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# Children's Memories for Painful Cancer Treatment Procedures: Implications for Distress

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Children (ages 3 to 18, $N = 55$) diagnosed with leukemia were tested for their memories of lumbar punctures (LPs), a repeated and painful part of the cancer treatment protocol. Memory for both event details and the child's emotional responses was assessed one week after the LP. Children of all ages displayed considerable accuracy for event details, and accuracy increased with age. Overall recall accuracy for event details and emotional responses was similar. Recall among children given oral Versed was similar to that among children not given Versed. Finally, higher distress predicted greater exaggerations in negative memory 1 week later (although controlling for age weakened this relationship); moreover, greater exaggerations in negative memory predicted higher distress at a subsequent LP. These results indicate that children's memories play an important role in their experience of distress during repeated stressful events.

## INTRODUCTION

Recent attention to the accuracy and suggestibility of children's testimonies in courtrooms has sparked numerous laboratory studies of children's memories (for a review, see Ceci & Bruck, 1993). Common paradigms involve manipulation of children's memories with misinformation (e.g., Leichtman & Ceci, 1995; Marche & Howe, 1995). However, some researchers argue that the artificial environments in which these manipulations occur lack generalizability to children's memories for real-life stressful events (Peterson & Bell, 1996).

The present study attempts to expand our understanding of children's memories for personally significant stressful events by evaluating memories for a painful, highly distressing medical procedure, lumbar punctures (LPs). Children undergoing treatment for cancer must endure a series of these invasive medical procedures, in which a needle is inserted into the spinal column to withdraw spinal fluid and administer chemotherapy. Children report that LPs are one of the most traumatic and painful parts of the cancer treatment process (Jay, Elliott, Ozolins, Olson, & Pruitt, 1985). The present study used the LP procedure to examine three specific questions outlined below.

### How Accurate Are Children's Memories for LPs?

Many previous research studies have examined children's memories for events that were either nonstressful or mildly stressful. For example, investigators have demonstrated good accuracy in memory for social events among preschoolers (Fivush & Hudson, 1990). Children as young as 3 years old have a high percentage of recall for physical and dental examinations (e.g., Baker-Ward, Gordon, Ornstein, Larus, & Clubb, 1993; Goodman, Hirschman, Hepps, & Rudy, 1991; Ornstein, Gordon, & Larus, 1992; Vandermaas, Hess, & Baker-Ward, 1993).

Research has also been conducted on children's memories for more stressful events. Children have been shown to remember over long intervals traumatic events such as the murder of a parent, physical or sexual abuse, and natural disasters (see Howe, 1997, for a review). Children also demonstrate high accuracy in recall for stressful medical events, including voiding cystourethrograms and traumatic injuries (Goodman, Quas, Batterman-Faunce, Riddleberger, & Kuhn, 1994; Howe, Courage, & Peterson, 1995; Merritt, Ornstein, & Spicker, 1994; Peterson & Bell, 1996), and their accuracy increases with age. Overall, research on children's memories for stressful events demonstrates that children show good memory for stressful medical and stressful nonmedical events both immediately after the event as well as after long intervals (e.g., 1 year). Memory is more accurate when the event is unique and distinctive. Additionally, memory is better for details central to the stressful event but may be worse for peripheral details (see Christianson, 1992, and Howe, 1997, for reviews).

The first goal of the present study was to extend this research to chronically ill children. That is, do chronically ill children display similar levels of recall for stressful events? We tested this question by exploring memory accuracy for LPs among a sample of pediatric cancer patients. Understanding memories for LPs is important because these stressful events are

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a predictable and regular occurrence for these children and may have important implications for subsequent distress, as discussed below.

### How Do Children's Memories Compare for Event Details Versus Emotional Responses?

The vast majority of memory studies in children have focused on memory for factual information during emotional events. Research has shown that people remember events more often when those events evoke emotional reactions (Bower, 1994). In addition, people remember details of a highly emotional event better than they remember details of the circumstances surrounding the event (Christianson & Hubinette, 1993). The greater the emotion experienced during a traumatic event, the greater the number of central details a person remembers (Christianson & Loftus, 1990). Emotional reactions are likely to be an important part of children's memories, especially for highly stressful or traumatic events, and yet recall for emotional responses (e.g., crying) has not been examined in this literature. Thus, the second goal of the study was to compare children's memories for emotional responses to an LP with their memories for the details of an LP.

### How Does Memory Relate to Distress?

#### Does Distress Influence Memory?

Yerkes and Dodson (1908) proposed a U-shaped curve to describe the relationship between arousal and performance, such that at lower levels increasing arousal increases cognitive efficiency and therefore increases memory performance. Beyond an optimal level, however, arousal results in decreased mental efficiency and worse memory performance. Easterbrook's cue-utilization hypothesis (1959) explains this phenomenon by postulating that increasing emotional arousal results in progressive restriction in the range of cues one attends to. At moderate levels, this restriction allows individuals to attend to relevant information and ignore irrelevant information. However, at higher levels of emotional arousal, relevant cues would also start to be ignored. Thus, one would predict that at lower levels, distress would be associated with better recall of a stressful event, whereas at higher levels, distress would be associated with poorer recall.

The existing research on medically related stressful events is somewhat difficult to evaluate in the context of these theories. Distress has been associated with poorer recall for a medical procedure or other stressful event (Merritt et al., 1994; Peters, 1987, 1991). Others found no relationship between distress and recall of doctors' visits (Baker-Ward et al., 1993; Howe et al., 1995). Still others find that higher experienced stress during an inoculation is associated with greater memory accuracy (Goodman et al., 1991). Researchers have hypothesized that there may not be one consistent relationship between memory and distress during stressful events. Rather, the relationship may vary depending on how distinctive and unique the event is as well as the types of details probed (see Christianson, 1992, and Howe, 1997, for reviews). In addition, difficulty comparing stress levels across studies makes assessing how well these studies fit into the previously noted theories problematic. In the present study, we focused on an event (LPs) that has consistently been rated as one of the most traumatic aspects of the cancer treatment protocol (Jay et al., 1985). We hypothesized that because distress among this population would fall on the high end of the Yerkes-Dodson curve, greater distress would be associated with poorer recall of LP details. Additionally, to obtain a fuller assessment of distress, we included self-report, observational, and physiological measures of distress and examined associations of all three domains of distress with children's memory of the details of their most recent LP.

Furthermore, some researchers hypothesize that distress should be associated with memory for only negative details because anxiety provokes preferential attention to and encoding of negative aspects of stressful experiences. Clinically anxious adults and children are more likely to interpret ambiguous situations as threatening (Barrett, Rapee, Dadds, & Ryan, 1996; Mathews, Richards, & Eysenck, 1989) and to display an attentional bias toward threatening information relative to neutral information (MacLeod, Mathews, & Tata, 1986; Vasey, Daleiden, Williams, & Brown, 1995). A memory bias for threatening information has been detected as well (Cloitre & Liebowitz, 1991; McNally, Foa, & Donnell, 1989). However, some researchers have found no such bias among anxious individuals: Milgrom, Weinstein, Beirne, & Fiset, 1993; Mogg, Mathews, & Weinman, 1987). Propranolol (a beta-blocker that reduces physiological arousal), given before a story was read to participants, impaired memory for an arousing short story but not for a neutral story, whereas a placebo condition produced no memory differences between the two types of stories (Cahill, Prits, Weber, & McGaugh, 1994). Children in the present study were probed about both negative and neutral/positive details of their LP. On the basis of previous research, we hypothesized that distress would be associated with memory for negative details but not with memory for neutral/positive details.

### Does Memory Influence Later Distress?

The vast majority of studies described previously emphasize the role of distress during an event on later recall of that event. The effects of a child's memory on subsequent distress has not been investigated as thoroughly, despite its potential implications. For example, when a stressful event occurs repeatedly, a relationship between memory and subsequent distress could lead to a cycle whereby distress leads to negative memories, which may then be associated with increased subsequent distress, and so forth. Research has shown that following a traumatic medical event (bone marrow transplant), children commonly demonstrate both negative memories (e.g., intrusive thoughts) and distress (e.g., being upset) over the event (Stuber, Naser, Yasuda, Pynoos, & Cohen, 1991). Studies among adults found support for an association between memory and subsequent anxiety and pain. Remembering a past stressful event leads to more current anxiety as compared with remembering non-anxiety-producing events (Harrigan, Lucic, & Rosenthal, 1991). Adults who remembered a painful or traumatic dental experience were more likely to report high anxiety over an upcoming dental procedure (Davey, 1989). Finally, case reports of phantom limb pain also provide support for this relationship. In this case, the direction of association is clear, whereby memories of pain in a missing limb affect current perceptions of pain (Katz & Melzack, 1990). In the present study, we sought to extend this research to children by exploring associations of memory for LPs with subsequent distress. We hypothesized that negative memories related to pain and anxiety would be associated with future LP distress. Specifically, we hypothesized that children whose pain and anxiety memories became more negative over time would show greater self-report, behavioral, and physiological distress during a subsequent LP.

Thus, the present study had three main goals: to examine the accuracy of memories for LPs among pediatric cancer patients; to examine differences between memory for factual details versus emotional responses to LPs; and to examine the relationship between memory and distress. In addition, we present preliminary descriptive data from a subset of our sample about the effect of an anxiolytic medication, oral Versed, on memory. Versed is commonly described as a "memory blocker" that minimizes memory of procedures such as LPs and therefore reduces distress. However, few studies have systematically examined children's memories under Versed.

## METHOD

### Participants

This study was conducted at the outpatient Childrens Center for Cancer and Blood Diseases at Children's Hospital of Los Angeles (CHLA). With a long history of research in behavioral distress associated with medical procedures, the outpatient staff fully supported the execution of this study. Children were eligible for the study if they were diagnosed with acute lymphoblastic leukemia (ALL), between the ages of 3 and 18, and English or Spanish speaking. In addition, eligible participants were undergoing regular LPs as part of their treatment protocol. All eligible participants at CHLA were invited to participate; one family declined participation, one family moved after consent was obtained but before completing study measures, and one patient died before completing any study measures. Fifty-five participants were included in analyses. Half of this sample received an intervention for LP distress, the results of which are reported elsewhere (Chen, Zeltzer, Craske, & Katz, 1999). Children in both groups were combined for the memory analyses in this study because the intervention had not been completed at the time of the memory interview.

Sixty-seven percent of participants were male. In addition, the sample consisted of 25% European American, 61% Hispanic, 11% Asian, and 4% African American. Twenty-nine percent of the children spoke Spanish only, and 33% of the parents spoke Spanish only. Children averaged 7.1 ($SD$ = 3.5) years of age, and ranged from 3 to 18 years of age. Many children (36%) had not yet started school; however, of those who had, the average grade in school was 3.1 ($SD$ = 3.2), ranging from kindergarten to 12th grade. Average annual household income was $27,000 ($SD$ = 22,000). Additionally, 67% of parents were married or remarried; 22% were divorced, separated, or widowed; and 12% were single.

### Measures

All measures were translated into Spanish, and children and parents completed the measures in their preferred language.

#### Memory Interview

The memory interview probed for details of the child's last nonsedated LP procedure. This interview format is similar to one developed by Merritt et al. (1994) for assessing the details of a novel, invasive medical procedure for young children and was shown by Merritt et al. to have high interrater reliability (.94). This type of interview has been used on children as young as age 3. Questions were ordered hierarchically, meaning that they began with general open-ended questions and progressed to specific yes–no questions if the child had difficulty with open-ended questions. Children were encouraged to respond with as much detail as possible to the initial open-ended questions. Also, they were asked about aspects of the procedure they did not mention. In total, 20 probes that captured the procedural and environmental details of the LP were included (see questions 1–20 in the Appendix). These details were assessed through yes/no questions if the child did not respond in an open-ended fashion. Within some probes were multiple yes/no components (e.g., people present in LP room). In addition, three questions probed children's memories of their emotional responses to the LP (e.g., crying). Two questions probed participants' memories about the intensity of their pain and anxiety during the last procedure. Finally, included in the interview were five "absent features" questions in which children were asked whether events occurred that are common to medical settings but which were not part of the child's LP (e.g., "Did the nurse take your temperature during the procedure?"). For a list of the items in the memory interview, see the Appendix.

Open-ended responses were coded as correct if children mentioned the detail being probed, even if their response also contained minor inaccuracies (e.g., reporting that they received a blue truck as a toy when in fact it was a brown truck). All children required some specific probes, and many children responded primarily at the level of yes/no questions. This may have been because many of the children did not possess the vocabulary to describe the details of a complex procedure such as an LP. It may also have been because these children were reluctant to discuss an event that was traumatic for them. Saywitz and colleagues (Saywitz, Goodman, Nicholas, & Moan, 1991) have found that children demonstrate much higher memory accuracy for a traumatic or embarrassing event when probed with specific yes/no questions compared with open-ended questions. As a result of this finding and the high number of responses to yes/no questions, we have presented results in terms of number of yes/no questions correctly endorsed (with any open-ended responses that mentioned a probed detail counted as correctly responding to that yes/no question). Probes that contained several components (e.g., people present in the room during the LP) were scored as percentage of yes/no components answered correctly.

The memory interview was scored by calculating the percentage of LP administration details correctly endorsed (total memory score), percentage of emotional response questions correctly endorsed, and the percentage of absent features incorrectly endorsed. Exaggeration in negative memory was calculated as the difference between recall of pain and anxiety intensity and child self-report of pain and anxiety during the LP. Higher scores indicated greater exaggeration in negative memory (memory of greater pain or anxiety than the child reported the day of the LP).

Finally, each yes/no component was rated by a group of five trained research assistants and one graduate student as negative or positive/neutral. The latter two categories were combined because few components were rated as positive. Seventeen yes/no components were rated as negative and 24 as positive/neutral. Agreement across all components was 81%, with a $\kappa$ of .61. We considered $\kappa$s greater than .60 acceptable agreement (Landis & Koch, 1977). Negative components included "How large do you think the needle was?" Positive components included "Did your mom hug you during the LP?" The percentages of negative components correctly endorsed and positive/neutral components correctly endorsed were calculated for each participant.

Interviews were conducted by a graduate student or trained research assistant. No memory interview scores differed by interviewer.

## Distress Measures

*Anxiety questions.* (1) Children rated their anticipatory and procedural anxiety on a 10-cm vertical visual analogue scale (VAS), ranging from 0 ("not at all anxious") to 10 ("extremely anxious"). Scales were designed such that the low range contained a thin, light-colored bar that gradually increased in width and darkness as one progressed toward the "extremely anxious" end. These cues were created to help younger children better understand the scale. (2) Parents rated their child's and their own anxiety on the same VAS. (3) The physician assistant (PA) who performed the LP rated the child's procedural anxiety on the VAS.

*Pain questions.* (1) Children rated their expected and procedural pain on a 10-cm VAS, ranging from 0 ("not at all painful") to 10 ("extremely painful"). (2) Parents also evaluated their child's pain on this same scale. (3) The PA rated the child's procedural pain on the VAS. Pain and fear scales such as thermometers, faces, and VAS that contain pictorial cues are probably the most common method of assessing self-report of pain and anxiety in children and have been used among children as young as 3, as well as for parents of children undergoing medical procedures (Jacobsen et al., 1990; Jay, Elliot, Katz, & Siegel, 1987; Jay, Elliot, Woody, & Siegel, 1991; LeBaron & Zeltzer, 1984; Manne et al., 1990). Previous research has shown that most children age 4 and older are able to understand the pain and fear thermometers (Katz & Kellerman, 1981). In the present study, pain and anxiety questions were administered to all children; however, if a child did not understand the question because of age (e.g., gave ratings that were markedly inconsistent with their description of the LP), the data were not analyzed. Fifteen children were eliminated from analyses for these reasons.

*Observational measure.* Children's distress during the medical procedure was rated by trained observers (either graduate students or trained research assistants), along 10 operationally defined behaviors that indicate anxiety, pain, or both, such as screaming, crying, verbalizations of anxiety, and so forth (Procedure Behavior Check List, PBCL; LeBaron & Zeltzer, 1984). Because anxiety and pain can be difficult to distinguish during acutely painful situations, typically they are combined in observational ratings as "distress" (Jay, Ozolins, Elliot, & Caldwell, 1983; Katz, Kellerman, & Siegel, 1980, 1981). Each behavior is rated on a scale from 1 (very mild) to 5 (extremely intense) during three time periods: preparation, procedure, and postprocedure. An observational distress score is calculated by summing the ratings for the 10 behaviors across the three phases of the procedure. Interrater reliability has been shown to be relatively high (84%) and this measure correlates significantly (.26–.53) with patient ratings of anxiety and pain before and during bone marrow aspirations (LeBaron & Zeltzer, 1984).

Upon completion of their training, all research assistants in the present study rated a series of five videotaped LPs. Reliability correlations (correlation in distress rating between every pair of observers across the five videotapes) were calculated separately for each phase of the LP, and correlations among the observers ranged from .82 to .90. In addition, 25% of all LPs at CHLA were observed by two raters, and reliability correlations for each phase of the LP ranged from .90 to .95.

*Physiological measures.* (1) Blood pressure was recorded from a Dinamap automatic system, which consists of a blood pressure cuff attached to a monitor. The cuff was placed around the child's arm over the brachial artery, and an automatic single reading of blood pressure was obtained. Three blood pressure readings taken 1 min apart were obtained at each time point described in the Procedure section, and an average blood-pressure reading was calculated. (2) Heart-rate also was recorded from the Dinamap automatic system. As with blood pressure, three heart-rate readings were taken 1 min apart, and an average heart-rate was calculated. (3) Salivary cortisol: A 1–2 mL saliva sample was obtained from each child at each time point described in the Procedure section. Saliva was obtained by having each child place a small cotton roll in his/her mouth for 1–2 min. Children of all ages tolerated this procedure well: fewer than 5% of the children declined participation in this aspect of the study. Saliva was extracted from the cotton using a 10-cc syringe and immediately frozen at −70°C, until shipped overnight on dry ice to the Pennsylvania State University Behavioral Endocrinology Laboratory. Samples were pH corrected by dilution using 20x phosphate buffered saline and then assayed in duplicate. The assay employed a commercially available serum cortisol radioimmunoassay (Pantex, Santa Monica, CA) modified for use with saliva by the University of Minnesota Endocrine Hospital. The average interassay coefficient of variation was 8.81%. All samples were tested in duplicate and scores used in the analyses were averages. Samples were reassayed if the values returned from duplicate tests had greater than 5% error.

## PROCEDURE

Children were assessed over two consecutive LPs, typically spaced 1 week apart. The length of time between LPs varied from 1 to 17 weeks depending on the child's treatment protocol. The modal and median number of weeks between LPs was 1. Length of time between LPs was not significantly associated with any LP distress variables or any memory interview scores.

On the day of LP 1, assessment before LP administration included parent and child anxiety and pain ratings and physiological measurements. During LP 1, one observer rated children's behavioral displays of anxiety and pain and the PA also rated each child's anxiety and pain. After LP 1 was completed, post-LP assessment included parent and child anxiety and pain ratings and physiological measures. Following the assessment, children in the intervention group participated in the first session of the intervention.

Children returned for their second LP typically 1 week later. Upon the child's arrival at the clinic, the memory interview was conducted. The questions referred to details of the previous week's LP. Following the memory interview, LP 2 assessment was conducted. This assessment was identical to LP 1 assessment. For children in the intervention group, the second session of the intervention was conducted after the memory interview but before the LP 2 assessment. The terms "LP 1" and "LP 2" correspond to the first and second LP observed during the study period; they do not necessarily indicate the child's first and second experiences with LPs. Children in both the intervention and control groups were combined into one group for the memory analyses that follows because the intervention had been only partially administered at the time of the memory interview.

Children identified as highly anxious by their physicians were administered the benzodiazepine oral Versed (midazolam) at .5 mg/kg (maximum dose of 15 mg) as a sedative for each of their LPs. Five children in this study received Versed approximately 30 min before each LP. Assessment and memory interview questions were administered in the same fashion for these children as for those not given Versed.

## RESULTS

### Memory Accuracy for Factual Details

Results from the memory interview showed that children remembered on average 65.4% ($SD$ = 23.7) of the factual details of their previous LP. Children remembered 59.3% ($SD$ = 28.3) of the negative factual details (e.g., the length of the needle), and 71.5% ($SD$ = 17.8) of the positive factual details (e.g., the support their parent gave them). In contrast, children identified only 29.2% ($SD$ = 37.5) of the absent features as having occurred.

#### Relationship of Memory Interview and Age

Age was divided into four categories, 3–4 ($n$ = 19), 5–7 ($n$= 17), 8–10 ($n$ = 11), and 11–18 ($n$ = 8), to analyze differences in memory interview scores by age group. A one-way ANOVA revealed a significant main effect of age on total questions answered correctly, $F(3, 43) = 14.50$, $p < .001$, negative questions answered correctly, $F(3, 43) = 12.19$, $p < .001$, positive questions answered correctly, $F(3, 43) = 14.94$, $p < .001$, and absent features endorsed, $F(3, 43) = 9.88$, $p < .001$.

Specific planned comparisons revealed that the youngest age group (3–4 years) answered significantly fewer total questions correctly than the 5–7 age group, $t(28) = 3.6$, $p < .01$. The 5–7 age group answered significantly fewer total questions correctly than the oldest group (11–18), $t(21) = 2.4$, $p < .05$. The youngest age group answered significantly fewer negative questions correctly than the 5–7 age group, $t(28) = 3.3$, $p < .01$. The 5–7 age group answered significantly fewer negative questions correctly than the oldest group, $t(21) = 2.3$, $p < .05$. The youngest age group answered significantly fewer positive questions correctly than the 5–7 age group, $t(16) = 3.8$, $p <$ .01. The 5–7 age group answered significantly fewer positive questions correctly than the oldest group, $t(21) = 3.5$, $p < .01$. Finally, the youngest age group endorsed more absent features as having occurred than the 5–7 age group, $t(28) = 3.5$, $p < .01$. The 5–7 age group endorsed more absent features as having occurred than the oldest group, $t(15) = 2.3$, $p < .05$. The 8–10 age group also endorsed more absent features than the oldest group, $t(8) = 2.8$, $p < .05$. See Figure 1 and Table 1 for a presentation of age-related memory interview data.

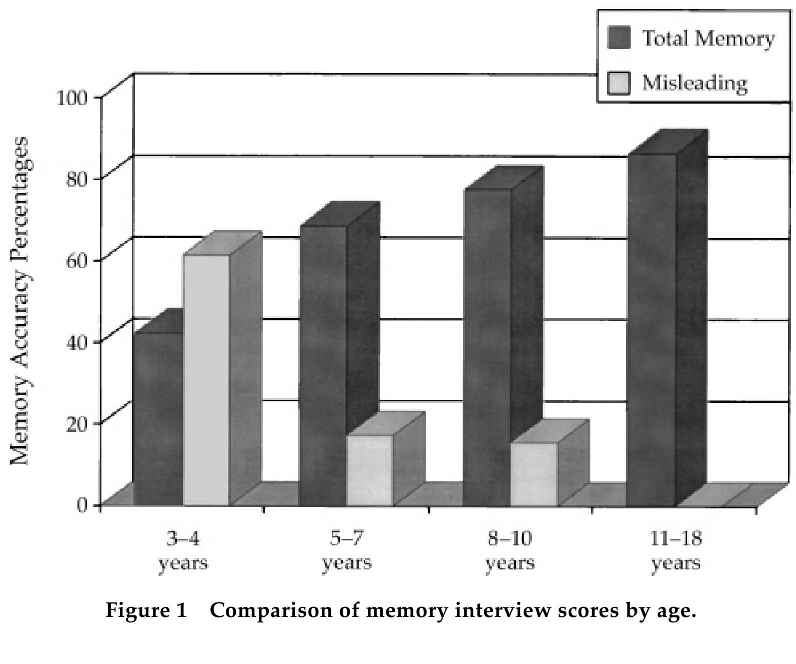


**Figure 1 Comparison of memory interview scores by age.**

Table 1 Memory Accuracy Percentages by Age Groups

| | Total Memory | Positive Details | Negative Details | Emotional Responses |
|---|---|---|---|---|
| 3- to 4-year-olds (*n*) | 14 | 14 | 14 | 14 |
| *M* (%) | 42.4 | 51.2 | 32.6 | 33.3 |
| *SD* | 21.1 | 21.9 | 22.6 | 37.0 |
| 5- to 7-year-olds (*n*) | 16 | 16 | 16 | 16 |
| *M* (%) | 68.6 | 75.0 | 61.8 | 75.0 |
| *SD* | 18.5 | 8.3 | 25.5 | 41.3 |
| 8- to 10-year-olds (*n*) | 9 | 9 | 9 | 10 |
| *M* (%) | 77.5 | 79.4 | 72.6 | 80.0 |
| *SD* | 12.0 | 10.4 | 14.4 | 23.3 |
| 11- to 18-year-olds (*n*) | 7 | 7 | 7 | 6 |
| *M* (%) | 86.5 | 87.9 | 85.5 | 83.3 |
| *SD* | 10.1 | 7.1 | 15.5 | 18.3 |

### Memory for Emotional Responses

On average, children's accuracy for negative emotional responses (e.g., crying) was 64.5% ($SD$ = 39.4). Sixty-three percent of children accurately reported whether they had displayed a positive emotional behavior (smiling) during the LP. In addition, children were fairly accurate in their memories of previous anxiety and pain. On average, children's memories of their anxiety and pain 1 week previously differed by less than 1 point (on a 10-point scale) from their reported anxiety and pain during the LP. Children's accuracy in recall for emotional responses versus factual details of the LP did not differ, $t(45) = .14$, $p > .5$.

In contrast to the patterns found for accuracy of LP details, memory for emotional behaviors differed only in the youngest age group. A one-way ANOVA revealed a significant main effect of age on responses to emotional questions, $F(3, 42) = 5.58$, $p < .01$. Younger children (3–4) were significantly less accurate in memory for emotional behaviors than 5- to 7-year-old children, $t(28) = 2.89$, $p < .01$. The other age groups (5–7, 8–10, 11 and older) showed no differences from one another in their memories for emotional behaviors (all $t$s < 1, all $p$s > .5). See Table 1.

### LP Distress and Memory

Distress and Subsequent Memory

We investigated the relationship between distress at LP 1 and children's memories 1 week later. Children varied in the number of LPs they had experienced before entering the study ($M$ = 5.8, $SD$ = 5.0; *range* = 0–20); therefore, all of the correlations reported throughout the LP Distress and Memory section were repeated controlling for number of previous LPs. The pattern of significant and nonsignificant correlations remained the same as those reported below.

Distress during LP 1 was associated with less accuracy in children's total memory scores 1 week later. Greater child anticipatory anxiety, $r(35) = -.34$, $p < .05$, and greater child self-report of anxiety during the LP, $r(29) = -.44$, $p < .05$, were both associated negatively with total memory scores 1 week later. Greater child expectation of pain, $r(35) = -.36$, $p < .05$, and PA rating of child pain were associated negatively with total memory scores, $r(47) = -.29$, $p < .05$. Behavioral observation of children's distress during the LP, $r(47) = -.41$, $p < .01$, was associated negatively with children's total memory scores. See Table 2 for data relating memory interview scores and distress. Child's age may serve as a potential confound. That is, the association between distress and memory may be due to the fact that younger children generally show more distress and also have poorer memory. Thus all correlations were recalculated controlling for child's age. Only associations with child self-report of anxiety during the LP, $r(26) = -.37$, $p = .05$, and expectation of pain, $r(32) = -.31$, $p = .08$, remained marginally significant. Another possible confounding factor is children's anticipatory anxiety about LP 2; that is, because the memory interview was conducted on the same day as LP 2, children's anticipatory anxiety could have influenced their answers on the memory interview. In addition, children's distress at LP 1 might relate to children's anticipatory anxiety before

Table 2 Correlation Coefficients between Baseline Anticipatory Distress and Memory Interview

| | Total Memory % | Absent Features Endorsed |
|---|---|---|
| Self-report | | |
| Child anxiety | −.34* | .18 |
| Child pain | −.36* | .36* |
| Parent rating | | |
| Child anxiety | −.14 | .15 |
| Child pain | −.07 | −.01 |
| Physician assistant rating | | |
| Child anxiety | −.22 | −.24 |
| Child pain | −.29* | .39* |
| Physiology | | |
| Heart rate | −.29 | .32* |
| Cortisol | −.12 | .02 |
| Systolic blood pressure | .15 | −.13 |
| Diastolic blood pressure | −.01 | .11 |
| Observation of Behavior | −.41** | .31* |

* $p < .05$; ** $p < .01$; *ns range* = 30–47.

LP 2, thereby making LP 2 anticipatory anxiety a possible mediator between LP 1 distress and memory scores. To address this possibility, we conducted mediational analyses by using Baron and Kenny's (1986) methods. LP 2 anticipatory anxiety did not mediate any of the significant associations reported previously.

To examine the relationship between distress during an LP and memory for emotionally valenced aspects of the LP, we examined correlations between distress during LP 1 and negative and positive memory interview scores 1 week later. Behavioral observation of children's distress during the LP correlated significantly with accuracy of answers for the negative questions of the memory interview, $r(47) = -.33$, $p < .05$. The more distressed children were during LP 1, the less accurately they remembered the negative aspects of that LP 1 week later. LP 2 anticipatory anxiety did not mediate this association. However, behavioral observation of children's distress also correlated significantly with accuracy for positive questions, $r(47) = -.42$, $p < .01$. Additionally, pre-LP heart rate, $r(45) = -.30$, $p < .05$, parent rating of their child's anxiety and pain, $r(43) = -.36$, $p < .05$, and $r(43) = -.34$, $p < .05$, respectively, and PA rating of the child's pain, $r(47) = -.29$, $p < .05$, correlated negatively with memory accuracy for positive questions. LP 2 anticipatory anxiety did not mediate any of the significant associations reported previously. However, note that none of these associations remained significant after controlling for child's age.

Less accuracy for negative questions could mean either that children's memories were more negative or more positive than the actual events themselves. To explore this issue further, we focused on the qualitative negative questions (e.g., the length of the needle used during the LP). Qualitative answers were coded in such a way that a correct score was given if the child responded with the correct or less negative response (e.g., smaller needle length). Thus, for the qualitative questions, a less accurate score indicates a more exaggerated negative memory. When negative qualitative questions alone were correlated with distress, behavioral observation still correlated negatively with negative memory scores, $r(47) = -.30$, $p < .05$. In addition, PA rating of child pain, $r(45) = -.31$, $p < .05$, and children's anticipatory heart rate, $r(47) = -.34$, $p < .05$, correlated with qualitative negative memory scores. Thus, more distress was associated with greater exaggeration of memories for negative details of the LP. See Table 3 for a presentation of correlations. Anticipatory anxiety at LP 2 did not mediate any of the significant associations reported previously. However, these associations were no longer significant once child's age was controlled.

**Table 3 Correlations between Exaggerations in Negative Memory and Distress**

| | Exaggerations in Negative Memory | |
|---|---|---|
| | Correlation with LP 1 Distress | Correlation with LP 2 Distress |
| Self-report | | |
| Child anxiety | .17 | .35 |
| Child pain | .18 | .66* |
| Parent rating | | |
| Child anxiety | .16 | .13 |
| Child pain | .11 | .51* |
| Physician assistant | | |
| Child anxiety | .18 | .09 |
| Child pain | .34* | .07 |
| Physiology | | |
| Heart rate | .31* | .10 |
| Cortisol | .05 | .00 |
| Systolic BP | −.11 | .13 |
| Diastolic BP | .07 | .19 |
| Observation of behavior | .30* | .44* |

* $p < .05$; ** $p < .01$; *ns range* = 19–47.

## Memory and Subsequent Distress

We examined the relationship between children's memories and LP distress later that day (LP 2). Exaggeration in negative memory for emotional responses was predicted to correlate with children's distress during LP 2. Children who remembered experiencing more pain than they had reported at LP 1 were rated as experiencing greater pain by their parents during LP 2, $r(19) = .51$, $p < .05$. Similarly, children who remembered experiencing more pain than they reported during LP 1 were observed to be more distressed during LP 2, $r(24) = .44$, $p < .05$. In addition, children who remembered experiencing more anxiety than they reported during LP 1 rated LP 2 as more painful, $r(22) = .66$, $p < .01$. See Table 3 for a presentation of correlations. All correlations reported previously remained significant after controlling for child's age. Another potential confound for this association is LP 1 distress; that is, exaggeration in negative memory may be associated with LP 2 distress only to the extent that both share a significant amount of variance with LP 1 distress. To address this potential confound, we conducted partial correlations to control for LP 1 distress. Exaggeration in negative memory remained significantly associated with LP 2 behavioral observation of distress, $r(22) = .42$, $p < .05$, and LP 2 child report of pain, $r(20) = .60$, $p < .01$. However, exaggeration in negative memory was no longer associated with LP 2 parent rating of child pain, $r(17) = .14, p > .5$.

Children's participation in the first intervention session may have affected their distress at LP 2. To address this potential problem, we reconducted analyses by using the control group only. This approach greatly diminished the sample size, thus reducing the power to detect significant effects. However, correlations remained of similar magnitude for behavioral observation, $r(12) = .68, p < .025$, and children's rating of pain during LP 2, $r(11) = .69, p < .025$. The correlation of memory with parent rating of child pain became nonsignificant, $r(11) = .41, p = .21$.

We next tested the hypothesis that exaggerations in negative memory might account for the *change* in distress from LP 1 to LP 2 by correlating exaggeration in negative memory for emotional responses with difference scores between LP 1 and LP 2 distress. Children who remembered more pain than they reported at LP 1 showed greater increases in pain ratings during the LP, $r(21) = .43, p = .05$, and greater increases in behaviorally observed distress, $r(25) = .53, p < .01$, over time. In addition, children who remembered more pain than they reported at LP 1 tended to be rated as in more pain by their parents, $r(23) = .38, p = .07$. In contrast, children who remembered more pain than they reported at LP 1 showed greater decreases over time in heart rate immediately after the LP, $r(24) = -.41, p < .05$, and greater decreases over time in systolic blood pressure immediately after the LP, $r(24) = -.41, p < .05$. These associations remained significant even after controlling for child's age.

Similarly as for the earlier analyses, we reconducted these analyses by using the control group only. Reduction in sample size diminished the power to detect significant differences; however, even with this small sample size, correlations remained significant. Significant correlations were found for behavioral observation and child self-report ratings, with exaggeration in negative memory associated with increases in behaviorally observed distress, $r(12) = .68, p < .025$, and marginally with increases in child pain during the LP, $r(9) = .64, p = .07$. The correlations reported previously with heart rate and systolic blood pressure were not significant.

## Versed and Memory

Children who were given Versed ($n = 5$) did not appear to have poorer memories than the rest of the children. Children on Versed accurately remembered 57.5% ($SD = 20.9$) of memory interview questions for factual details of the LP, 54.1% ($SD = 26.1$) of negative questions, and 68.4% ($SD = 8.0$) of positive questions. Additionally, children on Versed endorsed 28.0% ($SD = 43.8$) of the absent features questions as true. Although the small number of children given Versed in the present study precluded statistical comparisons, children on Versed apparently processed as much information regarding their LPs as children not on Versed (Figure 2). However, because children given Versed are generally those most fearful (as identified by hospital staff), how these children's memories might differ if not given Versed is unclear.

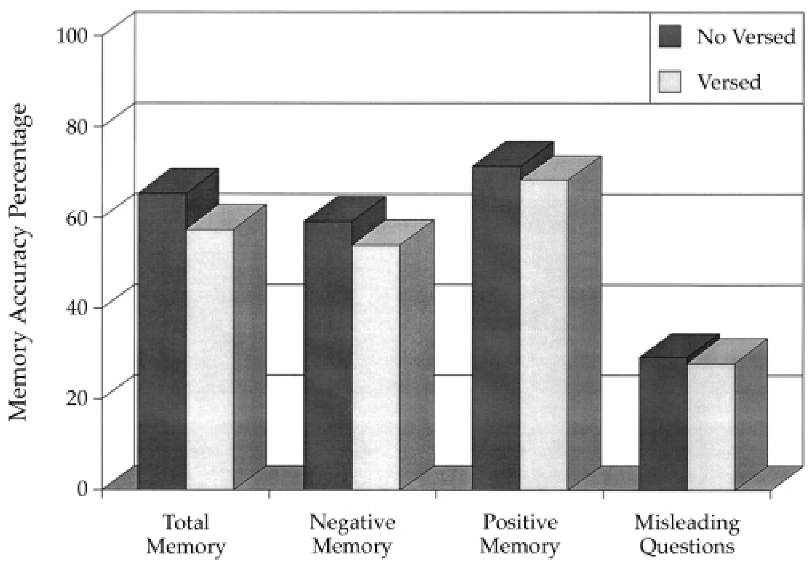


**Figure 2** Comparison of memory interview scores for children on Versed and children not on Versed.

## DISCUSSION

### Children's Memory Accuracy during a Highly Stressful Event

Findings from the overall accuracy scores in the memory interviews revealed that, as expected, older children displayed more accurate memory for details of their LPs than younger children. Older children were able to recall more aspects of their LPs and were able to correctly challenge absent features compared with younger children. Controlling for number of previous LPs did not diminish this association, which indicates that this finding is not due to older children having greater familiarity with LPs. These results extend a robust finding in terms of children's memories for salient medical events (Goodman et al., 1994; Howe et al., 1995; Merritt et al., 1994; Peterson & Bell, 1996) to chronically ill children's memories. On average, children's memories for LPs appeared slightly less accurate than their memories for other highly stressful events. For example, children undergoing voiding cystourethrograms recalled 88% of the features of this procedure (Merritt et al., 1994), and children who experienced a traumatic injury remembered 80% of the central details of the event (Peterson & Bell, 1996). In contrast, pediatric cancer patients remembered on average 68% of the details of an LP. Pediatric cancer patients differ from the children in these other studies in part because LPs are only one element of their cancer treatment. That is, these children have a life-threatening illness that requires multiple aversive procedures. In contrast, other children studied may experience only one aversive or traumatic event over the course of the study. Because children's memories are more accurate for events that are unique and distinctive (Howe, 1997), the multiple types of procedures that pediatric cancer patients undergo may help explain why they have relatively poorer recall for any one specific procedure.

### Memory for Event Details Versus Emotional Responses

Children remembered a similarly high percentage of their emotional responses to the LP (66%). There was no difference between their memory for factual details versus emotional responses to the LP. Unlike memory for factual details, however, memory for emotional responses did not increase with age. Only the youngest age group (3–4) showed difficulties with memory for emotional responses. Children ranging in age from 5 to 18 showed equivalent memory for their emotional responses. These findings suggest that children's emotional memories develop at a relatively young age and remain stable over time, whereas children's memories for event details continue to improve with age. Children display impressive developments in labeling basic emotions during preschool years (Brown & Dunn, 1991). Moreover, emotional states, once established, do not change with age (Izard, 1994). Thus children's ability to remember emotions such as fear may develop at a young age and remain stable over time. In contrast, children's understanding of medical procedures such as LPs may increase with age, thereby allowing them to remember more accurately the details of the procedure with increasing age. This suggests that younger children may benefit from more emotionally based interventions for distress, whereas older children may benefit more from factually based interventions. In addition, these results raise an intriguing possibility that some of the developmental changes in behavioral distress (e.g., older children exhibiting less distress, Katz & Kellerman, 1981; Katz et al., 1980) may be mediated by cognitive changes in memory for details of the stressful event.

### Relationship between Distress and Memory

#### Distress and Subsequent Memory

Simple correlations revealed that distress had a debilitative effect on memory. Children who displayed greater distress at LP 1 remembered fewer details of the LP 1 week later. This finding is consistent with previous evidence that distress is associated with less recall of medical and dental procedures (Merritt et al., 1994; Ornstein, Gordon, Baker-Ward, & Merritt, in press; Vandermaas et al., 1993). This negative relationship between distress and memory may exist because as anxiety increases, it occupies more of an individual's attentional capacity, thereby leading to less concentration on the actual event. This decrease in attentional resources toward an event then leads to poorly organized memories of the event (Eysenck, 1982) and thus poorer recall of the event. On a biological level, the distress–memory relationship may exist because increased distress may increase cortisol levels. High levels of cortisol have been associated with impairments in memory, perhaps due to detrimental effects of elevated cortisol levels on the hippocampus. That is, elevations in glucocorticoids have been associated with downregulation of and decrease in hippocampal glucocorticoid receptors, both of which may suppress the ability of the hippocampus to filter out irrelevant stimuli (McEwen, 1982; Newcomer, Craft, Hershey, Askins, & Bardgett, 1994; Sapolsky, Krey, & McEwen, 1984; Sapolsky & McEwen, 1986). Although the present study did not find associations of cortisol with memory, this may have been due to timing of measurement issues (i.e., elevations in cortisol may not have been detectable until a later time point following the LP).

The relationship between distress and memory persisted after controlling for number of previous LPs and was not due to anticipatory anxiety the day of the memory interview. However, the strength of the relationship between distress and memory was reduced when age was controlled. That is, the finding may be accounted for by the fact that younger children show more distress during LPs and also have poorer memories relative to older children. Although age and distress share common variance and are both associated with memory, which factor is primarily responsible for the association with memory remains unclear.

Distress was also associated with poorer recall of both negative and positive aspects of the LP. Poorer recall of negative aspects of the LP indicated more inflated or exaggerated negative memories. Thus, greater distress at LP 1 was associated with more exaggerated negative memories one week later. This finding extends previous research that individuals in a state of high anxiety or pain recall previous experiences as more painful (Arntz, van Eck, & Heijmans, 1990; Eich, Reeves, Jaeger, & Graff-Radford, 1985), by demonstrating that anxiety and pain at the time of the event also influence later recall of that event.

Our finding that distress is associated with poorer recall for neutral/positive aspects of the LP is not consistent with previous findings that anxiety influences encoding of only negative or threatening information (e.g., Chen, Lewin, & Craske, 1996; McNally et al., 1989; Cahill et al., 1994). However, Christianson (1992) has theorized that when a negative emotional event occurs, individuals remember the details that elicited the emotional reaction but do not remember well the neutral details that are more peripheral to the event. Thus the finding from the present study suggests that a continuum exists, such that the more negative an event, the more an individual focuses on the emotion-eliciting components of that event, and thus the less they remember the neutral or positive aspects of that event.

However, as discussed previously, it should be noted that the relationship between distress and negative or neutral/positive memory may be accounted for by age, given that the strength of the correlations was not significant when age was controlled. That is, the finding may be accounted for by the fact that younger children show more distress during LPs and also have poorer memories relative to older children. Whether age or distress is primarily responsible for the association with memory remains unclear.

Memory and Subsequent Distress

Whereas much of the previous research on stressful emotional events and memory has focused on the impact of a stressful event on children's memories, our study also tested the effect of memory on future distress during repeated exposures to the stressful event. We found that greater exaggeration in children's memories of anxiety and pain was associated with higher distress during a future LP. Additionally, we found that greater exaggeration in children's memories of anxiety and pain was associated with increases in self-report and observed measures of distress from LP 1 to LP 2. Moreover, these associations are more robust than the distress-memory ones because they remain even after controlling for age of the child. That is, at any given age, children with greater exaggerations in negative memory report and display greater distress during future LPs. Additionally, these associations remain significant after controlling for number of previous LPs and initial LP distress.

Together with the other findings, these results provide evidence for a temporal association in which the influence of memory on subsequent distress appears to be stronger than the relationship between distress and subsequent memory. This indicates that additional factors other than initial child distress may influence the way in which a child remembers a stressful event such as an LP but that once exaggerated memories have developed, they become a strong predictor of levels of distress during future encounters with the same stressful event.

This relationship between exaggerations in negative memory and later distress may be due to the effects of reexperiencing a traumatic or stressful event. For example, individuals with post-traumatic stress disorder often experience intrusive thoughts that consist of negative memories about the traumatic event they experienced. Cues that remind these individuals of their negative memories often elicit both heightened anxiety and physiological arousal (e.g., a war veteran exhibiting a startle response upon hearing a helicopter passing overhead). With the children in this study, cues about the LP (e.g., walking past the LP room) may have triggered exaggerated negative memories about the previous LP, which may have led to heightened self-report and physiological distress both before and during the next LP.

Interestingly, however, these same exaggerations were associated with decreases in physiological measures of distress over time. The results in the physiological domain suggest that although an individual's perceptions of an event may become more negative over time, they nonetheless habituate to repeated exposures to that event, thus producing dampened physiological responses. This phenomenon has been found with individuals exposed to chronic stressors: Individuals exposed to higher levels of life stresses respond with smaller physiological responses to laboratory stressors (Boyce & Chesterman, 1990). On the other hand, Katz et al. (1982) found positive associations between LP distress and beta-endorphin immunoreactivity. This suggests that various physiological and neurochemical parameters may respond differently to repeated stress.

## Versed Effects on Memory

The data from the few children in the present study who were given Versed presents an extremely interesting finding that contradicts the common clinical notion of Versed as an amnesiac. Although the number of children given Versed was too few to enable us to conduct statistical analyses, descriptive data revealed that these children remembered a substantial proportion of the details of their previous LP. Additionally, they endorsed relatively few misleading questions as true. These findings indicate that despite the Versed, these children are aware of what is happening to them as they undergo their LPs. These findings also may explain anecdotal evidence that children on Versed often continue to display anticipatory anxiety before each LP. A number of experimental studies have found that Versed impairs memory (Ghoneim, Block, Ping, El-Zahaby, & Hinrichs, 1993; Kupietzky, Holan, & Shapira, 1996); however, one significant difference between these studies and the present one is that memory in previous studies typically was tested through recall of word lists. Although participants have a more difficult time concentrating on tasks such as remembering word lists when given Versed, they may be able to focus on and remember events that are personally relevant.

## Limitations and Future Directions

One limitation of the present study's design is the incorporation of the memory interview into a psychological intervention protocol, thus risking a possible confound of the intervention on memory interview answers. The difficulty in gathering data with this population as well as the time-limited nature of LPs necessitated the design used, with an attempt to minimize intervention effects by conducting the memory interview as early as possible (before the intervention was completed). Future studies that examine children's memories during LPs, independent of psychological interventions, are warranted.

In addition, effects would likely be stronger if the sample size were increased. The young ages of some of the children precluded obtaining self-report data, which reduced the power of the study. Furthermore, the secondary analyses with the control group only were hindered by small sample sizes. Additionally, the lack of consistency in correlations of distress measures with exaggerations in negative memory over time raises questions about the reliability of this finding. One possibility may be that self-report distress ratings over time are subject to greater variability than trained observer ratings of distress. Thus, behavioral observations showed a consistent relationship over time with exaggerations in negative memory, whereas the self-report measures did not.

Another potential limitation arises from the question of the generalizability of this finding to other populations. For example, whether similar associations of exaggerations and negative memory with distress would be found with healthy children or children with other types of illnesses is unclear. Previous research has shown that some aspects of cancer treatment (e.g., cranial radiation) may produce negative cognitive and neuropsychological effects (see Madan-Swain & Brown, 1991, for a review). Thus, this population might be quite different from others in terms of memory ability, and some of the study findings, such as the percentage of total recall for LPs, may be unique to this population of cancer patients.

In sum, the present study demonstrated associations between distress and subsequent memory, as well as more robust associations between exaggerations in negative memory and subsequent distress. On the basis of evidence that the majority of children who undergo treatment for cancer and survivors of childhood cancer experience PTSD-like symptoms that persist for at least 1 year posttreatment (Steward, O'Connor, Acredolo, & Steward, 1996; Stuber et al., 1991), this relationship between distress and memory has important implications. For example, the association between exaggerations in negative memory and subsequent distress suggests that an intervention that successfully reduces children's negative memories may alleviate their distress during future stressful events, and in fact, this has been demonstrated (see Chen et al., 1999). Previous intervention studies in this area have often focused on teaching children coping strategies to help them better tolerate a painful procedure (Jay et al., 1987, 1995; Katz, Kellerman, & Ellenberg, 1987; Zeltzer & LeBaron, 1982). Emphasizing children's exaggerated negative memories represents a new approach to intervention that has not been widely studied before but that has the potential to significantly impact procedural distress. In addition, because certain aspects of cancer treatment protocols, including more intense treatment regimens, have been associated with increased behavioral problems and more negative mood among cancer survivors (Chen et al., 1998; Mulhern, Wasserman, Friedman, & Fairclough, 1989), this link between memory and LP distress may have important long-term implications for children's psychological adjustment to cancer diagnosis and treatment.

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## APPENDIX

## LIST OF LP DETAILS PROBED DURING MEMORY INTERVIEW

1. EMLA cream
2. People present during LP (nurse, PA, parent, sibling, experimenter)
3. Furniture in the LP room (equipment cart, exam table, chair, TV)
4. Child's position on LP table (lying/sitting, curling up, shoes/shirt off)
5. PA appearance details (gloves, mask, shirt color)
6. Parent appearance details (gloves, mask, shirt color)
7. Parent actions during LP (held child's hand, hug child, stroke child's hair, close child's eyes)
8. Nurse actions during LP (hug child, held child down)
9. Tape on child's back
10. Number of times PA cleaned child's back
11. Materials used to clean child's back
12. PA probing child's back
13. PA administering shot (LP)
14. Location of shot (LP)
15. Length of needle
16. Duration of LP
17. Spinal fluid dripping from LP needle
18. Administration of chemotherapy
19. Bandaid on back after LP
20. Toy received after LP
21. Crying during LP
22. Screaming during LP
23. Smiling/laughing during LP
24. Child talking during LP
25. Amount of pain during last LP
26. Amount of anxiety during last LP

### Absent Features

1. Nurse took temperature?
2. PA tapped knee with hammer?
3. Nurse drew blood during LP?
4. Took pill during LP?
5. Nurse took blood pressure during LP?

*Note:* LP, lumbar puncture (spinal tap); EMLA, eutectic mixture of local anesthetics; PA, physician assistant.

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