-490, 1999

15. Chen E, Zeltzer LK, Craske MG, Katz ER: Children's memories for painful cancer treatment procedures: Implications for distress. Child Dev 71:933-947, 2000

16. Cohen LL, Blount RL, Cohen RJ, Ball CM, McClellan CB, Bernard RS: Children's expectations and memories of acute distress: Short- and long-term efficacy of pain management interventions. J Pediatr Psychol 26:367-374, 2001

17. Collie R, Hayne H: Deferred imitation by 6- and 9-month-old infants: More evidence for declarative memory. Dev Psychobiol 35:83-90, 1999

18. Crombez G, Eccleston C, Baeyens F, Eelen P: Habituation and the interference of pain with task performance. Pain 70:149-154, 1997

19. Dahlquist LM, Gil KM, Armstrong FD, DeLawyer DD, Greene P, Wuori D: Preparing children for medical examinations: The importance of previous medical experience. Health Psychol 5:249-259, 1986

20. Davey GC: Dental phobias and anxieties: Evidence for conditioning processes in the acquisition and modulation of a learned fear. Behav Res Ther 27:51-58, 1989

21. DeCasper AJ, Spence MJ: Prenatal maternal speech influences newborns' perception of speech sounds. Infant Behav Dev 9:133-150, 1986

22. Edwards RR, Fillingim RB: Effects of age on temporal summation and habituation of thermal pain: Clinical relevance in healthy older and younger adults. J Pain 2:307-317, 2001

23. Eich E, Reeves JL, Jaeger B, Graff Radford SB: Memory for pain: Relation between past and present pain intensity. Pain 23:375-380, 1985

24. Fivush R: Developmental perspectives on autobiographical recall. In: Goodman GS, Bottoms BL (eds): Child Victims, Child Witnesses: Understanding and Improving Testimony. New York, NY, Guilford Press, 1993, pp 1-24

25. Fivush R, Hamond NR: Autobiographical memory across the preschool years: Toward reconceptualizing childhood amnesia, in Fivush R, Hudson JA (eds): Knowing and Remembering in Young Children. New York, NY, Cambridge University Press, 199, pp 223-248

26. Fradet C, McGrath PJ, Kay J, Adams S, Luke B: A prospective survey of reactions to blood tests by children and adolescents. Pain 40:53-60, 1990

27. Goodenough B, Champion GD, Laubreaux L, Tabah L, Kampel L: Needle pain severity in children: Does the relationship between self-report and observed behaviour vary as a function of age? Aust J Psychol 50:1-9, 1998

28. Goodenough B, Kampel L, Champion GD, Laubreaux L, Nicholas MK, Ziegler JB, McInerney M: An investigation of the placebo effect and age-related factors in the report of needle pain from venipuncture in children. Pain 72:383-391, 1997

29. Goodenough B, Thomas W, Champion GD, Perrott D, Taplin JE, von Baeyer CL, Ziegler JB: Unravelling age effects and sex differences in needle pain: Ratings of sensory intensity and unpleasantness of venipuncture pain by children and their parents. Pain 80:179-190, 1999

30. Goodman GS, Hirschman JE, Hepps D, Rudy L: Children's memory for stressful events. Merrill Palmer Quarterly 37: 109-157, 1991

31. Goodman GS, Quas JA, Batterman Faunce JM, Riddlesberger MM: Predictors of accurate and inaccurate memories of traumatic events experienced in childhood. Consciousness and Cognition: An International Journal 3:269-294, 1994

32. Haberlandt K: Human Memory: Exploration and Application. Needham Heights, MA, Allyn & Bacon, 1999

33. Harris CV, Bradlyn AS, Ritchey AK, Olsen BR, Pisaruk HI: Individual differences in pediatric cancer patients' reactions to invasive medical procedures: A repeated measures analysis. Pediatr Hematol Oncol 11:293-299, 1994

34. Howe ML: The Fate of Early Memories: Developmental Science and the Retention of Childhood Experiences. Washington, DC, American Psychological Association, 2000

35. Howe ML, Courage ML: On resolving the enigma of infantile amnesia. Psychol Bull 113:305-326, 1993

36. Jay SM, Ozolins M, Elliott CH, Caldwell S: Assessment of children's distress during painful medical procedures. Health Psychol 2:133-147, 1983

37. Ji RR, Kohno T, Moore KA, Woolf CJ: Central sensitization and LTP: Do pain and memory share similar mechanisms? Trends Neurosci 26:696-705, 2003

38. Johnson R, Spence S: Pain, affect and cognition in children: Recall bias associated with pain. Prog Pain Res Manage 2:877-884, 1994

39. Kain Z, Hofstadter M, Mayes L, Krivutza D, Alexander G, Wang S, Reznick J: Midazolam: Effects on amnesia and anxiety in children. Anesthesiology 93:676-684, 2000

40. Kent G: Memory of dental pain. Pain 21:187-194, 1985

41. Koutantji M, Pearce SA, Oakley DA, Feinmann C: Children in pain: An investigation of selective memory for pain and psychological adjustment. Pain 81:237-244, 1999

42. Koyama Y, Koyama T, Kroncke AP, Coghill RC: Effects of stimulus duration on heat induced pain: The relationship

between real-time and post-stimulus pain ratings. Pain 107: 256-266, 2004

43. Lander J, Hodgins M, Fowler Kerry S: Children's pain predictions and memories. Behav Res Ther 30:117-124, 1992

44. Lehmann HP, Bendebba M, DeAngelis C: The consistency of young children's assessment of remembered painful events. J Dev Behav Pediatr 11:128-34, 1990

45. Merritt KA, Ornstein PA, Spicker B: Children's memory for a salient medical procedure: Implications for testimony. Pediatrics 94:17-23, 1994

46. Oates K, Shrimpton S: Children's memories for stressful and non-stressful events. Med Sci Law 31:4-10, 1991

47. Ornstein PA, Manning EL, Pelphrey KA: Children's memory for pain. J Dev Behav Pediatr 20:262-277, 1999

48. Pate JT, Blount RL, Cohen LL, Smith AJ: Childhood medical experience and temperament as predictors of adult functioning in medical situations. Children's Health Care 25: 281-298, 1996

49. Peterson C, Dowden C, Tobin J: Interviewing preschoolers: Comparisons of yes/no and wh- questions. Law Hum Behav 23:539-555, 1999

50. Pipe M-E, Salmon K, Priestley G: Enhancing children's accounts: How useful are non-verbal techniques?. in Westcott H, Davies G, Bull R (eds): Children's Testimony: A Handbook of Psychological Research and Forensic Practice. New York, NY, Wiley & Sons, 2002, pp 161-174

51. Poole DA, Lindsay DS: Interviewing preschoolers: Effects of nonsuggestive techniques, parental coaching, and leading questions on reports of nonexperienced events. J Exp Child Psychol 60:129-154, 1995

52. Pringle B, Dahlquist LM, Eskenazi A: Memory in pediatric patients undergoing conscious sedation for aversive medical procedures. Health Psychol 22:263-269, 2003

53. Quas JA, Goodman GS, Bidrose S, Pipe M-E, Craw S, Ablin DS: Emotion and memory: Children's long-term remembering, forgetting, and suggestibility. J Exp Child Psychol 72: 235-270, 1999

54. Rocha EM, Prkachin KM, Beaumont SL, Hardy CL, Zumbo BD: Pain reactivity and somatization in kindergarten-age children. J Pediatr Psychol 28:47-57, 2003

55. Salmon K, Pipe M-E: Recalling an event 1 year later: The impact of props, drawing, and a prior interview. Appl Cogn Psychol 14:184-220, 2000

56. Salmon K, Price M, Pereira JK: Factors associated with young children's long-term recall of an invasive medical procedure: A preliminary investigation. J Dev Behav Pediatr 23: 347-352, 2002

57. Schechter NL, Bernstein BA, Beck A, Hart L, Scherzer L: Individual differences in children's response to pain: Role of temperament and parental characteristics. Pediatrics 87:171-177, 1991

58. Spafford PA, von Baeyer CL, Hicks CL: Expected and reported pain in children undergoing ear piercing: A randomized trial of preparation by parents. Behav Res Ther 40:253-266, 2002

59. Stafstrom CE, Rostasy K, Minster A: The usefulness of children's drawings in the diagnosis of headache. Pediatrics 109:460-472, 2002

60. Steward MS, Steward DS: Interviewing young children about body touch and handling. Monogr Soc Res Child Dev 61:1-214, 1996

61. Sun-Ok S, Carr D. Pain and Memory: International Association for the Study of Pain. Pain: Clinical Updates 7:1-4, 1999

62. Taddio A, Katz J, Ilersich AL, Koren G: Effect of neonatal circumcision on pain response during subsequent routine vaccination. Lancet 349:599-603, 1997

63. Taddio A, Shah V, Gilbert-MacLeod C, Katz J: Conditioning and hyperalgesia in newborns exposed to repeated heel lances. JAMA 288:857-861, 2002

64. Tessler M, Nelson K: Making memories: The influence of joint encoding on later recall by young children. Consciousness Cogn 3:307-326, 1994

65. van den Brink M, Bandell-Hoekstra EN, Abu-Saad HH: The occurrence of recall bias in pediatric headache: A comparison of questionnaire and diary data. Headache 41:11-20, 2001

66. Weisman SJ, Bernstein B, Schechter NL: Consequences of inadequate analgesia during painful procedures in children. Arch Pediatr Adolesc Med 152:147-149, 1998

67. Zelikovsky N, Rodrigue JR, Gidycz CA, Davis MA: Cognitive behavioral and behavioral interventions help young children cope during a voiding cystourethrogram. J Pediatr Psychol 25:535-543, 2000

68. Zeman J, Garber J: Display rules for anger, sadness, and pain: It depends on who is watching. Child Dev 67:957-973, 1996

69. Zonneveld LN, McGrath PJ, Reid GJ, Sorbi MJ: Accuracy of children's pain memories. Pain 71:297-302, 1997