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'And I Was Very Very Crying': Children's Self-Descriptions of Distress as Predictors of Recall

CAROLE PETERSON*

Department of Psychology, Memorial University of Newfoundland, Newfoundland and Labrador, Canada

SUMMARY

One hundred and forty-five children's (2–13-year-olds) self-descriptions of how much they cried when injured and subsequently treated in a hospital emergency room were used as predictors of their recall accuracy, completeness and number of unique details in interviews occurring a week, a year and 2 years later. Hierarchical regressions showed that stress was related to all three ways of evaluating children's recall of their *injury* in initial interviews, although only the completeness of *hospital* recall was related to stress. For accuracy, stress compromised recall of 2–6-year-olds in initial but not later interviews; for completeness, stress compromised recall of both events in initial but not later interviews. In contrast, highly distressed children provided the most detail in their first two interviews and the oldest children still did so 2 years later. However, stress effects were modest.

The relation between children's emotional reactions to stressful events and subsequent memory is an important one, playing a role in both clinical and forensic situations. There has been considerable debate about the relation between stress and memory with various studies differing in empirical findings. According to a recent meta-analytic review, part of this variation may be attributable to the nature of the distressing events and the definition of 'high stress' (Deffenbacher, Bornstein, Penrod, & McGorty, 2004). According to these authors, one must distinguish events that merely elicit an arousal mode of attention control (orienting response) from ones that elicit an activation mode of attention control (defensive response). The latter is elicited by events that threaten bodily integrity or self-esteem and involve considerably higher degrees of distress than events eliciting an orienting response. Deffenbacher et al. argue that some studies had procedures that only elicited an orienting response, and it may thus be difficult to compare the effects of stress on memory when there is such variation in what constitutes the 'high stress' category. As an example of this variation, Peters (1997) exposed children to an unexpected fire alarm. Although children in his highest stress group had elevated blood pressure and pulse rates, none of them cried or showed hysterical distress. In contrast, in a study of children who suffered an unexpected and very painful injury (such as a broken bone or deep laceration), the high stress group was composed of children who suddenly began to scream in pain and were often described

*Correspondence to: Carole Peterson, Department of Psychology, Memorial University of Newfoundland, St. John's, NL A1B 3X9, Canada. E-mail: carole@mun.ca

by their parents as hysterical (Peterson & Bell, 1996). Such variation in stress may partly account for the different findings of various studies.

In the meta-analytic review by Deffenbacher et al. (2004), the authors found that as stress increases, memory for details that are the focus of participants' attention are increasingly recalled until stress levels become very high, at which time there is a catastrophic drop in memory. But this pattern only fits the data for how well adults identify faces from line-ups and how accurately *adults* recall event details when events elicit defensive responses. However, there are other important measures of recall that were not included in their meta-analysis such as recall completeness and amount of unique detail. These measures assess how comprehensive one's recall is for the different aspects of the overall event and how descriptively elaborate that recall is. In addition, as pointed out by the authors, in comparison with the robust literature on the relation between stress and memory in adults, much less is known about *children*. Surprisingly, in the few reviewed studies on children, there was no relation between stress and memory, for either recall accuracy or face identification. This underscores the need for more research.

There is another methodological issue besides variation in the definition of a high stress response that muddies the water, according to Laney, Heuer and Reisberg (2003). Virtually all of the studies of stress and memory in adults involve emotion aroused by visual stimuli (slides or videos of gory injuries or surgery), but outside of the laboratory, emotion is typically induced by personal involvement in an emotional event, termed 'thematically-induced arousal' by Laney et al. as opposed to 'visually-induced reactions' typically used in adult research. These authors wonder if the relation between stress and memory differs when stress is induced in these two ways. Although they did not consider the research on children, almost all of it involves naturally occurring, or real-world stressful events, i.e. thematically-induced arousal, necessitated by ethical concerns about deliberately exposing children to potentially highly disturbing visual imagery. It is possible that this methodological difference may partly account for divergent findings between children vs. adults. Thus, it is important for empirical investigations to be clear about the nature of their stressful events. In the present study, real-world painful events are used, specifically injuries requiring emergency room treatment. Although there is variation in how distressed the children are at both the time of injury and during treatment, children in the 'high stress' group clearly demonstrate what Deffenbacher et al. would call a defensive response.

Memory scoring

As mentioned above, another issue that must be explored is the way that memory is assessed, i.e., the type of memory measure used. Face recognition, which has been used in some research, is not relevant to the present investigation but accuracy, another measure that has considerable importance forensically, is assessed here. The amount of information provided is also important and has typically been scored in different ways. In general, the three most common methods of assessing children's recall of stressful events involve (1) the accuracy of recall, (2) assessments of completeness, often via a checklist of relevant event features, and (3) counting the amount of unique narrative detail.

Accuracy

In those studies where there was a checklist or video of medical or experimental procedures, children's memory was compared with records collected at the time. For interviews about unexpected and idiosyncratic injuries, children's reports were compared

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with accounts from adult witnesses or by asking parents to review transcripts of child interviews.

Recall completeness

This measure captures how many of the component aspects of the target event are recalled. Some studies assessed the number of details provided about standardized medical procedures like inoculations or urinary catheterization (e.g. Burgwyn-Bailes, Baker-Ward, Gordon, & Ornstein, 2001; Shrimpton, Oates, & Hayes, 1998; Vandermaas, Hess, & Baker-Ward, 1993). Children's recall was compared to a checklist of medical procedures to calculate the proportion recalled, and then correlated with measures of child distress. In studies on memory for injuries requiring hospital emergency room treatment, Peterson and her colleagues (Peterson, 1999; Peterson & Bell, 1996; Peterson & Whalen, 2001) assessed recall completeness by developing standardized prototypes of injury and hospital treatment events and then assessed the proportion of prototype components children provided.

Unique narrative details

This measure tabulates the number of unique information units about people, activities, objects, descriptors and locations that children provide about stressful events (Goodman, Hirschman, Hepps, & Rudy, 1991; Goodman, Quas, Batterman-Faunce, Riddlesberger, & Kuhn, 1994, 1997; Quas, Bauer, & Boyce, 2004). A variation is the number of subject-verb propositions, used to assess the amount recalled about a destructive hurricane (Bahrick, Parker, Fivush, & Levitt, 1998; Fivush, Sales, Goldberg, Bahrick, & Parker, 2004; Sales, Fivush, Parker, & Bahrick, 2005).

Comparing recall completeness and amount of unique detail

Completeness of recall and number of unique narrative details are complementary ways of assessing children's recall even though they focus on different aspects of children's reports. Completeness provides information about the overall structure of events and how well children provide that overview. For completeness, each event component is scored as present or not, regardless of how much narrative detail is provided. In contrast, when the amount of unique narrative detail is assessed, the emphasis is on elaboration and so each unique detail is separately counted. (For similar arguments, see Baker-Ward, Ornstein, Gordon, Follmer, & Clubb, 1995.) Compare 'we were in the backyard' with 'we were in the backyard down by that hole in the fence where the mud is.' These are equivalent under the prototype completeness scoring system (they both specify where events took place), but the latter contains considerably more detail. Both ways of assessing children's recall are important forensically. A child who gives a relatively complete account of a target experience, including information about who, what, when, where and the sequence of events, is providing information about the overall structure of the event. This is considerably more helpful in forensic situations than someone who only relates a few components of the experience, even if those are accurate. But specifying event components is even more useful if their description is rich and detailed rather than only a sparse, barebones account. Furthermore, a child who is able to provide elaborative detail about event components is more likely to be believed as a witness (Bala, Lee, & McNamara, 2001). Currently, little research directly compares these two ways of assessing memory; an exception is Baker-Ward et al. (1995) who compared children's reports of pediatric examinations by scoring the number of features (similar to the scoring of completeness) vs. units of information (similar to the unique narrative detail scored here). They concluded

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that general findings about children's memory were unlikely to be artifacts of procedural differences in scoring.

Stress may also interact differently with these two ways of assessing recall. For example, if high emotions produce 'memory narrowing' (Christianson 1992; Laney et al., 2003), then highly distressed children may provide a less complete account of their experience, recalling only those prototype components that were the focus of their attention. Such an outcome would fit with the findings in the adult literature on the relationship between stress and memory. On the other hand, focusing on fewer components of the entire experience would not necessarily be related to less narrative detail because children may provide more details about the components of the event that they did focus on (the 'weapon' effect). This would also be consistent with the literature showing that children are more likely to recall emotional than non-emotional events (Bauer, 2007). However, a direct comparison of these two methods has not so far been done.

In terms of prior research exploring stress and memory using these different ways of assessing memory, for studies involving completeness, the relation between stress and completeness is inconsistent with some finding a positive (e.g., Shrimpton et al., 1998) and others a negative (e.g., Peterson & Bell, 1996) relation. However, the stressful events in different studies varied in whether or not they elicited Deffenbacher et al.'s (2004) defensive response. Looking just at studies with more stressful events, high stress was typically associated with less complete recall. None of these studies found a curvilinear relation between stress and memory. Yet such a relation was found when investigators used a variant of the information units scoring system, specifically the number of information propositions (rather than individual words coded as information units) that children provided about a destructive hurricane (Bahrick et al., 1998; Fivush et al., 2004; Sales et al., 2005). In those studies, children were placed into stress categories on the basis of how much damage their home sustained, and children with moderately damaged homes recalled more than those whose homes had little or heavy damage during initial interviews but not 6 years later. Because the focus of completeness scoring and unique detail scoring is so different and because each provides a different window on children's memory as well as may interact differently with stress, it is important to assess both types of recall measure.

Retention interval

Several studies have investigated children's memory across delays of one or more years, and clearly event salience is important: Children are poor at recalling mundane events for long periods but their recall of highly salient events is excellent (see reviews in Bauer, 2006, 2007; and Peterson, 2002). For example, all but one child who was at least 2.5 years of age at the time of an injury requiring emergency room treatment recalled considerable detail about that event 5 years later (Peterson & Parsons, 2005; Peterson & Whalen, 2001). Likewise, former preschoolers had good recollection of a destructive hurricane 6 years later (Fivush et al., 2004; Sales et al., 2005). However, there have been few studies that have assessed whether stress interacts with retention interval, and most of those have included delays of only weeks or months. For example, more distressed 3–7-year-olds getting urinary catheterization had poorer recall than did less distressed children after 6 weeks (Merritt, Ornstein, & Spicker, 1994) and 6 months (Salmon, Price, & Pereira, 2002). Stress had little effect on 2–13-year-old children's recall of an injury 6 months later but higher stress levels compromised their recall of subsequent hospital treatment (Peterson & Bell, 1996). In terms of delays measured in years, Goodman et al. (1991) found

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that 3–7-year-olds who had been highly distressed after an inoculation had better memory shortly after the event but there was little effect of distress after a year (although better free recall). In contrast, preschoolers in the highly distressed category provided less information about a destructive hurricane than did those who had been moderately distressed soon after the event, but 6 years later there was little effect on how many propositions of new information were provided in interviews (Fivush et al., 2004; Sales et al., 2005). In short, in the few studies conducted so far, stress has been associated with children's recall when assessed shortly after the event occurred but not after long delays measured in years. This suggests the possibility that it is children's willingness to talk about the event rather than the memory itself of the event that is affected in the short term. It is also possible that children's recall of the overall structure of the event (i.e., completeness of memory for the various component aspects of the event) demonstrates a different pattern long-term than their inclusion of elaborative detail. Thus, after the passage of a year or more when children are no longer so distressed, they may be more willing to provide a comprehensive overview of the event but still be unwilling to elaborate on some parts of their experience. However, the paucity of long-term follow-up research on children who differ in their distress reactions to highly salient negative events makes it difficult to derive any conclusions about the effect of stress on long-term memory at this time.

Hypotheses

Consistent with Deffenbacher et al.'s (2004) review for studies focusing on children (but not adults), children are not expected to decrease in the *accuracy* of their recall of event details with increased stress in any interview. In contrast, consistent with prior research on the *completeness* of children's recall of stressful events, children in the highest stress group are expected to have less complete recall in their initial interview, although there is too little extant research to inform a hypothesis about long-term recall. Extant research comparing distress and the provision of information propositions suggests that those in the moderate stress group should provide more information than children in either the high or low stress group, at least in the initial interview. However, the method of classifying children into stress categories (amount of damage to the family home vs. ratings of individual children's emotional reactions) as well as the target events (injuries vs. hurricane disasters) were so different that no *a priori* predictions on the relation between stress and unique details are made.

METHOD

Participants

Children were recruited from the emergency room of a children's hospital, the only facility treating children in that community. Because medical care is free in Canada, the sample was a cross-section of the community. All children had a trauma injury, mostly bone fractures or lacerations requiring suturing. A total of 145 children participated: 17 2-year-olds (12 girls, mean age 2;5), 39 3–4-year-olds (19 girls, mean age 4;0), 48 5–6-year-olds (23 girls, mean age 5;10), 21 8–9-year-olds (11 girls, mean age 8;11) and 20 12–13-year-olds (8 girls, mean age 12;7). One hundred and fourty-five participants, the data of

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66 children had been included in Peterson, 1999, specifically 7 2-year-olds, 12 3–4-year-olds, 27 5–6-year-olds, 15 8–9-year-olds and 13 12–13-year-olds.

Recruitment spanned 8 years. Although differential recruitment presents confounds such as children injured in different years, variation in treatment personnel at hospital, different recruitment personnel and different people scoring data, there are several reasons why such confounds do not appear to be problematic when evaluating the current findings: Interviewers were rigorously trained by the same person, the interview protocol was unchanged and the supervisor of recruitment and interviewing has been the same throughout the collection of data. In addition, the person who read all transcripts and trained people in scoring data has also remained the same, and she routinely compared earlier and later transcripts for scoring consistency. Furthermore, the emergency room is a training facility through which a large number of residents and physicians regularly rotate, but all of them were trained and supervised by the same supervisory staff. Sample socioeconomic status and racial composition were not deemed a significant analytic issue since according to 2001 census information provided by Statistics Canada the area sampled is 97% Caucasian of European descent and the hospital used in the research is the only tertiary level care facility in the province and is publicly funded such that all children go there.

Procedure

Families were approached in the emergency room where the study was explained, a handout provided and consent forms allowing us to telephone were signed. A few days later, families were contacted to answer questions and set up home visits. At the visit, children and parent witnesses were independently interviewed using the same interview protocol. Free recall was elicited first about injury, then hospital treatment ('Tell me about what happened when you/your child got hurt.' 'Tell me about what happened when you/your child went to the hospital.'). Then they were asked a series of mostly *wh-* questions about the injury (e.g. where and when did it occur, what caused it) and then the hospital visit (e.g. what did the doctor do). They were also asked whether and how much the child cried at injury and treatment. Parents also filled out a Likert scale on degree of child distress. One and 2 years later, parents were re-contacted for re-interviews, and asked to not talk to children about the events prior to visits. The same interview was administered to children at all visits. All aspects of the study were approved by the University's Human Investigation Committee for ethical treatment of human participants.

Data coding

Recall completeness

Idealized prototypes of typical injury and hospital treatment events were developed in earlier research (Peterson & Bell, 1996) which guided questioning. These idealized prototypes formed a checklist of prototype components or features of the target events. These checklists then needed to be tailored to fit each child. Although each child's injury and hospital treatment was unique, it conformed to this idealized prototypical pattern. By searching parent transcripts, it was determined which prototype components applied to each child. Although most prototype components applied to all children (e.g. the injury occurred in a specific location), some prototype components only applied to a subset of the children (e.g. 'getting a cast' was not relevant to a child who got sutures). Because of

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variation in how many prototype components applied to each child, different children had different numbers of scorable components or prototype features that could potentially be present in their recall. After determining which prototype components applied to each child, their transcripts were searched to determine whether the child supplied information relevant to each prototype component. For the present study, a prototype component provided by the child was only counted if it was correct according to parental report. That is, only correctly recalled components were included in the completeness score. The completeness proportion was derived separately for injury and hospital treatment. The completeness of a child's recall was calculated by dividing the number of component items correctly recalled by the number of component items that were relevant for that child according to parent report and thus could potentially have been recalled. For example, if parents identified 10 of the components as relevant to their child's injury but their child only correctly recalled 7 of them, he was a given a proportion score of .70 for injury completeness.

Unique narrative details

This is the 'units of information' approach to scoring recall. Each unique unit of information introduced by the child was counted. The total number of unique units was tabulated, which included details pertaining to person ('*Daddy* took me'), location ('I went to the *hospital*'), activity ('I was *running* '), object ('I had a *hamburger*') and attribute ('I had a *big* cut'). These were separately counted for injury and hospital events.

Accuracy of unique narrative details

Although those authors using a 'completeness' scoring system and those using a 'units of information' scoring system have both presented data on how accurately children recall each type of coding unit, in the present study we are only analyzing the accuracy of units of information. That is because this method of determining accuracy is the more detailed of the two. Thus, the proportion of unique information (or narrative) units that were accurate is the one used here. It is also the one most similar to that used in adult research. To determine accuracy, adult witness transcripts were searched to assess the accuracy of each unique unit of information provided by children. Accuracy is defined as the number of details confirmed as correct divided by the number confirmed as either correct or incorrect.

Stress categories of children derived from self-reports of crying

Children were classified as being highly distressed, moderately distressed or not very distressed on the basis of their descriptions of how much they cried. Children who said they did not cry were classified as low stress; children who said they cried but provided little further elaboration (or minimized crying) were classified as moderately distressed and children who said they cried a lot ('and I was very very crying'), screeched or screamed ('I never cried—I just screamed') were classified as highly distressed. Stress scores were derived separately for injury and hospital treatment.

Reliability of scoring

To establish reliability, 15% of transcripts were scored by two raters independently. Agreement for completeness was 98%, for identification of unique units of information was 92%, for accuracy of those units was 84% and for children's self-descriptions of distress was 82%.

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RESULTS

Preliminary ANOVAs were conducted on the three memory measures of recall (completeness, number of unique details and the accuracy of unique details) to assess the effect of age, gender, delay interval and event (injury vs. hospital treatment) on each of these measures. An α level of .05 was used for all statistical tests. Overall, older children had more complete, detailed and accurate recall than younger ones. The completeness of children's reports changed minimally over time and for the number of unique details recalled, children (specifically 3–6-year-olds) provided more, not less, information with time, but only about their injury. Accuracy of unique details decreased over time, especially those about hospital treatment. Overall, children's recall was better about the injury than hospital event, and gender effects were negligible. Information on details of these analyses can be obtained from the author.

In terms of children's level of distress, classification of children into categories of distress by means of children's self-descriptions of crying and parental ratings on a distress scale were highly similar (identical classification was found for 67.2% of the children for the injury event, Pearson's $r = .58$ for the relation between child- and parent-derived stress scores, $p < .001$, and for 72.0% of the children for the hospital event, $r = .72$, $p < .001$). Furthermore, all analyses were done using both child-derived stress scores and parent-derived stress scores for the stress measure, and results were highly similar. For simplicity and because the child-derived stress score is new, only the analyses using the child-derived stress score are presented below. In terms of children's degree of distress, for the injury event, 21 children (15%) were classified as experiencing low stress, 57 children (39%) were classified as moderately distressed and 67 children (46%) as highly distressed. For the hospital event, 63 children (43%) were classified as low stress, 42 children (29%) were classified as moderately distressed, and 40 children (28%) were classified as highly distressed.

Stress and recall

To assess the association between stress and children's memory, correlations were first computed between both age and gender and all recall measures, and for every recall measure, age was highly significant with Pearson *r*s averaging $r = .43$ (range = .28–.65), all *p*s $< .001$. The correlations between memory and gender ranged from $r = .00$ to .10, mean $r = .05$, all *p*s nonsignificant. Next, hierarchical regression analyses were computed for each recall measure separately. (Preliminary regressions included both age and gender in the first step and an age and gender interaction in step 2, followed by stress and finally interactions that included gender; since gender never accounted for a significant proportion of the variance, this variable is not considered further.) Age was entered in step 1, followed by stress in step 2. To see if there was a curvilinear relation for stress, stress^2 was entered in step 3. The age $\times$ stress interaction was entered in step 4 and finally the age $\times$ stress^2 interaction in step 5 to see if there was a curvilinear relation of stress that interacted with age. Age was a significant predictor in step 1 of every analysis, with *R*-squares ranging from .18 to .42 (all *p*s $< .001$); our interest here is whether stress accounted for additional variance above the contribution of age and so step 1 (age) in all the regressions is deleted from the table because of space considerations. A summary of hierarchical regressions for the injury event is found in Table 1, which also indicates which ones found stress (or stress interacting with age) to be a significant predictor of children's recall. A parallel set of

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Table 1. Summary of hierarchical regression analyses for accuracy, recall completeness, and number of unique details for the injury event in all three interviews[a,b]

Recall measure	Interview	Predictor	SE	R^2_{change}	β
Accuracy	Initial	Step 2: stress	.01	.003	−.059
		Step 3: stress^2	.01	.007	.548
		Step 4: age × stress	.01	.022*	.554
	1-year	(Only age)			
	2-year	(Only age)			
Completeness	Initial	Step 2: stress	1.38	.017**	.143
	1-year	(Only age)			
	2-year	(Only age)			
Unique detail	Initial	Step 2: stress	1.73	.016*	.132
	1 year	Step 2: Stress	1.76	.020*	.148
	2 year	Step 2: stress	2.47	.033**	.203
		Step 3: stress^2	3.52	.000	.118
		Step 4: age × stress	2.07	.032*	.688

[a]Order of variable input: Step 1 = age, Step 2 = stress, Step 3 = stress^2, Step 4 = age × stress, step 5 = age × stress^2.
[b]Age in Step 1 was significant in every regression, with R^2s varying between .18 to .42 (all $ps < .001$). To save space, details on step 1 in each analysis are not included in Table 1 but are available from the author.
*$p < .05$; **$p < .01$.

regressions were conducted for the hospital event, although as discussed below, only one was significant.

Accuracy

Stress was not a significant predictor for the hospital event. For the injury event, there was a significant age × stress interaction for the accuracy of unique details during initial interviews (see Table 1 and Figure 1). Follow-up regression analyses were done on each of the stress groups separately, and age was a significant predictor at all three stress levels, although the difference between ages increased as their stress level increased: $t(23) = 2.59$

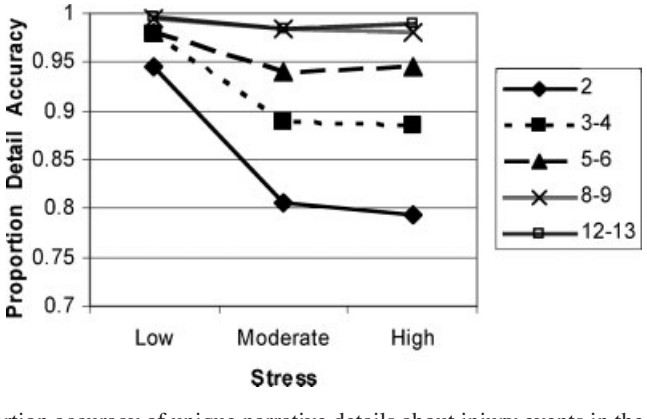

Figure 1. Proportion accuracy of unique narrative details about injury events in the initial interview provided by children in different age groups who were classified into low, moderate or high stress categories

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Table 2. Summary table for means (and standard deviations) for low, moderate and high stress for the hierarchical regression analyses in which stress was predictive of recall. I have included some of the prior words in parentheses (...in which stress was predictive of recall) of completeness and number of unique narrative details

			Stress level		
Recall measure	Interview	Event	Low	Moderate	High
Completeness	Initial	Injury	74.0 (18.2)	73.3 (18.1)	72.3 (15.8)
	Initial	Hospital	62.2 (23.1)	56.8 (19.7)	48.6 (21.25)
No. of details	Initial	Injury	45.0 (22.9)	38.8 (19.0)	41.0 (19.2)
	1 Year	Injury	45.3 (17.5)	40.0 (19.1)	43.9 (17.2)

for low stress, $t(84) = 4.88$ for moderate stress and $t(94) = 5.03$ for high stress. In general, younger children had poorer accuracy at higher stress levels whereas older children did not deteriorate in accuracy as stress increased.

Completeness of recall

As stress increased, children correctly recalled fewer components of both hospital treatment ($R^2 = .27$, $\Delta R^2 = .03$, standardized $\beta = -.18$ for the hospital event) and their injury (see Table 1) in their initial interview. Table 2 shows the mean completeness proportions for children who experienced low, moderate or high levels of stress in both events. For follow-up analyses, regressions were re-computed that included only two stress levels at a time. For the hospital event, poorer recall was associated with higher levels of stress, with low-stress children more complete than highly distressed children ($R^2 = .293$, $\Delta R^2 = .038$, standardized $\beta = -.200$, $p < .01$), with moderately distressed children intermediate and differing from neither other group. For the injury event, children who experienced low stress were more complete than were those who were moderately distressed ($R^2 = .468$, $\Delta R^2 = .021$, standardized $\beta = .151$, $p < .05$) or highly distressed ($R^2 = .424$, $\Delta R^2 = .041$, standardized $\beta = .219$, $p < .01$), although the difference between the moderately and highly distressed group did not reach significance ($p > .05$). There was no significant age $\times$ stress interaction for either event; nor was there a curvilinear relationship between stress and completeness. However, when children were interviewed one and two years later, stress was unrelated to the completeness of their recall of both events.

Number of unique narrative details

For children's recall of hospital treatment, there was little relationship with stress in all three interviews. In terms of the injury event, stress was related to how many unique details children recalled in all three interviews (see Table 1). Table 2 shows the mean number of unique details recalled by children in the first two interviews, grouped into the different stress categories. Follow-up analyses involved regressions that included only two stress levels at a time. There was a significant effect of stress when the moderately distressed group was compared with the high stress in both interviews ($R^2 = .318$, $\Delta R^2 = .018$, final standardized $\beta = .132$, $p < .05$ for the initial interview and $R^2 = .201$, $\Delta R^2 = .026$, final standardized $\beta = .164$, $p < .05$ for the 1-year interview). Specifically, children who were highly stressed provided more unique narrative details than did children who were moderately distressed. However, although the means in Table 2 suggest that children classified as experiencing low stress recalled even more details, regressions that included

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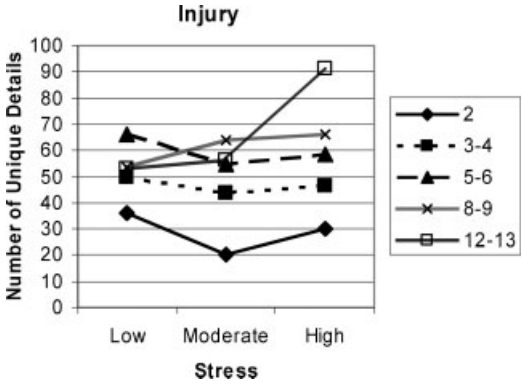

Figure 2. Number of unique narrative details about injury events in the 2-year follow-up interview provided by children in different age groups who were classified into low, moderate or high stress categories

the low-stress group plus either of the other stress groups were not significant. The smaller *N* for the low-stress group as well as large *SD*s undoubtedly contributed; nevertheless, 85% of the children fell into either the moderately or highly distressed group, and for these children, higher stress levels were associated with increased narrative detail. In contrast to earlier interviews, in the 2-year interview there was a significant interaction between stress and age. Follow-up regression analyses were conducted separately for each age group, and only the oldest age group still showed a significant effect of stress (see Figure 2), with the amount of unique detail recalled increased with increasing levels of stress, $R^2 = .195$, $\Delta R^2 = .195$, final standardized $\beta = .450$, $p < .05$.

Summary

Children's accuracy was unrelated to stress for the hospital event in all interviews. For recall of their injury, younger children were less accurate with increasing stress in the initial interview, although stress was not related to the accuracy of older children's recall. In follow-up interviews, accuracy was unrelated to stress level.

In terms of recall completeness, children recalled proportionately more correct prototype components during the initial interview in their accounts of both events when stress was low and they became less complete as stress levels increased. However, stress was unrelated to completeness after long delays. Thus, stress was related to poorer accuracy and completeness, but only in the initial interview.

For the number of unique narrative details, this measure was not related to stress when children talked about the hospital event but was related to stress when children talked about the injury event in all three interviews. Highly distressed children in all age groups recalled more, not fewer, details of their injury in initial and 1-year interviews than did moderately distressed children, but only the oldest children continued to show this pattern in the 2-year interview.

DISCUSSION

In order to appropriately investigate the interaction between stress and memory, Deffenbacher et al. (2004) emphasize that target events need to be stressful enough to elicit

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the activation mode of attention control, i.e., a defensive rather than orienting response. Furthermore, one needs a contrast between individuals experiencing different levels of stress. The present study fits these criteria, and it focused on the relation between children's degree of distress and their recall about real-world, naturally-occurring stressful events, using three different measures of recall: How completely they recalled the components of prototypical injury and hospital treatment events, the amount of unique detail they recalled and the accuracy of that detail.

In Deffenbacher's meta-analytic review, *adults* who experienced high levels of distress had decreased accuracy in their recall when stimuli were highly stressful, whereas in the few studies involving *children*, there was little decrease in accuracy at high stress levels. In terms of children's recall of their injury, the present study replicates the latter finding only for children who were at least 8 years of age at the time of injury. Younger children showed poorer accuracy with higher stress levels, but unlike adults, their data did not follow the pattern of increasing accuracy followed by a precipitate drop at high stress levels. In contrast, older children did not demonstrate compromised accuracy rates with increasing stress—similar to the few extant studies involving children. It should also be noted that the significant relation between stress and accuracy that was found for younger children was only found for recall of their injury, not hospital treatment, and was only found for the initial interview.

At least two questions arise from this pattern of results. First, why is there a difference between younger and older children in terms of how stress interacts with accuracy in their initial interview? It may be that highly distressed younger children were more hysterical than older children, and as a consequence may be less able to process relevant information. The categorization of children's distress was not fine-grained enough to make distinctions among highly distressed children; rather, any child who stated that he or she cried a lot was placed into the highly distressed group. Thus, a more differentiated classification of distress may account for the differences between age groups. Another possibility is that the stress measure used here may vary in its ability to capture experienced distress across age. For example, older children who are highly distressed may not cry as intensely as younger children, despite feeling comparable amounts of pain or discomfort. Or, it may also be that because of processing limitations, younger children are more vulnerable to memory narrowing when highly distressed.

A second question arising from these findings is why the relation between stress and accuracy is so different between adults and children. This issue is a puzzle yet to be solved. However, the sorts of stimuli or events that elicit stress are mostly quite different for adults vs. children. As pointed out by Laney et al. (2003), adult stress is typically visually-induced arousal whereas children experience thematically-induced arousal, i.e. visual stimuli vs. real-world stressful events. For ethical reasons it would be problematic to subject children to the sorts of visually stressful stimuli used with adult participants, but future research should compare recall in adults who experience visually-induced vs. thematically-induced distress. It may well be that discrepancies between adult and child data are methodologically induced and that if stimuli similar to those used in child research were used with adults, findings might be more comparable.

In terms of the completeness of recall, children at all ages who experienced little distress had the most complete recall about both injury and hospital events in their initial interviews, and as stress increased, recall completeness deteriorated linearly. Thus, as hypothesized, high levels of stress seemed to compromise how complete children's accounts were, but an important caveat is that this was true only in the initial interview.

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Like findings on the relation between younger children's recall accuracy and distress, the negative impact of stress on children's recall completeness is both similar to and different from what investigators have found when studying adults' accuracy and face identification (Deffenbacher et al., 2004). The similarity derives from the findings that children's recall is compromised by high levels of stress. However, unlike adults, children in the current study showed a linear decrease in recall completeness as stress increased. These data are consistent with theoretical conceptions about increasing stress producing memory narrowing (Christianson 1992; Laney et al., 2003).

When one considers the amount of unique narrative detail that children provide, stress seems to have a positive rather than a negative impact on recall. For this measure, children who were most distressed at the time of injury recalled more unique units of information about that event than did moderately distressed children, at least in their first two interviews. The same was true for children in the oldest age group in the 2-year follow-up interview. Thus, unlike findings for recall completeness, higher levels of stress seem to help children's recall, and it was also found in all three interviews for the oldest children and for the first two interviews for other children. That is, children seem to recall more, not less, detailed information with increasing distress at the time of injury.

An important question is why stress effects are found for all three measures for children's recall of the injury event, but only completeness is affected for the hospital event. This may be at least partly due to the uniqueness of the injury event in contrast to the frequency of children's visits to that particular emergency room. Comparable children in the same geographical area were found to visit the emergency room an average of 12 times (Peterson & Bell, 1996), and thus many components of children's emergency room treatment for their injury would have been similar to those experienced in other visits for other reasons. Indeed, when children have similar repeated experiences with hospitals, they have difficulty differentiating which specific aspects are associated with each visit (Steward et al., 1996). Not surprisingly, children's overall recall of their hospital event is typically worse than that for their injury (Peterson, 1999; Peterson & Bell, 1996; Peterson & Whalen, 2001), and this may account for relations between stress and recall being found primarily for the injury event.

Another important issue is that stress effects are primarily located in the initial interview; specifically, accuracy and completeness are only related to distress in that interview although the amount of narrative detail is still related to distress in later interviews. The fact that stress effects were only found in initial interviews about the injury event when the completeness method of coding was used is consistent with prior findings of Peterson and Whalen (2001). However, 5 years after being treated in a hospital emergency room, Peterson and Whalen found that highly distressed children had more complete and more accurate recall of the central components of hospital treatment, specifically the major treatment they received such as getting a cast or sutures, although not of non-central components. Thus, considering the entirety of their interview, long-term stress effects tended to be minimal, consistent with the present findings for completeness. In terms of long-term research on children's recall of narrative detail, there is little with which to compare these findings; an exception is the long-term follow-up of children who experienced a destructive hurricane (Fivush et al., 2004; Sales et al., 2005). In interviews that took place a few months after the hurricane, Bahrick et al. (1998) found that children who were classified as moderately distressed recalled the most narrative detail whereas children in the high stress category recalled the least. Six years later, children in all stress categories recalled similar amounts of information although those in the high-stress group

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had to be prompted more (Fivush et al., 2004; Sales et al., 2005). In contrast, children in the present study who were classified as moderately distressed seemed to recall the least rather than the most narrative detail. However, there are methodological differences between the hurricane studies and the present investigation that may account for these differences. Two methodological issues are likely to be particularly salient: The way stress was measured is quite different (amount of damage to the family home vs. children's verbal description of emotional reactions to an injury) and the nature of the stressful event differed (hurricane vs. injury). Injuries are relatively frequent events in childhood, although fortunately not those that are as extreme as the ones experienced by some of the children studied here. Thus, the target events used in the present investigation are more commonly encountered by children, who also see friends or acquaintances with casts or sutures. In contrast, destructive hurricanes are rare phenomena. As well, the long-term consequences of a destructive hurricane (children's home damaged or destroyed, loss of their belongings) are much greater than those associated with broken bones or lacerations. Thus, it is difficult to meaningfully compare the findings from these two different types of events.

Why might relations between stress and two of the recall measures, namely completeness and accuracy, disappear over time such that in both follow-up interviews, there was little residual relation between stress and either measure of recall? A possible explanation is that the early and highly detailed interview reinstated the event so effectively that differences between stress groups in completeness and accuracy were counteracted in later interviews. In fact, the efficacy of an earlier interview in reinstating parallel complex events has been demonstrated in earlier work with preschoolers (Peterson, Pardy, Tizzard-Drover, & Warren, 2005; Tizzard-Drover & Peterson, 2004). This lack of long-term stress effects replicates findings of some other research. Although residual effects of stress on memory have been found for delays spanning only a few weeks or months (Merritt et al., 1994; Peterson & Bell, 1996; Salmon et al., 2002), investigators have found little long-term compromising of recall amount or accuracy after delays measured in years (Goodman et al., 1991; Fivush et al., 2004).

However, stress is still related to how much elaborative detail children provide a year later, and for the oldest children, 2 years later. It may be that these bone fracture and laceration events have become marks of distinction within their peer group; instead of being seen as distressing events to be suffered through, they have entertainment value or demarcate the child as having peer-valued traits such as adventurousness or risk-taking (Brown, 2004). Thus, increased elaboration of event details may occur, even though the overall structure (or completeness) of children's accounts is unchanged.

Overall, in some ways high levels of distress seem to compromise children's recall of injuries that are serious enough to require hospital emergency room treatment. This was found for recall accuracy of the injury event and completeness of both events. Analyses for both these measures were most consistent with theoretical proposals of memory narrowing with increasing stress (Christianson 1992; Laney et al., 2003). Thus, as stress classification increased, there was a linear decrease in children's recall completeness for both injury and hospital events as well as a linear decrease for younger children in accuracy for their injury. In contrast, high levels of stress seemed to help children's recall of these injuries in that the components that were recalled were described with more elaborative narrative detail. This is reminiscent of the 'weapon' effect.

A qualification to these findings is the age of the child. Older children did not decrease in accuracy as stress level increased, unlike younger children, and in their 2-year interview the oldest children still provided an increased amount of narrative detail as stress classification

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increased. However, no interactions with age were found for completeness of recall nor for the amount of narrative detail in children's first two interviews. Thus, age had only a modest effect.

In conclusion, stress seems to have both a deleterious and a positive effect on children's recall of a stressful injury, although the effects are not large. When children were interviewed soon after a stressful injury occurred, higher levels of stress were associated with less complete accounts by all children as well as poorer accuracy by younger children. However, this negative association was only found in children's initial interview and for later interviews there were no long-term negative associations for either the recall of correct completeness components or accuracy of detail. In contrast, children who were most distressed recalled the most narrative detail about their injury not only in their initial interview but a year later as well, and older children continued to do so 2 years later. Forensically, this can be reassuring when assessing children's accounts of stressful events that are brought before the courts. However, the differences between research on children vs. adults, differences related to the nature of the stressful event and differences related to the specific aspects of recall that are investigated all highlight the need for more research on how children's memory is influenced by stressful events.

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REFERENCES

Bahrick, L. E., Parker, J. F., Fivush, R., & Levitt, M. (1998). The effects of stress on young children's memory for a natural disaster. *Journal of Experimental Psychology: Applied*, *4*, 308–331.

Baker-Ward, L., Ornstein, P. A., Gordon, B. N., Follmer, A., & Clubb, P. A. (1995). How shall a thing be coded? In M. S. Zaragoza, J. R. Graham, G. C. N. Hall, R. Hirschman, & Y. S. Ben-Porath (Eds.), *Memory and testimony in the child witness* (pp. 61–85). Thousand Oaks, CA: Sage.

Bala, N., Lee, J., & McNamara, E. (2001). Children as witnesses: Understanding their capacities, needs, and experiences. *Journal of Social Distress and the Homeless*, *10*, 41–68.

Bauer, P. J. (2006). Event memory. In W. Damon, R. M. Lerner (Series Eds.), & D. Kuhn, R. S. Siegler, (Vol. Eds.), *Handbook of child psychology: Vol. 2. Cognition, perception, and language* (6th ed., pp. 373–425). New York: Wiley.

Bauer, P. J. (2007). *Remembering the times of our lives: Memory in infancy and beyond*. Mahwah, NJ: Erlbaum.

Brown, B. (2004). Adolescents' relationships with peers. In R. Lerner, & L. Steinberg (Eds.), *Handbook of adolescent psychology*, 2nd ed. (pp. 363–394;). New York: Wiley.

Burgwyn-Bailes, E., Baker-Ward, L., Gordon, B. N., & Ornstein, P. A. (2001). Children's memory for emergency medical treatment after one year: The impact of individual difference variables on recall and suggestibility. *Applied Cognitive Psychology*, *15*, 25–48.

DOI: 10.1002/acp

Christianson, S.-A. (1992). Emotional stress and eyewitness memory: A critical review. *Psychological Bulletin*, *112*, 284–309.
Deffenbacher, K. A., Bornstein, B. H., Penrod, S. D., & McGorty, E. K. (2004). A meta-analytic review of the effects of high stress on eyewitness memory. *Law & Human Behavior*, *28*, 687–706.
Fivush, R., Sales, J. M., Goldberg, A., Bahrick, L., & Parker, J. (2004). Weathering the storm: Children's long-term recall of Hurricane Andrew. *Memory*, *12*, 104–118.
Goodman, G. S., Hirschman, J. E., Hepps, D., & Rudy, L. (1991). Children's memory for stressful events. *Merrill-Palmer Quarterly*, *37*, 109–158.
Goodman, G. S., Quas, J. A., Batterman-Faunce, J. M., Riddlesberger, M. M., & Kuhn, J. (1994). Predictors of accurate and inaccurate memories of traumatic events experienced in childhood. *Consciousness and Cognition*, *3*, 269–294.
Goodman, G. S., Quas, J. A., Batterman-Faunce, J. M., Riddlesberger, M. M., & Kuhn, J. (1997). Children's reactions to and memory for a stressful event: Influences of age, anatomical dolls, knowledge, and parental attachment. *Applied Developmental Science*, *1*, 54–75.
Laney, C., Heuer, F., & Reisberg, D. (2003). Thematically-induced arousal in naturally-occurring emotional memories. *Applied Cognitive Psychology*, *17*, 995–1004.
Merritt, K. A., Ornstein, P. A., & Spicker, B. (1994). Children's memory for a salient medical procedure: Implications for testimony. *Pediatrics*, *94*, 17–23.
Peters, D. P. (1997). Stress, arousal, and children's eyewitness memory. In N. L. Stein, P. A. Ornstein, B. Tversky, & C. Brainerd (Eds.), *Memory for everyday and emotional events* (pp. 351–370). Mahwah, NJ: Erlbaum.
Peterson, C. (1999). Children's memory for medical emergencies: Two years later. *Developmental Psychology*, *35*, 1493–1506.
Peterson, C. (2002). Children's long-term memory for autobiographical events. *Developmental Review*, *22*, 370–402.
Peterson, C., & Bell, M. (1996). Children's memory for traumatic injury. *Child Development*, *67*, 3045–3070.
Peterson, C., & Parsons, B. (2005). Interviewing former 1- and 2-year-olds about medical emergencies five years later. *Law & Human Behavior*, *29*, 743–754.
Peterson, C., & Whalen, N. (2001). Five years later: Children's memory for medical emergencies. *Applied Cognitive Psychology*, *15*, 7–24.
Peterson, C., Pardy, L., Tizzard-Drover, T., & Warren, K. (2005). When initial interviews are delayed a year: Effect on children's 2-year recall. *Law & Human Behavior*, *29*, 527–541.
Quas, J. A., Bauer, A., & Boyce, W. T. (2004). Physiological reactivity, social support, and memory in early childhood. *Child Development*, *75*, 797–814.
Sales, J. M., Fivush, R., Parker, J., & Bahrick, L. (2005). Stressing memory: Long-term relations among children's stress, recall and psychological outcome following hurricane Andrew. *Journal of Cognition & Development*, *6*, 529–545.
Salmon, K., Price, M., & Pereira, J. K. (2002). Factors associated with young children's long-term recall of an invasive medical procedure: A preliminary investigation. *Developmental and Behavioral Pediatrics*, *23*, 347–352.
Shrimpton, S., Oates, K., & Hayes, S. (1998). Children's memory of events: Effects of stress, age, time delay and location of interview. *Applied Cognitive Psychology*, *12*, 133–143.
Steward, M. S., Steward, D. S., Farquhar, L., Myers, J. E. B., Reinhart, M., Welker, J., et al. (1996). Interviewing young children about body touch and handling. *Monographs of the Society for Research in Child Development*, *57*, (4–5, Serial No. 248).
Tizzard-Drover, T., & Peterson, C. (2004). The influence of an early interview on long-term recall: A comparative analysis. *Applied Cognitive Psychology*, *18*, 1–17.
Vandermaas, M. O., Hess, T. M., & Baker-Ward, L. (1993). Does anxiety affect children's reports of memory for a stressful event? *Journal of Applied Psychology*, *7*, 109–128.

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