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Flashbulb Memories of Public and Private Events:

Detailed but Not Special

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Abstract

Following major world events, individuals have reported exceptionally vivid and long-lasting memories of how they learnt about the news. These are termed *flashbulb memories* (FBMs) (Brown & Kulik, 1977), formed often in response to important, shocking and emotional episodes. A wealth of research suggests that FBMs constitute a special class of autobiographical memories, encoded at that moment in time like a snapshot. Recent studies have defined FBMs as only occurring with public events. In this study, we address the debate regarding whether FBMs are truly as special as previous findings show, and whether they also occur for private events. We argue that unlike what its term suggests, FBMs arise post-encoding and are operated on by a similar rehearsal mechanism as are ordinary memories. We compared memories of public and private events amongst 32 participants in 2 phases of data collection. The first phase constituted traditional measures of self-report, and the second phase involved an autobiographical implicit association task (aIAT). We hypothesized that 1) memory strength (assessed by explicit and implicit indices) for private events would be greater than that of public events as the former are more personally significant for individuals, and that 2) rehearsal frequency mediates this relationship. The present evidence did not support our hypotheses, nor did it support the view in previous literature that FBMs only occur for public events. There was no difference between explicit nor implicit indices across public and private events and rehearsal frequency was not predictive of memory strength. We also found that FBMs were recalled to high degrees of specificity, consistency and confidence, but were not automatically facilitated by the aIAT and hence implicate ordinary reconstructive processes. Future research directions, implications and limitations are discussed.

Keywords: flashbulb memory, autobiographical implicit association task, encoding, rehearsal

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What are Flashbulb Memories (FBMs)?

Following major world events such as the assassination of President John F. Kennedy (Brown & Kulik, 1977) or the attack of September 11, 2001 (Hirst et al., 2009, 2015), many people have reported extraordinarily vivid accounts of their learning of the event. Seminal work by Brown and Kulik (1977) led to the coining of *flashbulb memories* (FBMs) to refer to recollections of the reception context in which one hears news of an emotionally-charged, consequential, and surprising event. As the term suggests, these memories are often characterized by acute, photographic-like perceptual information regarding how they learnt the news and other details down to the minutiae (Brown & Kulik, 1977; Conway et al., 1994). They also prove to be largely consistent after long retention intervals, a pattern not found in everyday memories (Hirst et al., 2015). In light of this, Brown and Kulik (1977) proposed that special encoding mechanisms favour the formation of FBMs from events we perceive to be highly emotional and important. These elaborate and highly durable recollections have thus led to postulates suggesting that FBMs do not just constitute a subtype of autobiographical memories but are a special class of memories on its own (Conway et al., 1994; Curci & Luminet, 2006).

Researchers often assess the accuracy of FBMs using explicit self-report measures (Conway et al., 1994; Curci & Luminet, 2006). While it is not possible to corroborate the objective accuracy of individuals' FBMs, the consistency of two (or more) retrospective self-reports over time acts as a proxy for accuracy (Talarico & Rubin, 2017). FBMs also tend to be highly specific and reported with confidence. Postulates who ascribe FBMs to special status argue that ordinary memories often pale in comparison on these three indices (*e.g.*, Conway et al., 1994). For example, U.K. nationals evinced highly precise and accurate FBMs for learning the news of the resignation of British prime minister, Margaret Thatcher, one year after the event occurred (Conway et al., 1994). In contrast, non-U.K. participants who perceived the

event to be less personally significant, displayed more ordinary memories which were less detailed and characterized by more confabulation. Prototypical questions often contain canonical categories inquiring one's location (*e.g.*, "Where were you when you heard about the event?"), day (*e.g.*, "What day was it?"), time, ongoing activity, source of news, and other idiosyncratic details of the reception context (Brown & Kulik, 1977).

However, while FBMs are held with high confidence, they are not unequivocally consistent (Hirst & Phelps, 2016; Neisser et al., 1996; Talarico & Rubin, 2003). Overwhelming evidence has shown that FBM details are also susceptible to reconstruction (Cubelli & Della Sala, 2008; McCloskey, Wible, & Cohen, 1988; Neisser & Harsch, 1992) and forgotten over time (Curci, Luminet, Finkenauer, & Gisle, 2001). When participants were re-tested on their FBMs of the infamous space shuttle *Challenger* explosion, only 7% of them showed consistent recall (Neisser & Harsch, 1992). Similarly, extensive research immediately following the 9/11 attacks revealed that participants' recollections had marked inconsistencies that became stable over the years (Hirst et al., 2009, 2015). President George Bush serves as a prime example for misattributing the source of news to a live broadcast of the attack, though the lack of footage rendered his account implausible (Greenberg, 2004). The same pattern was found amongst nearly half of U.K. respondents who reportedly watched a (non-existing) footage of the Princess of Wales, Diana's car crash (Ost, Vrij, Costall, & Bull, 2002). Moreover, confronting individuals with the improbability of their accounts do not always dampen their confidence (Neisser & Harsch, 1992).

The inconsistency of FBMs suggests that they are equally prone to temporal decay and reconstructions just as ordinary memories are – this has been the central proposition against the special status hypothesis (Cubelli & Della Sala, 2013). However, we insist that the presence of reconstructive aspects is neither necessary nor sufficient to reject the special status hypothesis (Brown & Kulik, 1977; Curci & Conway, 2013). It is more important to consider

the psychology behind how FBMs are formed (Cubelli & Della Sala, 2013). We need to be asking: *Are there functionally different mechanisms underlying the formation of FBMs and ordinary memories?*

Are Flashbulb Memories Special?

Comparing FBMs and Other Memories

A number of studies have attempted to clarify whether FBMs are truly divergent from other types of memories by comparing FBMs and event memories i.e. memory for original event facts (Curci, Lanciano, Maddalena, Mastandrea, & Sartori, 2015; Hirst et al., 2009, 2015; Pezdek, 2003). Most studies have defined the former as surrounding the reception context of an event (*e.g.*, hearing the news from a person) while the latter as personally experienced and not pertaining to any specific reception context. Research on the 9/11 attacks revealed that US respondents tend to correct wrongly recalled event facts, but perseverated in inconsistent FBMs over time (Hirst et al., 2009, 2015). Similarly, Curci et al. (2015) corroborated this distinction between FBMs and event memories; Italian participants had significantly more vivid memories of hearing the news of the Pope's resignation than memories of the original event. They asserted that this is not confounded by the implication of different memory systems (episodic for FBMs vs. semantic for event memories), but that FBMs involving a reception context activate automatic processes whereas retrieving the original news invoke slower reconstructive processes.

These results were established based on the underlying assumption that all FBMs involve some sort of news reception. Bohannon and colleagues (Bohannon, Gratz & Cross, 2007) argued that a reception context contains the episodic, idiosyncratic details, thus facilitating the formation of FBMs. However, recent evidence contradicts this as flashbulb-like qualities are similarly elicited when an event is associated with a first-hand involvement of an individual (Pillemer, 2009; Sharot, Martorella, Delgado, & Phelps, 2006; Thomsen & Berntsen, 2003). In a study conducted on accounts of the 1989 Loma Prieta earthquake, Neisser et al. (1996) found that Californians who were personally involved in the quake displayed stronger FBMs than those who merely heard the news. Emotionally-charged personal events, such as

witnessing a car accident or engaging in psychotherapy, often do not involve a reception context and have been shown to elicit FBMs as well (Lanciano, Curci, Matera, & Sartori, 2018; Thomsen & Berntsen, 2003). Moreover, previous studies did not adequately control for contextual details as participants are often asked to recount the news reception of a public event and a first-hand experience of a private event. Whether the formation of FBMs necessitates a reception context remains unconfirmed.

Nearly all of the research on FBMs has been conducted on the aftermath of major public events. Limited research on memories of private events points to another problematic assumption, which concerns the idea that only memories of public, well-known events qualify as FBMs. Evidence has shown that just as individuals display graphic recall of their circumstances when learning the news of a major public event, extraordinary private events similarly give rise to distinctive recall of peripheral details (Lanciano et al., 2018). The latter may simply be difficult for researchers to investigate as there is no known common time of encoding across participants (Rice, Hamamouche, & Bohannon, 2017). Not only do private FBMs elicit greater emotional intensity, be it positive or negative, they also serve a higher purpose in individuals' lives (Demiray & Freund, 2015). This includes enhancing self-identity, well-being and social bonding, as well as directing future behaviours and goals (Demiray & Freund, 2015; Lanciano et al., 2018; Rasmussen & Berntsen, 2009). Since important private events appear to be more impactful and intimately central to one's life, they may give rise to more evocative memories than public events (Pillemer, 2009).

Overall, previous research has differed in the way they measure FBMs, with a majority studying only public and not private events, and some necessitating a reception context. We suggest that the inconsistent definitions of FBMs across and within studies may invalidate attempts at resolving the special status debate.

Role of Rehearsal Processes

Neisser (1982) was the first to argue against Brown and Kulik's (1977) idea that FBMs are formed solely through special encoding mechanisms, proposing instead that the inaccuracy of FBMs reflect post-encoding processes. Subsequent studies similarly present evidence against encoding factors like surprise and emotional intensity as being critical for the formation of FBMs. In relation to the 9/11 attacks, Luminet et al. (2004) found that Turkish respondents displayed equally strong FBMs despite perceiving the incident as less important, less shocking and less emotional than U.S. respondents. Other studies corroborate this, reporting that neither surprise (Curci et al., 2001; Lanciano, Curci, Mastandrea, & Sartori, 2013; Otani et al., 2005), emotional intensity (Neisser et al., 1996; Otani et al., 2005) nor personal significance (Davidson & Glisky, 2002; Otani et al., 2005) can reliably predict the formation of FBMs. While these encoding factors can contribute to the vividness of a FBM, they do not seem to be necessary.

Flashbulb-like qualities may be products of more ordinary memory processes like rehearsal (Neisser et al., 1996; Pezdek, 2003). Individuals who displayed FBMs regarding the 1999 nuclear accident in Japan reported higher levels of rehearsal than those who did not show FBMs (Otani et al., 2005). Other studies have also shown that both overt rehearsal (*e.g.*, social sharing, following the media) and covert rehearsal (*e.g.*, rumination) are correlated with the formation of FBMs (Curci et al., 2001; Davidson & Glisky, 2002; Tinti, Schmidt, Testa, & Levine, 2014). While repeated rehearsal can enhance the strength of memory traces, it can also introduce distortions in autobiographical memories (Campbell, Nadel, Duke, & Ryan, 2011). Moreover, individuals are motivated to think and talk about important memories because it reinforces their personal and social identities (Talarico & Rubin, 2017). Thus, reconstructed elements can become resistant to forgetting due to their coherent fit with the overall narrative (Neisser, 1982; Pezdek, 2003). Whether rehearsal is a prerequisite for FBMs has not been

thoroughly investigated. If a shared rehearsal mechanism is responsible for the formation of both FBMs and everyday memories, FBMs may be best viewed as a continuum rather than a distinct category.

Assessing FBMs using the aIAT

In recent years, the debate regarding FBMs' status has propelled with researchers' utilization of an autobiographical implicit association test (aIAT) (Greenwald, McGhee, & Schwartz, 1998; Greenwald, Nosek, & Banaji, 2003). It assesses the strength of relations between concepts in which participants have to categorize stimuli as accurately and as quickly as possible. Predictably, participants with vivid FBMs would be faster at associating FBM details with true events than associating them with false events (Lanciano et al., 2013; Sartori, Agosta, Zogmaister, Ferrara, & Castiello, 2008). The aIAT is thus a measure of automatic cognitive processes, contrary to the activation of an effortful memory search during self-report tests (Sartori et al., 2008).

Recent studies have revealed that explicit and implicit measures concur with each other: FBMs of major public events were highly associated with true statements relative to false statements and also recalled to high degrees of specificity, consistency, and confidence (Curci et al., 2015; Lanciano et al., 2013). This constitutes a large aIAT effect and serves as validation for the accuracy of FBMs (Curci et al., 2015; Lanciano et al., 2013). Curci et al. (2015) was the first to show a functional dissociation between FBMs and event memories using an aIAT where participants experienced automatism when categorizing the former but not the latter. They concluded that processes involved in the recall or preservation of FBMs may be fundamentally distinct from ordinary memories. Hence, implicit measures serve as an important supplement to traditional self-report measures for delineating the nature of FBMs. To our knowledge, no study has tested the robustness of automatic associations in assessing FBMs of private events.

The Present Study

We utilized both explicit and implicit measures (aIAT) in assessing memories like Curci et al. (2015) to investigate the mechanisms underlying the formation of FBMs. It is important to note that there is no plausible way of ensuring that the reported accounts in this study are objectively and completely true to detail, as many past researchers have acknowledged. Many findings converge on the suggestion that it is the durable and resistant levels of confidence that make FBMs more distinct than other memories (Denver, Lane, & Cherry, 2010; Neisser et al., 1996; Talarico & Rubin, 2003). Hence, in the present study, we emphasize that the aIAT effect is not indicative of how factual an autobiographical episode is, but to what extent individuals believe a memory to be veracious.

We propose that rehearsal elaboration is the underlying mechanism for the emergence of flashbulb-like characteristics in response to an emotional, important, and surprising event (Cubelli & Della Sala, 2013). An impactful event is more likely to be thought and talked about to a greater extent, giving rise to explicit and idiosyncratic details when recounting it. Since memories of private events are more personally and functionally significant, they may be rehearsed more substantially and generate stronger flashbulb-like qualities than public events (Pillemer, 2009).

Thus, we hypothesize that i) memory strength, as quantified by explicit indices and automatic associations, will be stronger for accounts of private events than for those of public events, ii) which can be explained by how much individuals think and speak of these memories. The first hypothesis is a test of whether FBMs occur for private events, though a null difference between private and public accounts would also lead us to favour the same conclusion. Conversely, if only public events trigger FBMs, higher explicit and implicit scores would be observed for public accounts than for private accounts. Our second hypothesis tests whether extraordinary characteristics observed in FBMs are mainly attributed to rehearsal processes,

making them vulnerable to distortions and confabulations just like typical autobiographical memories. We predict that the difference between FBMs and ordinary memories is more likely to be quantitative than qualitative. A positive result would allow us to rule out any unique mechanism supporting the formation or maintenance of FBMs.

This study also aims to disentangle methodological issues that emerge from rare findings comparing FBMs of public and private events – for example, the lack of ecological validity from staging a private event (Kvavilashvili, Mirani, Schlagman, Erskine, & Kornbrot, 2010) or the lack of control over which personal events participants chose to recall (Denver et al., 2010). We provided participants with selected choices of events to recall, all of which do not involve masses as large as those in 9/11, but do not obstruct the formation of flashbulb-like memories (Luminet & Curci, 2017). Our selected accounts thus ensure authenticity. Additionally, we address the definition of FBMs based on the presence of a reception context, which is inconsistently operationalized across and within many studies. To remove any possibility of observed differences in memory being confounded with contextual details, we controlled for whether memories surrounded a reception context or a first-hand involvement.

Method

Participants

An a priori power analysis determined a sample size of 26 which would provide 0.95 power to detect a medium-sized effect of Cohen's f = 0.5 (G*Power 3.1.9.4). In total, we recruited 34 participants through word of mouth (18 females) due to time limitations and counterbalancing constraints. These consisted mainly of undergraduate students from the University of Edinburgh, with the exception of 2 individuals who were working adults. Altogether, there were 15 Malaysians (44%), 8 Indonesians (23.5%), 4 Singaporeans (11.7%), 1 American (2.9%), and 6 EU citizens (17.6%). All participants were fluent English speakers and based in Edinburgh. There were no records of any known cognitive impairments that would have hindered performance. Participation was voluntary and no remuneration was offered. Ethical approval for this study (reference number: 28-1819/3) was obtained from the Psychology Research Ethics Committee (PREC) at the University of Edinburgh.

Materials and Procedure

The experimental set-up was kept as close as possible to Curci et al.'s (2015). In the initial test phase, online questionnaires were distributed to participants through which consent was obtained. Each participant was asked to complete two questionnaires – one recount of a public event and another of a private event. The FBM questionnaires assessing participants' accounts of public events and private events were adapted from Curci et al. (2015) and Lanciano et al. (2018) respectively. The main measures of confidence, specificity, and rehearsal frequency were obtained at test for both public and private events. As per past literature, we also included additional measures of encoding factors – emotional intensity, surprise, and importance. Participants were informed that a completed survey would constitute an agreement to participate in the follow-up aIAT procedure where they would be retested on their reported memory accounts. On average, the retest phase occurred 15 days (SD = 6.77,

range = 4-33) after the first data collection. During retest, participants were presented with a personalized aIAT task which was administered in two consecutive blocks, one on their public memory account and another on their private memory account. They then completed the same questionnaires they saw during the test phase. Questionnaire responses during the retest phase provided an index of their memory consistency for both types of events (*e.g.,* Conway et al., 1994). We also counterbalanced the order of event type presented during both test and retest phases across participants. Participants were fully debriefed at the end of the retest phase.

Test phase. Participants filled in a questionnaire concerning their memory of a public event and a private event. For each event type, participants chose one out of 3 events to recount. The choice of public events was (1) The election loss of Malaysian Prime Minister Najib Razak, (2) The Sulawesi (Indonesia) earthquake and tsunami, and (3) A major UK Snowstorm known as "The Beast from the East". Conversely, the choice of private events was (1) The death or illness of a loved one, (2) The pregnancy of a close friend or relative, (3) Other. For "(3) Other", participants reported an alternative event that did not fall within the first two categories. These events were chosen for their likelihood to trigger FBMs based on emotional arousal and consequentiality (Rice et al., 2017). We did not select events based on their valence as they are subjective (*e.g.,* pregnancies can be perceived as negative or positive); it is also unlikely that the population would be equally divided on their emotional reactions to the same event (Rice et al., 2017). Participants were instructed that any event that they chose to recount should have occurred within the year (2018). The recall interval was kept small to reduce retrospective bias (Schacter, 2002). They also specified whether their memories were related to news reception or a first-hand involvement. For the public event, items corresponded to 8 FBM attributes: (1) date, (2) day, (3) time, (4) informant, (5) location, (6) other people present, (7) ongoing activity, and (8) change in activity. We adapted this from the reported 6 attributes in Curci et al. (2015) to make this comparable to our private event questionnaire. Items for the private event tapped

all the same canonical categories except items 4, 6 and 8; these were replaced with questions corresponding to (4) weather, (6) clothing, and an open-ended question inquiring (8) other significant details (See Appendix A for full questionnaire composition). This revision was due to the idea that the latter categories would be more informative of one's private experience than the former (Lanciano et al., 2018).

Public event questionnaire scoring for specificity. For items (3) time, (4) informant, (5) location, (7) ongoing activity, and (8) change in activity, score 2 was assigned if respondents showed a totally detailed recall (*e.g.,* "Edinburgh, home, bedroom"). Score 1 was assigned when the response was partially detailed (*e.g.,* "Edinburgh"). Score 0 indicates that the participant had forgotten the attribute (*e.g.*, if answer was missing) or gave an irrelevant response to the question. For items (1) day, (2) date and (6) other people present, score 1 was assigned if respondents provided a recall and 0 when the answer was missing or irrelevant.

Private event questionnaire scoring for specificity. For (3) time, (5) location, (6) clothing, and (7) ongoing activity, score 2 was assigned for a totally detailed recall, score 1 for a partially detailed recall, and score 0 for a missing or irrelevant answer. For items (1) day, (2) date, and (4) weather, score 1 was assigned if respondents provided a recall and 0 when the answer was missing or irrelevant. For item (8) other significant details, each individual detail summed up to give a score for that item. Scores for each canonical category were summed to get an FBM specificity index for each event type.

Confidence. Participants rated how confident they were in their recollection on a 5-point scale (0 = *not confident at all*; 4 = *completely confident*) for each canonical category. An FBM confidence index per event type was obtained by averaging these scores.

Other variables. Participants also evaluated a series of statements regarding 1) how surprised they were about the event, 2) how consequential it was for themselves, 3) how

consequential it was for others, 4) how upset they were, and 5) how happy they were. These were rated on a 5-point scale (0 = *strongly disagree*; 4 = *strongly agree*). We collapsed variables 4) and 5) into one variable indexing emotionality intensity, with the former reverse-scored. For our main variables of interest, participants specified to what extent they had rehearsed about the event in terms of how often they 6) thought about it (rumination) and 7) talked about it (social sharing), which were scored on a 5-point scale (0 = *never*; 4 = *always*).

Retest phase.

Table 1

Description of aIAT blocks (adapted from Curci et al., 2015)

		Press "Z" key	Press "M" key
Block 1	Logical categorization	True statements 1. "I am in front of the computer" 2. "I am doing a psychology experiment" 3. "We are in 2018" 4. "I am sitting on a chair" 5. "I am in Edinburgh"	False statements 1. "I am seeing a movie" 2. "I am doing shopping" 3. "I am playing cards" 4. "I am sitting in my car" 5. "I am on the beach"
Block 2	FBM categorization	Present FBM statements 1. I was in the library at the Psychology building 2. I was doing my take-home exam 3. It was 1 March 2018 4. I was with a friend 5. It was 8pm	Absent FBM statements 1. I was at the supermarket 2. I was grocery shopping 3. It was 1 June 2018 4. I was alone 5. It was 9am
Block 3	Double categorization (congruent)	True and present FBM statements	False and absent FBM statements
Block 4	Reversed FBM categorization	Absent FBM statements	Present FBM statements
Block 5	Reversed double categorization (incongruent)	True and absent FBM statements	False and present FBM statements

aIAT measures. A personalized aIAT was constructed based on participants' questionnaire responses during the initial test phase. We adapted the aIAT procedure from Curci et al. (2015) who similarly administered two consecutive runs of the task in a single session. Participants were presented with 5 blocks of categorization trials for each of their two memory accounts. Prior to the start of the task, participants were informed that a stimulus statement would appear in the middle of the computer screen, of which they were to categorize it by pressing one of two keys. They were told to be both as accurate and as fast as possible, but not to sacrifice accuracy for speed. Block 1 consisted of 20 logical categorization trials, where participants responded to the truthfulness of each statement (*e.g. "I am doing a psychology experiment",* See Table 1). Here, they pressed "Z" if it was true and "M" if it was false. In block 2, instructions informed participants to think about the memory account that they had previously reported (corresponding either to a public or private event). They then responded to a series 20 FBM categorization trials which required them to classify statements as being present ("Z") or absent ("M") from their memory accounts. Distractor items were presented as fabricated details of plausible scenarios of learning the news or experiencing the event in question. In cases where possible, we kept these fabricated statements the same across participants. Block 3 consisted of 60 double categorization congruent trials, where participants classified statements as being either true or present in their memory accounts ("Z") and false or absent from their memory accounts ("M"). Block 4 consisted of 40 reversed FBM categorization trials, where response keys corresponding to the presence and absence of details were reversed. Specifically, participants pressed "M" if statements were present in their memory accounts, and "Z" if they were absent. Finally, in block 5, 60 reversed double categorization incongruent trials were presented. Participants categorized sentences by pressing "Z" if statements were either false or present in their memory accounts, and pressing "M" if statements were either true or absent from their memory accounts. This concluded the

end of the first half of the aIAT procedure. The second half was a repeat of these same 5 blocks, except with statement stimuli pertaining to the other memory account that participants had reported, depending on which counterbalanced condition they were in. The sequence and the number of times in which statements were repeated were randomly presented to participants within blocks.

The main blocks of interest were the congruent block (block 3) and incongruent block (block 5). The aIAT effect, approximated by the *D* index, is thus a measure of the relative speed at which participants associate congruent (present FBM details with true statements and absent FBM details with false statements) versus incongruent stimuli (present FBM details with false statements and absent FBM details with true statements) (Greenwald et al., 1998). As the algorithm recruited by Curci et al. (2015) for the calculation of the *D* index did not take into account incorrect responses on the aIAT procedure, we instead followed the steps listed by Lanciano et al. (2013), which adhered to Greenwald et al.'s (2003) recommendations closely. The procedure was as follows: (1) Eliminate trials with latencies greater than 10,000ms; (2) Eliminate participants who produced latencies of less than 300ms on at least 10% of their trials; (3) Calculate the mean of correct latencies for the two double categorization blocks, one for block 3 and one for block 5; (4) Replace each error latency with the block-corrected mean, with an addition of a 600ms error penalty; (5) Calculate one standard deviation for all trials in blocks 3 and 5; (6) Calculate means for block 3 trials and block 5 trials; (7) Calculate the difference between the two means obtained from step 6; and (8) Divide the difference score obtained from step 7 by the standard deviation obtained from step 5 – this gives the *D* index. The larger the *D* index, the greater the aIAT effect. We generated two *D* scores for each participant, one related to their public event memory and another to their private event memory.

Consistency scoring. Immediately after the aIAT procedure, participants completed the

same questionnaires they saw in the initial test phase. Consistency was scored by comparing responses of each canonical category across the test and retest phases. For each item, a score of 2 was given if responses were identical at both phases, with no loss, gain, or change of information. A score of 1 was given if answers were fundamentally similar though not completely identical, such as when additional or less information was provided (*e.g.*, when "*At home, Edinburgh*" becomes just "*Edinburgh"*). A score of 0 was assigned under 2 conditions – firstly, when responses at both phases were completely different (*e.g.* when "*At home"* becomes "*Tesco"*), or secondly, when the corresponding specificity score for that item is 0. The latter indicates that the provided response in the initial test phase was missing or irrelevant. A consistency index for each event type was obtained by summing the scores for each item.

Analysis Strategy

We employed a one-way ANOVA design with type of FBM (Event Type: Public vs. Private) as a within-subject factor. The dependent variables were the 3 explicit indices: specificity, confidence, and consistency, as well as the implicit *D* index from the aIAT procedure. These variables act as proxies for memory strength.

Our main confirmatory hypothesis concerns whether rehearsal frequency is a mediating factor for the memory strength typically seen in traditionally classified FBMs. Hence, if a main effect of event type was found, the two rehearsal variables, rumination and social sharing, were added as covariates in our ANOVA models. If a main effect was not observed, explicit and implicit indices would be collapsed across event type and correlated with the rehearsal variables. Counterbalanced condition and reception context were also added as additional controls should there be a main effect of event type.

To examine evidence for the special encoding hypothesis (Brown & Kulik, 1977), we correlated indices with encoding variables (emotional variables: *emotional intensity, surprise, personal importance* and *importance for others*). As findings regarding the encoding account

have been largely mixed, we emphasize that the results obtained from this analysis would be purely exploratory. Correlation analyses were also run on explicit and implicit indices to corroborate our adopted methodology. All correlation analyses were based on ranked data and hence, Spearman's rank-ordered correlation was used instead. We compared our results with those reported in previous literature (*e.g.*, Curci et al., 2015) and highlight any implications these may entail. All analyses were performed in R (Version 3.3.1; R Development Core Team, 2016).

Results

Two participants did not qualify for the aIAT procedure as they did not adhere to the instructions of the questionnaire (1 participant reported an event that had occurred more than 8 years ago and 1 participant reported the same event for both public and private events). Subsequently, only 32 participants were tested on the aIAT. 0.25% of trials generated latencies of over 10,000ms and were excluded accordingly (Greenwald et al., 2003). Amongst these participants, none had more than 10% of trials in which they responded faster than 300ms. Hence, no further participants were excluded after inspection of the aIAT data. We additionally reported results excluding participants whom *D*-index scores were negative ($N = 6$) as this may suggest poorly deployed attention during the experiment (See Appendix B for individual scores).

Two independent coders scored the consistency and specificity of participants' questionnaire responses. Inter-rater reliability was assessed using spearman's rank-order correlation for all questionnaire items, as well as for items after excluding dissimilar canonical categories tapped on by the public and private event questionnaires (See Appendix A for questionnaire disparities). There was high consistency between the two coders across all items ($\rho = .92$) as well as across just shared items ($\rho = .91$). We thus computed scores of explicit indices using all items as these would be more representative of overall memory strength

Effect of Event Type

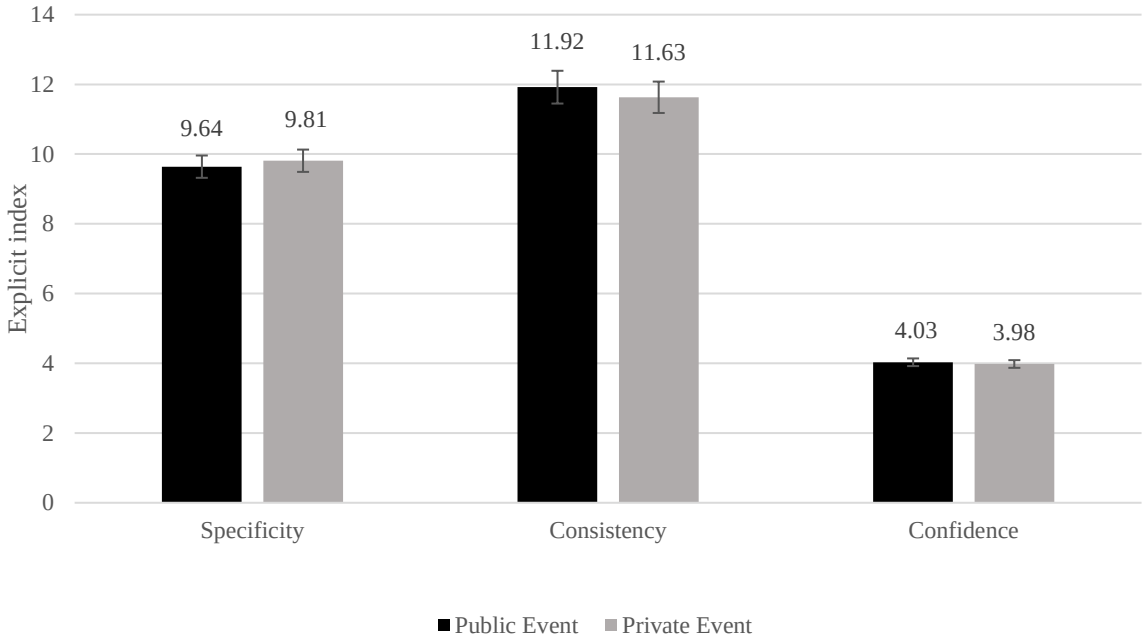

Figure 1. Explicit FBM indices as a function of event type. Error bars represent standard deviations of the mean. Means are labelled on top of the bars.

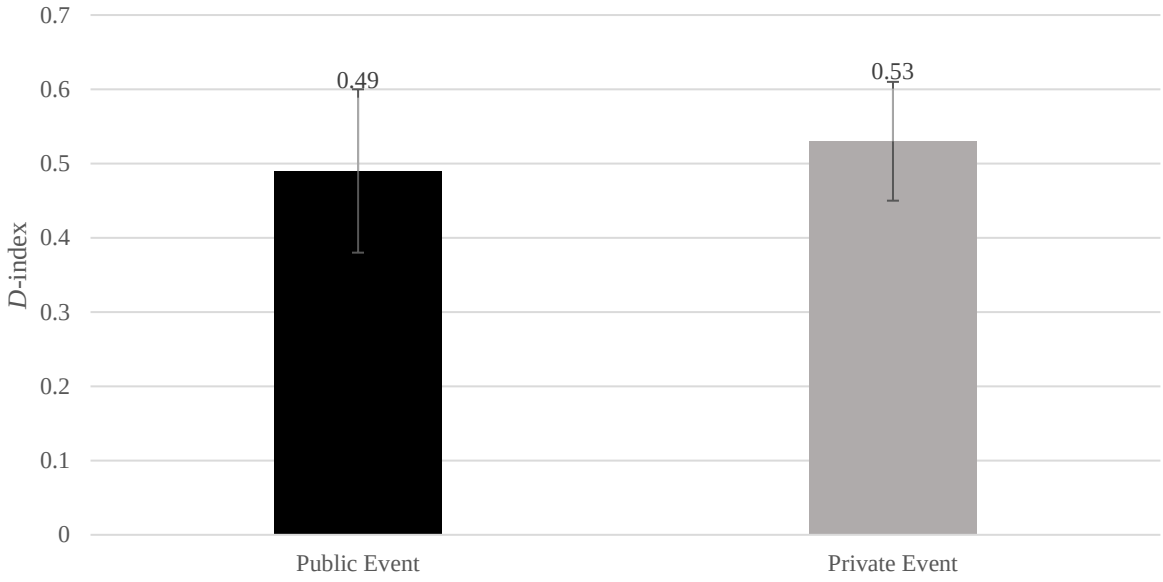

Figure 2. Mean *D*-index scores as a function of event type. Error bars represent standard deviations of the mean. Means are labelled on top of the bars.

Results here were reported with respect to a Bonferroni-corrected alpha level of .0125. Figure 1 illustrates the differences in scores of explicit indices across public and private events. Our ANOVA analyses revealed that memories of public and private events did not significantly differ from each other on specificity ($F(1, 60) = 0.01$, $p = .92$), confidence ($F(1, 60) = 3.04$, $p = .09$), nor consistency ($F(1, 60) = 4.62$, $p = .04$). On average, *D* index scores were higher for memories of private events ($M = 0.53$, $SD = 0.48$) than for memories of public events ($M = 0.49$, $SD = 0.62$) (See Figure 2) but this difference did not reach significance ($F(1, 60) = 0.56$, $p = .46$). All results remain non-significant even after excluding participants with negative *D* index scores (specificity ($F(1, 48) = 0.021$, $p = .89$); confidence ($F(1, 48) = 1.45$, $p = 0.24$); consistency ($F(1, 48) = 4.31$, $p = .04$); *D*-index scores ($F(1, 48) = 0.18$, $p = .67$)). These results demonstrate that FBMs do occur for private events and not just for public events. In light of non-significant effects, covariate analyses were not run for moderating factors (counterbalanced condition, reception context) and mediating factors (rumination, social sharing).

Relationships Between Indices, Rehearsal and Emotional Variables

Table 2

Spearman's rank-order correlations between rehearsal frequency and explicit and implicit indices

	Rehearsal Frequency (range: 0-5)	Specificity (range: 0-13)	Consistency (range: 0-16)	Confidence (range: 0-5)	*D* index
Rehearsal Frequency	**3.16 (**0.84)	-	-	-	-
Explicit Indices					
Specificity	-0.03	**9.73** (1.80)	-	-	-
Consistency	-0.06	0.42**	**11.77** (2.58)	-	-
Confidence	0.12	0.25*	0.27*	**4.00** (0.61)	-
Implicit Indices					-
D index	0.10	0.02	0.04	0.15	**0.51** (0.55)

Note. *$p < .05$, **$p < .001$. Means and standard deviations (in parentheses) are reported in the diagonal of the matrix. Rehearsal frequency was a combination of social sharing and rumination. When excluding conditions that produced negative *D*-index scores, mean *D*-index score becomes 0.67. For comparison, mean scores of specificity, consistency, confidence, and *D*-index in Curci et al. (2015) were 7.61 (out of 10), 8.47 (out of 12), 4.26 (out of 5), and 1.13 respectively.

With regards to the following correlational tests, $p < .05$ was used as the *a priori* criteria for significant effects. As our main test of hypothesis, spearman's rank-order correlations were calculated to assess whether rehearsal frequency was a significant predictor of memory strength. As the correlation between rumination and social sharing was small ($r = 0.28$, $p < .05$), this suggests that they are tapping slightly different aspects of the rehearsal mechanism. Hence, we combined them into one variable, rehearsal frequency.

Table 2 shows that rehearsal frequency was not significantly correlated with any of the explicit or implicit indices. In contrast to our hypothesis, this indicates that rehearsal does not account for memory strength. While all three explicit indices were significantly correlated with each other, corroborating the reliability of traditional FBM assessment, none of them were significantly correlated with the *D* index (See Table 2). We assert that this finding does not put into question the reliability of implicit measures as previous studies have substantiated the use of the aIAT in approximating memory strength – this will be discussed in detail later.

Exploratory analyses. Curci et al. (2015) demonstrated that while a highly emotional and rehearsed event may potentially contribute to a flashbulb-like memory, emotionality and rehearsal frequency do not predict the aIAT effect in the same way that it does for an explicitly measured FBM. Results from our correlation analyses are in line with this perspective. We similarly found that the *D*-index did not significantly correlate with any other emotional variables such as surprise (r = -0.10, p = .42), personal importance (r = 0.14, p = .26), importance for others (r = -0.18, p = .15), and emotional intensity (r = 0.14, p = .39). Like Curci et al. (2015), these correlations remain $r < |0.20|$.

Contradictory to the special encoding hypothesis, our explicit indices also did not significantly correlate with any of the emotional variables, with the exception of confidence and personal importance (r = 0.34, $p < .01$).

Discussion

The present study aimed to address the debate regarding the special nature of FBMs. Using both self-report measures and experimental manipulations, we investigated if an ordinary memory process like rehearsal mediates the relationship between memory strength and the type of event recounted (public or private). We did not find flashbulb-like qualities, as indexed by explicit and implicit indices, to be stronger for private events than for public events. Critically, memory strength could not be reliably predicted by how much one ruminated or engaged in social sharing about the memory. While results did not support our expectations, our findings generate new insights. We also highlight some methodological issues crucial for scientific progress in this field.

Firstly, previous researchers often only investigate FBMs of major public events that have an extensive impact on masses. Our study fills the gap in existing literature regarding FBMs of personal episodes. While our participants generally rated private events to be more personally important and emotional than public events (Pillemer, 2009), there were only marginal differences in rehearsal elaboration (See Appendix C). This may explain why we found no difference in memory strength across public and private events. Importantly, this demonstrates that FBMs do occur for private events, rejecting previous assumptions that FBMs only arise with public events.

Secondly, it is crucial to know whether a reception context is both necessary and sufficient to evoke flashbulb-like qualities so that the inconsistency in the way researchers operationalize FBMs can be reduced. However, as FBMs for public events did not differ from those of private events in our study, we could not test news reception as a potential moderator. Our investigated scenarios were designed to trigger FBMs and we were thus unable to directly test whether a reception context confers privileged encoding of events (*e.g.*, Bohannon et al.,

2007). For greater clarity, future research should compare a range of events that differ on how likely they are to generate FBMs with and without a reception context, using a 2 (Event: Extraordinary vs. Ordinary) x 2 (Context: News Reception vs. First-Hand Involvement) design.

Are FBMs Special?

On closer inspection of our data, mean scores of specificity, consistency, and confidence were comparable to those reported in Curci et al.'s (2015), attaining high 70th to 80th percentile ranks (See Table 2). Thus, we can be sure that the probed accounts in our study were sufficiently vivid and consistent to be termed FBMs. The free recall items in the questionnaires also allowed participants to report any significant details they could remember, ensuring that distinctive features of one's memories were captured by the scores. Explicit indices were also significantly associated with each other, supporting the convergent validity of traditional self-report measures. As a variety of different events were investigated in our study, we can be sure that the flashbulb-like qualities of memories are generalizable across various public and private events (Demiray & Freund, 2015).

However, evidence from the aIAT did not converge with traditional self-report assessments. We obtained an average *D*-index score of 0.51, which is less than half of that reported by Curci et al. (2015) (See Table 2). While previous studies demonstrated a reliable positive correlation between explicit indices and *D*-index scores for FBMs (Curci et al., 2015; Lanciano et al., 2013), little association was found in the present study. It is unlikely that this is caused by inadequacies of the aIAT manipulation since our positive *D*-index scores indicate that participants did find it harder to inhibit associating true memory details with false statements than with true statements. Curci and colleagues (Curci et al., 2015; Lanciano et al., 2013) who reported high *D* scores (> 1.00) in FBMs had employed small sample sizes using between-subjects designs that were not based on power calculations. In contrast to our within-

subjects design which yields good power, we propose that their findings are likely underpowered. Our mean *D*-score of 0.51 still reflects good classification accuracy of above 80% (Agosta & Sartori, 2013), although it would seem to concur with the detection of more ordinary autobiographical memories (Sartori et al., 2008). Specifically, our longer latencies indicate that retrieving FBMs during the aIAT did not involve the level of automatic facilitation or feelings of familiarity that were previously posited (Lanciano et al., 2013). Instead, our participants spent more time generating vivid details during the experimental task, implying that an effortful and controlled process of recollection was involved (Lanciano et al., 2013; Yonelinas, 2002). FBMs thus do not seem to be automatic, neither are they different from other memories except in the level of detail recalled (Cubelli & Della Sala, 2013). We show here that FBMs can evince distinctive and persistent features and yet implicate similar reconstructive processes as those in ordinary memories. Hence, our current findings, albeit unpredicted, demonstrate that a special mechanism underlying the formation of FBMs is unlikely.

Is encoding or rehearsal responsible for FBMs?

Moreover, our exploratory analyses of the emotional variables do not support the special encoding perspective put forth by Brown and Kulik (1977). In our study, emotional reactions (including the degree of surprise) did not determine how detailed, consistent, or confident individuals were in their recall, or how well they performed on the aIAT. Our findings are consistent with previous studies showing that an event can be expected and unsurprising and still result in FBMs (Curci et al., 2001; Lanciano et al., 2013; Otani et al., 2005). Our evidence also converges with past literature showing that one's subjective experience of an event does not have to be extremely upsetting or pleasant to generate typical FBM characteristics (Hirst et al., 2015; Neisser et al., 1996; Otani et al., 2005; Talarico &

Rubin, 2003). Overall, our findings go against Brown and Kulik's (1977) proposal that detailed encoding is facilitated through emotional affect.

We found that only personal importance was significantly associated with how confident individuals were in their accounts. This parallels Day and Ross' (2014) findings which revealed that a sense of attachment was the most important predictor of participants' confidence in their recounts of Michael Jackson's death. While public events prime social group membership (Day & Ross, 2014), private events make personal identities salient and foster well-being (Demiray & Freund, 2015), both of which contribute to one's phenomenological experience of an event. Amongst the encoding-related factors mentioned, one's perceived significance of the event may be the most promising determinant of FBMs (Talarico & Rubin, 2017). In our study however, psychological significance alone would still not have been sufficient to predict the formation of a specific, consistent FBM. Together with the aIAT data, this indicates that the special encoding hypothesis does not hold true.

However, we also did not find evidence for the role of rehearsal in the formation of FBMs. Rehearsal frequency neither determined one's memory scores on explicit indices nor their performance on the aIAT. Our null results may be partly due to cultural differences. A large proportion of our participants were international undergraduates of Asian descent who participated due to their identification with the Sulawesi tsunami and the Malaysian Election. Firstly, we can assume that physical proximity did not affect their strength of memory for these events as past literature has shown that living closer to the critical event does not significantly enhance recall for it (Pezdek, 2003). Instead, their collectivistic culture may explain why our observed ratings on rehearsal frequency (See Table 2) paled in comparison to most major FBM research that has been conducted in Western populations (e.*g.* 9/11 attack, assassination of John F. Kennedy, *Challenger* explosion etc.). In the former, sharing emotional reactions with others

verbally or non-verbally may be less socially desirable than in the latter (Fernandez, Carrera, Sánchez, Paez, & Candia, 2000; Otani et al., 2005). Collectivistic cultures orient individuals less towards the self as compared to individualistic cultures, thus discouraging ruminating and sharing about one's feelings or experiences (Luminet et al., 2004). This means that Easterners tend to remember an event from a third person's perspective – hence, they may be less likely to develop FBMs or may display FBMs that are weaker in distinctiveness (Cohen & Gunz, 2002). However, as our study was not designed to test cultural differences, we cannot confirm this possibility. The aforementioned cultural reasons are thus only speculative. We suggest that culture may be one of several boundary conditions that need to be considered when conducting FBM research. In summary, our data favours neither the encoding nor the rehearsal account.

Caveats

In light of this, we propose that previous research may have operationalized FBMs in ways that bias results to favour the special status hypothesis. For example, Conway et al. (1994) had quantified FBMs based on whether explicit indices passed a strict criterion of 90th percentile. Using the same criterion, Otani et al. (2005) found that very few participants qualified as having FBMs for the 1999 nuclear accident in Japan. We argue that any threshold distinguishing FBMs and vivid autobiographical memories would be arbitrary (McCloskey et al., 1988). A lack of agreement on the special status of FBMs means that it would be problematic to define *a priori* that FBMs constitute a distinct category of memories. This methodology paves way for verification of FBMs as discontinuous and not its falsification. To make a case for its special status, the premise that FBMs are continuous with ordinary memories should be falsifiable and thus be treated as such. In context of the present study, explicit and implicit measures do not show evidence against the continuity of FBMs with ordinary memories.

We also highlight some caveats of the present study caused by the temporal nature of FBM research. Firstly, examining how FBMs evolve over time is beyond the scope of our study. Hence, our investigated accounts are only consistent insofar that the test-retest interval does not exceed 2 months. This delay period is considerably shorter than many other studies (*e.g.*, Conway et al., 1994; Hirst et al., 2009, 2015; Lanciano et al., 2013). Conclusions drawn about consistency thus cannot be generalized to the long-term preservation of FBMs.

Secondly, due to practical constraints of investigating private events, we were unable to assess memories immediately following the probed event. Previous studies propounding the encoding account often find a high incidence of FBMs when memories are assessed immediately following an event (*e.g.*, Conway et al., 1994; Curci et al., 2015). Conversely, we assessed memories after the events in question had occurred anywhere within the year. This meant that some individuals in our study were tested for the first time several months after the triggering event. For them, an emotional event could have enhanced encoding processes in the immediate aftermath but their emotional reactions may decline with time and become less associated with memory strength. Though some studies assessing FBMs at two time points (*e.g.*, immediate aftermath and 1 year later) argue that rehearsal is a more contributing factor than encoding (*e.g.*, Otani et al., 2005), we cannot confirm whether emotional variables were equally unimportant for memory strength during the initial conception of the event as it was when memories were assessed here. Our results therefore do not strictly exclude the possibility that encoding factors contribute to the formation of FBMs, with rehearsal playing a more secondary role in maintenance (Conway et al., 1994).

Lastly, as our study investigated a range of events, there is considerable variability in our participants' recall intervals. As with most FBM research, we cannot confirm the objective accuracy of when events occurred and were hence unable to test for effects of recall intervals.

Some individuals may have engaged in extended rehearsal across several months whereas others may not have had the chance to think or talk about it very much. Variance in recall intervals and the lack of experimental control over naturalistic rehearsal may thus explain why our rehearsal ratings were largely unrelated to memory strength. Another possibility that may have undermined the contribution of rehearsal in our study is that we only investigated events that were likely to trigger FBMs. Without compromising on the ecological validity of selected events, we suspect that a comparison between memories for mundane day-to-day events and extraordinary events would generate greater support for the rehearsal account (Kvavilashvili et al., 2010).

Future Directions

Where were you when you heard about the 9/11 attacks? What were you doing when you witnessed a car accident? Memories of events like these are often reported with extraordinary detail and high confidence, but are not always accurate. In the past, theoretical definitions used to define FBMs (i.e. whether they are accurate or not) have constantly divided researchers. Neisser's rejection of the special status hypothesis was largely based on the apparent striking inaccuracy of FBMs; Rice et al. (2017) countered this, contending that inconsistency rates (not including instances of forgetting) in studies were never more than 35% and thus not more pronounced than ordinary memories. Importantly, we argue that probing at its accuracy or lack thereof is a superficial descriptive approach and will not resolve the special status debate – the psychology underlying it will. Some researchers have argued that the idea of FBMs being recalled with high confidence despite poor consistency may be the defining characteristic of FBMs (Curci & Conway, 2013; Talarico & Rubin, 2017). Indeed, our consistency-confidence correlation of $r = 0.27$ concurs with Neisser and Harsch's (1992) of 0.29, indicating some dissociation between the accuracy and confidence in which a memory is

held. It may be that FBMs are special insofar that metacognitive processes are fundamentally distinct from those of ordinary autobiographical memories. We propose that phenomenology may be a promising avenue for future research to clarify whether there are unique processes underlying FBMs.

Our most important contribution to the ongoing special status debate is the striking finding that FBMs are special in the vividness of recall, but ordinary in their underlying processes. We asked whether FBMs are formed at rehearsal instead of being specially encoded, with our current findings supporting neither accounts. In light of this, Neisser proposed that the presence of FBMs in the absence of any special encoding factors would favour the rehearsal account. However, we do not preclude the possibility that FBMs are formed at encoding: day-to-day recall and FBMs can both be products of a selective mechanism that facilitates the encoding of arousing events (Rice et al., 2017). Distinguishing between these two accounts is a tricky endeavour as emotional-related encoding factors are often associated with rehearsal – an unexpected, emotional, and significant event is likely talked about and ruminated more frequently. To delineate these two accounts with greater methodological control over time-related confounders, future studies may need to experimentally manipulate rehearsal across different time points to test for its causal role in generating flashbulb-like qualities (*e.g.*, presenting visual or oral repetitions of autobiographical stimuli in the lab and comparing longitudinal ratings of rehearsal with initial encoding ratings, see Svoboda & Levine (2009)).

We thus end with a more agnostic view regarding whether FBMs are formed at encoding or rehearsal. Importantly, we are convinced from our findings that FBMs occur for both public and private events, and that FBMs do not involve processes that are fundamentally different from those of ordinary memories. We leave the identification of specific mechanisms to future pursuits.

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Appendix A

Composition of Flashbulb Memory Questionnaire

Memory Attributes	Confidence Ratings	Encoding Variables	Rehearsal Variables
Date	C-Date	Affect	Times thought about (Rumination)
Day	C-Day	Surprise	Times talked about (Social
Time	C-Time	Negative emotionality	sharing)
Place	C-Place	Positive emotionality	
*People/Clothes	*C-People/C-Clothes	Importance	
*Activity/Weather	*C-Activity/C-Weather	Personal importance	
*Change in activity/Other	*C-Change in activity/C-Other	National importance	
significant details	significant details		

Note. C=Confidence. ***People, Activity, Change in activity*** were assessed in public event questionnaires; *clothes, weather, other significant details* were assessed in private event questionnaires. Questionnaire items were adapted from Curci et al. (2015) and Lanciano et al. (2018).

Appendix B

Participants' Mean Scores on Explicit and Implicit Indices

Subject	Event Type	Context	*D*-index	Specificity	Consistency	Confidence
1	Public	Experience	0.50	11	13.5	4
	Private	Experience	0.87	11	11	3.89
2	Public	News	0.64	11.5	11.5	4.25
	Private	Experience	0.66	11	7	4.14
3	Public	Experience	0.37	12	13.5	5
	Private	News	0.98	11	11	3.29
4	Public	News	0.78	11	13	4.38
	Private	Experience	0.94	11.5	12	5
5	Public	Experience	0.57	9.5	11.5	3.6
	Private	News	0.79	7.5	4.5	3.14
6	Public	News	0.71	9	14	4.88
	Private	Experience	0.55	9	8.5	4.29
*7	Public	News	0.31	13	13	4.38

	Private	News	-0.02	11	11.5	2.71
8	Public	News	0.41	7	12	4.63
	Private	Experience	1.11	10	11	4.43
9	Public	News	0.73	9.5	14	2.5
	Private	Experience	0.29	10	12	2.71
10	Public	Experience	0.81	8	7.5	4.63
	Private	Experience	0.48	10.5	12.5	4.14
11	Public	Experience	0.88	12	10	4.63
	Private	News	0.90	9	11	4.29
12	Public	Experience	0.73	9	15	4.13
	Private	Experience	0.12	10	12.5	3.86
13	Public	News	0.74	8	9	4.25
	Private	Experience	0.91	10.5	11.5	4.71
14	Public	News	0.83	7	11	4.75
	Private	News	0.44	8	9.5	4.43
15	Public	Experience	0.50	11	13	4

	Private	Experience	0.74	7	10	4.57
16	Public	News	0.66	10.5	12.5	4
	Private	News	0.88	10	16	3.86
17	Public	Experience	0.66	7	7.5	3.75
	Private	News	0.58	12	12.5	4.29
18	Public	Experience	1.02	12	15.5	4.75
	Private	News	0.25	14.5	14	3.86
19	Public	Experience	0.82	13	15	4.25
	Private	Experience	0.10	9	14	4.43
20	Public	Experience	1.17	8	12	3.63
	Private	News	0.45	9	14.5	4.29
*21	Public	News	0.04	8	11.5	3.63
	Private	News	-0.38	5	7	3.57
22	Public	Experience	0.87	9	15.5	4.38
	Private	News	0.79	8.5	14	4
23	Public	Experience	0.58	7	9	2.38

	Private	News	0.71	12.5	10	3.86
24	Public	Experience	0.65	9	12.5	4
	Private	Experience	0.85	8	13.5	3.29
25	Public	News	0.17	10	11.5	3.75
	Private	Experience	0.33	10.5	15	4.86
*26	Public	Experience	-0.24	7	4.5	3.63
	Private	News	0.19	9	12	3.14
27	Public	News	0.71	9	14	4
	Private	News	1.06	8.5	11.5	4.14
*28	Public	Experience	-1.76	11.5	16	4.63
	Private	News	-0.39	8	11	3.43
*29	Public	Experience	0.86	9	9	3.63
	Private	News	-0.19	10	10	4.14
30	Public	Experience	1.37	11	14	3.88
	Private	News	1.68	10	12.5	3.29
31	Public	News	0.00	9.5	10	3.88

	Private	Experience	0.62	11	13.5	4.57
*32	Public	News	-1.26	9.5	10	2.88
	Private	Experience	-0.34	11.5	15.5	4.71

Note. Experience = personal involvement in event; News = news reception. *Participants with negative *D*-index scores

Appendix C

Participants' Mean Ratings of Variables

	Surprise	Personal Importance	National Importance	Emotional Intensity	Rehearsal Frequency
Public Event	4.06	3.91	4.34	2.73	3.06
Private Event	3.50	4.43	4.31	3.33	3.27

Note. All variables were scored out of a maximum rating of 5.