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Memory Narrowing in Children and Adults

ELIZABETH B. RUSH, JODI A. QUAS* and ILONA S. YIM

Department of Psychology and Social Behavior, University of California, Irvine

Summary: The memory narrowing effect posits that stress enhances memory for central information at the expense of memory for peripheral details. This effect is well established in adults, but not in children, although studies have not directly compared children's and adults' memory for central versus peripheral details of an identical distressing experience. In the present study, 9–12 year-old and adult participants completed a laboratory stressor during which measures of self-reported stress was collected. Two weeks later, participants returned for a surprise memory test regarding central and peripheral details of the laboratory stressor. Greater stress predicted memory narrowing in both children and adults, as indexed via decreased correct responses and increased don't know responses to questions about peripheral relative to central details. Findings have implications for theories concerning stress and memory, particularly in children, and for evaluating eyewitness memory in legal contexts. Copyright © 2010 John Wiley & Sons, Ltd.

One of the more widely cited phenomena in studies of emotion and memory is that of memory narrowing: Emotional arousal enhances memory for central details of a stressful experience at the expense of memory for peripheral details. Memory narrowing is well established in adults (see Christianson, 1992; Reisberg & Heuer, 2004). However, few studies have tested memory narrowing in children, and results have been inconsistent. Moreover, studies have not directly compared memory narrowing between children and adults. Without such a comparison, it is not possible to disentangle whether methodological or developmental differences underlie the inconsistent patterns in children relative to adults. It is our contention that memory narrowing should differ between children and adults, primarily as a result of developmental changes in emotion regulation, coping, and memory abilities. To test this possibility, we exposed 9- to 12-year-olds and 18- to 25-year-olds to an identical, mildly arousing laboratory event. Of primary interest was whether, with increasing levels of stress, memory for central information increased while memory for peripheral information decreased, and whether the magnitude of these changes varied between children and adults.

Before discussing empirical evidence relevant to our research, it is important to define what we mean by 'central' and 'peripheral' information. Prior studies have distinguished the two types of information in several different ways (e.g. Laney, Campbell, Heuer, & Reisberg, 2004; Loftus & Burns, 1982; Reisberg & Heuer, 2007), for instance, in terms of gist *versus* details (e.g. Cahill, Gorski, Belcher, & Huynh, 2004) or whether information is attention grabbing or not (see Levine & Edelstein, 2009, for a review). Among the definitions, the most well known and theoretically salient was articulated by Christianson (1992), who postulated that central and peripheral information differ in the degree to which they are related to the actual *cause* of the stress (see also Brierley, Medford, Shaw, & David, 2007; Mather, 2007; Quas, Goodman, Ghetti, & Redlich, 2000). Central information is directly related to the cause of the stress, while peripheral information is not. Thus, both central and peripheral features may include actions, people, or objects; what differs is their degree of relatedness to the actual experience of distress in the individual.

Turning to empirical research concerning memory narrowing, most studies with adults have taken one of two general approaches to investigate the phenomenon. One involves assessing memory for negative emotional stimuli in a laboratory context, such as memory for slides that vary in whether a critical scene shows a violent act (e.g., a woman lying next to a bicycle with a serious injury) or shows a comparable, but emotionally neutral act (e.g. the same woman simply riding the bicycle). Participants who view the emotional or violent version tend to remember central details of that scene better than peripheral details, whereas participants who view a scene without the violence tend to have superior memory for peripheral details (Burke, Heuer, & Reisberg, 1992; Christianson & Loftus, 1991). Researchers have used similar types of stimuli to demonstrate the occurrence of weapon focus: Individuals who view a weapon remember details of the weapon (which presumably reflect central details) at the expense of other details in the slides (Kramer, Buckhout, & Eugenio, 1990; Steblay, 1992).

Because viewing emotionally evocative images is unlikely to elicit the especially high levels of personal distress that theoretically would lead to the strongest occurrence of memory narrowing, some researchers have taken a second approach and studied adults' memory for naturally occurring, highly distressing experiences, such as violent crimes. Victims and witnesses report and retain memory for actions and weapons very well, but have more difficulty remembering details of the surrounding circumstances (Christianson & Hubinette, 1993, Yuille & Cutshall, 1986, 1989). Of course, with actual crimes, the actual accuracy of victims' and witnesses' reports of former crimes may not be verifiable, but the evident trends in the types of details reported are consistent with memory narrowing and findings from laboratory studies.

*Correspondence to: Jodi A. Quas, Department of Psychology and Social Behavior, University of California, 4201 Social and Behavioral Sciences Gateway, Irvine, CA 92697-7085, USA. E-mail: jquas@uci.edu

Of note, a few studies have reported that stress impairs memory even for seemingly 'central' aspects of a to-be-remembered event, such as what the perpetrator looked like (e.g. Morgan et al., 2004; see Deffenbacher, Bornstein, Penrod, & McGorty, 2004 for a review). However, these studies did not explicitly test the links between stress and memory for central and peripheral information. Thus, it is still possible that variability in stress responses was differentially related to memory for central and peripheral information: Enhancing memory for the former *relative* to the latter.

As mentioned, far fewer studies have focused on memory narrowing in children, although numerous studies have examined the associations between stress and memory generally across childhood. Findings, however, still vary, with some results suggesting stress is beneficial to children's memory (e.g. Quas, Goodman, Bidrose, Pipe, Craw, & Ablin, 1999; Alexander, Goodman, Schaaf, Edelstein, Quas, & Shaver, 2002), and others suggesting that stress is either unrelated or negatively related to children's memory (e.g. Bugental, Blue, Cortez, Fleck, & Rodriguez, 1992; Merritt, Ornstein, & Spicker, 1994). Some of the discrepant findings may be attributable to whether memory was tested for central rather than peripheral information, with positive effects of stress emerging when memory was tested for information causally related to the stress (e.g. Goodman, Hirschman, Hepps, & Rudy, 1991; Lindberg, Jones, & McComas-Collard, 2001), and negative effects emerging when memory was tested for information unrelated to the cause of the stress (Peters, 1991).Yet, the central-peripheral distinction does not account for all discrepant findings in the developmental literature, and some studies have failed to uncover differential associations between stress and memory for central *versus* peripheral information (e.g. Peterson & Bell, 1996; Vandermaas, Hess, & Baker-Ward, 1993). However, the events themselves often varied between children, and characteristics other than stress (e.g. event duration, salience of video *versus* live experience) may have affected memory. Also, young children may differ from older children and adults in what they perceive as the cause of the stress (see Quas et al., 2000), making it difficult to compare findings across studies with widely varying age ranges.

In order to evaluate, in a systematic manner, memory narrowing in children, a controllable to-be-remembered event that reliably elicits stress responses is needed. Further, this event should be similarly arousing between children and adults so that comparisons across age can be made. With such an event, it is possible that, not only would memory narrowing emerge in children, but it may actually do so more robustly than in adults. That is, although older children evidence considerable improvements relative to younger children in their mnemonic abilities, even older children exhibit deficits in memory strategy use relative to adults and older children still require additional assistance from others to facilitate their ability to recount information (Dietze & Thomson, 1993; Roebers & Schneider, 2000; Wood, Willoughby, McDermott, Motts, Kasper, & Ducharme, 1999). Children are also more limited than adults in the range of complex emotion regulation strategies they employ when faced with stress or challenge (Amirkhan & Auyeung, 2007; Compas, Connor-Smith, Saltzman, Thomsen, & Wadsworth, 2001; Skinner & Zimmer-Gembeck, 2007), and even adolescents are not as competent as adults in emotion regulation. Both of these factors may differentially influence how children and adults encode and hence recount emotional information. Further, insofar as children do not understand emotional events as well as adults, especially subtle or peripheral components, they may not attend to or encode these aspects as well. And finally, when arousal is high, children may need to devote more resources to regulating this arousal at the expense of attending to environmental information, especially that which is unrelated to the cause of that arousal.

It is difficult to design a study that directly tests for age differences in the associations between stress and memory, including age differences in memory narrowing. Few to-be-remembered events are equally stressful and appropriate for use across age. With age, the amount of stress experienced or displayed during particular events changes because of age-related differences in knowledge and experience with stressful events and in knowledge of appropriate emotional display rules (e.g. Chen, Zeltzer, Craske, & Katz, 2000; LeBaron & Zeltzer, 1984; Saarni, 1979; Peterson & Bell, 1996; Vandermaas et al., 1993). It is also not appropriate to show children some of the highly emotional images included in studies with adults, given the graphic nature of the images (Burke et al., 1992; Loftus & Burns, 1982; Wessel & Merckelbach, 1997). Finally, as mentioned, with age, what is considered central may actually vary. What is needed, therefore, is a controllable stressful experience that is comparably understandable and arousing to children and adults. One such experience is the modified Trier Social Stress Test (TSST, Kirschbaum, Pirke, & Hellhammer, 1993; TSST-M, Yim, Quas, Cahill, & Hayakawa, 2010), which requires participants complete a speech and mental arithmetic task in front of unfamiliar observers. The TSST reliably induces physiological and behavioural stress responses in adults and children ages 9 and older (e.g. Buske-Kirschbaum, Jobst, Wustmans, Kirschbaum, Ruah, & Hellhammer, 1997; Federenko, Nagamine, Hellhammer, Wadhwa, & Wüst, 2004; Gordis, Granger, Susman, & Trickett, 2006; Yim et al., 2010). It is also controllable, and an objective record of the event is available. By comparing children's and adults' memory for the TSST, so long as the children are old enough to be aware of and concerned about self-presentation and social acceptance (e.g. Banerjee, 2002; Bennett & Gillingham, 1991; Steinberg, 2008), key stress-inducing components of the TSST-M (Dickerson & Kemeny, 2004), insight into age differences in memory narrowing can be gleaned.

In the current study, 9-12 year-olds and 18-25 year-olds came to a laboratory and completed the TSST-M as part of a large project concerning stress physiology and memory (Quas, Yim, Edelstein, Cahill, & Rush, in press; Yim et al., 2010). After a 2-week delay, they returned for a surprise memory test that included questions about central and peripheral details of the TSST-M. Of interest was whether memory narrowing occurred with increasing stress, and if so, whether the magnitude of this increase varied between the age groups.

Several hypotheses were advanced. First, we expected age related improvements in memory. Although older children can perform as well as adults when answering recognition-type questions (e.g. Cassel & Bjorklund, 1995; Goodman & Reed, 1986; Leippe, Romanczyk, & Manion, 1991; Parker & Carranza, 1989, Shapiro, Blackford, & Chen, 2005), the complexity and novelty of the to-be-remembered event, combined with adults' greater general knowledge (Bjorklund, 1987; Chi & Ceci, 1987, Lindberg, 1980; Schneider & Bjorklund, 1998), was expected to lead to their better memory overall. Second, we predicted that central information would be better recalled than peripheral information, again consistent with prior research (e.g. Goodman et al., 1991, Peterson & Bell, 1996, Roebers & Schneider, 2000; Shapiro et al., 2005). Third, and more specific to memory narrowing, we hypothesized that stress would be positively related to memory for central information but negatively related to memory for peripheral information (e.g. Christianson, 1992), and that this pattern would be more robust in children than adults given the former's more limited knowledge and coping abilities (Compas & Boyer, 2001; Lindberg, 1980; Skinner & Zimmer-Gembeck, 2007).

METHOD

Participants

Participants included 28 children (16 male), ages 9–12 ($M = 10.68$ years), and 30 adults (13 male), ages 18–23 ($M = 19.87$ years). Among children, 78.6% were non-Hispanic white, 7.1% were Asian, 3.6% were Pacific Islander and 10.7% were multiethnic. Among adults, 30% were non-Hispanic white, 30% were Asian, 20% were Hispanic or Latino and 20% were multiethnic or other. Parents of participants were well educated: 60% of mothers and over 70% of fathers had at least a college education. Children were recruited from a database of families interested in research. Adults were recruited from the university social science subject pool.

Materials and procedures

Session 1

As mentioned, participants included in the current study were taking part in a larger project concerning stress physiology and memory. Only aspects relevant to the current study are described here (see Quas et al., in press; Yim et al., 2010 for details concerning the larger project). Upon arrival, a researcher explained the study in detail to parents and participants and obtained adult and parental consent and child assent. Participants were taken by the researcher to a quiet room for a 20-minutes period where they completed background questionnaires.

The Participants were then escorted to a second room where a male and a female observer in white lab coats were waiting. The researcher introduced the TSST-M: Participants would be asked to give a 6-minutes speech in which they should pretend to be a new student in a class, introduce themselves, and explain why they would be a good and popular student. Participants were further asked to include at least one positive and one negative characteristic about themselves and were informed that they would be videotaped and the tapes would be analysed later by experts. The researcher then left, and participants had 3 minutes to prepare.

After the 3-minute preparation, the male observer turned on the video camera and asked participants to stand and give their speech. If participants stopped speaking before the 6 minutes were up, the male observer asked scripted open-ended questions for the remainder of the time. At the end of 6 minutes, the female observer introduced a math task, which involved subtracting 5 (for children) or 13 (for adults) from 1027 out loud as quickly and accurately as possible. The math task lasted for 4 minutes. When participants made a mistake, the female observer asked them to start again from the beginning. Throughout the session, observers took notes, maintained a neutral, monotone stance, and did not smile or give any nonverbal or verbal feedback (see Yim et al., 2010 for details).

After the math task, participants returned to the first room and filled out several questionnaires, one of which asked participants to rate their how stressed they felt during the TSST-M on a scale from 1 (Not at all) to 7 (Extremely),[1] followed by additional filler-tasks unrelated to the current report. At the end, participants were thanked and the researcher explained that the next session would involve different activities. Parents were asked not to discuss the session with their children.

Session 2

After a 2-week delay ($M = 14$ days, range = 11–20 days) participants returned for the memory interview, which took place in a different building than the first session. Additional parental and participant consent and assent were obtained.

Participants were taken to a new room where a female interviewer unfamiliar to the participant and blind to the study's hypotheses was waiting. She built rapport for a few minutes and then began the memory interview, which consisted of a free-recall portion and direct questions. The free-recall prompts included: 'Tell me everything you remember about what happened when you visited the other building two weeks ago', and 'tell anything else you remember'. Direct questions asked about a range of details concerning the prior session, and included similar numbers of questions requiring yes, no, and short answer responses to control for response biases. An approximately equal number

[1]Salivary cortisol was collected as part of the larger study throughout Sessions 1 and 2. Changes in salivary cortisol across the first session were not differentially related to memory for central *versus* peripheral information specifically for the TSST. However, cortisol trajectories were positively related to participant's memory for the entire laboratory visit (Quas et al., in press). Participants' behaviours during the TSST-M were coded from videotapes for indicia of anxiety or stress using items adapted from the Preschool Observational Scale of Anxiety (POSA, Glennon & Weisz, 1978). Children displayed a greater number of anxious behaviours than did adults (see Yim, Quas, Cahill, & Hayakawa, 2010), but such behaviours were unrelated to memory for central and peripheral information in both children and adults.

of the direct questions asked about central (e.g. 'When you had to say something negative about yourself in your speech, what did you say?') and peripheral (e.g. 'Was there a telephone in the room?') details regarding the TSST-M procedures. Participants were asked all direct questions, regardless of the content of their free-recall reports.

After the interview, participants were thanked and debriefed. They were informed of our interest in emotional responses and memory, that the TSST was designed to be challenging, and that most individuals experience distress during the procedure. Finally, child participants were paid for their participation, and adult undergraduates were provided with course extra credit.

Coding

To score participants' free-recall responses, a checklist was created describing 29 factual features of the TSST-M. Undergraduate research assistants with experience serving as TSST-M observers rated each feature on the extent to which it was related to the cause of participants' stress on a 5-point scale (1 = very unrelated, 5 = very central). Nineteen features had mean ratings above the midpoint on the scale, $M = 4.30$, and were thus considered central (e.g. math task, had to say something positive/negative during the speech). Ten features had ratings below the midpoint of the scale, $M = 2.50$, and were thus classified as peripheral (e.g. stated name and grade, were given feedback at the end). Because performed actions are remembered better than observed actions (Baker-Ward, Hess, & Flannagan, 1990; Tobey & Goodman, 1992), care was taken to ensure that both central and peripheral features included action as well as non-action items. Participant's free recall narratives were reviewed, and the number of central and peripheral features mentioned was counted. These were averaged to create scores reflecting the proportion of central and peripheral TSST-M features reported.

Sixteen direct questions asked about details of the TSST-M. Using the same rating procedure described above, undergraduate research assistants rated nine questions as being 'central' (i.e. ratings fell above the midpoint of the scale, $M = 3.95$; e.g. 'What questions did they ask during the speech part?'). Seven questions were classified as 'peripheral', (i.e. ratings fell below the midpoint of the scale, $M = 2.15$; e.g. 'Were there pictures of flowers on the walls?'). Participants' responses were coded as correct, incorrect, don't know, or unscoreable. Proportion scores were computed separately for correct, incorrect, don't know, and unscoreable responses to central and peripheral questions. Unscoreable responses (2%) are not considered further. For both free recall and direct questions, two independent coders scored 30% of the sample and reached a .97 proportion agreement. Discrepancies were discussed, and one rater scored the remainder of the sample.

RESULTS

Preliminary analyses

Descriptive data for study variables are presented in Table 1. Preliminary analyses revealed that delay between sessions

Table 1. Descriptive statistics for stress and memory measures ($N = 58$)

	Children		Adults	
	Mean	SD	Mean	SD
Stress ratings	4.68	1.74	4.97	1.40
Free recall correct ($N = 54$)				
Central	0.19	0.12	0.39	0.20
Peripheral	0.03	0.04	0.08	0.10
Direct question correct				
Central	0.79	0.19	0.84	0.16
Peripheral	0.44	0.16	0.44	0.17
Direct question incorrect				
Central	0.07	0.09	0.09	0.10
Peripheral	0.43	0.16	0.36	0.12
Direct question don't know				
Central	0.14	0.14	0.06	0.09
Peripheral	0.13	0.21	0.20	0.22

Note: Self-report stress ratings were derived from participant's ratings of how stressed they felt during the TSST-M (scale range 1–7). Free recall scores reflect the proportion features reported out of the total possible. Direct question scores reflect the proportion of each type of response out of the total direct questions asked.

was unrelated to participants' self-reported stress and memory performance, *r*s ranged from −24 to .18, *p*s = .07–.80, and did not vary between children and adults, $t(29.64) = .478$, $p = .64$. Also, *t*-tests confirmed that neither the stress nor the memory measures varied by gender. Thus, neither delay nor gender is considered further. Stress ratings also did not differ based on age, $t(56) = -.70$, $p = .49$.

Correlations computed among the memory measures revealed that the number of central details reported in free recall was positively related to the number of peripheral details reported in free recall and the proportion of correct responses to direct questions about central details, *r*s (54) > .35, *p*s < .01. Also, the number of central details in free recall was negatively related to proportion of don't know responses to direct questions about peripheral details, $r(54) = -.29$, $p < .05$. The proportion of correct responses to central questions was negatively related to both incorrect and don't know responses to central questions, *r*s(58) < −.45, *p*s < .001. Finally, the proportion of don't know responses to peripheral questions was negatively related to both correct and incorrect responses to peripheral questions, *r*s < −.63, *p*s < .001. No other significant associations among the memory measures were uncovered.

Stress and memory

The study's main hypotheses concerned age-related differences in memory narrowing. These were tested using Generalized Estimating Equations (GEE), a regression based technique that accounts for dependency resulting from the inclusion of the within-subjects factor of central and peripheral question type in the same model. Analyses were conducted using STATA, version 10.1 (Stata Corp, 2007).

Dependent variables included the proportions of features reported in free recall, and the proportions of correct, incorrect, and don't know responses to the direct questions. In each analysis, the central and peripheral proportion scores were entered concurrently. A main effects model first

Table 2. GEE analyses predicting memory based on age, self-reported stress,[a] and question type (QT).

	Free recall correct		Direct question correct		Direct question incorrect		Direct question don't Know	
	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Wald χ^2	154.05***		165.36***		237.10***		14.19**	
Age group[b]	0.35***	0.07	0.03	0.03	0.11	0.07	−0.01	0.03
Question type[c]	−0.16***	0.03	−0.37***	0.03	0.36***	0.03	0.06*	0.03
Stress	0.00	0.01	0.06	0.03	−0.01	0.01	0.03	0.03
Age × QT	0.12**	0.04	—	—	−0.09*	0.04	0.15*	0.06
Age × Stress	—	—	—	—	—	—	—	—
Stress × QT	—	—	−0.04*	0.02	—	—	0.04*	0.02
Age × Stress × QT	—	—	—	—	—	—	—	—

Note: Coefficients and standard errors are only reported for the final models. Effects of lower-order terms are presented in the text.
[a]Coded on a 7-point scale.
[b]0 = child, 1 = adult.
[c]0 = central, 1 = peripheral.
*$p < .05$; **$p < .01$; ***$p < .001$.

examined the contributions of age group (child/adult), stress, and question type (central/peripheral). Then, interaction terms were computed to determine whether age group or stress interacted with question type to predict memory. Finally, the full factorial model including the three-way interaction term (age group × stress × question type) was evaluated. Table 2 presents coefficients and standard errors for the models. Coefficients are only presented for the models that contained the highest order of significant effects for each memory variable. This was done so that coefficients presented in the text match those presented in the table, and thus, the models for each memory variable differ. Finally, the *n*s varied slightly across analyses due to missing data for four adults, whose videos failed to record the free-recall portion of the interview).

Free recall

Participant's free-recall responses (i.e. their proportion central and peripheral features reported out of the total number of features possible) were considered first. The main effects of age group (coef. = .13, $p < .001$) and central versus peripheral features (coef. = −.23, $p < .001$) were significant. Consistent with hypotheses, adults reported more in free recall, $M = 0.29$, $SD = 0.14$, than children, $M = 0.13$, $SD = 0.08$, and participants reported more central, $M = 0.29$, $SD = 0.19$, than peripheral features, $M = 0.05$, $SD = 0.08$. These main effects were subsumed by a significant age × feature type interaction (coef. = −.15, $p < .01$). Adults reported greater proportions of central features of the event than children, but adults and children did not differ in the proportions of peripheral features reported (see Table 1). Turning more specifically to memory narrowing, proportions of central and peripheral features reported in free recall did not vary based on self-reported stress, and no interactions involving the stress measure were significant.

Direct questions

Next, the proportions of correct, incorrect, and don't know responses to the direct questions were examined. For correct responses, models revealed a main effect of question type (coef. = −.37, $p < .001$). Again, as expected, participants provided a higher proportion of correct responses to central, $M = 0.82$, $SD = 0.17$, than peripheral, $M = 0.44$, $SD = 0.17$, questions. However, this effect was subsumed by a significant stress × question type interaction (coef. = −.04, $p < .05$). To interpret the interaction, the regression lines for correct responses to central and peripheral questions were plotted as a function of self-reported stress. As shown in Figure 1, with increased stress, memory for central information remained fairly constant, whereas memory for peripheral information decreased. In other words, memory narrowing was observed. Of note, this effect was not further moderated by age. Thus, the memory narrowing effect was similar in children and adults.

Next, the models were repeated predicting participants' proportions of incorrect responses. Again, a main effect of question type (coef. = .31, $p < .001$) emerged. Better memory overall, here as indexed via fewer errors, was evident for central than peripheral details, *M*s = 0.08 and 0.39, *SD*s = 0.10 and 0.15, respectively. This effect, however, was subsumed by a significant age × question type interaction (coef. = .11, $p < .01$): Children provided a greater number of incorrect responses to peripheral questions than

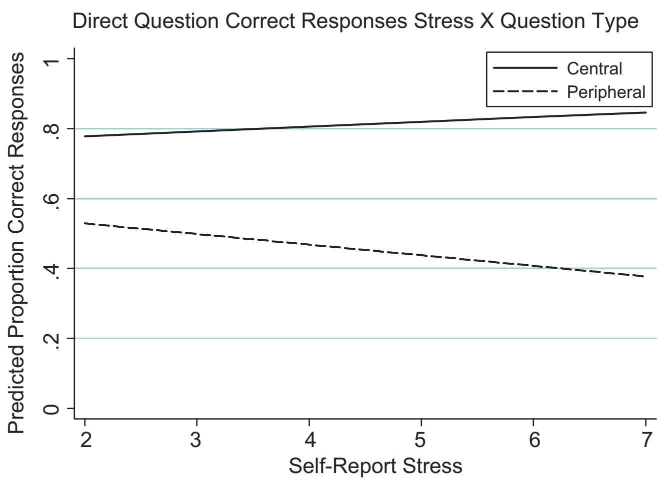

Figure 1. Predicted proportion of correct responses to central and peripheral questions as a function of self-report stress (measured on a scale from 1 to 7), collapsed across age groups

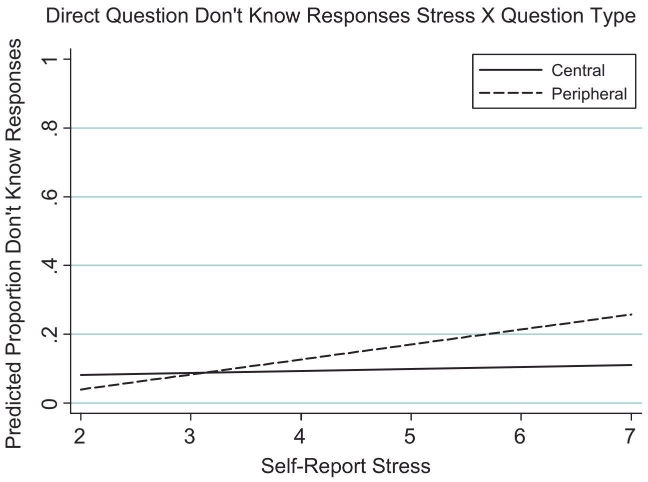

Figure 2. Predicted proportion of don't know responses to central and peripheral questions as a function of self-report stress (measured on a scale from 1 to 7), collapsed across age groups

did adults, but children and adults did not differ in number of incorrect responses to central questions (see Table 1). Neither the main effect of stress nor any interaction involving stress was significant.

Finally, participants' don't know responses were considered. Again, the main effect of question type was significant (coef. = .06, $p < .05$). Overall, participants provided a greater number of don't know responses to peripheral ($M = 0.16$, $SD = 0.22$) than central ($M = 0.10$, $SD = 0.12$) questions. Additionally, the stress × question type interaction was significant (coef. = .04, $p < .05$). Figure 2 depicts the interaction. As stress increased, predicted proportions of don't know responses to central questions did not change, but predicted proportions of don't know responses to peripheral questions increased. Thus, at higher levels of stress, participants appeared less certain (though not necessarily more inaccurate) when answering questions about peripheral details of the TSST experience, a pattern that further supports memory narrowing.

DISCUSSION

Interest in relations between stress and memory has a long history, both in terms of understanding mechanisms linking emotion, attention and cognition, and in terms of practical contexts involving eyewitness capabilities. Despite fairly widespread belief that stress produces memory narrowing, whereby memory for central details is retained or even strengthened at the expense of memory for peripheral details (Christianson, 1992; Levine & Edelstein, 2009; Reisberg & Heuer, 2007), such effects have not, until the current study, been clearly demonstrated in children.

Some previous studies (e.g. Peterson & Bell, 1996; Vandermaas et al., 1993) have failed to uncover differential associations between stress and memory for central *versus* peripheral information in children. However, details of the to-be-remembered experiences varied across children, so unique characteristics of each child's experience may have affected memory. Moreover, in some studies, stress and memory accuracy were determined not *via* objective indices but instead *via* parental or observer-report (Howe, Courage, & Peterson, 1994; Peterson & Bell, 1996), which also could affect the patterns of results obtained.

The present study used a controlled laboratory stressor as the to-be-remembered event. An objective record was available for verification, and the event was identical for both child and adult participants. Additionally, stress ratings were obtained from participants themselves and thus were based on their own subjective experiences rather than another person's interpretation of their experience during the TSST-M event. Using this approach, we observed memory narrowing in both children and adults: With increasing levels of self-reported stress, participants provided fewer correct and more don't know responses to questions about peripheral details of the TSST-M. Both children and adults needed to attend to the main instructions in the TSST-M, and as such, may have focused on details related to the completion of the task during the procedure, especially at high levels of stress, leading to enhanced encoding of these details, possibly at the expense of other, peripheral details.

Of note, Laney, Campbell, Heuer, and Reisberg (2004) have argued that memory narrowing for highly emotional information may be an artifact of the stimuli presented. The argument was based on a study in which two groups of participants viewed slides accompanied by narration. The slides for the two groups were identical with the exception of one critical slide in which the narration accompanying the slide was varied to elicit emotional arousal (specifically empathy) in the experimental group, but no emotion in the control group. Thus, the 'thematically induced arousal' for the experimental group was elicited through the unfolding of the story rather than through the use of a shocking visual stimulus. In a subsequent memory test, no evidence for memory narrowing was observed. Instead, the experimental group remembered both central and peripheral details of the story better than the control group. The researchers concluded that memory narrowing may not occur when emotion is elicited thematically rather than through the use of an attention-grabbing visual element, such as a weapon or a gory injury. Certainly, visually shocking stimuli may have especially strong effects on attention and thus contribute to correspondingly strong memory narrowing effects (see Levine & Edelstein, 2009). However, our findings indicate that personally experienced negative emotional events produce memory narrowing as well, and not only in adults. Whether memory narrowing reflects increased attention to stress-inducing information, increased rehearsal of this information, or both, however, is not yet clear and awaits further research.

Three other findings in the current study deserve further comment. First, we expected adults to evince better memory accuracy than children, an expectation that was only supported when free-recall responses were considered. Adults' narratives contained more details about the TSST-M than children's narratives. However, children and adults did not differ in their ability to correctly answer direct questions about the TSST-M. The free-recall findings are consistent with prior research, which has often shown that memory reports in response to open-ended questions become longer and more complex with age (Pipe, Lamb, Orbach, & Esplin, 2004; Schneider & Pressley, 1997). The lack of age differences in responses to direct questions was likely due to our inclusion of older (9–12) rather than younger children. Older children may have strong enough memory abilities to answer direct (recognition) questions about a very unique and salient personally experienced event with comparable accuracy to adults, even though the children's independent narrative reports were shorter. Thus, children did not appear to remember less about the TSST-M than adults. Instead, children were more reliant on prompting to elicit the information stored in their memory.

Second, the effects of age on incorrect responses varied depending on whether questions probed for central or peripheral information. Concerns about adverse effects of direct, focused questions on children's accuracy have been expressed by many researchers, and closed-ended questions are generally associated with increased errors (Pipe et al., 2004). Our results suggest that these concerns are warranted, but that the magnitude of age-related changes in errors depends on question type: Errors were only greater in children relative to adults when questions asked about peripheral information. Children did not make more errors than adults in response to questions about central information. Practically, these patterns are somewhat positive in that peripheral details of an event may be less likely to be forensically relevant in the case of a criminal investigation than central details. Of course, any increase in errors, even for peripheral details, must still be taken seriously, and restraint in the use of closed-ended questions is still warranted.

Third, we expected age differences in memory narrowing to emerge. We theorized that children, due to their less extensive repertoire of coping strategies, would need to devote more resources to regulating their arousal relative to adults, which would result in deficits for peripheral details among children. However, memory narrowing was not moderated by age. The lack of age differences may have stemmed from our inclusion of 9–12 year olds rather than younger children. Although coping strategy use continues to undergo changes and strategies become more complex through adolescence, considerable developmental advances have occurred by later childhood (Compas et al., 2001), which may have helped the children in our study attend to the TSST-M in a manner more comparable to that of adults. Also, by ages 9–10, children have considerable experience talking in front of others (e.g. in school), and thus may be adept at regulating arousal during this particular challenge, again allowing them to encode various aspects of the session similarly to adults. It should be noted, however, that children were more likely than adults to err in response to peripheral questions, consistent with our contention that children have more trouble than adults remembering peripheral information when exposed to stress. Had younger children been included, perhaps age differences in memory narrowing would have emerged, a possibility important to consider in further research. In doing that research, however, care needs to be taken to ensure that the to-be-remembered event is comparably stressful across age (e.g. evidence indicates that younger children may react differently to the TSST-M, Yim et al., 2010, perhaps because they do not yet fully understand the stress-inducing social evaluative component, Dickerson & Kemeny, 2004). It will also be necessary, in this research, to confirm that what is considered central and peripheral is similar across age.

Although the present study offers new insight into memory narrowing for complex personal experiences, limitations must also be mentioned. For one, although the public speaking task employed here elicited reliable and clear stress responses, the stress levels did not approximate those likely endured during a real-world potentially traumatic event, such as a crime or natural disaster. Some research suggests that at very high levels of stress, memory even for central information is impaired (e.g. Morgan et al., 2004; Valentine & Mesout, 2009), although in this research, only the identification of perpetrators was examined, not central *versus* peripheral features generally. Nonetheless, continued research will need to test the patterns we observed here in children using a range of different distressing personal experiences.

Second, these analyses focused on participants' self-reported stress during the TSST-M. It is unknown whether children and adults interpreted the scale in a comparable manner, but any differences in their interpretation may have masked age differences in memory narrowing. Validated methods of assessing subjective feelings of stress across age are much needed. Of note, we collected saliva before and after the TSST-M to identify psychobiological stress responses to the TSST-M, and we coded children's and adults' behaviours for indicia of nervousness or anxiety (see Yim et al., 2010). Neither of these measures differentially predicted memory for central *versus* peripheral information, although changes in cortisol trajectories over the entire visit were positively related to participants' overall memory for the visit (Quas et al., in press). Cortisol may have led to improvements in memory overall and not memory narrowing specifically because of a general enhancing effect of cortisol on attention to emotional or salient information, and not just information causally related to the heightened cortisol. (Gorski, Gorski, & Le, in press; Putman, van Honk, Kessels, Mulder, & Koppeschaar, 2004). In terms of memory narrowing, participants' subjective perceptions of stress may be particularly important in directing their attention (and hence encoding) during or their rehearsal after the TSST-M, although certainly it will be important in future research to continue to explore how different indices of stress, including those obtained online as an event is unfolding, relate to memory for different types of information. And third, because the current study did not experimentally manipulate stress, the relations between stress responses and memory cannot be inferred to be causal. A logical next step will be to employ a similar methodology, but to experimentally manipulate stress across individuals to draw causal inferences about memory narrowing across age.

In closing, these data suggest that memory narrowing occurs in both children and adults when they recount stressful events. Of theoretical importance, these findings extend Christianson's (1992) hypothesis to younger ages and have important implications for the legal system. Practically, law enforcement officials interviewing eyewitnesses should take into account what details of an emotional experience were likely to be centrally related to the source of witness arousal, as these types of details are likely to be most accurately recalled. Overall, memory for much important and relevant information about stressful events appears to be well encoded and retained, even at high levels of stress, in both children and adults.

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