

Is flashbulb memory a special instance of source memory? Evidence from older adults

Patrick S.R. Davidson & Elizabeth L. Glisky

University of Arizona, USA

Flashbulb memories (FMs) are vivid, stable memories for the reception of arousing, consequential news. Although such memories have been found in people of all ages, in the only examination of age differences to date, Cohen, Conway, and Maylor (1994) reported that older adults were less likely than young adults to experience a FM. We hypothesised that FM would be impaired in older adults with reduced frontal lobe (FL) function. To test this hypothesis, we asked older adults, who had been characterised according to FL function, to recall details of the moment that they first heard the news about the deaths of Princess Diana and Mother Teresa. Long-term retention was tested 6 months later. Details concerning the reception of the news about Princess Diana's death were retained better than those associated with Mother Teresa's death. Importantly, there was no evidence that memory for these contextual details was related to FL function. A measure of medial temporal lobe function, derived from neuropsychological tests of episodic memory, was also not associated with memory for the reception events, although it was associated with memory for the details of an everyday autobiographical event. We speculated that emotionally arousing autobiographical memories may be qualitatively different from everyday memories and may involve the amygdala.

A flashbulb memory (FM) is a vivid, long-lasting memory for the circumstances surrounding the reception of news about a surprising or shocking event. The quintessential example of FM involves the assassination of President Kennedy: Many people claim to have strong memories of where they were and what they were doing when they first heard about his death. Since Brown and Kulik (1977) introduced the concept of FM, however, there has been considerable debate (see Winograd & Neisser, 1992) about whether FMs are qualitatively different from other kinds of autobiographical memories and what exactly accounts for the enhanced memory. Another issue concerns the brain mechanisms involved in FM and whether these are special, as suggested by

Brown and Kulik, or are the same as those involved in other kinds of memory. In the present study, older adults were asked about their memory for learning about the deaths of Princess Diana and Mother Teresa—two possible “flashbulb” events. They were also asked analogous questions about an everyday autobiographical event that occurred around the same time. We examined several variables thought to be critical to the formation and/or preservation of FMs, and tested the hypothesis that frontal lobe function is important for FMs.

Brown and Kulik (1977) originally described FM as a highly accurate recollection of the moment a person first hears about a surprising and important event. They asked people to recall the

Requests for reprints should be sent to Patrick S.R. Davidson, Amnesia and Cognition Unit, Department of Psychology, University of Arizona, Tucson AZ 85721-0068, USA. Email: pdavidso@u.arizona.edu

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circumstances in which they first learned of such events in recent American history, and found that most people provided vivid descriptions of the *reception event* (that is, the point in time at which they first received news). In analysing the responses, the authors noticed that information about certain aspects of the reception event was often present in the reports. These included where the person was, what activity the news interrupted, what activity followed the news, the person's emotional response, other people's emotional responses, and the source of the news. Since Brown and Kulik's original work, numerous studies have reported similar findings for a range of shocking or surprising public events that have occurred worldwide. Most of the recent studies have used a consistency measure as an indicator of a FM, reporting high levels of consistency between participants' memories shortly after the event and their memories several months later (for example, see Bohannon & Symons, 1992; Cohen et al., 1994; Conway et al., 1994). Investigators have also examined a variety of factors occurring during the reception of the news (i.e., *encoding variables*) or during the period between the reception event and subsequent reports (i.e., *rehearsal variables*), in an attempt to identify the major contributors to the formation and/or preservation of FMs. Some studies have shown that the details of FMs can be forgotten or become confused over time (e.g., Schmolck, Buffalo, & Squire, 2000), although FMs appear generally to be more stable than other kinds of autobiographical memories. For example, Christianson (1989) found that Swedish participants, although they forgot some circumstantial details, could remember much more about the reception of news of their prime minister's death after a year than about an ordinary event that occurred around the same time as the assassination (see also Larsen, 1992).

ENCODING AND REHEARSAL VARIABLES

The encoding and rehearsal variables that have most often been related to FM include surprise, the perceived importance or consequentiality of the event, the level of emotional intensity experienced during the reception event, and subsequent rehearsal. However, not all of these have been implicated in every study. Surprise and consequentiality were initially proposed by Brown

and Kulik (1977) as critical to the formation of FMs. Later studies by Christianson (1989) and Cohen et al. (1994) confirmed the importance of surprise in FM, and a study by Conway and colleagues (1994) indicated that both personal and national importance of the event were also important contributors to FM. A relation between the intensity of the emotional response to news and the strength of FMs has also been found by Bohannon (1988), Conway et al. (1994), Pillemer (1984), and Schmolck et al. (2000). Rehearsal may have a positive or negative effect on the long-term retention of FMs. On the one hand, several studies have reported that rehearsal enhances FMs, whether it occurs in the course of talking about the event (Bohannon, 1988), thinking about the event (Conway et al., 1994), or media exposure to the event (Conway et al., 1994). On the other hand, Neisser and Harsch (1992) found that college students' memories for learning about the space shuttle *Challenger* disaster became increasingly distorted over time. They suggested that such distortions occurred because new contextual details were incorporated into the memory each time it was rehearsed. Finally, recent causal modelling approaches by Conway et al. (1994) and Finkenauer et al. (1998) suggest that complex interactions among the variables of surprise, consequentiality, emotional state, and rehearsal underlie the formation of the highly detailed and stable memories that are characteristic of "flashbulb" events.

FLASHBULB MEMORY, SOURCE MEMORY, AND THE BRAIN

Flashbulb memory is often discussed as a particular instance of autobiographical memory—that is, memory for the events and experiences of one's personal past (for reviews, see Conway & Fthenaki, 2000; Neisser & Libby, 2000). In most studies of flashbulb memory, however, the emotionally arousing event itself is not personally experienced, and what is of interest is memory for the *reception* of information about the event—when, where, and from whom the news was heard. Flashbulb memory may thus represent a special case of source memory (Brewer, 1992; for review, see Johnson, Hashtroudi, & Lindsay, 1993). By definition, both involve memory for the spatial, temporal, or perceptual contexts in which facts or events are acquired or experienced, but unlike the source or context of most autobiographical events,

the reception context of these emotionally arousing news events appears to be very well remembered. Nevertheless, it may be that flashbulb memory depends on the same cognitive and neural processes as source memory.

Considerable evidence points to the frontal lobes (FLs) as important contributors to performance on source memory tasks. For example, patients with focal frontal lesions show a greater than normal incidence of source memory errors when asked the time and place that facts were acquired, despite showing normal memory for the facts themselves (Janowsky, Shimamura, & Squire, 1989; Johnson, O'Connor, & Cantor, 1997). Similarly, amnesic patients exhibit source memory deficits, but only if they also show deficits on FL tasks (Schacter, Harbluk, & McLachlan, 1984). Older adults have also displayed a disproportionate deficit in source memory relative to item or fact memory (Brown, Jones, & Davis, 1995; Ferguson, Hashtroudi, & Johnson, 1992; Henkel, Johnson, & De Leonardis, 1998; McIntyre & Craik, 1987; Schacter, Kaszniak, Kihlstrom, & Valdiserri, 1991; Spencer & Raz, 1994; Trott, Friedman, Ritter, & Fabiani, 1997), and this deficit appears to be related to performance on neuropsychological tests of FL function (Craik, Morris, Morris, & Loewen, 1990; Glisky, Polster, & Routhieaux, 1995; Schacter et al., 1991). Importantly, only older adults with below average FL function show impairments on source memory tasks, relative to young adults (Glisky, Rubin, & Davidson, *in press*). Although the relation between source memory and FL function has not always been obtained (e.g., Spencer & Raz, 1994), and other brain areas may also be implicated in source memory (see Henkel et al., 1998), there is a general consensus that the FLs are in some way involved in source memory. Thus, if FM is just another instance of source memory, one might expect to see deficits in FM among individuals with compromised FL function.

In their study of FM for news of British Prime Minister Margaret Thatcher's resignation, Cohen et al. (1994) found that 90% of young Britons had stable FMs when tested 1 year later, whereas only 42% of older Britons did. The authors speculated that the inability of older adults to remember details about where, when, and how information about Margaret Thatcher's resignation was acquired might be indicative of a general source memory deficit related to the FL decline thought to accompany normal ageing. Although Cohen et al. did not include any measures of FL function in

their study, their hypothesis nevertheless seems reasonable given the findings outlined earlier and the additional neuroimaging evidence suggesting that the FLs are particularly vulnerable to ageing (e.g., Coffey et al., 1992; Cowell et al., 1994; Raz et al., 1997; for review, see Raz, 1999).

Recently, however, Kapur (1997; Kapur, Abbott, Graham, & Simons, 2000), in the only report of FMs in neurological populations of which we are aware, has proposed a competing hypothesis, namely that temporal lobe structures, not the FLs, are critical for the formation and retention of FMs. He reported that amnesic patients with damage to medial temporal and diencephalic structures were aware that Princess Diana had died, but were unable to remember how they heard about her death. In other words, they did not experience FMs. On the other hand, patients with frontal lobe damage (with one exception) had normal FMs. Kapur et al. suggested that the same temporal lobe and diencephalic structures that support other autobiographical memories are involved in FM. This finding thus raises an alternative possibility: that the lower incidence of FMs in older adults is attributable to reduced functioning of the temporal lobes, which also occurs as people age (e.g., Coffey et al., 1992; Raz et al., 1997).

We thought that the death of Princess Diana would likely result in a FM in our participants. She was a celebrity in the United States as well as in the United Kingdom, and her death was unexpected and likely to be emotionally upsetting to many people. The event was covered extensively for several days by local and national media, so most people in the community were exposed to the news. When Mother Teresa died shortly after Princess Diana, we decided to include in our study a within-subject comparison of memory for the circumstances surrounding these two highly similar events. Although both events involved the deaths of famous women, the amount of surprise, emotional intensity, personal consequence, and rehearsal associated with the two events may well have differed. The contrast between them might thus provide information concerning the contribution of these encoding and rehearsal variables to FM.

The present study was motivated by a number of questions. First, we wanted to test the hypothesis that FM would be related to FL function in older adults. Because we have conducted several source memory experiments in older adults (Glisky et al., 1995, 2001) and have consistently

found a robust relation between source memory and a neuropsychological measure of FL function, we expected that our FL measure would also predict FM in older people. Second, because the Cohen et al. (1994) study is the only one (of which we are aware) to examine FM in older adults, we wanted to replicate the finding that older adults are impaired in FM. However, our prediction, in line with our findings in source memory, was that only older adults with reduced FL function would be impaired relative to young adults. Older adults with above average FL function were expected to show normal FM. To test this hypothesis, we included a control group of young college students in our study. Third, because of the alternative hypothesis that FMs may not be qualitatively different from other kinds of autobiographical memory and may therefore depend on the same brain structures, namely the temporal lobes (Kapur, 1997; Kapur et al., 2000), we also proposed to look at the relation between a measure of medial temporal lobe (MTL) function and FM. Fourth, we wanted to assess the contribution of the four encoding variables (surprise, importance to the participant, importance to the world, and emotional intensity) and three rehearsal variables (thinking about the event, media exposure, and discussion with other people) that have most often been found to affect FM. Finally, we examined memory for another personal event that occurred around the same time, in order to assess possible differences between memory for “flashbulb” events and memory for everyday autobiographical events.

METHOD

Participants

A total of 53 older adults from the Amnesia and Cognition Unit’s pool of older participants completed the initial questionnaire. Of these, 39 were available for retesting 6 months later. The results of three older adults were discarded from the analyses of long-term retention, because they could not recall any information about the reception events in question.¹ However, their zero scores are included in the initial memory measures. All older

participants were healthy, non-demented, and community-dwelling, and had previously undergone extensive neuropsychological testing. The results of the neuropsychological tests were used to create two orthogonal composite scores for each older adult, one thought to reflect FL function and the other thought to measure MTL function. Tests for the composite measures were derived from a factor analysis of neuropsychological test scores from which variance attributable to age was first removed (see Glisky et al., 1995, for details). The composite measure of FL function was based on scores from the following five tests: an abbreviated version of the Wisconsin Card Sorting Test (number of categories achieved; Hart, Kwentus, Wade, & Taylor, 1988), a measure of verbal fluency commonly referred to as the FAS test (Spren & Benton, 1977), the Mental Arithmetic subtest from the Wechsler Adult Intelligence Scale–Revised (WAIS–R; Wechsler, 1981), and the Backward Digit Span and Mental Control measures from the Wechsler Memory Scale–Revised (WMS–R; Wechsler, 1987). The composite measure of MTL function consisted of scores from the following episodic memory tasks: Logical Memory I, Verbal Paired Associates I, and Visual Paired Associates II from the WMS–R, and the Long Delay Cued Recall score from the California Verbal Learning Test (CVLT; Delis, Kramer, Kaplan, & Ober, 1987). The individual composite scores represent average *z* scores derived from a normative group of 100 adults over the age of 65. For purposes of comparison to younger adults, each older adult was categorised as high or low in FL function, depending on whether his or her *z* score was above or below the normative group mean.

Of the 53 older adults who contributed memory data on the initial questionnaire, 29 had FL scores above the mean and 24 had FL scores below the mean. Of the 36 older adults who contributed data to the congruence analyses, 17 had FL scores above the mean, and 19 had FL scores below the mean. Table 1 shows the characteristics of the older individuals who participated in the initial testing along with the subgroup of older adults who were available for retesting. Independent-sample *t* tests revealed that the high and low FL groups did not differ significantly at either time in age, years of education, or Mini Mental Status Exam score (MMSE; Folstein, Folstein, & McHugh, 1975), all *ps* > .05.

A total of 21 younger adults from undergraduate introductory psychology classes at the University of Arizona comprised the control

¹ If zero scores were retained in the analysis, there would be perfect consistency between initial and delayed testing. However, this perfect consistency would not represent long-term retention given that there was nothing to be retained.

TABLE 1
 Characteristics of older adults participating in initial and
 6-month delayed test as a function of group

	<i>Initial test</i>		<i>Delayed test</i>	
	<i>FL function</i>		<i>FL function</i>	
	<i>High FL</i>	<i>Low FL</i>	<i>High FL</i>	<i>Low FL</i>
<i>n</i>	29	24	17	19
Age (years)	73.97	72.42	73.76	72
Education (years)	16.14	14.88	16.18	14.89
MMSE(/30)	27.97	28.25	29.18	28.21
FL function score ^a	.58	-.39	.67	-.45

^a See text for explanation of FL scores.

group. The scores of one younger adult were omitted because he did not know that Mother Teresa had died. Only 15 of the young participants (mean age 19.87, age range 18–32) were available for retesting 6 months later. All were awarded course credit for participation at the initial test, and were offered \$6 for participating in the retest.

Materials

The questionnaire was modelled on those used by Cohen et al. (1994), Conway et al. (1994), Neisser and Harsch (1992), and Pillemer (1984). The form included specific questions about the target events (the deaths of Princess Diana and Mother Teresa), the reception events, and the control event. For the present purposes, we will focus specifically on those questions about the reception events thought to be important for measuring FM. The six relevant questions concerned place (*Where were you?*), the participants' interrupted activity (*What were you doing before you heard the news?*), the participants' ensuing activity (*What did you do after you heard the news?*), other people's presence (*Who were you with?*), time of day (*What time of day did you hear the news?*), and the source of the news (*How did you hear the news, i.e., from what source?*). Unlike some previous studies (Cohen et al., 1994, Conway et al., 1994) no open-ended narrative description of the reception event was included, but at the end of each section of the questionnaire we asked participants to include anything they remembered that they had omitted in earlier answers or that we had not asked about. The same questionnaire was administered at both the initial test and 6 months later. Both the initial and the retest questionnaires included self-ratings (1 = very low, 5 = very high) of surprise, emotional intensity, the event's

importance to the participant and to the world, and the frequency of thoughts about, media exposure to, and discussion of the event. Identical questions were asked about both Princess Diana and Mother Teresa. In addition, we included a section with analogous questions about a control autobiographical memory, which was the most interesting event experienced by each participant during Labor Day weekend in 1997; however, this section did *not* include a specific question about source (i.e., it did not ask *How did you hear about this interesting event?*), and did not include encoding and rehearsal variable ratings.

Procedure

At the initial session, participants were administered questionnaires about news of the death of Princess Diana, which occurred on 31 August 1997, and about the most interesting event in their own lives that occurred on the same weekend. Older adults were contacted by telephone, and were read the questions one at a time. Responses were recorded as close to verbatim as possible. Younger adults were tested in one of two large groups and wrote down their responses on a printed questionnaire. When the death of Mother Teresa occurred (1 week after that of Princess Diana), we readministered the FM questionnaire. Both younger and older adults responded to this second survey by telephone. In all cases, participants were encouraged to provide as detailed answers as possible. The initial tests were conducted within 3 weeks of each event, and participants were not warned that they would be contacted again later.

The retest was conducted approximately 6 months after the initial test. All participants were contacted by telephone, and asked the same

questions that they had been asked earlier. The order of the reception event questions (Princess Diana versus Mother Teresa) was counter-balanced. Questions about the control event were always asked following the Princess Diana questions. For the control event, participants were first asked whether they could remember the most interesting thing they had done on Labor Day weekend of 1997. If they could not remember, or gave a different answer from the one they gave at the initial test, they were provided with a minimal cue (for example, "a party"). The rest of the control questions were then asked.

Scoring

For the initial test, subjects were assigned a score of 0 if they did not provide an answer to a question, or 1 if they did; a score of 6 was thus the maximum possible score for the Princess Diana and Mother Teresa reception events and a score of 5 for the control memory. For the delayed test, we used a measure of congruence similar to that adopted by Cohen et al. (1994), Conway et al. (1994), and Neisser and Harsch (1992). Two naïve judges rated the congruence between the content of answers on the initial test and those on the delayed test on a scale of 0, 1, or 2. They assigned a score of 0 if at retest no answer was provided or it was incongruent with the initial test, 1 if the retest answer was somewhat congruent with or less specific than the initial test (e.g., "television news, Channel 4" at the initial test, and "television" at retest), or 2 if the retest answer was highly congruent with the initial test. For each participant, if no answer was provided for any question at the initial test, that item was eliminated from the congruence scoring. This scoring method reflects forgetting and/or distortions that take place between two points in time, and as such represents an index of retention. The judges were furnished with the congruence criteria from Cohen et al. (1994) and Conway et al. (1994). Pearson correlations revealed that overall interrater reliability for the congruence measures (across events) was .85. All disagreements between the raters were settled by a third rater.

A summed memory congruence score was derived for each of the two reception events (receiving news of Princess Diana's death, and receiving news of Mother Teresa's death) from the six relevant questions concerning place, the participants' interrupted activity, their ensuing

activity, other people's presence, the time of day, and the source of the news. Thus, a participant's summed congruence score for each of the reception events could reach a maximum of 12. A similar memory congruence score was derived for the autobiographical control event, but because the control event section of the questionnaire did not include the specific source question, the summed control memory congruence score was based on 5 attributes only, with 10 being the maximum possible score. Because some items may have been excluded for some participants (that is, they failed to provide an answer on the initial test), congruence scores are shown and were analysed as proportions. Analyses of the encoding variables were based on responses on the initial test, and analyses of rehearsal variables were based on responses taken from the retest 6 months later.

RESULTS

Responses on initial questionnaire

Responses on the initial questionnaire to reception event questions about Princess Diana and Mother Teresa are shown in Table 2. (Scores for initial answers regarding the autobiographical control event were at ceiling). A 2×3 mixed ANOVA with the two "flashbulb" events (Princess Diana, Mother Teresa) as the within-subject variable and group (young, High FL, Low FL) as the between-subjects variable revealed significantly more answers on the initial test to the six questions about the Princess Diana reception event ($M = 5.79$) than to those about the Mother Teresa event ($M = 5.16$), $F(1, 70) = 15.69$, $MSE = .79$, $p < .001$. This variable did not interact with group, $F(2, 70) = 2.10$, $MSE = .79$, *ns*. Although the omnibus F test indicated an overall difference among groups, $F(1, 70) = 3.13$, $MSE = 1.70$, $p = .05$, the Bonferroni t -test for multiple comparisons found none of the comparisons to be significant, all $ps > .05$. Importantly, there was no hint of a frontal effect; the Low FL group actually performed slightly better than the High FL group, and the correlations between FL score and responses to questions about the two events were non-significant, $r(51) = .09$ and $-.07$ for Princess Diana and Mother Teresa, respectively. An analysis comparing young adults to the entire group of older adults also revealed no overall effect of age, $F(1, 71) = 2.74$, $MSE = 1.76$,

TABLE 2
Responses to reception event questions on initial questionnaire (/6) as a function of event and group

Event	Group		
	Young	High FL	Low FL
Princess Diana	5.95 (.22)	5.66 (1.14)	5.83 (.48)
Mother Teresa	5.60 (.88)	4.66 (1.90)	5.42 (.83)

Standard deviations reported in parentheses.

$p = .10$. Correlational analyses also indicated that MTL function was similarly unrelated to the number of answers given to either the Princess Diana questions, $r(51) = .04$ or the Mother Teresa questions, $r(51) = .04$.

Reception event congruence

Proportional congruence scores for those participants who were retested 6 months later are shown in Table 3. All groups showed better retention of the circumstances surrounding the death of Princess Diana ($M = .54$) than of Mother Teresa ($M = .37$) and better retention of the Mother Teresa event than the control event ($M = .19$)². A 3×3 mixed ANOVA with reception event (Princess Diana, Mother Teresa, control) as the within-subject variable and group (young, High FL, Low FL) as the between-subjects variable indicated a main effect of event, $F(2, 86) = 28.66$, $MSE = .05$, $p < .001$. All pairwise comparisons were significant ($ps \leq .01$). There were no significant differences among the groups, $F < 1$, and no interaction between group and event, $F(4, 86) = 1.45$, $MSE = .05$, *ns*.

Because many participants were unable to remember the control event at all without a cue, we also assessed the group effect using answers obtained after cueing of the event was provided. Although there was a trend towards a group effect, with the Low FL group remembering somewhat fewer circumstantial details than the High FL and young groups, a one-way ANOVA indicated that the difference was not reliable, $F(2, 43) = 1.73$, $MSE = .05$, $p = .19$. Further, the correlation between FL score and retention of the

TABLE 3
Proportion of memory retained after 6 months as a function of event and group

Event	Group		
	Young	High FL	Low FL
Princess Diana	.61 (.21)	.50 (.17)	.52 (.18)
Mother Teresa	.37 (.29)	.32 (.21)	.42 (.24)
Control event	.20 (.24)	.22 (.34)	.16 (.24)
Control event (prompted)	.44 (.19)	.49 (.27)	.34 (.23)

Standard deviations reported in parentheses.

prompted control event also failed to reach significance, $r(29) = .31$, $p = .09$. MTL function, however, was related to memory for details of the prompted control event, $r(29) = .49$, $p = .005$, although there was no correlation between MTL function and memory for either the Princess Diana reception event, $r(34) = .13$ or the Mother Teresa event, $r(34) = .02$.

Encoding and rehearsal variables

Encoding and rehearsal ratings for the two reception events for each group are shown in Table 4. Separate 2×3 mixed ANOVAs with reception event as the within-subject variable and group as the between-subjects variable were conducted for each of the four encoding variables. Analyses indicated that the death of Princess Diana was significantly more surprising than that of Mother Teresa, $F(1, 48) = 65.46$, $MSE = 1.09$, $p < .001$, and was higher in emotional intensity, $F(1, 48) = 5.00$, $MSE = 1.09$, $p = .03$. Princess Diana's death was also thought about more often, $F(1, 48) = 13.70$, $MSE = .70$, $p = .001$, discussed more often with other people, $F(1, 48) = 15.90$, $MSE = .51$, $p < .001$, and had greater media exposure, $F(1, 48) = 108.75$, $MSE = .83$, $p < .001$. There were no reliable differences among groups for any of the encoding and rehearsal variables and no interactions, with one exception. The young group registered greater surprise than either of the older groups concerning the death of Mother Teresa, $F(1, 48) = 3.61$, $MSE = 1.09$, $p = .04$. None of the encoding or rehearsal measures correlated reliably with either the FL or MTL scores.

Although the measures of surprise, emotional intensity, and rehearsal were all greater for the event that was better remembered—the death of Princess Diana—within each event, only two of these measures were marginally correlated with

² The responses of six older adults were not included in the control event analyses, because they misunderstood the instructions at retest and told investigators about the most interesting event they had experienced on a Labor Day weekend prior to 1997. Thus, analyses of the control event were based on 31 older adults, 14 high FL and 17 low FL.

TABLE 4
Encoding and rehearsal variable ratings (/5) as a function of event and group

	<i>Young</i>	<i>Group High FL</i>	<i>Low FL</i>
Encoding Variables			
<i>Surprise</i>			
Princess Diana	4.60 (.91)	4.82 (.53)	4.63 (.90)
Mother Teresa	3.73 (1.16)	2.71 (1.26)	2.58 (1.57)
<i>Emotional Intensity</i>			
Princess Diana	3.20 (1.21)	3.59 (1.00)	3.90 (1.29)
Mother Teresa	2.80 (1.26)	3.18 (1.07)	3.32 (1.38)
<i>Personal Importance</i>			
Princess Diana	2.73 (1.28)	2.27 (1.25)	3.21 (1.51)
Mother Teresa	2.60 (1.35)	2.71 (1.16)	2.53 (1.65)
<i>World Importance</i>			
Princess Diana	4.40 (.91)	3.62 (1.11)	4.11 (1.28)
Mother Teresa	4.27 (.88)	4.41 (.80)	4.21 (.98)
Rehearsal Variables			
<i>Thought</i>			
Princess Diana	2.20 (.94)	2.65 (.86)	2.53 (1.07)
Mother Teresa	1.40 (.51)	2.18 (1.01)	1.95 (1.03)
<i>Media Exposure</i>			
Princess Diana	3.60 (1.12)	3.41 (1.12)	3.95 (1.22)
Mother Teresa	1.60 (.83)	2.00 (1.12)	1.68 (.75)
<i>Discussion</i>			
Princess Diana	2.13 (.83)	1.94 (1.09)	2.74 (1.33)
Mother Teresa	1.60 (.74)	1.68 (.88)	1.84 (1.17)

Standard deviations reported in parentheses.

retention: in older adults, retention of the Mother Teresa memory was related to personal importance, $r(34) = .30$, $p = .07$, and to amount of discussion, $r(34) = .31$, $p = .07$.

DISCUSSION

Contrary to our hypothesis and that of Cohen et al. (1994) that FL function might predict FM in older adults, there was no relation between the composite measure of FL function and memory for either of the "flashbulb" events. The low FL group was as likely as the high FL group to report reception event details on the initial questionnaire and to retain them over a 6-month interval. In numerous studies in our laboratory (Glisky et al., 1995, in press), the FL composite measure has been consistently and robustly associated with source memory (i.e., memory for contextual detail). Studies in other laboratories have also found an effect of FL function on source memory in normal older adults (Craik et al., 1990; Schacter et al., 1991). The FM scores that we analysed

consisted entirely of answers to questions about context, and included both the traditional source question (i.e., "How did you learn about the news?") as well as questions about other aspects of context (i.e., "What happened before and after the reception of the news, what time of day was it, and who was present?"). Nevertheless, there was no hint of frontal involvement in the recollection of contextual details surrounding the deaths of Princess Diana and Mother Teresa. It should also be noted that, consistent with our findings of no effects of reduced FL function on FM, Kapur et al. (2000) also found normal FMs in 9 of 10 patients with frontal lobe pathology.

Why might such differences exist between findings from laboratory studies of source memory and the kinds of naturalistic events investigated in the present study? There are a number of possibilities. First, the FLs may play a role in source memory only when discriminations are required among highly similar contexts. In laboratory studies, participants are often asked to choose between two sources that are spatially, temporally, or perceptually confusable, whereas

in the present study people were required to remember details about events that were quite contextually distinct. Second, the FLs may be implicated only when the source memory task is novel or difficult, requiring controlled processing (Henkel et al., 1998; Shallice, 1982). Remembering the context in which important real-world news is heard may occur more automatically and thereby require less FL input than remembering contextual information in less realistic laboratory situations. A third possibility is that extra rehearsal accorded to emotional events may enhance the retention of reception event details. Princess Diana's death was thought about, covered in the media, and discussed more than Mother Teresa's death and was correspondingly better remembered. Extra rehearsal may allow people with low FL function to overcome the source memory deficits that they normally experience. Finally, it may be that the emotional arousal associated with FMs facilitates the functioning of the FLs. At a cognitive level, emotional arousal may have an attention-enhancing effect such that under conditions of moderately high arousal, more aspects of an event may be sampled and encoded, including background or peripheral information (cf., Kahneman, 1973; Revell & Loftus, 1992). Consistent with this notion are studies showing that people tend to remember more central and background details from emotionally arousing stories than from emotionally neutral stories (Heuer & Reisberg, 1990, 1992; Libkuman, Nichols-Whitehead, Griffith, & Thomas, 1999; but see Easterbrook, 1959, for a contrary view). If older adults with low FL function have reduced attentional capacity or are impaired in their ability to allocate attentional resources appropriately, they may fail to take account of contextual details or source information. The attentional enhancement that occurs under conditions of emotional arousal may thus benefit them selectively, increasing their attention to background information and thereby eliminating their source memory deficit.

The hypothesis suggested by Kapur (1997; also Kapur et al., 2000), that FM is dependent on the medial temporal lobes rather than the frontal lobes, was also not supported in the present experiment. Kapur et al. found no FMs for the death of Princess Diana in patients with medial temporal lobe damage. In contrast, the composite measure of MTL function used in the present study was unrelated to memory for either of the emotionally arousing reception events. Older

adults with relatively poor episodic or event memories based on neuropsychological testing were no less likely than those with good episodic memories to retain information about the deaths of Princess Diana and Mother Teresa. The different findings from these two studies may reflect differences in the populations sampled. Kapur's amnesic patients had relatively severe memory deficits as a result of damage to hippocampal and diencephalic structures. The older adults in our study, although heterogeneous with respect to their MTL function, were nevertheless functioning within normal limits. It may be that when MTL function is more severely affected, as in the case of neurological patients, memory for all episodic information will be reduced or lost. In these cases, the benefits of emotional arousal may be sufficient to ensure encoding of the core information (thus the retained memory that Princess Diana had died), but not of the peripheral details.

Note also that there were no differences between older and younger adults in memory for the reception events in the present study, contrary to the Cohen et al. (1994) report. The older adults reported memories that were initially almost as vivid and detailed as those of younger people, and were retained to an equivalent degree over a 6-month period. The reason for the lack of age differences in FM retention in this study, compared to Cohen et al.'s, is not immediately apparent. Different measurement methods may have contributed to the differences. Using a criterion of 90% congruence as a measure of FM, Cohen et al. reported that 90% of younger adults experienced FMs, whereas only 42% of older adults did. The participants in our study appeared overall to have lower congruence scores, but in an analysis similar to Cohen et al.'s we still failed to find significant age differences: 33% of our younger adults and 14% of our older adults had scores of 75% or greater congruence in their Princess Diana reports ($\chi^2 [1, N = 51] = 2.54, ns$), and 20% of younger adults and 11% of older adults had congruence scores of at least 75% for Mother Teresa ($\chi^2 [1, N = 51] = .71, ns$). Although according to this criterion many fewer participants experienced FMs in our study than in the Cohen et al. study, there were still no significant differences in the numbers of older and younger adults who had such enduring memories. We acknowledge, however, that the relatively small number of young participants may have limited our power to find age differences.

The older adults in our study reported somewhat higher levels of emotional arousal than the

young people, although not significantly so. To the extent that emotional intensity contributes to the long-term retention of FMs, the increased emotionality of these events may have contributed to their better retention among older adults. There is evidence that the intensity of emotional experience is preserved in normal ageing (Levine & Bluck, 1997; Malatesta & Kalnok, 1984), and that older adults are unimpaired in memory for emotional stimuli. Carstensen and Turk-Charles (1994), in a study of prose recall, found that although elderly adults remembered less neutral content than young adults, both age groups recalled equivalent amounts of emotional material (but see also Yoder & Elias, 1987). It may be that such benefits apply not only to memory for item or content information, but also to memory for source or context. As noted earlier, Libkuman et al. (1999) found that both central *and* background details were remembered better when they were from an emotionally arousing story compared to an emotionally neutral one. The finding that memory for these emotionally arousing events seems to be preserved in older adults, even in those with compromised memory function in other domains, suggests the involvement of brain structures that may be less affected by age than the frontal or medial temporal lobe regions associated with episodic memory.

Preservation of emotional responsiveness in older adults and the amygdala's hypothesised importance in emotional memory processing (Bechara et al., 1995; LeDoux, 1996) suggest that the amygdala may be such a structure, although preliminary data concerning changes in it with age are as yet inconclusive. There are suggestions of some decline in its size with age (Herzog & Kemper, 1980; Jack et al., 1997; Smith et al., 1999), but the functional effects of these changes are unknown. Evidence from patients with focal lesions (Cahill, Babinsky, Markowitsch, & McGaugh, 1995; Phelps et al., 1998) suggests that the amygdala is involved in the enhanced memory for emotionally arousing stimuli, and neuroimaging studies of normal individuals have demonstrated that greater amygdalar activations are associated with higher levels of memory for emotional stimuli (Canli et al., 2000; Hamann, Ely, Grafton, & Kilts, 1999). However, the amygdala has connections to numerous other brain regions (LeDoux, 1996), and may interact with one or more of these regions to enhance emotional memory. For example, in the case of FM, the amygdala's connections to prefrontal

cortex may be able to modulate frontal function under conditions of emotional arousal. It may be that emotionally arousing events stimulate or boost frontal processes, perhaps enhancing attentional mechanisms as suggested earlier, and thus reduce or eliminate the source memory deficit typically observed in normal ageing. Preserved amygdalar function in older adults may also account for the inconsistency between our findings and those of Kapur et al. (2000). Many of the amnesic patients described by Kapur and colleagues had amygdalar damage, which may have contributed to the absence of FMs in that group (although note that one amnesic patient with encephalitis of unknown origin and no detectable amygdalar lesions had no FM).

Although other public events that have been reported in the FM literature may have been more consequential to participants than those investigated in this study, Princess Diana was an internationally known celebrity, and the news of her death led to high ratings of surprise and moderately high ratings of emotional arousal. Thus, her death meets the criteria for a FM reception event. The death of Mother Teresa was also surprising and arousing, although less so. The death of Princess Diana was also rehearsed more. These encoding and rehearsal differences may account for the fact that both older and younger adults had better memory for events associated with the death of Princess Diana than for those associated with the death of Mother Teresa. Memory for the control autobiographical event was poorer still. Although we did not obtain ratings of emotional arousal or significance of the everyday autobiographical event, the experiences reported for the most part were events that occurred commonly and on multiple occasions, such as backyard barbecues, parties, family gatherings and so forth, and appeared to be emotionally neutral. Many people, in fact, could not recall the control event at all without prompting, and their responses to questions tended to be rather generic (e.g., "If I was at a barbecue, then it must have been a Saturday"). Importantly, the data suggest that the emotionally neutral control event was qualitatively different from the two emotionally arousing events. Long-term memory for the contextual details of the control event was significantly related to MTL function and marginally correlated with FL function, whereas, as already noted, there was no hint of an effect of either MTL or FL function on memory for the two "flashbulb" events. These

results are thus consistent with the notion that there may be a special neurobiological mechanism associated with the encoding of emotionally arousing events—perhaps, as mentioned earlier, involving the amygdala and its connections with prefrontal cortex. This mechanism, however, does *not* create a veridical, permanent record of the arousing event as suggested by the model of Brown and Kulik (1977); details may be lost or distorted over time (e.g., Neisser & Harsch, 1992; Schmolck et al., 2000). Nevertheless, it may enable enhanced encoding and retention of arousing events and the details surrounding them. Autobiographical memories may vary along a continuum of emotional arousal (see also Christianson, 1989), with better memory for those events that are more affectively arousing. FMs such as those associated with President Kennedy's assassination may fall at one end of this continuum, and ordinary events at the other end of the continuum. For participants in the present study, the two "flashbulb" events would likely have fallen somewhere in between, with Princess Diana's death falling closer to the emotional end of the range than Mother Teresa's.

Our findings concerning the variables important for FMs are broadly consistent with the models advanced by Conway et al. (1994) and Finkenauer et al. (1998), with the exception that we did not find any evidence that ratings of personal or world importance contributed to the differences in memory between our two reception events. The ratings of world importance, however, were quite high for both events and so the failure to observe an effect of importance on memory may be the result of a ceiling effect. Our results are also consistent with the original suggestion of Brown and Kulik (1977) that reception events are better remembered when news is surprising, emotionally arousing, and subsequently rehearsed.

Is flashbulb memory a special case of source memory? We believe that it is. Although it may be influenced by many of the same variables that influence non-emotional memories (for example, rehearsal; see Schooler & Eich, 2000), it was unaffected by the neuropsychological measures of FL and MTL function that have been found to predict the performance of older adults in previous studies (Glisky et al., 1995, in press). There was no evidence in the present study that FM was dependent on the medial temporal lobe structures associated with episodic memory and ordinary autobiographical memories. Although there was

also no evidence of frontal involvement in FM, we speculate that the amygdala, activated by the emotional aspects of the flashbulb event, may have enhanced frontal lobe functioning and thereby eliminated the source memory deficit that would normally be present in the low FL group of older adults. Further studies of source memory and emotion, perhaps incorporating functional neuroimaging, may be able to cast further light on the processes and brain regions involved in emotional memory.

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