

Arousal at Encoding, Arousal at Retrieval, Interviewer Support, and Children's Memory for a Mild Stressor

JODI A. QUAS* and HEATHER C. LENCH

University of California, Irvine, USA

SUMMARY

The relations among children's physiological arousal at encoding and retrieval, interviewer-provided social support and children's memory for a mild stressor were examined in 109 five- and six-year-olds. The children came to a research laboratory and watched a fear eliciting video clip. A week later, their memory for the video clip was tested by either a supportive or nonsupportive interviewer. While watching the video and completing the memory interview, children's heart rate was monitored. Increased heart rate at encoding was associated with fewer incorrect responses. In contrast, increased heart rate at retrieval was associated with poorer memory, but only when the interviewer was nonsupportive. Heart rate was unrelated to memory when the interviewer was supportive. Results suggest that arousal at encoding and retrieval have different implications for children's memory for a mild stressor, particularly in nonsupportive interview contexts. Copyright © 2006 John Wiley & Sons, Ltd.

For some time, there has been considerable interest in understanding how emotions, particularly negative emotions, affect mnemonic processes in children. This interest stems from theoretical questions concerning the effects of emotions on cognitive processes and applied questions concerning coping with stress, the development of trauma disorders, and the accuracy of children's eyewitness testimony. Although numerous researchers have examined the relations between negative emotions and memory in children, researchers have not concurrently taken into account children's arousal at both encoding and retrieval as separate predictors of memory. Nor have researchers considered how interviewer demeanour, specifically interviewer supportiveness, affects children's memory for stressful events, directly and also in conjunction with children's arousal. In the present study, we examined the relations between children's physiological arousal, both at encoding and retrieval, and their memory for fearful information. Of importance, we manipulated the interviewer's demeanour to investigate the extent to which variations in social support, in conjunction with children's arousal at retrieval, affect their memory.

Prior studies of emotion and memory in children have typically focused on how differences in children's 'arousal' or 'distress' relate to their memory. Results have revealed somewhat inconsistent findings. Although many researchers have reported

*Correspondence to: J. A. Quas, Department of Psychology and Social Behavior, University of California, Irvine, 3340 Social Ecology Building II, Irvine, CA 92697-7085, USA. E-mail: jquas@uci.edu

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negative associations (e.g. Bahrick, Parker, Fivush, & Levitt, 1998; Bugental, Blue, Cortez, Fleck, & Rodriguez, 1992; Merritt, Ornstein, & Spicker, 1994), a few researchers have found positive or no direct associations (e.g. Alexander et al., 2002; Goodman, Hirschman, Hepps, & Rudy, 1991; Vandermass, Hess, & Baker-Ward, 1993). Some inconsistencies in findings are likely due to methodological differences. For instance, across studies, the to-be-remembered events have ranged from mildly arousing laboratory incidents (e.g. Bugental et al., 1992; Peters, 1991) to highly distressing personal experiences (e.g. Peterson & Bell, 1996; Quas et al., 1999). It is difficult to compare findings when the to-be-remembered events vary substantially. Moreover, although studying children's memory for highly distressing events offers unique insight into how children recount some personal experiences, such events are difficult to control experimentally. Naturalistic events are also often not amenable to obtaining online assessments of children's arousal as the events unfold. Although laboratory events are not highly distressing, they can be controlled experimentally and can target specific emotions. In addition, children's emotional reactions can be monitored concurrent with the to-be-remembered event. Once the mechanisms contributing to children's memory for emotional events are identified via laboratory studies, the knowledge can be applied to other contexts to determine the generalizability of findings.

Another source of variability across studies concerns how arousal has been measured. Some studies have relied on observer or parent-report measures of distress, including parents' retrospective memory of how distressed their child was during a particular event (Goodman et al., 1991; Peterson & Bell, 1996; Quas et al., 1999). Such measures, although useful indicators of children's expressed distress, may not completely reflect children's experienced distress. For instance, children may mask their true feelings, parents may interpret children's behaviour incorrectly, or parents may not accurately remember their child's reactions. One method of overcoming these challenges is to rely on a third type of measure, namely physiological responses. Physiological stress responses, particularly autonomic arousal, can be measured noninvasively and reliably as an event is taking place. The magnitude of change in children's autonomic responses between a baseline event and stressor is taken as an index of their stress response (Boyce et al., 2001; Boyce & Jemerin, 1990; Porges, 2003). Arguably, young children cannot volitionally control their physiological arousal to the same extent that they might control overt expression of emotion. Thus, physiological measures can provide valuable insight into children's experienced distress during a to-be-remembered event, insight not possible with other measures of children's stress responses.

Studies of children's memory for stressful events that have included physiological measures have generally found that greater arousal is associated with poorer memory (e.g. Chen, Zeltzer, Craske, & Katz, 2000; Merritt, Ornstein, & Spicker, 1994). For instance, Peters (1991) assessed children's memory for a woman who entered a room when a fire alarm or radio sounded. Children who heard the alarm had significantly higher blood pressure and demonstrated poorer memory than did children who heard the radio. Bugental et al. (1992) similarly found a negative relation between heart rate and memory for a video of a child receiving an inoculation in 5-year-old children. Finally, Quas, Bauer, and Boyce (2004) interviewed children about a fire alarm incident shortly after it occurred. Greater arousal, as driven by the parasympathetic nervous system during a set of laboratory tasks, was associated with poorer memory of the alarm.

Despite a seeming convergence of evidence suggesting that physiological arousal is negatively related to children's memory, several important questions remain concerning

how to interpret this relation. For one, in the aforementioned studies, the memory interviews took place shortly after the to-be-remembered events. In general, fear evokes increased attention to the environment (Frijda, 1987; Scherer, 1999), and greater attention should enhance rather than inhibit memory. Some children, however, may still have been too aroused during the interview to be able to report the original information. That is, perhaps they had attended to the event but simply needed additional time for their arousal to decrease so that they could recount what happened. This possibility is consistent with Quas et al. (2004), who, as mentioned, found a negative association between parasympathetically driven arousal and memory for an alarm when the children's memory for the alarm was tested immediately after the alarm. However, this association was no longer significant when children's memory was tested a few weeks later.

Also, studies to date have rarely considered how children's arousal at retrieval may affect their memory. Yet, investigations of children involved in criminal proceedings suggest that arousal at retrieval (e.g. while testifying in mock or actual trials), including when measured via physiological indices, is negatively related to children's ability to communicate and positively related to children's memory errors (e.g. Goodman, Taub, Jones, & England, 1992; Nathanson & Saywitz, 2003; Saywitz & Nathanson, 1993). Accordingly, it is important to distinguish the effects of arousal at encoding from arousal at retrieval when evaluating children's memory for emotional events. By increasing the delay between the to-be-remembered event and memory test, it would be possible to investigate how arousal at each time point independently relates to children's memory.

Finally, the context at retrieval may influence children's willingness to recount prior experiences, including those that were distressing. Specifically, researchers have distinguished between highly supportive and nonsupportive interviewers (e.g. Carter, Bottoms, & Levine, 1996; Davis & Bottoms, 2002; Goodman, Bottoms, Rudy, & Schwartz-Kenney, 1991). Highly supportive interviewers build rapport, sit close to children, and are positive and encouraging. Nonsupportive interviewers, in contrast, do not build rapport, maintain eye contact, or smile. They also maintain a closed and formal body posture and do not foster warmth while interviewing children. Children may encounter non-supportive interviewers in an array of contexts, such as social interactions with adults who lack the time or emotional energy to engage a child; educational settings, especially those that concern disciplinary matters; or legal cases that involve adversarial parties. Children are often more complete and accurate in their memory reports and less suggestible when questioned by a high rather than low support interviewer (e.g. see Bottoms, Quas, & Davis, *in press*, for a review). A few researchers, however, have found that social support does not affect all children equally (e.g. Davis & Bottoms, 2002). Specifically, some children seem more easily perturbed by variations in interviewer demeanour than others. Quas et al. (2004) found that the effects of interviewer support depended upon children's physiological stress responses. In the study, 4- to 6-year-olds completed several challenging laboratory tasks, including the fire alarm incident already mentioned, during which their autonomic arousal was monitored. A few weeks later, children's memory of the tasks was tested. Children who were highly aroused physiologically during the tasks displayed poorer memory than did children who were less aroused. However, such a pattern was only evident among children questioned by the nonsupportive interviewer. Among children questioned by a supportive interviewer, general physiological arousal was unrelated to memory. Quas et al. (2004) interpreted their results as suggesting that children's arousal during the tasks did not affect how well they encoded the event. Instead, children who were aroused during the tasks were similarly

aroused at retrieval when questioned by the nonsupportive interviewer, and this greater arousal at retrieval precluded them from conducting an adequate memory search and answering the questions (see also Nathanson & Saywitz, 2003). However, Quas et al. did not actually measure arousal at retrieval. Thus, their interpretation remains speculative. By measuring arousal at retrieval under high and low interviewer support conditions, the mechanisms underlying the associations between arousal and memory in children can be better understood.

STUDY OVERVIEW

In the present study, 5- and 6-year-olds came to a research laboratory for a two-session study. During the first session, they watched a brief fear-eliciting video clip and completed a baseline activity while their heart rate was monitored. Following a week delay, children returned to the laboratory for a memory interview and second baseline activity. Again, their heart rate was monitored. The interview was conducted in either a warm and supportive or an emotionally unavailable and cold manner.

We had two main hypotheses. First, given that fear evokes increased attention to the environment (Frijda, 1987; Scherer, 1999), greater arousal during the fear video (i.e., at encoding) was expected to be positively related to memory. Second, an interaction between arousal at retrieval and social support was hypothesized. Specifically, children who were both highly aroused at retrieval and questioned by a nonsupportive interviewer were expected to evince poorer memory than highly aroused children questioned by a supportive interviewer and than less aroused children questioned by both a nonsupportive and supportive interviewer (Nathanson & Saywitz, 2003; Quas et al., 2004).

METHOD

Participants

One hundred and nine 5- and 6-year-olds ($M = 73.18$ months, range = 60 to 83 months), 56 males, served as participants. This age range was selected so that results could be directly compared to other studies of physiological arousal and memory in children, most of which have included similarly aged children. Fifty-nine per cent of the children were Caucasian, 8% were Hispanic nonCaucasian, 8% were Asian American, 5% were African American, and 18% were multiethnic. Most parents were married or in a long-term relationship (92%), made over \$60,000 a year (69%), and were fairly well educated (54% had at least a 4-year college degree). Five additional children completed both sessions but declined to wear the physiological monitoring equipment and were thus excluded (these children's memory did not vary from those who agreed to wear the equipment). Two additional children did not return for the second session, and two did not answer the video memory questions due to experimenter error. Finally, due to equipment malfunction or noise, between two and seven children across the two sessions were missing one or more of the physiological measures. Thus, the sample size varied slightly across analyses.

Families were recruited from a database of parents interested in research, advertisements at childcare facilities, a local marketing firm, and word-of-mouth. In exchange for participating, parents received an honorarium and children received a prize. One child per family participated.

Materials and procedure

Parents interested in research were contacted via phone and the study was explained. An initial session at a child development laboratory was scheduled for parents who wished to take part. The study was approved by the University of California, Irvine, Institutional Review Board.

Session 1

Upon arrival, the study was explained in detail, and parental consent and child assent were secured. Parents completed a brief demographics questionnaire concerning the child's age, ethnicity, gender, and the parent's education and income. The child was then escorted to a separate room where an adult male researcher was waiting (the parent observed the session via a two-way mirror). A female researcher who had already built rapport with the child introduced the physiological equipment, which consisted of a respirometer belt placed around the child's abdomen to obtain continuous respiration data and three spot electrodes connected to a BIOPAC MP100 (BIOPAC Systems Incorporated, Santa Barbara, CA). The electrodes were placed on the child's right clavicle, left rib cage, and above the waist to acquire an electrocardiograph (ECG) signal, from which heart rate and respiratory sinus arrhythmia (RSA, a measure of cardiac parasympathetic withdrawal) data were derived. These measures provide on-line information about children's emotional reactions as events unfold and have been used in prior studies of physiological arousal and memory in children (e.g. Bugental et al., 1992; Quas et al., 2004). RSA, which is an index of parasympathetically driven arousal versus regulation, did not relate to children's memory, a point to which we return in the Discussion.

Once the child was comfortable with the equipment, the female researcher left. The male researcher then administered a series of tasks that were mildly challenging to children. These included a working memory task, questions about their likes and dislikes, observing emotionally evocative video clips, and a story completion task. One of these tasks, the focus of the present study, required children to watch a 2-min video clip designed to elicit fear.¹ The fear video clip was selected on the basis of its emotional content, developmental appropriateness, and use in prior studies of physiological stress responses in children (e.g. Alkon et al., 2003). The video depicted four boys crossing a bridge when a train comes (scene from the movie, *Stand By Me*). The boys run to make it across the bridge before the train is upon them. The video was pilot tested on a separate group of 18 children (M age = 6.94 years, 44% female) who were asked to rate on 4-point face scales (1 = neutral to 4 = most intense) how happy, sad, angry, and fearful the story protagonists were. The

¹Because the television was brought out specifically to watch the videos, this portion of the laboratory experience was clearly differentiated from the other tasks. Moreover, children watched three videos, one sad, one happy and one fearful, each with different constellations of characters. The television was stopped before and after each clip, separated by explanations by the male researcher, enabling clear distinctions among the clips. Finally, the sad and happy videoclips did not as clearly target the appropriate discrete emotions as the fear video and thus are not considered further.

protagonists were rated as significantly more afraid, $M = 3.39$, than happy, sad, and angry, $M_s = 1.78, 1.89, 1.83$, indicating that children recognized the target emotion associated with the video.

At the start and end of the tasks, children listened to neutral stories. After the tasks were complete, the female researcher returned and removed the belt and electrodes. Once the child and parent were reunited, they were thanked, and the parent was asked to avoid discussion of the session until after the second session.

Session 2

Following a one-week delay ($M = 7.22$ days, range = 4 to 13 days), the parent and child returned to the laboratory. The second session was described to parents, which included explaining that their child would be interviewed by a warm, supportive interviewer or by a serious interviewer. This manipulation was not described to parents before the session to preclude them from preparing their child for the possibility of the nonsupportive interview. Parents were also shown the interview questions. All parents agreed to the second session interview and support manipulation.

Following parental consent, a female researcher escorted the child to a new location for the memory interview. Physiological equipment was placed on the child in a manner identical to that in the first session. The researcher read a neutral story.

Next, the interviewer, who the child had not met previously and was blind to the study's hypotheses, entered. She administered the memory interview in either the high or low support manner. In the high support condition, she introduced herself and sat down close to and facing the child. She built rapport for 2 min by asking the child questions about her/his day. Throughout the interview, she maintained an open body posture, smiled, maintained eye contact, and provided verbal encouragement at proscribed times. In the low support condition, the interviewer entered, and sat three feet from and next to the child. She did not introduce herself and quietly reviewed papers for 2 min. If the child spoke during this time, she briefly explained that she would begin in a few moments and returned to her paperwork. Throughout the interview, she maintained minimal eye contact, did not smile, and talked in a monotone voice. Although she asked for clarification when necessary, she did not provide any feedback to the child about her/his performance. This manipulation is based on studies of perceived support in interpersonal contexts (e.g. Mehrabian, 1969), has been used successfully in prior child eyewitness studies (e.g. Carter et al., 1996; Davis & Bottoms, 2002), and is noticeable to children (e.g. Quas et al., 2004). In this study, two raters, naïve to the manipulation, rated the behaviour of 14% of the interviews (randomly selected to include different interviewers in each condition) on a scale from 1 = very unsupportive to 4 = very supportive. The raters' scores were reliable ($\kappa = 0.81$) and differed only for two children and only by one point. Scores, collapsed across raters, significantly differed between the high, $M = 3.63$, and low, $M = 1.14$, support conditions, $t(13) = 9.62$, $p < 0.001$. Finally, no significant memory performance differences emerged within the high and low support interviewer conditions based on who the interviewer was.

In both the high and low support conditions, after the introductory 2 min, the interviewer explained that she needed to ask the child questions about the last time the child was at the laboratory, that the child should answer as best as possible, but the child could say 'I don't know' if the child forgot an answer. She then asked the memory interview questions, which included 78 questions about what happened during the entire previous session (see Quas, Papini, Wallin, Lench, & Scullin, 2005, for details). Of interest in this study were 10 questions that asked about children's memory of the fear video clip (see Appendix). At

the outset of questions about the videos, children were asked how many videos they saw. Children were then asked about each video in order of appearance.² The first question about the fear video asked children to freely recall what happened in the video. Children who answered, 'I don't know' ($n = 11$), were given a prompt corresponding to the emotional tone of the video ('it was a scary video'), and the free-recall question was repeated. These children's memory performance did not differ in amount or accuracy from the performance of children who did not receive the prompt, $t_s < 1.68$. Next were nine closed-ended questions about specific details of the video. The questions included an approximately equal number of 'yes', 'no,' and short-answer correct responses. Four questions were misleading in that they contained false embedded clauses or incorrect suppositions.

After the questions were complete, the interviewer left. The researcher returned and administered the Peabody Picture Vocabulary Test (PPVT)—IV. The PPVT is a widely used standardized test of receptive vocabulary understanding that provides age-equivalent scores reflecting individuals' vocabulary understanding level (Dunn & Dunn, 1997). It was included because children's verbal ability could affect their memory and ability to answer questions (Clarke-Stewart, Malloy, & Allhusen, 2004; Roebers & Schneider, 2005). Finally, the researcher administered the Video Suggestibility Scale for Children (VSSC). Results concerning children's performance on the other Session 1 study tasks and the VSSC are not relevant to the present study and are described elsewhere (Lench, Quas, & Edelstein, in press; Quas et al., 2005).

At the end of the session, the child was debriefed, including about the interviewer's demeanour. The child and parent were thanked, the parent was paid, and the child received a toy.

Coding

Physiological variables

The heart rate and respiratory sinus arrhythmia (RSA) data were collected during both sessions and were cleaned and edited for artifact using a custom software package, Mindware (Westerville, OH, 2002). Heart rate was calculated as the number of beats per minute. Four raw scores and two difference scores were computed from the data: In Session 1, children's minute-by-minute heart rate scores while they listened to the second neutral story were averaged to create raw baseline response scores. The second story was selected rather than the story read at the outset of the session because children may have been aroused in the beginning of the session due to the introduction of the novel physiological equipment.³ Children's heart rate during the second minute of the fear video was taken as an index of their encoding arousal. The emotional content was at its height during this

²None of the children confused the three videos during the memory interview. Children accurately answered three when asked how many videos they had seen, and none of their video descriptions contained any intrusions from the other videos. Children who were incorrect in the order of the videos' appearances were allowed to finish their description of each video and were then asked to describe 'the other' one(s) they saw.

³Due to equipment malfunction or noise, five children did not have heart rate data for the Session 1 Baseline story, and eight children did not have heart rate data during the Session 2 baseline story. Children's heart rate during the first and second stories that had been read in Session 1 (one at the outset of the activities, and one half way through the set of challenges) were highly correlated, $r = 0.92$. Thus, for the children missing Session 1 baseline, their first story heart rate was included. In Session 2, children's heart rate during the neutral portion of another video task in the second session was highly correlated with their Session 2 story baseline, $r = 0.91$. Thus, for the children missing Session 2 baseline, their heart rate during the video was included.

portion of the video (e.g. during the first minute of the video, the boys are walking on the bridge; the train appears at the end of the first minute), and thus the second minute was selected for inclusion. Two raw scores from Session 2 were also calculated, including a mean heart rate score averaged during the neutral story and a mean heart rate score during the first 2 min of the memory interview. Difference scores were calculated by subtracting children's baseline scores in each session from their video and interview scores, respectively. The Session 1 difference scores reflect children's autonomic arousal in response to the fear video (i.e. at encoding). The Session 2 difference scores reflect children's autonomic response to the memory interview (i.e. at retrieval).⁴ Adjusted difference scores (i.e. standardized residuals from regressing children's video and interview heart rate scores on their baseline scores) were highly related to the raw difference scores, $r_s > 0.97$, and results did not vary when they were included. For ease in interpretation, raw difference scores are reported here.

Memory measures

Children's responses to the free-recall question about the video were reliably coded for units of information, with units defined as words or phrases that provided unique information about the agent(s), actions(s) or object(s) associated with the video. For example, the statement, 'Boys, boys walked and there was a train' received three units (one each for 'boys,' 'walked,' and 'there was a train'). Two raters independently scored 18% of the children's data (across age, gender and social support condition). Proportion agreement was 0.89. Disagreements were discussed, and one coder scored the remaining data. Units were summed. The mean for units of incorrect information was 0.46. Due to lack of variability, incorrect units are not considered further.

Children's responses to the direct questions were coded as correct, incorrect, do-not-know or unscorable.⁵ Again, two independent coders scored 18% of the interviews. Kappas ranged from 0.70 to 1.00 (mean = 0.91). Once disagreements were resolved, one coder scored the remaining data. Proportions were computed by dividing the number of each type of response by the number of questions asked. Correct and incorrect proportions, although negatively correlated, $r(109) = -0.55$, were not the exact inverse of each other because of do-not-know (0.10 proportion) and unscorable (0.01 proportion) responses. Only correct and incorrect proportions are considered further.

RESULTS

Preliminary analyses investigated potential confounds, associations among the physiological measures, and differences in children's physiological responses as a function of the

⁴Children's heart rate score at retrieval was obtained during the first 2 min of the memory interview, which included questions about children's memory for the entire prior session. We reconducted our analyses to ensure that our findings concerning associations among arousal at retrieval, social support and memory remained when children's arousal specifically while talking about the fear video was considered. In these analyses, we selected only children who began answering questions about the fear video early in their interviews ($n = 27$). The direction and magnitude of the findings remained identical to that reported in the text, although the smaller sample size reduced the power to detect significant differences.

⁵Children responded to misleading and nonmisleading questions during the interview. These questions were combined for the purpose of this investigation. Separate analysis of misleading and nonmisleading questions yielded similar trends.

Table 1. Means and standard deviations (*SD*) of key study variables

Variable	Mean	<i>SD</i>	N
Child Demographics			
PPVT age equivalent in months	79.92	12.53	106
Session 1 Physiological Responses			
Baseline story heart rate	91.52	10.25	108
Fear video heart rate	92.85	11.24	103
Video heart rate difference score	0.97	7.24	103
Session 2 Physiological Responses			
Baseline story heart rate	95.00	10.74	108
Interview heart rate	99.01	10.71	106
Interview heart rate difference score	3.74	4.37	105
Memory Performance			
Free-recall units of correct information	6.73	5.71	109
Direct question proportion correct responses	0.53	0.18	109
Direct question proportion incorrect responses	0.34	0.17	109

Note: The *ns* varied slightly due to equipment failure or administration errors.

interview support manipulation. The main analyses examined the independent and combined associations of children's arousal at encoding, arousal at retrieval, and social support with their memory. Table 1 presents the means and standard deviations for the primary variables of interest.

Preliminary analyses

Potential confounds included the delay between sessions and children's gender, age and receptive vocabulary. No significant differences emerged between children interviewed in a high versus low support manner in the delay between sessions, age or PPVT, $t(104-106) < 1.86$, *n.s.* Nor did children in the two interview conditions differ in their Session 1 heart rate difference scores, $t(101) = 0.80$. Correlations revealed first that the delay between sessions was not related to children's memory performance and second that children's age was unrelated to their physiological responses or memory, *rs* ranged from -0.07 to 0.19 , $dfs = 102-109$. Also, individual *t*-tests revealed that gender was not related to children's encoding or retrieval arousal or memory performance, $t(101-108) < 1.58$. Children's age-equivalent PPVT scores were correlated with their age, $r(107) = 0.29$, and their arousal during the fear video, $r(100) = 0.25$, $p < 0.01$, but not with their memory. Because the age range of children in the sample was more restricted than children's PPVT scores (see Table 1), and because children's PPVT scores were related to their arousal, PPVT and not age was controlled statistically in subsequent analyses.

Next, we examined the consistency of children's physiological arousal. Within and across sessions, children's raw baseline and video heart rate scores were highly correlated, *rs* ranged from 0.56 to 0.92 , $ps < 0.001$. However, children's video difference scores in Session 1 were unrelated to their interview difference scores in Session 2, $r(99) = -0.01$. Nor was this correlation significant when children in the high and low support conditions were considered separately, $rs = -0.12$ and 0.06 and $dfs = 54$ and 45 , respectively. Thus, although children's absolute heart rate levels were consistent over time, their discrete reactions to the two different stressors, specifically the video and interview (especially that conducted by a nonsupportive interviewer), were not. In other words, children who were

highly aroused while watching the video were not necessarily also aroused during the memory interview.

Finally, an independent samples *t*-test comparing children's interview heart rate difference scores between those questioned by a high versus low support interviewer revealed no significant differences, $t(103) = -0.30$. Mean heart rate difference scores were 3.87 ($SD = 4.66$) and 3.61 ($SD = 4.07$) for children in the high and low support conditions, respectively. Although we expected children in the low support condition to exhibit larger changes in their heart rate responses due to the interviewer's behaviour, the lack of significant differences in heart rate between children in the two support conditions may well have been due to the talking that took place in the rapport-building phase among children in the high support condition, which can also increase heart rate (e.g. Alkon et al., 2003), albeit for different reasons than simply increased arousal.

Physiological arousal, social support, and memory for emotional information

The main goal of this study was to examine the effects of arousal at encoding and retrieval, in combination with interviewer demeanour, on children's memory for fearful information (see Table 2 for the bivariate correlations between the physiological and memory variables). To address this goal, three hierarchical linear regressions were conducted.

Specifically, the memory measures (i.e. correct units of free recall, and direct question proportion correct and incorrect) were entered into separate regressions. On the first step, children's PPVT age equivalent scores, video heart rate difference scores, memory interview difference scores and social support condition (0 = low, 1 = high) were entered. Two interaction terms: video difference scores \times support condition and memory interview difference scores \times support condition, were entered on the second step to test our hypotheses that children highly aroused at retrieval would be more strongly affected by variations in interviewer demeanor than would less aroused children (variables were centred prior to their inclusion in the regressions). The model predicting free-recall was nonsignificant at both steps, $F(6, 90) = 0.60$ (step 2).

When children's proportion correct responses were examined, the model approached significance (Table 3). The interaction between children's memory interview arousal and

Table 2. Correlations between the physiological arousal and memory variables (dfs ranged from 103–109)

	Memory Performance		
	Free Recall	Proportion Correct	Proportion Incorrect
PPVT age equivalent	0.11	0.16	-0.14
Video heart rate difference score	0.09	0.14	-0.27*
Interview heart rate difference score	-0.03	-0.14	0.10
Support (0 = low, 1 = high)	-0.13	0.09	-0.18 ^t

^t $p < 0.10$; * $p < 0.01$.

Note. Free recall was scored for units of correct information. The direct questions were scored as correct, incorrect, do-not-know or unscorable, with proportion scores reported here. The difference scores were computed by subtracting children's heart rate during the video or interview from their heart rate during each session's baseline activity.

Table 3. Results of regressions predicting children's correct and incorrect responses to direct questions

	Memory Performance			
	Correct Proportion		Incorrect Proportion	
	Step 1	Step 2	Step 1	Step 2
Model Statistics				
F	2.26 ^t	2.12 ^t	3.36**	3.55**
Df	4, 92	6, 90	4, 92	6, 90
Adjusted R ²	0.09	0.12	0.13	0.19
Predictors				
	Standardized Betas			
PPVT age equivalent	0.16	0.16	-0.12	-0.12
Video heart rate difference score	0.12	0.12	-0.23*	-0.23**
Interview heart rate difference score	-0.14	-0.14	0.10	0.12
Support (0 = low, 1 = high)	0.17 ^t	0.16	-0.20*	-0.19 ^t
Video difference score × support Interaction	—	-0.07	—	0.09
Interview difference score × support interaction	—	0.17 ^t	—	-0.24**

^t $p < 0.10$; * $p < 0.05$; ** $p < 0.01$.

Note: The direct questions were scored as correct, incorrect, do-not-know or unscorable, with proportion correct and incorrect responses reported. The heart rate difference scores were computed by subtracting children's heart rate during the video (encoding) or interview (retrieval) from their heart rate during each session's baseline activity.

social support was marginally related to correct responses. Two subsequent regressions conducted separately for children in the high and low support conditions examined the interaction further. Predictors included children's PPVT scores and their video and memory interview difference scores. When only children questioned by the supportive interviewer were considered, arousal was unrelated to their proportion of correct responses, $F(3, 49) = 0.57$. When only children questioned by the nonsupportive interviewer were considered, however, greater arousal during the memory interview was associated with children providing fewer correct responses, $\beta = -0.33$, $p < 0.05$, $F(3, 40) = 3.27$, $p < 0.05$.

Next, children's proportion incorrect responses were entered as the dependent measure into the full regression analysis. Results were similar to and more robust than those for proportion correct responses: both children's arousal during the video and the interaction between their memory interview arousal and social support significantly predicted their memory errors. As evident in Table 3, on the first step, higher heart rates while watching the fearful video, that is, at encoding, were associated with fewer errors. Also, children questioned by a supportive interviewer provided fewer incorrect responses than did children questioned by a nonsupportive interviewer. This latter effect, however, was subsumed in step 2 by a significant interview arousal by support interaction, step 2 $r^2\Delta = 0.06$, $p < 0.05$.

The interaction, plotted in Figure 1, was analysed further by conducting follow-up regressions separately for children in the high and low support conditions (predictors included children's PPVT scores and their video and interview heart rate difference scores). As hypothesized, among children questioned by a supportive interviewer, arousal

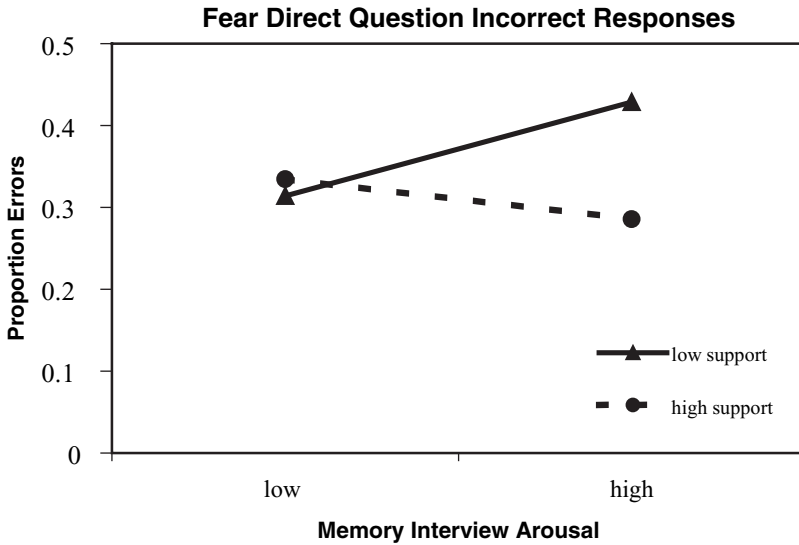


Figure 1. Children's proportion errors to direct questions about the fear video as a function of their arousal during the interview and interviewer support. The end points on the lines correspond to one standard deviation above and below the mean on children's arousal difference scores

at retrieval was unrelated to the number of errors children provided to direct questions, $F(3, 49) = 0.98$. However, among children questioned by a nonsupportive interviewer, greater arousal at retrieval was associated with increases in the number of errors, $\beta = 0.34$, $p < 0.05$, $F(3, 40) = 4.75$, $p < 0.01$. Stated another way, as is evident in Figure 1, the greatest numbers of memory errors were made by children who were highly aroused during the memory interview and questioned by a nonsupportive, cold interviewer.

DISCUSSION

The goals of our study were twofold: to examine relations between arousal at encoding and retrieval and children's memory for a mild stressor, and to determine whether arousal interacts with social context to affect children's memory. Results revealed that arousal at encoding and retrieval had different implications for children's memory, as did the supportiveness of the environment in which children were interviewed. Next, we discuss these trends in greater detail, focusing on their implications for theories concerning emotions and memory in development.

Both of our hypotheses concerning the relations among arousal, support and memory were supported, at least in part. As expected, physiological arousal at encoding was positively related to children's memory, although only when children's direct question performance was considered. Increased heart rate during the fear video was associated with children providing fewer incorrect responses to direct questions. In other words, 'stress,' as indexed via larger heart rate changes at encoding, was positively related to performance. Such a finding is consistent with some former studies in children (e.g. Alexander et al., 2002; Goodman, Hirschman et al., 1991) and studies of arousal and memory in adults (e.g.

see Hamann, 2001; McGaugh, 2000), including those that examined adults' heart rate in relation to their memory of distressing video clips (e.g. Holmes, Brewin, & Hennessey, 2004). The arousal children experienced as a result of the fear-eliciting information may have heightened the salience of information, leading to better encoding of specific details. Fear may have further directed children's attention to the video's content to determine how the protagonists would respond, and increased attention should enhance encoding and later memory. As an aside, the fact that arousal was unrelated to children's free recall suggests that all children encoded some information about the video. When children were able to select what information they wished to recount, all children could describe, on average, a comparable amount of details. It was only when direct questions probed for particular information that children's arousal differentially predicted their performance.

In contrast to our results, some studies have reported negative relations between children's autonomic arousal and memory for mildly arousing information (e.g. Bugental et al., 1992; Peters, 1991; Quas et al., 2004). However, such patterns have primarily emerged when children's memory was tested shortly after the to-be-remembered event occurred, not when children's memory was tested later. Children who were particularly aroused during the to-be-remembered event may still have been aroused when attempting to answer the memory questions and thus not had adequate resources available to conduct a comprehensive memory search. Results of Quas et al. (2004) are consistent with such a possibility. In that study, children who were chronically aroused during a series of laboratory challenges evinced poorer memory for a fire alarm shortly after it occurred, but not a few weeks later. When the longer delay ensued, children who had been chronically aroused at encoding exhibited better memory when the interviewer was supportive than nonsupportive, whereas children who had not been chronically aroused were unaffected, in terms of memory performance, by interviewer demeanour. Moreover, because the aroused children performed comparably to the nonaroused children when the interviewer was supportive, the aroused children had in fact encoded the original event as well. During the initial interview, the former children had been either unwilling or unable to recount what happened. It was only after the delay, and with considerable support, that they were able to engage in the memory interview. Quas et al. speculated that children who were chronically aroused at encoding were similarly aroused at retrieval when the interviewer was nonsupportive, and that this arousal at retrieval inhibited their memory performance. However, retrieval arousal was not actually assessed. Unlike Quas et al., in the present research, we were able to distinguish empirically the differential associations between arousal at encoding versus retrieval and children's memory.

According to our results, arousal at retrieval appeared to have a different effect on memory than arousal at encoding. As predicted, greater arousal was associated with reduced accuracy in the nonsupportive condition but was unrelated to memory in the high support condition. Saywitz and Nathanson (1993; see also Nathanson & Saywitz, 2003) similarly found that children were more accurate in recounting a play event when their memory was tested in a classroom rather than courtroom. The classroom setting was more familiar to children, who rated it as less intimidating and were less anxious as measured via heart rate responses compared to children in the court setting. Further, among children in the courtroom, increased arousal, as assessed both via self-report and heart rate, was associated with reduced accuracy to direct questions about the play event. Thus, not only was the courtroom arousing to some children, but also their increased arousal inhibited memory or at least performance. The increased arousal may have reduced children's ability to focus adequately and answer the memory questions or may have led children to be

unwilling to answer the questions. It will be important, in the future, to determine which of these possibilities better accounts for the negative associations we and others have observed between children's arousal at retrieval and memory in nonsupportive contexts.

As a final note, although our results are largely consistent with those reported in Quas et al. (2004), several important differences also emerged. For one, Quas et al. measured children's arousal at encoding only and included three separate measures: one indexing chronic sympathetic activation, one indexing chronic parasympathetic withdrawal, and one that combined sympathetic and parasympathetic reactivity. In the initial interview, children's chronic parasympathetic arousal was negatively related to their memory for the fire alarm. In the second interview, the combined index of chronic arousal or reactivity at encoding interacted with interviewer demeanour to affect children's memory. In the present study, we measured children's arousal at both encoding and at retrieval via parasympathetic withdrawal and heart rate. Unlike Quas et al., we failed to uncover significant associations between children's parasympathetic withdrawal and memory, although our measure focused on children's discrete responses to the fear video rather than their more chronic parasympathetic responses. Moreover, in the current study, children's heart rate (which can itself be influenced by both sympathetic activation and parasympathetic withdrawal) predicted memory. Chronic versus discrete stress responses may not be tapping identical underlying processes and may have different implications for memory (see Quas, Carrick, Alkon, Goldstein, & Boyce, *in press*). Specifically, chronic arousal may reflect more problematic emotion regulatory difficulties, whereas shorter-term discrete responses may reflect appropriate reactions to novel, potential stressors in the environment. Subsequent research will need to take into account not only the context within which children are asked to retrieve former experiences, but also the type of to-be-remembered event and how arousal is measured and defined when assessing the relations between physiological arousal and memory.

Limitations and conclusions

Although our results highlight the importance of arousal and social context as joint predictors of children's memory for fearful information, caveats must be mentioned. First, the age range of the sample was restricted. This reduced potential for age-related changes in children's physiological responses to emotional events (e.g. Alkon et al., 2003) and age-related differences in relations between emotion and memory (e.g. Bugental et al., 1992; Quas et al., *in press*) to influence our results. It will be important to evaluate how the associations between stress and memory, particularly in conjunction with social context, change developmentally.

Second, our procedures, like most studies of emotion and memory in adults (e.g. Cahill, Gorski, & Le, 2003; McGaugh, 2000), involved testing children's memory for a mildly arousing video that they watched. Deffenbacher and colleagues (e.g. Deffenbacher, 1994; Deffenbacher, Bornstein, Penrod, & McGorty, 2004) have argued that, at especially high levels of cognitive anxiety and physiological arousal, stress has a debilitating effect on memory. Although the evidence cited for such a possibility was stronger in adults than in children (e.g. Deffenbacher et al., 2004), it is important to note that our findings may not generalize to highly distressing, personal experiences. Systematic investigations of children's physiological stress responses and memory for multiple emotional laboratory and naturalistic events are needed to clarify when and how physiological responses relate to memory.

Third, in the present study, children's sympathetic responses were not measured. Yet, such responses may have unique implications for memory that vary from those associated with parasympathetically driven arousal. For instance, sympathetically driven arousal, typically associated with the fight-flight response, may well direct attention toward threatening or fear-inducing information, possibly leading to greater encoding and later memory for a stressful event (see Quas et al., in press). Because children's sympathetic and parasympathetic systems often respond independently during laboratory tasks (e.g. Boyce et al., 2001), continued research is needed to determine how children's responses across multiple systems relate to their memory.

In closing, findings from this study, in conjunction with other, ongoing research, will continue to elucidate how arousal and social context affect children's encoding and retrieval of discrete emotional information. Such knowledge will enhance understanding not only of the role emotions play in children's emerging cognitive processes but also of how children differentially attend to and remember distressing emotional information over time.

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APPENDIX

FEAR VIDEO MEMORY INTERVIEW

Free Recall

Tell me what happened in the video.

Direct Questions

1. How many boys were there?
2. The boy in the front fell when they were running, didn't he? (Misleading)
3. Why did the train stop on the bridge? (Misleading)
4. Was one of the boys running with a stick?
5. None of the boys had any trouble when they were running across the bridge, isn't that right? (Misleading)
6. Did one of the boys see the smoke from the train?
7. Why did the boys decide to go across the bridge?
8. Did all four boys run across the bridge?
9. Did the boy who was really scared get a hug from his mom in the end? (Misleading)