

Weathering the storm: Children's long-term recall of Hurricane Andrew

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Children who experienced a highly stressful natural disaster, Hurricane Andrew, were interviewed within a few months of the event, when they were 3–4 years old, and again 6 years later, when they were 9–10 years old. Children were grouped into low, moderate, or high stress groups depending on the severity of the experienced storm. All children were able to recall this event in vivid detail 6 years later. In fact, children reported over twice as many propositions at the second interview as at the first. At the initial interview, children in the high stress group reported less information than children in the moderate stress group, but 6 years later, children in all three stress groups reported similar amounts of information. However children in the high stress group needed more questions and prompts than children in the other stress groups. Yet children in the high stress group also reported more consistent information between the two interviews, especially about the storm, than children in the other stress groups. Implications for children's developing memory of stressful events are discussed.

Unfortunately, all of us experience stressful and traumatic events during our lifetime, and there is growing evidence that the way in which we remember these experiences has implications for coping and psychological well-being (e.g., Pennebaker, 1997). Yet within the memory literature there is continuing controversy over how well we may remember various kinds of stressful experiences. Research findings support contradictory common-sense beliefs about memory and stress; some studies find stressful events extremely well remembered, almost as if they were “burned into our brains” and other studies find stressful events poorly remembered, as if these experiences overwhelm our abilities to process, store, and retrieve these events (see Christianson, 1992, and Chris-

tianson & Lindholm, 1998, for reviews). Several theorists have argued that stress, up to a point, may enhance memory by increasing arousal and focusing attention, but extremely high levels of stress may hinder memory by overwhelming the cognitive system and leading to a breakdown in the ability to process incoming information (as reviewed by Christianson, 1992).

There are, of course, multiple ethical issues inherent in studying the relation between memory and stress. Clinical researchers have provided dramatic qualitative descriptions of memory and forgetting for various kinds of highly stressful experiences, including abuse (Briere & Elliot, 1994; Herman & Schatzow, 1987; Williams, 1995), sexual assault (Foa, Molnar, & Cashman, 1995;

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Koss, Figueredo, Bell, Tharan, & Tromp, 1996), and witnessing violent crimes (Yuille & Cutshall, 1986), but these studies often lack the systematic control necessary for generalisation of findings. Experimental memory researchers, on the other hand, have conducted controlled, systematic studies of memory for stressful experiences under laboratory conditions in which participants are presented with videos or photos of negatively arousing stressful stimuli (Reisberg, Heuer, McLean & O'Shaughnessy, 1988), and generally find better memory for more highly arousing material. Unquestionably, however, these laboratory studies cannot (and should not) induce the levels of stress inherent in real-world, often life-threatening, situations. Thus many questions about relations between level of stress and memory remain unanswered.

Within the developmental literature, this question has received increasing attention as more and more children are being brought into the legal system as victims or witnesses of violence (Ceci & Bruck, 1993; Myers, Goodman, & Saywitz, 1996). Moreover, for theoretical reasons, the ways in which children recall stressful experiences is especially important, as children's mnemonic capacities are still in the process of developing, and early experiences set the stage for future comprehension and recall (Ornstein, Larus, & Clubb, 1991). Children exposed to stressful events early in life may be particularly vulnerable to memory disturbances, both for those particular events (Ceci & Bruck, 1993), as well as for events in general; early trauma may change basic memory capacities in negative ways (Bremner, Krystal, Southwick, & Charney, 1995a; C. Nelson & Carver, 1998). For example, adults survivors of early childhood sexual abuse show deficits in both short-term memory (Bremner et al., 1995b) and in quantity of childhood autobiographical memories (Edwards, Fivush, Anda, Nordenberg, & Felliti, 2001). From a pragmatic perspective, even more so than with adults, researchers simply cannot ethically induce high levels of stress under controlled laboratory conditions in order to study memory effects with children.

Thus the developmental community has evolved innovative methods for studying stress and memory, relying for the most part on necessary but painful medical procedures. While there are many nuances to these studies, overall, the conclusion is that stressful medical procedures, such as voiding cystourethograms (Goodman, Hirschman, Hepps, & Rudy, 1991; Ornstein,

Gordon, & Larus, 1992), and injuries requiring sutures or casts (Peterson & Bell, 1996), are recalled at least as well, if not better, than more mundane medical procedures such as well-doctor visits (see Fivush, 1998, and Pezdek & Taylor, 2001, for reviews). However, while certainly stressful, these medical procedures may not capture the high level of stress necessary to begin to see decrements in memory. Perhaps most important, young children take their cues from their caregivers, and in these situations, caregivers may be concerned about the child's level of discomfort, but they are not worried about the child's, or indeed their own, survival.

We untangled some of these issues in a previously published study of young children's memories of a highly stressful natural disaster, Hurricane Andrew (Bahrack, Parker, Levitt, & Fivush, 1998). This was a class IV hurricane that hit the Florida coastline in 1992. Importantly, there was not a lot of preparation time (forecasters initially thought the hurricane would not hit shore) and when it did hit, it devastated neighbourhoods, literally tearing houses down while families remained inside often moving from room to room to escape injury. Perhaps even more important from a research perspective, although many areas were warned and prepared for the hurricane, only a small area was badly hit. Thus we were able to group children who had experienced the hurricane into one of three stress levels. Children in the high stress condition were at home with their families when their houses fell apart around them, including roofs caving in, trees coming into living areas, and window glass flying. Children in the moderate stress group also experienced a severe storm with winds knocking down trees, and water seeping into their homes, but the perimeters of their homes remained intact. Finally, families of children in the low stress group prepared for the storm, but fortunately only experienced a heavy rainfall. Thus children in all three groups engaged in the same activities to prepare for the storm, but only children in the severe stress group experienced the full force of the storm.

As detailed in the previous report (Bahrack et al., 1998), we interviewed 3- and 4-year-old children about their experiences within 6 months of the storm. We chose this age group because this is the age which autobiographical memory is becoming consolidated, and children are just beginning to be able to recall their past experiences in coherent narrative form (see Fivush,

2002, and K. Nelson, 1993, for reviews). Children were asked both open-ended free-recall questions and a set of specific cued-recall questions. All children recalled a great deal of information about their hurricane experiences, but children in the moderate stress group recalled more overall than either children in the low or the high stress groups. Thus the previous study provided the first evidence in the developmental literature for enhanced memory under moderate stress but hindered memory under high stress.

An important question remains about children's ability to recall this experience over time. Even for adults, recall of stressful and traumatic events over a period of years is little studied. Most of the research has been on so-called "flashbulb memories", memories of when and where participants heard the news of a public event such as the space shuttle *Challenger* disaster or the assassination of a political leader (see Conway, 1995, for a review). This research has provided mixed findings, with some studies indicating highly consistent recall for one's personal circumstances when hearing such news, and other studies demonstrating high levels of contradictory recall over time. However, while these kinds of news stories may be disturbing, it is not at all clear that they are highly stressful, or that they have important personal significance or consequences for the respondents.

In studying adults' memories of the Santa Cruz earthquake, Neisser et al. (1996) assessed both immediate recall and recall two years later from individuals who directly experienced the earthquake, people who heard about the earthquake and personally knew people in the affected region, and people who heard about the earthquake but did not know anyone in the area. Two years after the event, people who directly experienced the quake and those who knew people who lived in the area recalled as much information, and were highly consistent in what they recalled, but people who did not know anyone in the area recalled less information over time and were less consistent in the information recalled. This pattern suggests that personally experiencing an event and/or having personal investment in the event leads to better and more consistent memory than simply hearing about disturbing news. In support of this interpretation, Wagenaar and Groeneweg (1990) interviewed concentration camp survivors 40 years after their liberation about their experiences, and compared their responses to debriefing interviews conducted within a few months of

release. Although they found evidence of errors of reconstruction, they concluded that memory was remarkably accurate after this extremely long delay.

Little is known about children's long-term memory of personally experienced events, especially in children very young at time of experience. The few studies that have been conducted indicate remarkably good recall of highly distinctive, emotionally positive events, such as family trips to Disneyland, across the preschool years (Fivush, 1993, 1998). Two empirical studies have further demonstrated that 3- and 4-year-old children are able to retain highly detailed memories of distinctive personally experienced events into middle childhood (Fivush & Schwarzmüller, 1998; Pillemer, Picariello, & Pruett 1994). Intriguingly, however, children are inconsistent in the information they provide over time, and this holds whether they are asked to recall the same event a few weeks apart or several years apart (Fivush, Hamond, Harsch, Singer, & Wolf, 1991; Fivush & Shakat, 1995). Yet several studies have shown that even though children are recalling different information on different recall occasions, what they recall remains highly accurate (see Fivush & Schwarzmüller, 1995, for a review).

But what of more emotionally negative stressful events? Terr (1988) has described several clinical cases of children traumatised under the age of 5 and concludes that, although all of the children evidenced behaviour disturbances, only those older than about age 3 at time of experience were able to verbally recall their experiences in a coherent way years later. More systematic research by Peterson and her colleagues (Peterson, 1999; Peterson & Bell, 1996; Peterson & Rideout, 1998) has examined preschoolers' ability to recall injuries requiring emergency room treatment. Children aged 1 and 2 at time of injury do not show very good recall over time, but children older than about 2.5 years at time of experience show little evidence of forgetting even 5 years later (Peterson & Whalen, 2001). Moreover, children recalling emergency room visits were highly consistent in the information provided over time (Peterson, Moores, & White, 2001) in contrast to the findings discussed earlier on more emotionally positive events. This suggests that negative events may be recalled more consistently over time than are positive events. Still, there was no relation between rated levels of stress at time of experience and recall. An issue in interpreting this lack of a relation, however, is that the

researchers relied on maternal ratings of stress. Other research suggests that stress ratings are inconsistent both over different raters and over time (Eisen, Goodman, Ghetti, & Qin, 1999; Ornstein, 1995; Parker et al., 1998). Would we see a relation between stress and memory with a more reliable and objective stress rating?

Relations between memory and stress are critical not only from a memory perspective, but because the ways in which we remember and carry the negative events of our lives with us has implications for coping and well-being (Pennebaker, 1997). In a very real sense, what we remember and how we make sense of our experiences is more important in everyday functioning than whether that memory conforms to some objective record of what occurred. Except in forensic situations, examining how and what children remember over time is as important as assessing accuracy for understanding memory and functioning in the real world.

Certainly, memory of Hurricane Andrew would be a good candidate for examining how stress affects the persistence of memory over time. This event was highly stressful and remained distinctive in children's lives, yet we can assume that children experienced different levels of stress depending on the amount of damage to their home. Children at home when hurricane winds ripped off their roof and sent trees toppling into their homes were most likely more stressed than children who experienced the storm with their homes remaining intact. Thus the major objective of this study was to follow-up on the previously published study (Bahrack et al., 1998) and to examine children's long-term recall of Hurricane Andrew as a function of level of stress at time of experience. Would we see the same inverted U-shape function of recall after several years have passed? How might level of stress influence both amount of recall and consistency of what is recalled over time? And how might recall differ for different aspects of the event? Would the more stressful aspects of the experience, such as the storm itself, be differentially recalled compared to the less stressful aspects, such as preparing for the hurricane?

In order to answer these questions, we re-interviewed children initially interviewed about their hurricane experience at 3–4 years of age 6 years later, when they were 9–10 years old. Importantly, no hurricane had occurred in this area in the interim, nor were there any hurricane warnings for which the families engaged in pre-

paratory activities. However, this was clearly a public event. Children not only experienced the event directly, but also talked about it with their families, teachers, and schoolmates, and saw it on the evening news. Obviously, this high level of rehearsal also effects interpretation of how and what children might recall, and we address this issue as well.

METHOD

Participants

Of the original 100 children in the Bahrack et al. (1998) study, 41 families with 42 children (one set of siblings) were located and all agreed to participate in the follow-up study. The children were 3 and 4 years old at the time of the initial interview, and were 9 and 10 years old at the time of the follow-up interview. The majority of the children were from mixed SES, middle-class families. Only those children who participated in both interviews were included in this re-analysis. All data from both the initial interviews and the follow-up interviews 6 years later were recoded both for number of propositions and for content of memory as detailed later. Thus the data reported here are not only a subset of the children who participated in the original study, but also represent new coding schemes developed to examine the amount and the consistency of long-term recall.

Participants were grouped into the same three stress categories as in the original study. Stress groups were determined by the amount of damage to the home as determined through a maternal questionnaire. Damage was assessed in terms of the type of damage incurred (e.g., roof damage, water damage, windows broken, etc.) and the cost of repairs (see Bahrack et al., 1998, for full details). Of the original 40 children in the high stress group, 19 participated in the follow-up, 10 boys and 9 girls (mean age 4 years, 4 months at the first interview and 9 years, 8 months at the second interview; mean of 66.5 months between interviews). These children feared for their lives during the storm, and witnessed the complete destruction of their homes and belongings. Their families were forced to relocate or have their homes rebuilt after the storm. They also experienced a clean-up period after the storm that involved searching for any intact items while living for extended periods of time without telephone service, water, or electricity.

Of the 42 children in the original moderate stress group, 17 participated, 10 boys and 7 girls (mean age 4 years, 1 month at the first interview and 9 years, 9 months at the second interview, mean of 69.08 months between interviews). These children experienced some exterior damage to their homes, and water damage to the interior of their homes. They also had to cope with the major clean-up of their homes and neighbourhood, but not to the extent of the high stress group. They too were without basic services (i.e., electricity and water) for a period of time, but they did not experience complete destruction of their homes.

Finally, of the 18 children in the original low stress group, six participated, two boys and four girls (mean age 4 years, 7 months at the first interview and 10 years, 5 months at the second interview, mean of 69.20 months between interviews). This group consisted of families who experienced no property damage from the storm, and little or no time without basic services. However, they prepared for the hurricane in much the same way as the other stress groups.

Note that we recruited proportionally the same number of participants from each stress group from the initial study into the follow-up. The initial interviews were conducted between 2 and 6 months after the hurricane; there were no differences in recall as a function of retention interval in the initial study (see Bahrack et al., 1998, for details). The follow-up interviews were conducted approximately 6 years later, and there was no difference in time between the first and second interview across stress groups.

Interview

One of several trained female research assistants conducted each interview in a neutral location, such as a public park or library. The interview was sometimes conducted in the child's home if it was not the same structure in which the child experienced Hurricane Andrew.

The initial and follow-up interviews were identical. Each interview was structured to elicit information about all three phases of the hurricane—the preparation, the storm itself, and the aftermath of the storm. Each interview began with the question, “Tell me everything you can remember about Hurricane Andrew”. After exhausting children's responses to this first, open-ended question, children were asked questions

about each phase of the experience; preparation, the storm itself and the aftermath. Each segment began with an open-ended question designed to elicit the children's free recall (e.g., “Tell me everything you and your family did to get ready for the hurricane”, “Tell me everything you remember about what happened during the hurricane”, and “Tell me everything you can remember about what happened after the hurricane”). After children had exhausted their free recall in each segment, the interviewer asked a series of prompting questions specific to each phase of the storm, before asking about the next phase of the storm. For example, “Did your mommy and daddy do anything to the windows?” is a specific question about the preparation for the storm. The question, “Did you hide or put anything over you?” refers to the storm phase of the interview, and “What did your yard look like?” refers to the aftermath phase of the event. The order in which the phase-specific segments were presented to the participants was counter-balanced. All interviews were audio-taped and transcribed verbatim.

Coding

Each transcript was divided into propositional units for coding. A proposition was defined as a unit of information about the hurricane (e.g., “the windows shattered”, “we boarded the windows”, “we cleaned up”). Propositions usually consisted of a subject and a verb or a subject with an implied verb, and lists of nouns were considered one proposition. Yes and no responses were not counted as recall. Two independent coders compared their divisions into propositions on 25% of the transcripts from each time point and achieved an intercoder reliability of 93.2% (range 93–97%).

Each proposition was then coded for content. Each proposition was assigned one of the following designations:

Preparation (PRE) included propositions pertaining to the experience of preparing for the storm (e.g., “We put boards on the window”, “We filled the bathtub with water”, or “We bought food that wouldn't spoil”).

Storm (STM) utterances focused on the experience of the storm itself (e.g., “I hid under the couch”, “I could hear the wind howling”, or “The lights went out”).

Aftermath (AFT) included propositions about the experience of the aftermath of the hurricane

(e.g., "There was lots of damage", "There was junk everywhere", or "I helped pick up the small branches").

Background (BGD) included information not directly relevant to the storm, but provides background information to events that occurred before, during, or after the hurricane (e.g., "My daddy's name is Chris", "We had three trees in the backyard", or "Melanie is my sister's friend").

Repetition (REP) was relevant information that was reported earlier in the interview.

Background and repetitions occurred infrequently and were not of theoretical relevance, and therefore were not considered in any of the analyses. Two independent coders compared content coded for 25% of the transcripts from each time point and achieved an intercoder reliability of 88.7% (range 73–97%).

Finally, children's responses provided to open-ended questions (e.g., "Tell me everything you and your family did to get ready before the hurricane?") were considered as free recall on the part of the child. Responses provided to more specific, prompting questions (e.g., "Did anything break or fall?") were considered as cued recall. Only new information not previously reported was coded into cued recall.

After coding was completed, children's responses were counted, yielding number of propositions in free and cued recall for each phase of the hurricane—preparation, storm, and aftermath—at each of the two interviews.

Consistency

Each participant's initial and follow-up interviews were compared proposition by proposition to determine how consistent each individual child was in their recall over time. Each proposition could be coded as being recalled at Time 1 only (initial interview only), Time 2 only (follow-up interview only), or at both Time 1 and 2 (information was provided during both interviews). It was also noted whether each proposition was recalled during free or cued recall, and which phase of the hurricane was targeted. Propositions in the initial interview that directly contradicted a proposition in the follow-up interview were also coded. However, the total number of contradictions across all interviews showed them to be so infrequent (less than 10 propositions across all 42 interviews), that this category was not included in any analysis.

RESULTS

Two primary questions were addressed: how much information are children able to recall after a long delay, and how consistent are children's reports over time as a function of level of stress experienced?¹ Preliminary analyses on gender indicated no main effects of gender, nor did gender enter into any second-order interactions. Thus gender was not considered in further analyses. It should be noted that although this was a smaller sample size than included in the initial study (Bahrack et al., 1998), and we used a different coding scheme, the effect of stress reported in the initial study replicated here. Specifically, as will be detailed later, children in the high stress group recalled less information than children in the moderate stress group at the first interview. However, in the first study, 4-year-olds recalled more overall than did 3-year-olds, whereas preliminary analyses on these data demonstrate no effects of age within each time point (i.e., 3- and 4-year-olds did not differ in how much they recalled at Time 1, and 9- and 10-year-olds did not differ in how much they recalled a Time 2) but, as will be detailed later, children recalled substantially more information at the second interview than they did at the first interview.

Amount recalled

In order to determine the amount of information children recalled, the total numbers of propositions reported at Time 1 (initial interview) and at Time 2 (follow-up interview) were determined. These means and standard deviations are displayed in Table 1 by stress group and phase of the hurricane.

A 2 (time; Time 1 or Time 2) by 3 (stress group; high, moderate, or low) by 3 (phase; preparation, storm, and aftermath) ANOVA was conducted with time and phase as within-subject factors, and stress group as a between-subjects factor. This analysis revealed main effects of time, $F(1,39) = 21.63$, $p < .001$, and phase, $F(2,78) = 63.83$, $p < .001$. Overall, children recalled about twice as much information at Time 2 (mean = 116.64 proposition, $SD = 65.13$) than they did at Time 1

¹ Obviously there are very few participants in the low stress group and we thought this might skew the analyses. Thus all analyses were also conducted on just the moderate and high stress groups, and all patterns were identical

TABLE 1

Mean number of propositions and percent free recall (and standard deviations) recalled at each interview by phase and stress group

	<i>Low</i>		<i>Moderate</i>		<i>High</i>		<i>Mean Total</i>	
	<i>Total</i>	<i>% Free</i>	<i>Total</i>	<i>% Free</i>	<i>Total</i>	<i>% Free</i>	<i>Total</i>	<i>% Free</i>
<i>Time 1</i>								
Preparation	14.00 (11.85)	40% (29%)	10.59 (5.69)	50% (25%)	4.53 (3.31)	33% (29%)	8.33 (6.93)	41% (28%)
Storm	24.50 (17.50)	46% (30%)	20.41 (8.38)	46% (14%)	12.26 (7.75)	34% (24%)	17.31 (10.70)	41% (22%)
Aftermath	27.67 (14.61)	50% (15%)	38.29 (18.83)	57% (16%)	26.74 (13.50)	45% (19%)	31.55 (16.19)	51% (18%)
Mean Total	66.17 (38.21)	51% (13%)	69.29 (24.49)	54% (11%)	43.53 (18.41)	40% (16%)	57.19 (26.84)	47% (15%)
<i>Time 2</i>								
Phase:								
Preparation	29.67 (22.67)	62% (24%)	23.35 (18.58)	72% (25%)	23.16 (11.58)	47% (18%)	24.17 (16.19)	59% (25%)
Storm	31.33 (12.40)	52% (12%)	33.94 (18.33)	68% (12%)	38.26 (28.33)	54% (18%)	35.52 (22.57)	59% (16%)
Aftermath	57.80 (25.56)	67% (16%)	46.06 (33.74)	72% (18%)	66.53 (38.22)	56% (17%)	56.95 (35.45)	64% (19%)
Mean Total	118.50 (49.96)	62% (11%)	103.35 (59.92)	70% (12%)	127.95 (73.98)	54% (14%)	116.64 (65.13)	61% (15%)

Cued recall is reciprocal to percent free recall.

(mean = 57.19 propositions, $SD = 26.83$). Children also recalled significantly more information about the aftermath (mean = 91.98 propositions, $SD = 35.92$), than about the storm itself (mean = 56.76, $SD = 27.43$), and more about the storm than the preparation (mean = 33.79, $SD = 17.69$), as determined by follow-up t -tests ($p < .05$). There was no main effect of stress group.

These main effects are qualified by a three-way interaction between time, phase, and stress, $F(2, 78) = 2.55$, $p < .05$. In order to interpret this interaction, a 2 (time) by 3 (stress group) ANOVA was conducted for each phase of the hurricane. For all three phases, there was a main effect of time, $F(1, 39) = 25.18$, $p < .001$, for preparation, $F(1, 39) = 15.74$, $p < .001$, for storm, and $F(1, 39) = 13.11$, $p < .001$, for aftermath, confirming that for all three phases, children in all three stress groups recalled more at Time 2 than at Time 1 (see Figure 1). In addition, there was a marginal interaction between time and stress for both the storm phase, $F(2, 39) = 2.34$, $p = .10$, and the aftermath, $F(2, 39) = 2.84$, $p = .07$. Children in the low and the moderate stress groups recalled more about the storm itself and the aftermath at Time 1 than children in the high stress group (as deter-

mined by Tukey post hoc tests $p < .05$), but there were no differences 6 years later. Although the pattern appears to be similar for the preparation phase, this interaction did not approach significance, $p = .61$. At the first interview, children in all three stress groups recalled similar amounts of information about preparing for the storm, but children in the high stress group recalled less information about the storm itself and the aftermath. However, this pattern no longer holds at the follow-up interview. Six years later, children in the high stress group are recalling as much as children in the moderate and low stress groups about all phases of the hurricane.

We were also interested in whether children were recalling information differently depending on the time of the interview (Time 1 or Time 2) or the phase of hurricane. Specifically, we were interested in their percentage of free recall at each interview, or the amount of information children provided in response to the open-ended questions as opposed to their responses following prompting questions. We calculated percentage free recall by dividing the amount of free recall provided about a given phase of the event by the total amount of information recalled (free and cued responses)

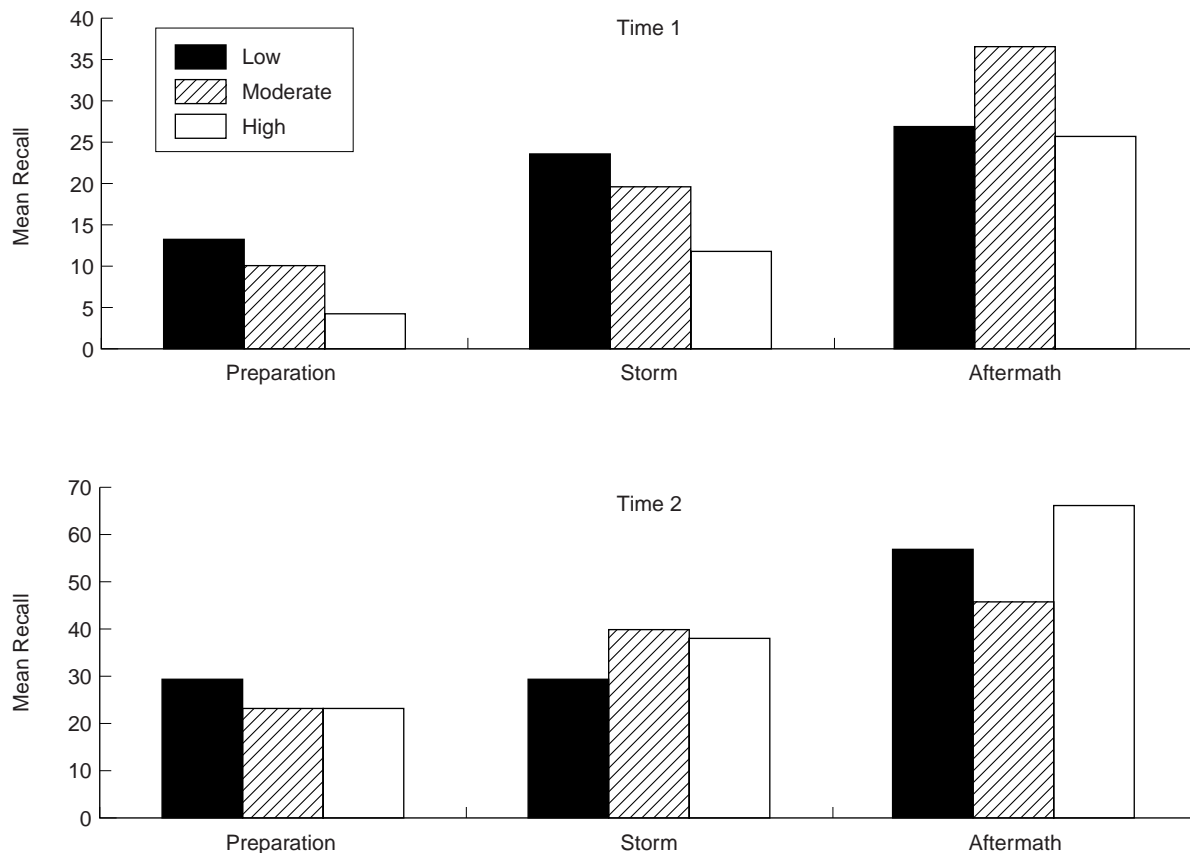


Figure 1. Mean amount of free and cued recall by stress group.

about that portion of the event. These means and standard deviations are presented in Table 1. Note that cued recall is the reciprocal of free recall.

A 2 (time; Time 1 or Time 2) by 3 (stress group; high, moderate, or low) by 3 (phase; preparation, storm, or aftermath) ANOVA was conducted on the percentage of free recall with time and phase as within-subject factors, and stress group as a between-subjects factor. This analysis revealed a main effect of time, $F(1, 39) = 35.44, p < .001$, phase, $F(2, 78) = 4.03, p < .05$, and stress group, $F(2, 39) = 8.66, p < .001$. Overall, children recalled significantly more information in free recall at Time 2 (mean = 61%, $SD = 15\%$) than they did at Time 1 (mean = 46%, $SD = 15\%$). Also, follow-up t -tests ($p < .05$) indicated that children recalled a higher percentage in free recall for the aftermath phase (mean = 59%, $SD = 16\%$) than they did for the storm phase (mean = 54%, $SD = 15\%$), but there were no differences between the storm and preparation phases (mean = 55%, $SD = 19\%$), or between the aftermath and preparation phases. Finally, Tukey's post-hoc tests on the main effect

of stress revealed that children in the moderate stress group recalled a higher percentage of information during free recall (mean = 62%, $SD = 10\%$) than the children in the high stress group (mean = 51%, $SD = 12\%$). However, the low stress group (mean = 59%, $SD = 12\%$), did not differ from either the moderate or high stress groups. Thus, while children in the high stress group recalled as much information as children in the low and moderate stress groups at the second interview, children in the moderate stress group were able to provide a higher percentage of information during free recall, whereas children in the high stress group needed more questions and prompts in order to recall the same amount of information.

Consistency

The second major question examined was whether children were consistent over time in the information they provided about Hurricane Andrew.

TABLE 2
Mean number of propositions (and standard deviations) recalled at Time 1 only, Time 2 only, and both Time 1 and Time 2 by stress group and phase

Phase	Low			Moderate			High		
	T1 only	T2 only	Both	T1 only	T2 only	Both	T1 only	T2 only	Both
Preparation	12.00 (12.02)	27.67 (23.30)	2.00 (2.53)	10.11 (5.49)	22.88 (18.73)	.47 (0.72)	2.84 (2.95)	21.47 (11.87)	1.68 (2.06)
Storm	22.83 (17.33)	29.67 (12.40)	1.67 (1.21)	18.29 (8.72)	31.82 (18.46)		2.11 (2.06)	6.05 (6.26)	6.21 (4.30)
After	25.67 (14.68)	55.50 (24.89)	2.00 (1.27)	36.53 (18.95)	44.29 (33.92)	1.77 (1.79)	21.26 (12.82)	61.05 (38.84)	5.47 (2.12)
Total	60.50 (39.36)	112.83 (50.49)	5.67 (3.01)	64.94 (25.02)	99.00 (60.71)	4.35 (4.00)	30.16 (14.11)	114.57 (74.65)	13.37 (6.41)

In order to address this, it was determined whether each proposition was recalled at Time 1 only, Time 2 only, or at both interviews. Table 2 displays the mean number of propositions in each of these categories by time and stress group. As can be clearly seen, overall, children recalled very little information in common between the two interviews.

Given that children recalled more than twice as much information at Time 2 than at Time 1, it is not surprising that most of the information recalled at Time 2 was not initially recalled at Time 1. However, it is still possible that children differed in the amount of information from Time 1 recalled again at Time 2 as a function of the level of stress experienced. In order to address this question, we determined the proportion of propositions recalled at Time 1 that were recalled again at Time 2. This was computed as the number of propositions recalled at both Time 1 and Time 2 divided by the total number of propositions recalled at Time 1. These proportions were entered into a 3 (phase) by 3 (stress group) ANOVA. (It would have been interesting to also examine whether the consistent information was reported in free or cued recall, but these numbers were too low to allow for statistical analysis). There was a main effect of stress, $F(2, 39) = 24.85$, $p < .001$, a marginal effect of phase, $F(2, 39) = 2.84$, $p = .06$, and a marginal interaction between phase and stress, $F(4, 78) = 2.33$, $p = .06$. As shown in Figure 2, Tukey's post-hoc comparisons ($p < .05$) revealed that the high and low stress groups were more consistent than the moderate stress group in information recalled about the preparation phase. For both the storm itself and the aftermath, the high stress group was more consistent than either the low or moderate stress groups. Thus, children in the high stress

group were significantly more likely to report information recalled at Time 1 again at Time 2 than children in the low or moderate stress groups, especially about the more stressful aspects of the experience. Overall, consistency ranged from 1/4 to over 1/2 of the propositions recalled at Time 1 recalled again at Time 2 for the high stress group, but hovered at about 10% for the low and moderate stress groups.

A second question of interest is whether the amount of new information provided at Time 2 was the same across stress groups. That is, regardless of how much previously reported information children provided at Time 2, were there differences in how much new information was reported at Time 2 as a function of experienced stress? In order to answer this question, we entered the amount of new information reported at Time 2 into a 3 (phase) by 3 (stress group) ANOVA. There was only a main effect of phase, $F(2, 78) = 26.24$, $p < .001$. Follow-up t -tests ($p < .05$) revealed that children recalled more new information about the aftermath (mean = 53.47 propositions, $SD = 35.34$) than about the storm (mean = 31.62, $SD = 22.52$), and more about the storm than the preparation (mean = 22.92, $SD = 16.41$). Thus, children in all three stress groups reported similar amounts of new information at the second interview.

Effects of rehearsal

Obviously, Hurricane Andrew was a public event, much discussed in the media and certainly discussed among family and friends. We asked mothers to estimate how often they and their child discussed the experience during the first year

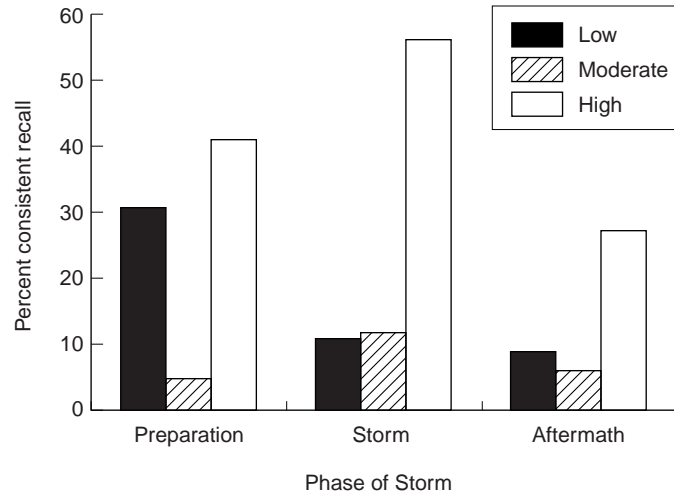


Figure 2. Percent of consistent recall across interview times for each phase of the hurricane by stress group.

following the hurricane, in the next 2–5 years and the past year, on a 0–3 scale, with 0 being not at all, 1 being several times a year, 2 being several times a month, and 3 being several times a week. Using the same scale, we also asked mothers if they had looked at photos or videos of the event, and whether their child had brought up the event. Nine of the mothers did not complete the scale, yielding 4 in the low, 11 in the moderate, and 16 in the high stress groups who completed the scale. Preliminary analyses indicated that the effects of stress groups and time were identical for the three questions (discussion with child, photos or videos, and child brings up event) so we computed a composite rehearsal measure by adding the responses to the three questions together, yielding a total rehearsal score between 0 and 9. Table 3 displays the mean composite rehearsal ratings for each stress group for the year following the hurricane, 2–5 years after the hurricane and the year before the Time 2 interview. A 3 (stress group) by 3 (time period) ANOVA indicated a main effect of stress group, $F(2, 28) = 5.14, p < .05$, and of time period, $F(2, 28) = 140.22, p < .001$, and an inter-

action between stress group and time period, $F(2, 28) = 3.87, p < .05$. While all three stress groups showed significantly decreasing rehearsal over time, Tukey's post-hoc tests on the interaction indicate that, during the first year after the hurricane, the high stress group rehearsed the event significantly more than the moderate stress group ($p < .05$), but the low stress group did not differ from either the moderate or high stress group. In the years following the first year after the hurricane, there were no differences in amount of rehearsal between the stress groups. Thus, although there is some indication that the high stress group rehearsed the event more than the moderate stress group immediately after the hurricane, there were no long-lasting differences in amount of rehearsal over time. Most important, children in all three stress groups had very little rehearsal of the event of the year immediately preceding the second interview.

DISCUSSION

All the children in this study demonstrated remarkable ability to recall Hurricane Andrew even 6 years after the experience. Every child interviewed recalled the event in great detail, and, counterintuitively, recalled more information overall, and more information in response to open-ended questions, 6 years later than they did just a few months after the event. Indeed, 6 years after the event children were recalling a mean of over 120 propositions about their hurricane experience. To give the reader a better sense of

TABLE 3
Mean rehearsal rating by stress group and time period

Time period	Low	Moderate	High
First year	7.00	5.27	8.00
2–5 years	3.75	2.64	3.69
Last year	2.00	1.45	1.75

Maximum score = 9

the way in which children recalled the hurricane initially and 6 years later, sample recall protocols are provided in the Appendix, which presents one child from the high stress group and one from the moderate stress group, responding to the first open-ended, "Tell me about Hurricane Andrew" prompt at each interview. As can be seen, children recalled this event in vivid detail, mentioning specific aspects of their individual experience of the storm.

That children actually reported twice as much information 6 years after the experience than they did immediately, and more information in free than cued recall must be interpreted within the context of developmental change. From a memory perspective, we would expect that there would be at least some forgetting over time, leading to either less overall information recalled, or less accessibility of information as demonstrated by less free recall and more cued recall. Yet over the time course of this study, these children aged from 3–4 years to 9–10 years. Obviously school-age children have more sophisticated language skills and are more mnemonically competent than preschoolers. In particular, there is growing evidence that differences in memory between preschool and school-age children reflect developing organisational and retrieval skills as much as encoding (Bjorkland & Douglas, 1997). Obviously no verbal recall exhausts what is remembered about an event, even for adults. The results of this study suggest that preschoolers are still having a difficult time retrieving and reporting what they remember about a personally experienced event, but that this information remains accessible for many years. Although there is undoubtedly some forgetting over time, when asked about the event 6 years later children are better able to retrieve and verbally report what they do remember.

The results further suggest that stressful events may be particularly well remembered over time. Comparing across studies, it seems that children showed much better recall of Hurricane Andrew over this period of time than of more mundane events examined in other research. For example, Hudson and Fivush (1991) found that 6 years after a novel kindergarten experience, children still recalled many accurate details about the event, but there was substantial forgetting as well. Similarly, Pillemer et al. (1994) found substantial forgetting of a fire drill experienced at age 3 or 4 when asked for recall 7 years later. Fivush and Schwarzmüller (1998) did not find much forgetting from age 3 to age 8 when children were asked

to recall highly distinctive emotionally positive events, but the children in that study recalled many fewer propositions overall (a mean of about 10–20 propositions in free recall) than the children in this study (a mean of over 120 propositions at the second interview). In contrast, Peterson and Whalen (2001) report almost no forgetting of injuries requiring emergency room treatment by 3- and 4-year-olds when asked for recall 5 years later, with children showing relatively exhaustive recall of main idea units. Across studies, the patterns indicate that emotionally negative, stressful events may be better retained than less negative experiences.

By examining recall for different phases of the hurricane in this study, we were able to directly compare children's memories for less stressful preparatory aspects of the event to their memories for more stressful aspects of the event, the storm itself, and the aftermath. All children, regardless of their subsequent hurricane experience, engaged in similar preparatory activities. At the initial interview, children in the high stress group showed diminished recall, suggesting that stress may hinder overall recall. This is particularly striking, as one could speculate that children in the high stress group experienced more details concerning the storm itself and the aftermath than children in the moderate or low stress groups. Yet 6 years later, we found no differences in amount of recall. At the follow-up interview, children in the high stress group recalled as much information overall as children in the moderate and low stress groups. However, they recalled less information in free recall at both interviews than children who had experienced moderate stress, and this was particularly true for the storm and aftermath phases.

That children who experienced higher stress needed more questions, cues, and prompts from the interviewer in order to recall as much information about the more stressful aspects of the experience as children in the moderate stress group suggests that, even 6 years after the event, these children remained either less willing or less able to verbally report what they remembered. More specifically, children who experienced high stress during the hurricane may have subsequently had more difficulty accessing and retrieving remembered information than children experiencing moderate or low stress. An alternative possibility is that children who experienced high stress during the hurricane found it stressful to recall their experiences and therefore were less willing to respond until directly probed and

prompted. Either possibility offers a different interpretation of the pattern found at the initial interview. Children in the high stress group do not seem to have encoded less information, as they were able to recall as much information as children in the other stress groups 6 years later. Rather, the effects of high stress on memory may be on ability and/or willingness to retrieve information.

Still, it must be noted that children in the high stress group, even at the initial interview, recalled a great deal of information compared to studies of more mundane or even emotionally positive events. However, we must be cautious in this interpretation as the hurricane and its aftermath was also of longer duration than many of the events studied in previous research. Future research needs to directly compare children's long-term memories of more and less emotional experiences over time, controlling for other factors in order to examine this question more fully.

Moreover, whereas children recalled a great deal of information 6 years after the hurricane, they did not recall the same information over time. The increase in children's recall did not reflect simply recalling more information over and above the information they recalled initially; much of the information recalled initially was not repeated at the follow-up interview. Inconsistency in recall has now been demonstrated in several studies in which children are asked to recall the same event either a few weeks apart (Fivush et al., 1991) or several years apart (Fivush & Schwarzmueller, 1998; Fivush & Shukat, 1995; but see Peterson et al., 2001). Although the finding seems to be robust, the explanation is elusive. One possibility is that given that all of these studies have examined recall of complex real-world events, children are simply selecting different aspects of the event to report on different recall occasions (Brewer, 1988). It must be emphasised that children rarely reported contradictory information, suggesting that selection of information may be the correct interpretation.

Of course, it is also possible that children reconstructed a great deal of information about what occurred through family discussions and public commemorations. All of the families reported discussing their experiences together at great length, especially in the months just after the hurricane occurred. However we do not think children were simply reporting what they had been told about the hurricane for several reasons.

First, there were no relations in either the previous report of these data using a more fine-grained measure of rehearsal (Baird et al., 1998), or in these analyses between level of rehearsal and amount of information recalled. Second, families in the high stress group reported discussing the event more than did families in the moderate or low stress groups in the months just after the hurricane occurred, yet these children actually recalled less information at the first interview. Third, as the sample protocols in the Appendix illustrate, children were not recalling general knowledge about the hurricane but specific details of their own personal experience. It is highly unlikely that family discussions focused on this level of detail, and certainly other forms of rehearsal (e.g., school discussions, media presentations, and so forth) would have focused on knowledge about hurricanes in general rather than the details of individual experience. Rather, we assume that, similar to all other autobiographical memories, these children reported a complex interweaving of what they had experienced, and how these events had been discussed and thought about over the years, that over time has come to be what is remembered. Importantly, however, we also assume that these reconstructive processes allow for mostly accurate memory, as most of what is rehearsed, discussed, and thought about are aspects of what actually occurred. Thus the assumption is that memories are reworked over time but not necessarily remade (see Fivush, 2000, for a more extended theoretical discussion of accuracy versus meaning in autobiographical memory).

Provisionally, although children in the high stress group showed some decrements in retrieval, what they did report was overwhelmingly more consistent over time than information reported by children in the moderate and low stress groups, and this was particularly true for the most stressful parts of the experience. Indeed, more than 50% of the propositions recalled about the storm itself at Time 1 were recalled again at Time 2. Thus, whereas stress might hinder ability or willingness to recall an event, stress may also lead to a more stable representation of what occurred. If children in the high stress group had more information available to recall, we would expect consistency, to be even lower than for the moderate and low stress children, who had a smaller pool of items from which to retrieve. Perhaps the very fact that recalling the event may be more stressful for these children can help explain this finding. Because

children who experienced the highest levels of stress may have coped by avoiding thinking about the event, they may have had less opportunity to reconstruct and reinterpret the event in the ensuing years, leading to a more consistent, but perhaps less processed, account of what occurred. This interpretation would be consistent with clinical descriptions of rigidity of memory for highly stressful events (see Spiegel, 2000, for a review). Obviously, this interpretation is highly speculative, but one study has suggested high consistency in children's recall of a negative experience over time (Peterson et al., 2001); future research should examine relations between consistency of memory report and continuing levels of stress and coping.

Finally, we return again to the issue of accuracy.² Although we did not assess accuracy in this study, we believe these results address alternative and equally important questions about stress and memory. What children tell us about their experiences reflects how they are making sense of these experiences, and how these experiences are affecting them in personally significant and meaningful way. That children who experienced a severe natural disaster are remembering this event in vivid detail indicates that this event continues to form a part of their autobiographical history. Moreover, the continuing effects of stress on memory suggest that highly stressful experiences may continue to create emotionally negative affect for children even years after the event. Implications of these results for children's understanding of and coping with emotionally negative and stressful experiences are important questions for future research.

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² In the initial study, accuracy was assessed on 10% of the transcripts by having mothers verify all information provided by their children. Virtually all information reported was verified as accurate by maternal report.

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APPENDIX SAMPLE RECALL PROTOCOLS

Response to the first open-ended question, "Tell me everything you remember about hurricane Andrew" (interviewer's comments are in parentheses):

I Moderate stress

Interview 1 (4-year-old child):

... when ... when the screen was knocked over, they had to get new screens, and there was all trees. My next door neighbor had to go all (makes noise) like that. (Anything else you remember about that?) Only this ... only my little screen fell off and nothing else. And all the trees fell off, a lot a lot, but not all. (Right.) Any you know what, and even when it was almost the hurricane we were cutting coconuts, and then, then we got

back inside, and then, and my dad, and then he is all sweaty and he has ants all over. That's it.

Interview 2 (same child at 10 years old):

Well, I remember we had a coconut palm in our backyard, and my dad had to cut all the coconuts off to make sure none of the windows broke or anything. (Uhhuh.) And, well, and that coconut palm broke in the Hurricane Andrew so now that's not there anymore. But we didn't, we were pretty lucky and we didn't have much happen. All it was was, like, fences and stuff. (Uhhuh.) And our pool was very dirty. (Really?) Yeah. We, uh, stayed in our, what used to be our play room, which is now our computer room, and we had little shutters that we put over the glass so no glass would break there so we were very safe there. And we had a, we had a patio by the pool. (Uhhuh.) And we have some sort of electrical shutters to close everything up in the patio, so we can put lots of our stuff in there. And I don't remember much of the hurricane because I don't know how, but I fell asleep in the middle of it.

II High stress

Interview 1 (4-year-old child):

Um, I remember we had friends over. (You had friends over, yeah, what else?) Um, I was, um, stuffed in a corner. (You were stuffed in a corner, yeah, what else can you remember?) I was in my bedroom. (In your bedroom, yeah.) And um . . . and um, during the hurricane, there was a window in my bedroom, and um, well we, I was stuffed in the corner and then we, then we, um, we had the [name of family] over and they, um, stayed at our house for a little bit longer after the hurricane. (Yeah, what else can remember about that?) Um, that they were sitting on the furniture and I wasn't.

Interview 2 (same child at 10 years old):

Okay. Um, I remember the hurricane was the day after my fourth birthday party. And we were scared. My grand-, grandparents came over. And our neighbors Sue and Terry. And it was me, my mom and my dad. And we were in my room and my grandparents were sleeping in my mom and dad's room. And I remember I had on, I sat, I wanted to go close to the window because we had a mattress over our window, because there's only one window in my room. And I sat and then this big lightening bolt came I was scared a lot and I remember half way through the night, part, a corner of our roof blew off. And our grandparents came and told us that it was off and we put two or three trashcans under it to catch it. And Terry, he had our little weather radio and he said he was sorry because there were no cartoons on, there was only weather about the hurricane. And I remember, I had my bed is in the corner of the room and about five feet before my closet and they made me, my mom and my dad made me stay there the whole night. Cause they were afraid if the window blew off, the mattress would hit me . . . And I was really scared because I had never been through anything like that, and um, I don't remember a lot.