Research Article

Emotion, Memory, and Attention in the Taboo Stroop Paradigm

An Experimental Analogue of Flashbulb Memories

Donald G. MacKay and Marat V. Ahmetzanov

University of California, Los Angeles

ABSTRACT—*This study tested the binding hypothesis: that emotional reactions trigger binding mechanisms that link an emotional event to salient contextual features such as event location, a frequently recalled aspect of naturally occurring flashbulb memories. Our emotional events were taboo words in a Stroop color-naming task, and event location was manipulated by presenting the words in different task-irrelevant screen locations. Seventy-two participants named the font color of taboo and neutral words, with instructions to ignore word meaning; in one condition, several words were location consistent (i.e., always occupied the same screen location), whereas in another condition, several colors were location consistent. Then, in a surprise recognition memory test, participants recalled the locations of location-consistent words or colors. Although attention enhanced overall location memory for colors (the attended dimension during color naming), emotion (taboo vs. neutral words) enhanced location memory for words but not colors. These results support the binding hypothesis but contradict the hypothesis that emotional events induce imagelike memories more often than nonemotional events.*

The present study addresses ongoing theoretical and empirical issues associated with emotionally charged, or flashbulb, memories. One issue concerns the main theoretical idea that has guided flashbulb memory research: analogies with photography and computer printouts. Several studies have demonstrated that naturally occurring flashbulb memories are less accurate or resistant to decay than these analogies would suggest (see, e.g., Christianson, 1989; McCloskey, Wible, & Cohen, 1988; Neisser & Harsch, 1992; Neisser et al., 1996). However, even when inaccurate, emotionally charged memories are experienced as extremely detailed and vivid, with imagelike or perceptual features that are unusual for ordinary memories (see, e.g., Talarico & Rubin, 2003). Perhaps nonemotional events are less likely to induce storage of perceptual images than emotional events (Livingston, 1967), even if the images are fuzzy, partial, inaccurate, and subject to decay (e.g., Pillemer, 1984). The present study tested this fuzzy-photograph hypothesis in an experimental paradigm that we argue induces analogues of flashbulb memories.

Flashbulb memories have also provoked empirical controversies. The flashbulb memory concept evolved from naturalistic studies of memories for traumatic events such as the assassinations of John F. Kennedy and Martin Luther King, Jr. (Brown & Kulik, 1977), the San Francisco and Loma Prieta earthquakes (Neisser & Harsch, 1992; Neisser et al., 1996), the deaths of Princess Diana (Davidson & Glisky, 2002) and French President Francois Mitterand (Curci, Luminet, Finkenauer, & Gisle, 2001), the Hillsborough stadium disaster (Wright, 1993), the space shuttle *Challenger* explosion (Bohannon, 1988; Bohannon & Symons, 1992; McCloskey et al., 1988; Neisser & Harsch, 1992), the assassination attempt on Ronald Reagan (Pillemer, 1984), the resignation of British Prime Minister Margaret Thatcher (Conway et al., 1994), the verdict announcement in the O.J. Simpson trial (Schmolck, Buffalo, & Squire, 2000; Winningham, Hyman, & Dinnel, 2000), and the September 11 (2001) tragedies (Pezdek, 2002; Weaver & Krug, 2002).

Most of these naturalistic studies suggest that confidence in the ability to accurately remember emotionally charged events is remarkably high, and that these events and contextual details associated with them are recalled with especially high accuracy (see, e.g., Davidson & Glisky, 2002). Examples of such contextual details are how and when participants first became aware of the event, where they were (event location), what they were doing, and who else was present (see, e.g., Bohannon, 1988; Brown & Kulik, 1977; Conway et al., 1994; Curci et al.,

Address correspondence to Don MacKay, Psychology Department, UCLA, Los Angeles, CA 90095-1563; e-mail: mackay@ucla.edu.

2001; Larsen, 1992). Although memory for contextual details may degrade over time (see, e.g., Neisser et al., 1996; but also Horn, 2001), intensity of the initially experienced emotion correlates with recall accuracy (Bohannon, 1988; Conway et al., 1994; Pillemer, 1984; Schmolck et al., 2000).

However, contradictory results abound. For example, Talarico and Rubin (2003) concluded that perceived, or subjectively experienced, accuracy rather than accuracy per se distinguishes memories for the September 11 tragedies. Such conflicting results may arise because stimulus factors, such as the complexity of emotional versus nonemotional events, and attentional factors, such as importance, distinctiveness, novelty, and interest, are difficult to control in naturalistic studies (see, e.g., Cahill & McGaugh, 1995; Christianson, 1992; Christianson & Loftus, 1987, 1990, 1991; Christianson, Loftus, Hoffman, & Loftus, 1991; Larsen, 1992; McCloskey et al., 1988; Neisser & Harsch, 1992). Rehearsal and elaboration following naturalistic events are likewise difficult to control because people tend to create narrative descriptions of salient emotional events that they subsequently repeat or communicate to others (see Neisser et al., 1996; Pezdek, 2002), often many times in the weeks, months, and even years between encoding and memory test (see, e.g., McCloskey et al., 1988; Neisser & Harsch, 1992; Neisser et al., 1996; Pillemer, 1984; Weaver, 1993). As a result, flashbulb memory effects may reflect enhanced elaboration and repetitive encoding of emotional experiences during the recall interval, rather than the superior initial encoding that the term “flashbulb” suggests.

To address these issues, we (MacKay et al., 2004) developed an experimental paradigm to assess memory for emotion-linked events and their contextual details while controlling for attention, stimulus factors, elaborative encoding, and rehearsal. The emotional events were taboo words, which enhance skin conductance, an unconscious index of emotional arousal (see, e.g., LaBar & Phelps, 1998). The contextual detail investigated was the font color of the words. Participants saw taboo and neutral words matched for length and familiarity, and named the font colors of the words as quickly as possible while ignoring word meaning. Then, in a surprise test following color naming, we tested recognition memory for the color of a subset of the taboo and neutral words that occurred in the same font color throughout the color-naming task.

Like contextual details associated with naturally occurring flashbulb memories, colors were remembered better and with higher confidence ratings when associated with taboo words than when associated with neutral words. Also indicating better memory for emotion-linked context, response times on correct trials were faster for colors associated with taboo words than for colors associated with neutral words (see also Doerksen & Shimamura, 2001). However, none of these effects were due to rehearsal during the recall interval (the surprise color-recognition test followed immediately after color naming) or during the brief interval between color-naming trials (2.0 s), especially given that the words and their relations to colors were unattended and task irrelevant. Nor were these effects due to elaborative encoding (because the recognition test provided the words) or to differences in stimulus complexity, importance, or inherent interest (because color, the contextual feature tested, was counterbalanced across word type).

The present study adopted similar procedures to test memory for another contextual feature in the taboo Stroop task, namely, the screen location of taboo and neutral words. Participants named the font color of words presented in different screen locations that were irrelevant to color naming. An analogue to rehearsal in the case of naturally occurring flashbulb memories was introduced by presenting some words repeatedly in the same screen location. We then tested memory for the location of these location-consistent words in a surprise recognition memory test following color naming. If word location on a monitor functions similarly to event location in naturally occurring flashbulb memories (e.g., Curci et al., 2001), then location memory should be better for taboo than for neutral words in this *word-location condition*.

In addition, in an independent taboo Stroop condition, we manipulated colors rather than words as the location-consistent feature: Two colors always occurred in the same screen location, and different taboo words always occupied one color-consistent screen location, whereas neutral words always occupied the other. Location memory for the location-consistent colors was then assessed in a surprise memory test following color naming. The purpose of this *color-location condition* was to test two competing accounts of experimentally induced flashbulb memory effects. The first is the fuzzy-photograph hypothesis: that emotional reactions induce storage of taboo words and their context as perceptual images that include color, word, and location in simultaneous (but perhaps fuzzy or degraded) form. For the color-location condition, the fuzzy-photograph hypothesis predicted better memory for color in locations containing taboo words than in locations containing neutral words because emotion triggers a “now print” command for storing all simultaneously active information (Livingston, 1967)—in this case, color, word, and location in image form.

The second account of experimentally induced flashbulb memory effects is the binding hypothesis of MacKay et al. (2004; see also MacKay, Burke, & Stewart, 1998): that emotional reactions trigger binding mechanisms that link the specific source of an emotion to salient aspects of the context in which the emotion occurs. In the case of taboo words, word meaning is the specific source of the emotion because meaning rather than orthography makes taboo words taboo. For example, a word such as *ask* is nonarousing and neutral in emotional tone despite sharing orthography with the taboo word *ass*. Under the binding hypothesis, then, word-specific emotional reactions to a taboo word would trigger binding mechanisms forming a direct and specific link between a word’s meaning and the word’s associated location in the word-location condition. However,

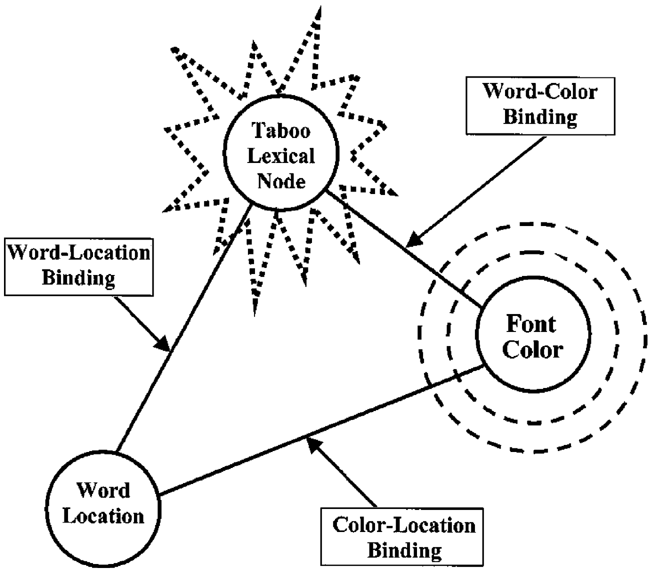

Fig. 1. Units representing font color, word location, and the lexical node for a taboo word, together with the three types of binding tested in the present study and MacKay et al. (2004): the binding between lexical node and screen location, the binding between lexical node and font color, and the binding between font color and screen location. The single irregular halo represents the emotion triggered by the lexical node for the taboo word, which under the binding hypothesis facilitates direct binding links between lexical node and screen location (tested for location-consistent words in the word-location condition) and between lexical node and font color (tested for color-consistent words in MacKay et al., 2004). The double regular halo over font color indicates the locus of attention in the color-naming task, which under the attentional-binding hypothesis facilitates the direct binding link between font color and screen location (tested for color-consistent locations in the color-location condition).

unlike the fuzzy-photograph hypothesis, the binding hypothesis predicted no effect of word emotion on memory for color location in the color-location condition because differing taboo words occupied the color-consistent locations whereas emotional reactions are word-specific and facilitate encoding only of contextual information directly connected with a specific taboo word (the source of emotion). Figure 1 illustrates these predictions: Word-specific emotions (represented as a single irregular halo over the taboo word meaning) facilitate the direct connection between a taboo word meaning and the word's screen location in the word-location condition, but not the indirect or second-order connection between a color and its screen location in the color-location condition.

Figure 1 also illustrates an *attentional-binding* hypothesis that we tested in the present study. Under this hypothesis, attention (like emotion) triggers binding mechanisms that help link a specific attended feature to salient aspects of context. If attention enhances memory for context of occurrence, then attention directed to color in the color-naming task (represented as a double halo in Fig. 1) would be expected to facilitate color-location memory in the color-location condition independently of whether taboo or neutral words occupied the color-consistent locations.

METHOD

Shared Procedures in the Word-Location and Color-Location Conditions

Seventy-two University of California, Los Angeles, undergraduates received course credit for participating in the word-location ($n = 36$) and color-location ($n = 36$) conditions. The experiment involved three back-to-back phases: color naming, location recognition, and word recall. The color-naming phase had a 2 (condition: word location vs. color location) $\times$ 2 (word type: neutral vs. taboo) design. The taboo words were socially proscribed profanities and insults from MacKay et al. (2004). The neutral words were animal names (e.g., *turtle*), a semantic category with high category coherence. Neutral and taboo words were matched in pairs for length in letters and syllables, as well as familiarity ratings in the Wordnet database (Miller et al., 2003).

Participants knew they would see words in various locations and colors, and simply named aloud the font color of each word as quickly as possible while ignoring its meaning and avoiding errors such as reading the word aloud. Each word appeared on the computer screen in one of six colors (blue, gray, green, pink, orange, and red) against a white background in one of six possible locations in an invisible 2 $\times$ 3 grid. A 500-ms fixation point preceded each stimulus, which remained on the screen until the participant responded. A brief between-trial interval (1,000 ms) discouraged location-linked encoding between trials. A computer connected to a headset microphone presented the stimuli in large (64-point) lowercase Arial font. Sessions were tape-recorded to allow subsequent checks of naming accuracy.

In the surprise location-recognition phase immediately following color naming, participants were asked to recognize the location of either words (word-location condition) or colors (color-location condition) that had occurred in a consistent location during color naming. Presentation order of the location-consistent words or location-consistent colors was randomized across participants. On each location-recognition trial, participants saw a 1.0-s fixation point, followed by the now-visible 2 $\times$ 3 grid with all six cells containing either the same location-consistent word in black font (word-location condition) or the letters "XXXX" in a single location-consistent color (color-location condition). Participants then pressed one of six keys in a 2 $\times$ 3 spatial layout as quickly as possible to indicate the original location of the word or color, guessing if necessary. After recording the response time, the computer prompted participants to press other keys labeled 1 through 5 to indicate their confidence in their location-recognition decision (1 = *not very confident*, 5 = *extremely confident*).

In the surprise free-recall phase, participants wrote on a blank sheet as many words as they could recall from the color-naming phase. They then saw and rated the actual words for familiarity, personal frequency of use, and degree of obscenity using 5-point scales (e.g., 1 = *completely unfamiliar*, 5 = *very familiar*). A questionnaire prior to debriefing asked participants

TABLE 1

The 12 Taboo and Neutral Word Pairs in the Word-Location Condition, with Mean Postexperimental Ratings

	Taboo words							Neutral words						
		Familiarity rating		Frequency-of-use rating		Obscenity rating			Familiarity rating		Frequency-of-use rating		Obscenity rating	
Word-pair number	Word	*M*	*SD*	*M*	*SD*	*M*	*SD*	Word	*M*	*SD*	*M*	*SD*	*M*	*SD*
1	chink*	4.03	1.36	1.20	0.62	3.87	1.19	sheep*	4.75	0.87	2.00	1.03	1.00	0.00
2	shit*	4.89	0.49	3.85	1.15	2.54	1.04	crow*	4.73	0.88	1.79	0.83	1.04	0.26
3	fag	4.77	0.72	1.77	1.15	3.72	1.16	bee	4.83	0.65	2.41	0.80	1.00	0.00
4	nigger*	4.77	0.74	1.23	0.64	4.45	0.84	turtle*	4.86	0.59	2.15	1.08	1.01	0.12
5	bitch*	4.93	0.31	3.20	1.21	2.96	0.98	skunk*	4.79	0.75	1.77	0.97	1.03	0.24
6	dick*	4.92	0.41	2.80	1.29	2.92	1.01	mule*	4.75	0.81	1.68	0.92	1.04	0.20
7	cunt*	4.68	0.71	1.37	0.81	4.10	1.00	boar	4.46	1.08	1.54	0.73	1.07	0.35
8	dyke*	4.65	0.93	1.41	0.84	3.62	1.14	bear*	4.80	0.77	2.48	0.94	1.00	0.00
9	fuck*	4.99	0.12	3.51	1.33	3.35	1.20	deer*	4.83	0.65	2.10	0.96	1.10	0.54
10	piss	4.85	0.65	2.56	1.20	2.04	0.99	hawk*	4.80	0.69	1.87	0.92	1.01	0.12
11	queer	4.72	0.83	1.51	0.95	3.25	1.27	shark	4.79	0.77	2.07	1.06	1.03	0.24
12	whore*	4.83	0.56	2.52	1.22	2.99	1.05	mouse*	4.79	0.72	2.14	1.05	1.01	0.12
Word-type means		4.75	0.65	2.24	1.03	3.32	1.07		4.77	0.77	2.00	0.94	1.03	0.18

Note. Asterisks indicate words used in the color-location condition.

whether they noticed during color naming that some words (word-location condition) or some colors (color-location condition) always occurred in the same location.

The Word-Location Condition

Materials

Table 1 shows the 12 pairs of taboo and neutral words in the word-location condition, together with the mean postexperimental ratings of word-location participants, which indicated no difference in mean familiarity for taboo ($M = 4.75$, $SD = 0.65$) versus neutral ($M = 4.77$, $SD = 0.77$) words, $t < 1$, or in mean frequency of use for taboo ($M = 2.24$, $SD = 1.03$) versus neutral ($M = 2.00$, $SD = 0.94$) words, $t < 1$, but higher mean obscenity ratings for taboo ($M = 3.32$, $SD = 1.07$) than neutral ($M = 1.03$, $SD = 0.18$) words, $t(22) = 11.65$, $p < .001$.

Color-Naming Procedures

Each word appeared in all six colors, yielding 144 trials per participant. Six taboo-neutral word pairs were fillers that each occurred in six different screen locations across trials to discourage location-linked encoding strategies. The remaining six taboo-neutral pairs were location-consistent targets that always occupied the same screen location (with one taboo-neutral target pair per screen location). Target versus filler pairs and screen locations containing particular words and word types were counterbalanced across participants.

The Color-Location Condition

Materials

Table 1 shows the taboo and neutral words used in the color-location condition. Postexperimental ratings again indicated higher mean obscenity ratings for taboo than neutral words, $p < .001$, but no difference in mean familiarity or usage of taboo versus neutral words, smaller $p > .39$.

Color-Naming Procedures

For the 18 color-naming trials in the color-location condition, each word appeared once in a single color in one of the six grid locations.[1] However, two of the six colors were location consistent (i.e., always occurred in the same screen location), with different taboo words occupying one color-consistent location and matched neutral words occupying the other. The remaining four screen locations contained inconsistent colors and word types to discourage location-linked encoding strategies. Relations between colors, words, word types, screen locations, and the color-consistent versus color-inconsistent conditions were counterbalanced across participants.

RESULTS

Figure 2 (left panel) shows mean correct location recognition in the word-location and color-location conditions. A 2 (word type: taboo vs. neutral) × 2 (condition: word-location vs. color-location) analysis of variance (ANOVA) on these data yielded an effect of word type, $F(1, 70) = 28.66$, $p < .01$, $\eta^2 = .29$, with better recognition accuracy for taboo words ($M = 62.73\%$, $SD = 29.27\%$) than neutral words ($M = 43.98\%$, $SD = 34.07\%$); an effect of condition, $F(1, 70) = 17.70$, $p < .01$,

[1]The reduced number of color-location trials was necessary to avoid ceiling effects, to preclude direct word-to-location connections that would result from repeating words during color naming, and to ensure maximum effects of emotion given that emotional responses to taboo but not neutral words habituate with repetition (see MacKay et al., 2004; also Hamann, Ely, Grafton, & Kilts, 1999).

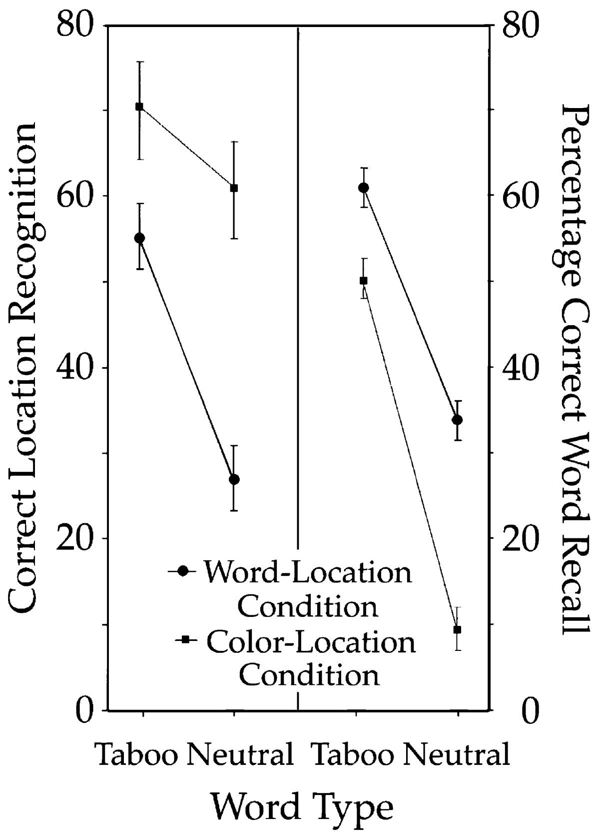

Fig. 2. Mean correct location recognition (left panel) and mean correct word recall (right panel) for taboo versus neutral words in the word-location and color-location conditions. The error bars represent ±1 *SE*.

$\eta^2 = .20$, with better recognition accuracy in the color-location ($M = 65.74\%$, $SD = 34.02\%$) than the word-location ($M = 40.97\%$, $SD = 26.97\%$) condition; and a Condition × Word Type interaction, $F(1, 70) = 7.34$, $p < .01$, $\eta^2 = .09$, reflecting better location recognition for taboo than neutral words in the word-location but not the color-location condition, and a larger accuracy difference between taboo and neutral words in the word-location ($M = 28.24\%$, $SD = 32.08\%$) than the color-location ($M = 9.26\%$, $SD = 27.15\%$) condition, $t(70) = 2.71$, $p < .01$.

Because postexperimental questions regarding repeated presentation of words (word-location condition) or colors (color-location condition) in the same location yielded numerous "yes" responses, we also computed a 2 (word type: taboo vs. neutral) × 2 (awareness: aware vs. unaware) ANOVA on location-recognition responses. This analysis yielded no interaction ($p = .106$) or effect of awareness ($p = .073$), ruling out effects of awareness on our results.

Mean response times for correct location recognition mirrored the location-recognition means, and so did confidence ratings for location-recognition decisions. A 2 (recognition accuracy: correct vs. incorrect) × 2 (word type) × 2 (condition) ANOVA on the confidence ratings also yielded an effect of recognition accuracy, $F(1, 36) = 41.72$, $p < .001$, $\eta^2 = .54$, with higher confidence for accurate ($M = 3.29$, $SD = 1.39$) than inaccurate ($M = 2.45$, $SD = 0.97$) responses, but no reliable interactions involving accuracy, $F < 1$, indicating that participants were confident of recognizing links between taboo words and locations rather than taboo words per se.

Figure 2 (right panel) also shows the free-recall results: proportion correct recall of taboo versus neutral words in the word-location and color-location conditions. A 2 (word type: taboo vs. neutral) × 2 (condition: word-location vs. color-location) ANOVA on these data yielded a main effect of word type, $F(1, 70) = 350.18$, $p < .01$, $\eta^2 = .83$, with better recall of taboo ($M = 55.56\%$, $SD = 16.42\%$) than neutral ($M = 21.80\%$, $SD = 17.01\%$) words; a main effect of condition, $F(1, 70) = 43.14$, $p < .01$, $\eta^2 = .38$, with better recall in the word-location ($M = 47.60\%$, $SD = 19.10\%$) than color-location ($M = 29.80\%$, $SD = 24.73\%$) condition; and a Condition × Word Type interaction, $F(1, 70) = 13.69$, $p < .01$, $\eta^2 = .16$, reflecting a larger difference in recall of taboo versus neutral words in the color-location ($M = 40.43\%$, $SD = 15.52\%$) than the word-location ($M = 27.08\%$, $SD = 15.09\%$) condition, $t(70) = 3.70$, $p < .001$.

DISCUSSION

The superior location memory for taboo relative to neutral words in the word-location condition suggests that screen location in the taboo Stroop paradigm functions similarly to event location in studies of naturally occurring flashbulb memories (e.g., Curci et al., 2001), despite differences in temporal parameters such as the time between encoding and memory test (weeks, months, and even years in naturalistic studies vs. minutes in the word-location condition), rehearsal or repetition (unknown and unlimited numbers of repetitions in naturalistic studies vs. six repetitions in the word-location condition), and complexity (unlimited complexity in naturalistic studies vs. three co-temporal features in the present study, word-color-location). Differences in novelty and uniqueness are also noteworthy: Whereas naturally occurring traumas are unexpected and relatively unusual, word-location participants received forewarning about familiar taboo words and encountered 12 of them repeatedly over the course of the experiment.[2] However, more closely mimicking naturally occurring flashbulb events by presenting a single taboo word once and without warning in the present paradigm is only likely to strengthen the effects of emotion because emotional responses to taboo words habituate as a function of both repetition and the number of taboo words (see,

[2]Another difference between unique emotionally charged events and the present taboo words concerns possible encoding interference between taboo and neutral words in mixed word lists. MacKay et al. (2004) demonstrated impaired recall of neutral words immediately before and after taboo words in rapid serial visual presentation (RSVP) lists presented at 170 ms/word. However, both theoretical considerations and empirical results (see MacKay et al.) indicate that the slower presentation rates used in the present study do not induce similar interference effects.

e.g., MacKay et al., 2004). Moreover, the goal of an experimental analogue is not to duplicate natural events, but to isolate, control, and manipulate their abstract characteristics so as to develop a theory for understanding the naturalistic phenomena. In this regard, the experimental study of flashbulb memories has just begun.

Nevertheless, one theoretical hypothesis already seems implausible on the basis of present results: that emotionally charged events are more likely to induce storage of (fuzzy) perceptual images than nonemotional events are. The fuzzy-photograph hypothesis predicted better location recognition for colors associated with taboo words in the color-location condition, contrary to present results. The failure of this prediction was not due to generally poor memory for color-to-location links: Location recognition was better in the color-location condition than in the word-location condition, in which emotion had an effect. Nor was this failure due to insufficient power, because power was more than sufficient for detecting the superior overall location recognition in the color-location condition.

Nor was the failure of the fuzzy-photograph prediction explicable in terms of attentional modulation. Under the attentional-modulation hypothesis of Raymond, Fenske, and Tavassoli (2003), emotion has relatively greater effects on unattended than attended features. This suggests that effects of emotion were exaggerated in our word-location condition (in which neither words nor locations were attended) relative to our color-location condition (in which color was attended). As a consequence, emotion had greater effects on word-location memory than color-location memory because attention modulated emotion, and not because the fuzzy-photograph hypothesis was incorrect.

However, if emotion induces imagelike memories, this attentional-modulation hypothesis predicts parallel effects of emotion on word recall and location recognition in the word-location and color-location conditions for two reasons: because words were unattended in both conditions, and because performance should not differ using words (word-location condition) or colors (color-location condition) as cues for retrieving images that simultaneously integrate color, word, and location. Contrary to this attentional-modulation prediction, emotion did not have parallel effects on word recall and location recognition in our two conditions (see Fig. 2): Word recall was better for taboo words in the word-location than in the color-location condition, whereas location recognition was better for taboo words in the color-location than in the word-location condition. This asymmetry in how emotion affected word recall versus location recognition therefore contradicts the hypothesis that attentional modulation of imagelike memories was at play in the failed prediction of the fuzzy-photograph hypothesis.

The present results support a different theoretical hypothesis for explaining why naturally occurring flashbulb memories usually include event location. Under this binding hypothesis, emotional reactions trigger binding mechanisms that link the specific source of an emotion to salient contextual aspects such as location. Consequently, word-specific emotional reactions to a particular taboo word enhance memory for contextual aspects directly linked with that word, but not contextual aspects indirectly linked with taboo words as a class: Emotions linked to different taboo words cannot facilitate formation of second-order color-to-location connections. Consistent with this hypothesis, location recognition was better for taboo than neutral words in the word-location condition, but not in the color-location condition.

Nevertheless, it is important to emphasize that seemingly minor changes in the present experimental conditions will yield different results according to the binding hypothesis. For example, using a previously presented word-color combination as a recognition cue in the color-location condition will yield artifactual support for the fuzzy-photograph hypothesis because the recognition cue will trigger recall via the direct link between taboo word (the source of emotion) and location (see Fig. 1).

Consider now the overall superior memory for taboo relative to neutral words in the surprise free-recall test following color naming. This difference was unrelated to the fact that taboo words generally represent a smaller and more cohesive semantic category than neutral words (see, e.g., McKenna & Sharma, 1995): Neutral words in the present study were animal names, a small, highly coherent category resembling taboo words. However, the superior recall of taboo words was consistent with the binding hypothesis, according to which word-specific emotional reactions to taboo words engaged binding mechanisms that linked the taboo words to salient aspects of the context—in this case, the list context that acted as a retrieval cue for later recall of the words (see the introduction).

Consider next the asymmetry in how emotion affected word recall versus location recognition: better word recall for taboo words in the word-location than the color-location condition, but better location recognition for taboo words in the color-location than the word-location condition. Two empirical details readily explain this asymmetry under the binding hypothesis. First, participants saw each word only once in the color-location condition, but six times in the word-location condition, which greatly strengthened the word-to-list-context links in the word-location condition and enabled superior word recall in the surprise free-recall test. Second, the test of recognition memory preceding word recall reminded participants of the words in the word-location condition but not in the color-location condition.

More noteworthy is the relatively better free recall of taboo than neutral words following color naming in the color-location than in the word-location condition. Under the binding hypothesis, this interaction is readily explained as due to the greater habituation of word-specific emotional reactions in the word-location condition (in which each taboo word was presented six times during color naming) than in the color-location condition (in which word-specific habituation could not occur because each taboo word appeared only once): Because habituation affects only emotion-linked events (see, e.g., Hamann, Ely, Grafton, & Kilts, 1999) and occurred only in the word-location condition, the stronger emotional reactions in the color-location condition strengthened word-to-list-context links relatively more for taboo than neutral words in the color-location than in the word-location condition, according to the binding hypothesis.[3]

Finally, the present results support the attentional-binding hypothesis: that attention triggers binding mechanisms that help link attended features to salient aspects of context such as location. This attentional-binding hypothesis correctly predicted the superior overall location memory for the attended feature (colors in the color-location condition) relative to the unattended feature (words in the word-location condition). Attention enhanced location recognition in the same way as emotion, a result consistent with the hypothesis that attention and emotion represent the glue that helps bind features together.

In conclusion, just as emotionally charged events in the real world often enhance memory for event location, emotionally charged words (even when unattended) in the present study enhanced location memory for the specific words experienced. However, emotionally charged words as a class did not enhance location memory for another concurrent experience, namely, congruence between location and font color, even though attending to color enhanced overall location memory for colors. These and other results contradict the hypothesis that emotion induces imagelike memories, but support the hypothesis that emotion triggers binding mechanisms that link an emotional event to contextual features such as its location.

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[3]Note that greater habituation of emotional reactions in the word-location than the color-location condition cannot explain the interaction in Figure 2 (left panel) because equating habituation across these conditions would have increased rather than eliminated the interaction.

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