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The effects of emotion and encoding strategy on associative memory

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Abstract Research has demonstrated that when discrete pieces of information are integrated together at encoding—imagining two items together as a single entity, for example—there is a mnemonic benefit for their relationship. A separate body of literature has indicated that the presence of emotional information can have an impact on the binding of associated neutral details, in some cases facilitating associative binding (MacKay et al. Memory and Cognition 32:474–488, 2004; Mather, Perspectives on Psychological Science 2:33–52, 2007), and in other cases impeding the processing of associated details (Easterbrook, Psychological Review 66:183–201, 1959; Kensinger, Emotion Review 1:99–113, 2009). In the present experiments, we investigated how memory for neutral words is affected by the emotionality of the information with which they are presented (whether with an emotional word or a second neutral word) and the encoding context (integrated or nonintegrated strategy). Participants viewed word pairs and were instructed to visualize the items as an integrated unit or to visualize them separately from one another. The results of Experiment 1 showed a disproportionate mnemonic benefit for neutral items that were integrated with other neutral items over those integrated with emotional items. The results of Experiments 2A and 2B showed that this effect interacted with encoding time: When given 2 s to encode, participants showed no effect of integration on memory for neutral–neutral pairs, but showed a significant mnemonic benefit for integrating emotional–neutral pairs. When given 4 or 6 s, the integrative benefit increased significantly for neutral–neutral pairs but decreased for emotional–neutral pairs. These results suggest that creating an integrated mental image of two neutral items requires a more time-consuming process than integrating an emotional and a neutral item, but that extra effort may result in a downstream mnemonic benefit.

Keywords Emotion · Associative memory · Integration

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The ability to form and later to retrieve associations between unrelated pieces of information is a critical aspect of human memory. Substantial work has investigated how we form such associations, and these investigations have indicated that associative memory is promoted when items are combined in some meaningful way at encoding (e.g., learning the verbal pair *surf* + *degree* by putting the words together in a sentence; Diana, Yonelinas, & Ranganath, 2008; Graf & Schacter, 1985, 1989). One particularly strong associative strategy involves integrating the items conceptually at encoding. For example, instead of putting *surf* and *degree* in a sentence together, one might imagine a person using his or her diploma as a surfboard, or might think of a *surf-degree* as a specific type of degree conferred upon completion of a surfing course. Behavioral and neural data have suggested that although, in general, memory for associations is supported by recollection (which requires specific, episodic detail about the context in which information was learned; see Yonelinas, 2002, for a review of the dissociability of recollection and familiarity), memory for well-integrated associations—such as the *surf degree*—can be supported by the less-context-specific process of familiarity (Diana Van den Boom, Yonelinas, & Ranganath, 2010; Giovanello, Keane, & Verfaellie, 2006; Staresina & Davachi, 2010). These findings indicate that the integration of two discrete pieces of information—the surfing degree, for instance—may yield a much different representation in memory than simply trying to remember that those two items co-occurred with one another.

These previous studies have typically employed neutral stimuli, but many real-world experiences elicit some emotional response. We know that emotional information is handled differently in memory than is neutral information, with emotional information typically receiving a mnemonic benefit over neutral information (Buchanan & Adolphs, 2002; Kensinger, 2009; reviewed by Hamann, 2001). However, the way emotion affects memory for associated details has been a source of much debate. Substantial evidence has pointed to a trade-off in memory, in which memory for the emotional components of a stimulus is enhanced and memory for the peripheral details is reduced. For example, after viewing a scene depicting a car crash, memory for the details of the crash itself may be excellent, but memory for the details of the street on which the crash occurred may be sparse (Easterbrook, 1959; Kensinger, 2009; Reisberg & Heuer, 2004). Easterbrook's (1959) cue-utilization hypothesis suggests that the presence of emotional information narrows the scope of available attention, requiring that we "select" the parts to which we attend. Given that the most pertinent information in such an instance is likely the emotional information, this leads to preferential processing of the emotional stimulus at the cost of the peripheral, nonemotional information.

Conversely, other evidence has suggested that the presence of emotional information may trigger prioritized binding mechanisms that facilitate the binding of peripheral details (Hadley & MacKay, 2006; MacKay & Ahmetzanov, 2005; MacKay et al., 2004). The priority-binding hypothesis is supported by a series of experiments showing that the presentation color of taboo words is more readily recalled than the color of neutral words (MacKay et al., 2004, Experiments 1–3) and that the presence and position of taboo words in a rapid serial visual presentation paradigm are remembered well, but the words immediately preceding or following the taboo words are not (because the taboo words are engaging available attention resources to bind the taboo word to its temporal context; Hadley & MacKay, 2006; MacKay & Ahmetzanov, 2005). A similar body of evidence comes from Guillet and Arndt (2009). In the first experiment of their study, participants read sentences that contained a peripheral (neutral) target word and a central (neutral, negatively valenced and moderately arousing, or highly arousing taboo) target word. Participants performed a cued recall test in which they had to fill in the missing central and peripheral words when reshown the studied sentences. Recall performance was best for central taboo words and for the peripheral neutral words paired with them. Memory for central negative and neutral words was significantly lower than for taboo words, and memory for peripheral neutral words was significantly lower if they were paired with a neutral or negative word than with a taboo word. In subsequent experiments within the same article, the authors asked participants to intentionally encode taboo + neutral, negative + neutral, and neutral + neutral pairs, and showed similar results: Memory for peripheral words was best if they were paired with a taboo word, and memory for taboo words was better than for negative or neutral words. The authors concluded that the presence of arousing information—that is, the taboo words—enhanced the associative binding of the peripheral neutral word; negative valence, in the absence of arousal, was not sufficient to enhance the binding of the neutral word.

Although cue-utilization theory (Easterbrook, 1959) and priority-binding theory (Hadley & MacKay, 2006; MacKay et al., 2004; MacKay & Ahmetzanov, 2005) may appear at odds with one another over how emotion affects the formation of novel associations, Mather (2007) noted an important difference between the two. Generally, cue utilization has referred to interitem effects, with emotion impeding the processing of items distinct from the emotional item; conversely, priority-binding theory may explain intra-item effects, with emotion enhancing the binding of features that are intrinsic to the stimulus. What is unclear, though, is which of these two categories the process of integration of verbal paired associates falls into. One way to manipulate how those neutral and emotional details are interpreted is to manipulate how participants relate the items at encoding—either instructing them to create an integrated representation of the two pieces of information, or instructing them to maintain separate memory representations.

In the present studies, we were specifically interested in how memory for a neutral item is affected by whether it was encoded in the presence of emotional or other neutral material and by the way in which it was related to that material. In our paradigm, we manipulated whether participants encoded word pairs as single, integrated units (e.g., given the pair *card* + *mouse*, imagine a playing card with a picture of a mouse on it) or maintained separate representations of the paired items (e.g., given the pair *card* + *mouse*, imagine a playing card and also imagine a mouse), and varied whether those pairs contain an emotional item or not. After a delay, participants' memory for all individual items and their relationships was tested through recognition, recall, or both.

We expected that this encoding manipulation would replicate the previously demonstrated effect that integrative imagery (e.g., picturing the card with a picture of a mouse on it) promotes associative memory (as tested on an associative cued recall test and an associative pair recognition test) and that nonintegrative imagery (e.g., picturing the card and mouse separately) promotes memory for the individual items (as tested on an item recognition test). What was unclear was how the presence of emotional information would interact with this effect. Cue-utilization theory (Easterbrook, 1959) would suggest that the presence of emotional items may divert attentional resources away from the less ecologically relevant aspects of the encoding episode—in other words, the neutral items—and hinder associative binding, even in an integrative condition. In this case, we would expect that, because emotional items would capture attentional resources, we would not see a mnemonic benefit from integrating neutral items with emotional items over not integrating them; memory for neutral items should be equivalently poor. Conversely, MacKay's priority-binding theory (Hadley & MacKay, 2006; MacKay & Ahmetzanov, 2005; MacKay et al., 2004) predicts that the pairing of a neutral item with an emotional item will be better remembered than the pairing of a neutral item with another neutral item, because the presence of the emotional item will trigger prioritized binding mechanisms. In the strongest possible version of priority-binding theory, all of the possible stimulus elements would be bound together in a single representation, but this theory has really only been tested using intra-item tests. By contrast, Mather's (2007) object-basted theory predicts that memory for a neutral word paired with an emotional word should be better than memory for two neutral words only when the items are studied integratively, because the integration will enable the neutral item to become part of the emotional representation. When studied nonintegratively, the presence of the emotional item may actually impair binding because the emotional item may capture encoding resources and leave fewer resources available for processing the neutral item or for binding the two together.

Experiment 1

Method

Participants

Participants were 48 young adults (31 female), of the ages 18–22 years ($M = 20.1$), recruited from the Boston College campus and from the greater Boston area through web-based advertisements. Participants were compensated with either course credit or at a rate of $10/hour. They were prescreened for history of psychiatric or neurological disorders and for current depression or high anxiety (see Table 1 for participant characteristics). Informed consent was obtained in a manner approved by the Boston College Institutional Review Board.

Three participants were excluded from analysis, for a final sample size of 45 (29 female, of the ages 18–22 years; $M = 20.3$); two were excluded because of errors found in their stimulus lists, and one was excluded for having an extremely low imagery success rate (<20 % of pairs rated as successfully imagined).

Stimuli

The stimuli were words selected from the Affective Norms for English Words (ANEW) series (Bradley & Lang, 1999), the Kučera and Francis (1967) word list, and word lists used by Kensinger and Corkin (2003). A total of 240 positive, 240 negative, and 520 neutral words were selected as stimuli for the study pairs and for the test items. Positive and negative words were selected from the ANEW database and Kensinger and Corkin and were matched on arousal, with mean (*SD*) arousal ratings of 5.7 (1.1) and 5.7 (0.9), respectively ("1" *considered to be extremely calming*; "9" *considered to be extremely arousing*). The mean valence rating for positive and negative items was 7.3 (1.5) and 3.1 (1.7), respectively. Neutral words were selected from the ANEW, Kučera and Francis, and Kensinger and Corkin word lists [$M_{\text{valence}} = 5.4$ (0.3), $M_{\text{arousal}} = 4.1$ (0.7)] and were matched to the positive and negative words on frequency. Words were pseudorandomly combined to form word pairs that included a positive + neutral word, a negative + neutral word, or a neutral + neutral word. Pairs were checked to minimize any pre-existing semantic relatedness between the right- and left-hand words.

All of the stimuli were presented on a Macintosh Intel Core 2 Duo computer running MacStim 3 software (WhiteAnt Occasional Publishing). Stimuli were presented at the center of the screen, as white text on a black background. All of the stimuli were presented in lowercase, with size 48 Lucida Grande font.

Procedure

The procedure was divided into an imagery practice phase, a study phase, and a memory test phase. The progression of each of these phases is described below.

Imagery practice phase All participants began with a practice phase, in which they were trained on the study styles of integrative and nonintegrative mental imagery. All participants practiced nonintegration first, followed by integration.

For the nonintegrative practice session, participants viewed 10 pairs of words and were instructed to generate a mental image of each item in the pair. They were told to visualize each item separately. For instance, if they saw *card* + *mouse*, they were to imagine a card and to separately imagine a mouse. Participants had 4 s to imagine the items and had an additional 2 s to rate their success at generating

Table 1 Participant characteristics for Experiments 1, 2A, and 2B

Experiment	Measure	M	SE
1	Beck Depression Inventory	2.47	0.33
	Beck Anxiety Inventory	4.06	0.48)
	BADS-DEX Questionnaire	12.49	0.87
	Shipley Vocabulary Test	33.28	0.39
	Digit Symbol	51.01	0.84
	Generative Naming (FAS) Word Fluency (*n*=22)	51.82	2.24
	Vividness of Visual Imagery Questionnaire (*n*=22)	60.96	1.88*
2A	Beck Depression Inventory	1.84	0.40
	Beck Anxiety Inventory	3.55	0.38
	BADS-DEX Questionnaire	10.11	1.98
	Shipley Vocabulary Test	33.30	0.71
	Digit Symbol	55.31	3.02
	Generative Naming (FAS) Word Fluency	58.01	6.62
	Vividness of Visual Imagery Questionnaire	59.14	0.93*
2B	Beck Depression Inventory	1.32	0.79
	Beck Anxiety Inventory	1.77	1.90
	BADS-DEX Questionnaire	13.15	2.03
	Shipley Vocabulary Test	35.18	1.80
	Digit Symbol	52.71	1.59
	Generative Naming (FAS) Word Fluency	47.77	3.97
	Vividness of Visual Imagery Questionnaire	66.51	4.06*

The Beck Depression Inventory and Beck Anxiety Inventory are from Beck, Epstein, Brown, and Steer (1988); the Behavioral Assessment of the Dysexecutive Syndrome—Dysexecutive Questionnaire (BADS-DEX) questionnaire is from Wilson et al. (1996); the Geriatric Mood Scale is from Sheikh and Yesavage (1986); the Shipley Vocabulary Test is from Shipley (1986); the Digit Symbol Copy is from Wechsler (1997); the Generative Naming (FAS) Word Fluency measure is from Spreen and Benton (1977); the Vividness of Visual Imagery Questionnaire (VVIQ) is from Marks (Marks, 1973; *we reversed the scoring scale so that a "1" would indicate low imagery and a "5" would indicate high imagery, to be consistent with the experimental task instructions; maximum possible imagery score=80)

their mental images using the 1–4 keys on the keyboard. They were given the heuristic that a "1" would indicate no success for that pair: They didn't know what one of the words meant, they could not generate an image for one or both words, or they could only generate a combined mental image; a "2" would indicate that they could imagine both items, but not vividly (their images were "fuzzy" or "blurry"); a "3" would indicate that they could generate moderately detailed images for both items; a "4" would indicate that both items were imagined separately, clearly, and with vivid detail. If a participant did not make their rating within 2 s, that pair was removed from analyses to ensure that we had accuracy information for all trials included in analyses.

Following the 10 nonintegrative practice trials, participants practiced integrative mental imagery. All of the participants practiced the nonintegrative strategy first, not only because this was always the order of the encoding task, but also so that they would better understand how to correctly integrate two items (e.g., imagining two items next to each other would not be "integrating" them). They viewed 10 word pairs and were told to generate a mental image that combined both items in the pair. For example, if they saw *owl* + *office*, they could imagine an office full of owls working, or an office building shaped like an owl. Participants again had 4 s to view the word pairs and an additional 2 s to rate their success using the 1–4 scale.

Study phase Participants visualized 100 semantically unrelated word pairs using the nonintegrative instructions, followed by 100 pairs visualized using the integrative instructions. Visualization and rating instructions were identical to those in the practice phase.

The order of encoding conditions was not counterbalanced across participants because pilot testing indicated that it was very difficult for participants to perform the integrative imagery task and then switch to the nonintegrative task; participants reported prohibitively low accuracy on the nonintegrative task in this counterbalancing order. However, to ensure that performance on the integrative trials was not affected by practice effects related to that task being second in the session, 12 pilot participants performed a variant of the study in which they studied two blocks of 100 integrative trials (with no nonintegrative condition), followed by taking the item recognition and associative cued recall tests described below. The number of successful encoding trials—those rated a "3" or "4"—did not differ from the first to second block, nor did they differ from the number of successful trials in Experiment 1. Similarly, memory performance did not differ between the two blocks of integrative items, suggesting that practice with the integration task is not a key factor. These pilot data are presented in the Appendix.

After visualizing the 200 word pairs, participants were given a half-hour break. They were not given specific instructions during the break, and most used the time to complete other course work.

Memory test phase Following the half-hour break, participants were given a surprise memory test. All of the participants completed an item recognition test. After the item recognition test, 24 participants completed an associate pair recognition test, and 21 participants completed a cued recall test. Participants did not receive feedback on accuracy during any test phase. Participants completed a practice of each test type prior to each test: Each test was preceded by six practice trials that used the practice pairs from the study phase as stimuli.

Although we collected a total of three test measures across participants—item recognition, associative recognition, and associative cued recall—we did not necessarily expect to find differences in recognition memory for emotional and neutral items and pairings. It has been previously shown that when just recognition memory is tested—without asking participants to make a "remember/know," "same/similar," or other memory specificity distinction—differences in memory are not always observed between emotional and neutral items (Kensinger, 2007; Kensinger, Garoff-Eaton, & Schacter, 2006; Ochsner, 2000; Richardson, Strange, & Dolan, 2004; Windmann & Kutas, 2001). Because our recognition tasks are similar to these that did not yield any emotional enhancement, we instead included the recognition measures for two other reasons: First, these measures acted as an encoding manipulation check, ensuring that we replicated the traditional integration benefit for associative recognition and nonintegration benefit for item recognition. Second, the item recognition test allowed us to assess whether there were differences in cue familiarity between emotional and neutral items; if emotional items were better recognized than neutral items, this could have implications for interpreting the results of the cued recall test in which the emotionality of the cue word varies, because different cued-recall processes could be invoked for familiar versus unfamiliar cues. Although finding no difference in recognition between emotional and nonemotional cues cannot definitively equate familiarity between cues—since we are not collecting any measure of strength of familiarity and since null effects are always risky to interpret—such a result would still reduce the likelihood that differences in familiarity for emotional and nonemotional items would be large enough to confound the cued recall results.

Item recognition test Participants viewed single items on the screen and were instructed to judge whether the item was "old"—seen during the study phase—or whether it was "new" and had not been encountered during the study phase. The item recognition test was self-paced, and participants indicated their responses by pressing "O" on the keyboard for "old" words and "N" for "new" words. A total of 600 words were tested: all 400 words from the study phase, as well as 200 new words (80 positive, 80 negative, and 40 neutral).

Presentation of the item recognition test differed slightly for each of the two test groups. For participants who would later complete the associate recognition test, the items on the item recognition test were presented sequentially: Once the participant had made a key press, the next test word appeared. If the participant was in the associative cued recall condition, the old/new judgment was followed by other test prompts, described in more detail below.

Associative pair recognition test Participants viewed pairs of words and were asked to indicate whether they thought the pair was intact (the identical word pair was seen during the study phase; press "I" on the keyboard), recombined (the words were seen during the study phase, but as parts of different pairs; "R"), or new (neither word had been studied; "N"). Participants also rated their confidence in their response using a 3-point scale, with 1 being *not at all confident* and 3 being *very confident*.

A total of 100 intact, 100 recombined, and 100 new pairs were randomly presented. The new pairs were generated from words that did not appear in either the study phase or on the item recognition test. For each pair type (intact, recombined, and new), 40 pairs contained a positive and a neutral item, 40 contained a negative and a neutral item, and 20 contained two neutral items. The recognition test was self-paced.

Associative cued recall test After making the old/new recognition judgment for an item (described above), participants in the recall condition recalled the valence of the word's paired referent and then recalled the word that had been paired with it. For example, if the participant judged the word *mouse* to be old, they would be prompted on-screen to recall whether *mouse* was paired with a positive word, a negative word, or a neutral word. Participants made their response by pressing the "P," "N," or "E" (for neutral) keys on the keyboard. They would then be cued to recall the word that was paired with *mouse*. Participants recorded their responses on a written sheet of paper labeled with the trial numbers. After writing his or her answer, the participant pressed the spacebar to proceed to the next trial.

If the participant responded "new" during the "old/new" judgment, they were instructed to press the spacebar once to bypass the valence and recall prompts, since those would not be applicable to a "new" response.

On the cued recall test, our focus was on the ability for participants to generate the right-hand neutral words, as a function of the emotionality of the word with which they had been paired (i.e., whether they were presented with a neutral or emotional left-hand word). However, we tested memory for both the right- and left-hand words so that participants would not always be generating a neutral word as the response item. This was done to allay concerns that if participants always had to generate a neutral word, that could create a confound regarding the emotionality of the cues, or of the mental images, that would most effectively guide recall.

The order of the tests was not counterbalanced, in that the associative test cues, both recognition and recall, always followed the individual item test cues. This ordering is consistent with other research comparing item and associative memory for components of emotional scenes (Touryan, et al., 2007), and it prevented what we viewed to be an important and likely confound: that cued recall of an item could influence later recognition of that item (Thus, items not recalled on the cued-recall test could be less likely to be recognized later). We thought it less likely that item recognition performance would confound cued recall performance, because the item recognition task would not provide any information about the word associations that were studied performance. Nevertheless, we will later present data Experiment (2B) that show that the results are not altered by the presence or absence of an item test; therefore, although test order is not counterbalanced in Experiment 1, it is unlikely that this created a confounding effect.

Results

Data included in analysis

Since study type was one of our factors of interest, pairs that were given a rating of "1" or "2" during the study phase—indicating that the participant did not generate an appropriate image —were not included in these analyses.[1] Participants on average were able to successfully imagine more nonintegrative pairs (M =84.1 %, SD = 12.6 %) than integrative pairs (M = 77.6 %, SD = 14.4 %), $t(44) = 4.10$, $p < .001$. There was no main effect of emotion on how many pairs were imagined successfully, nor did emotion and encoding condition interact to influence imagery success.

Memory performance was comparable when neutral words were studied with positive or with negative words, so these items were therefore collapsed into one "emotion" category for all analyses. This was true for memory performance on the item recognition test, $F(1, 44) = 1.01$, $p > 0.3$, on the associative recognition test for intact pairs, $F(1, 23) = 0.18$, $p > .65$, and recombined pairs, $F(1, 23) = 0.63$, $p > .4$, and on the cued recall test, $F(1, 20) = 0.20$, $p > .6$.

Item and associative recognition tests

As described in the Method section, the intention of the recognition tests was two-fold: to serve as an encoding manipulation check, and to examine whether there were differences in familiarity for emotional and neutral items.

The recognition tests did indeed replicate the expected effects of study type, with nonintegrative study supporting item recognition and integrative study supporting associative recognition. On the item recognition test, corrected recognition rates were higher for words that were studied in the nonintegrative condition than for those studied in the integrative condition, $F(1, 44) = 7.50$, $p < .01$, partial $\eta^2 = 0.15$. The results of the item recognition test did not differ according to whether it was followed by the associative recognition task or interspersed with the associative cued recall task, $F(1, 44) = 0.07$, $p > .75$. On the associative recognition test, pairs presented as intact were better recognized if they had been studied integratively rather than nonintegratively, $F(1, 23) = 80.34$, $p < .001$, partial $\eta^2 = 0.77$. For both tests, corrected recognition was computed separately for each valence (positive, negative, and neutral).

[1] Because of the relatively small number of "1" and "2" trials observed, when all trials (those rated 1, 2, 3, and 4) were included in the analyses, the pattern of data remained as described in the Results sections for all three Experiments. However, some of the effects described failed to reach significance. A significant main effect of study type was still observed across all tests (for all recognition and recall tests in Experiments 1, 2A, and 2B). In Experiments 2A and 2B, the main effect of encoding time still reached significance. For the associative cued recall test in Experiment 1, the significant Study Type × Emotion interaction approached, but no longer reached, significance, $F(1, 20) = 3.40$, p = 08. For Experiments 2A and 2B, the three-way interaction among study type, emotion, and encoding time did not reach significance (although it did not reach significance in Experiment 2B originally): $F(2, 44) = 2.54$, $p = .09$ in Experiment 2A; $F(2, 40) = 2.15$, $p = .13$ in Experiment 2B.

On the item recognition test, false alarms were considered to be endorsements of nonstudied items. On the associative recognition test, false alarms were considered to be endorsements of new items as intact. For both the item and associative recognition tests, analyses using hit rates rather than corrected recognition yielded similar effects. Hit rates on the item recognition test were higher for integrative pairs than for nonintegrative pairs, $F(1, 44) = 28.39$, $p < .001$, partial $\eta^2 = 0.39$, and hits on the associative recognition test were higher for integrative pairs than for nonintegrative pairs, $F(1, 23) = 55.59$, $p < .01$, partial $\eta^2 = 0.70$. The false alarm rates for the item recognition test were 14.3 % (1.1) for emotional items and 14.7 % (1.4) for neutral items. The false alarm rates on the associative pair recognition test (incorrectly responding "intact" to "new" items) were 4.2 % (0.9) for pairs containing an emotional item and 5.3 % (1.0) for pairs containing two neutral items.

The item recognition test also revealed that there was no difference in corrected recognition for emotional versus neutral items; emotional and neutral items were recognized equally well, $F(1, 44) = 0.06$, $p > .80$. This was true for the hit rates on the item recognition test, $F(1, 44) = 0.14$, $p > .70$, as well. It should be noted that performance on the associative recognition test also showed no effect of emotion, for both corrected recognition, $F(1, 23) = 0.42$, $p > .5$) and hits, $F(1, 23) = 0.60$, $p > .4$. The corrected recognition and hit rate data for the recognition tests are shown in Table 2.

Table 2 Memory performance, Experiment 1

Item Recognition (*n*=45)					
Study Type	Word Type	Corrected %	SE	Hit %	SE
Nonintegrative	Emotional	56.3	2.9	70.6	2.5
	Neutral	55.3	3.2	70.0	2.4
Integrative	Emotional	48.9	3.4	63.2	3.0
	Neutral	52.0	3.2	60.0	2.6
Associative Recognition (*n*=24)					
Study Type	Pair Type	Corrected %	SE	Hit %	SE
Nonintegrative	Emotional	50.0	2.4	54.2	3.6
	Neutral	48.4	2.7	53.7	5.2
Integrative	Emotional	66.7	3.5	70.9	3.7
	Neutral	68.7	3.7	74.0	4.3
Associative Cued Recall of Neutral Words (*n*=21)					
Study Type	Pair Type	M	SE		
Nonintegrative	Emotional	4.4 %	1.4		
	Neutral	6.7 %	1.7		
Integrative	Emotional	9.4 %	2.1		
	Neutral	19.0 %	3.1		

Associative cued recall test[2]

To examine how the cued recall of neutral words was affected by study type (i.e., integrative versus nonintegrative) and emotional context (i.e., paired with an emotional or another neutral word), a 2 (study type: nonintegrative, integrative) × 2 (emotion context: neutral words studied with emotion words, neutral words studied with neutral words) repeated measures ANOVA was run, examining recall of the right-hand neutral words from the studied pairs.[3]

A significant main effect of encoding strategy was observed, $F(1, 20) = 18.25$, $p < .001$, partial $\eta^2 = 0.48$, with more neutral words recalled from the integrative than from the nonintegrative condition. There also was a significant main effect of emotion context, $F(1, 20) = 11.19$, $p < .01$, partial $\eta^2 = 0.36$, with better recall for neutral words studied in a neutral context (i.e., with a neutral left-hand word) than in an emotional context (i.e., with an emotional left-hand word).

These main effects were qualified by a significant study type × emotion context interaction, $F(1, 20) = 5.57$, $p = .03$, partial η2 = 0.22. Although neutral words studied in an emotional context showed some benefit from integration—

[2] We have omitted discussion of the analysis of the valence judgments (whether participants believed the cue word was paired with a negative, positive, or neutral item) for a few reasons. Before describing those reasons, it should be noted that the results of the valence judgment yielded similar results to the cued recall test. There were main effects of study type, $F(1, 20) = 8.93$, $p<.01$, partial eta = 0.31, and emotion $F1, 20) = 13.3$, $p < .01$, partial eta = 0.40, as well as a Study Type × Emotion interaction, $F(1, 20) = 7.48$, $p = .01$, partial eta = 0.27, all in the manner described in the results of Experiment 1. We also conditionalized the cued recall results based on a correct valence judgment in two different ways. First, we marked as incorrect any items for which there was a correct item recall judgment, but an incorrect valence judgment. Most participants had a few items that met these criteria—in both the integrative and nonintegrative conditions—which resulted in near floor-level recall (since the recall levels for Experiment 1 were low to begin with). Second, we recategorized the items, for each participant, according to their valence judgment where available (although note that it was not available for all items). In other words, a participant may study the pair *owl* + *ocean*, and when given *owl* as the recall cue, indicate that it was paired with a neutral (E) word. This could either be because the participant incorrectly recalled *owl* being paired with some other neutral word, or the participant may have correctly recalled that *owl* was paired with *ocean*, but interpreted *ocean* as a neutral, rather than positive, word. If the participant called *ocean* neutral during the valence judgment, *ocean* was treated as a neutral word in the analysis for that participant. Importantly, this did not change the overall results in any appreciable way.

[3] A separate 2 (study type: nonintegrative, integrative) × 2 (emotion context: neutral words studied with neutral words and emotion words studied with neutral words) repeated measures ANOVA was run on memory for the left-hand words. A significant main effect of encoding strategy was still observed, $F(1, 20) = 4.83$, $p = .04$, although paired-samples t tests revealed that this was driven entirely by memory for neutral words, $t(20) = 4.85$, $p < .001$; memory for emotion words studied integratively did not differ from memory for those studied nonintegratively, $t(20) = 1.01$, $p > .3$.

from 4.4 % (*SE* = 1.4 %) in the nonintegrative condition to 9.4 % (2.1 %) in the integrative condition—neutral words studied in a neutral context showed a disproportionately larger benefit from integration, from 6.7 % (1.7 %) in the nonintegrative condition to 19.0 % (3.1 %) in the integrative condition. These data are shown in Table 2.

Discussion

The results of Experiment 1 confirm that integrating two items at encoding promotes subsequent associative memory (Graf & Schacter, 1985, 1989), but the results also reveal that this effect interacts with the emotional context in which the items are studied. Neutral words that were integrated with emotional words showed only a small benefit over those not integrated, whereas neutral words integrated with other neutral words showed a two-fold increase in memory performance over those that were not integrated. This finding may suggest that there are different routes to integrating neutral information studied in an emotional context versus a neutral context. It could be the case that the emotional context conditions differ in terms of integrative effort required. One possibility is that it may be easier for participants to integrate a neutral item with an emotional item; on the other hand, participants may need to work harder to integrate two neutral items together, because the binding of these items may not be facilitated. If integrating emotional–neutral pairs happens quickly and requires relatively little effort, then those integrative representations may be encoded more shallowly and less durable over the delay between encoding and test than the integrated representations of two neutral items. Additionally, although not a direct measure of familiarity strength, the lack of an emotion effect on item recognition suggests that no large difference in familiarity existed between the emotionality of the cue word.

It does not appear that cue-utilization theory (Easterbrook, 1959) can explain the data found in Experiment 1. Cue-utilization theory would have suggested that the presence of emotional information should draw participants' attention away from the less salient details of the encoding trial—the neutral item—and divert those attentional resources toward the emotional item, resulting in an inability to bind those disparate elements. However, we see that there is still a significant mnemonic benefit from integrating a neutral item with an emotional item over not integrating the two. Although this integrative benefit is less than is observed for pairs containing two neutral items, the fact that we do still see an integrative benefit leads us to believe that either priority-binding theory (Hadley & MacKay, 2006; MacKay & Ahmetzanov, 2005; MacKay et al., 2004) or object-based theory (Mather, 2007) would better explain the data.

In Experiments 2A and 2B, we tested the hypothesis that the binding of two neutral items is a more time-consuming process than the binding of an emotional and a neutral item by manipulating how long participants had to encode the word pairs, using the time needed to form an integrated representation as a proxy for the effort required for that integration (i.e., longer time-on-task would signify a greater expenditure of effort). Generally, we know that increasing encoding time leads to improved downstream memory performance (Hockley & Cristi, 1996), but we expected that the interactive effect of emotion and encoding strategy would be influenced by how much time participants were given to encode the pairs. Participants were given either 2, 4, or 6 s to follow the encoding task instructions. If neutral pairs require more elaborative effort to integrate than emotional pairs, we would expect participants to rate fewer neutral–neutral pairs than emotional–neutral pairs as successfully visualized when only given 2 s to do so. We would also expect that in the 2-s condition, little or no integrative memory benefit would be observed for neutral pairs, because participants would not have enough time to create a sufficiently elaborated and durable representation for those pairs. Increasing the encoding time should disproportionately benefit the integration of neutral items, both in terms of the success of initial imagery and in terms of the integrative memory benefit. Thus, we expect that for those longer encoding times, imagery success for neutral pairs should equal that for pairs containing an emotion word, and recall performance for neutral pairs should meet or exceed memory performance for pairs containing an emotion word (consistent with Experiment 1).

Experiment 2a

Method

Participants

Participants were 23 healthy young adults (15 female) of the ages 19–30 (*M* = 22.8), as was described for Experiment 1. No participant who participated in Experiment 1 also participated in Experiment 2A. Participant characteristics are available in Table 1.

Stimuli

A total of 120 of the pairs used in Experiment 1 were used in Experiment 2 (40 pairs containing a positive and neutral word, 40 containing a negative and neutral word, and 40 containing two neutral words). A total of 120 of the new "lure" words from Experiment 1 (40 positive, 40 negative, and 40 neutral) were used as new "lure" words for the memory test. Stimulus pairs were presented for either 2, 4, or 6 s, such that 20 pairs in each encoding condition were seen for 2 s, 20 pairs were seen for 4 s, and 20 pairs were seen for 6 s in each condition. Stimulus emotionality (whether the pair contained an emotion word or not) was also varied across presentation time, such that each presentation time block contained between six to eight pairs of each emotion type (negative + neutral, positive + neutral, and neutral + neutral). To reduce set-shifting demands, the timing was blocked: Participants would see 10 trials of the same encoding speed in a row. The particular word pairs that were assigned to each time block condition were counterbalanced across participants.

Procedure

The encoding phase of Experiment 2 proceeded identically to that of Experiment 1: Participants imagined 60 pairs using the nonintegrative imagery strategy (20 for 2 s, 20 for 4 s, and 20 for 6 s), followed by 60 pairs using the integrative imagery strategy with the same breakdown in timing. Participants were then given a 30-min break, during which they performed a series of pencil-and-paper tasks.

Following the 30-min break, participants performed the item recognition and associative cued recall tests described in Experiment 1. The valence recall judgment was omitted from the associative cued recall test for reasons described in Footnote 2. Therefore, participants made only an item recognition judgment and a cued recall response.

Results

Item recognition test

Consistent with Experiment 1, the item recognition test showed the expected main effect of study type, with nonintegrative items recognized better than integrative items, $F(1, 22) = 25.25$, $p<.001$, partial $\eta^2 = 0.53$. There was again no significant main effect of emotion, $F(1, 22) = 0.20$, $p > .6$, partial $\eta^2 < 0.01$.

A main effect of encoding time was observed, $F(2, 44) = 6.04$, $p = .005$, partial $\eta^2 = 0.22$, with item recognition better after longer encoding times. However, encoding time did not interact with study type, $F(2, 44) = 0.01$, $p > .95$, partial $\eta^2 < 0.01$, or emotion, $F(2, 44) = 0.86$, $p > .4$, partial $\eta^2 = 0.04$. As in Experiment 1, the results of the item recognition test did not differ if hit rates were assessed instead of corrected recognition. There also was no effect of emotion on false alarm rates: On 2-s trials, the false alarm rates were 7.0 % (1.8) for emotional items and 6.8 % (1.8) for neutral items; on 4-s trials, the false-alarm rates were 7.2 % (1.8) for emotional items and 7.3 % (1.7) for neutral items; on 6-s trials, the false alarm rates were 5.5 % (1.5) for emotional items and 5.9 % (1.5) for neutral items. The item recognition data are displayed in Table 3.

Percentage of qualified pairs

To explore the hypothesis that integrating two neutral items requires disproportionately more effort than integrating an emotional and neutral item, we examined what percentage of *integrated* pairs participants rated with "3"s or "4 s," as a function of whether the pair contained an emotion word or two neutral words. A 3 (time: 2 s, 4 s, 6 s) × 2 (emotion: emotion, neutral) repeated measures ANOVA revealed no main effect of emotion, $F(1, 22) = 0.49$, $p > .4$, partial $\eta^2 = 0.02$, with participants giving a "3" or "4" rating to 78.2 % (SE = 2.3 %) of all integrated pairs containing an emotion word and 76.0 % (SE = 2.4 %) of all pairs containing a neutral word.

A main effect of time was observed, $F(2, 44) = 22.24$, $p<.001$, partial $\eta^2 = 0.50$, and this was qualified by a significant emotion × time interaction, $F(2, 44) = 10.95$, $p < .001$, partial $\eta^2 = 0.33$. Seen in Fig. 1, encoding time did not affect participants' success ratings for pairs containing an emotion word (Panel A: M_{2sec} = 77.5 %, SE_{2sec} = 3.0 %; M_{4sec} = 77.5 %, SE_{4sec} = 2.9 %; M_{6sec} = 79.5 %, SE_{6sec} = 2.6 %). However, for pairs containing two neutral words, participants awarded "3" or "4" ratings to significantly fewer pairs at 2 s (M = 64.8 %, SE = 3.9 %) than at 4 or 6 s (M_{4sec} = 79.9 %, SE_{4sec} = 3.3 %; M_{6sec} = 83.2 %, SE_{6sec} = 2.9 %).

The same analysis for nonintegrative pairs revealed a main effect of emotion, $F(1, 22) = 5.03$, $p = .04$, partial $\eta^2 = 0.19$, with more pairs containing an emotion word rated a "3" or "4" ($M_{emotion}$ = 75.9 %, SE = 2.3 %) than pairs containing two neutral words ($M_{neutral}$ = 71.8 %, SE = 3.0 %). However, no effect of time was observed, $F(2, 44) = 1.62$, $p > .2$, and emotion and time did not interact, $F(2, 44) = 0.03$, $p > .95$.

Table 3 Item recognition performance, Experiment 2A

Time	Study Type	Emotion	Corrected %	SE	Hit %	SE
2 s	Nonintegrative	Emotional	69.8	3.3	76.8	3.1
		Neutral	76.2	3.3	83.0	3.1
	Integrative	Emotional	64.8	3.4	71.8	3.3
		Neutral	66.4	3.4	73.2	3.0
4 s	Nonintegrative	Emotional	71.5	3.4	78.7	3.2
		Neutral	68.7	2.7	76.0	2.7
	Integrative	Emotional	63.0	3.7	70.2	3.9
		Neutral	63.7	5.4	71.0	4.7
6 s	Nonintegrative	Emotional	77.0	4.1	82.5	3.7
		Neutral	79.6	3.3	85.5	2.9
	Integrative	Emotional	72.9	2.6	78.4	2.1
		Neutral	70.7	2.4	76.6	2.3

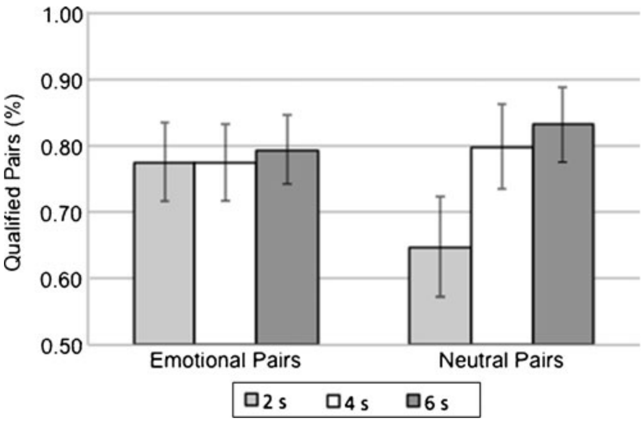

Fig. 1 Percentage of pairs rated as successfully encoded (i.e., given a "3" or "4" rating) in the integrative condition in Experiment 2A, as a function of study time. Error bars represent 95 % confidence intervals around the means

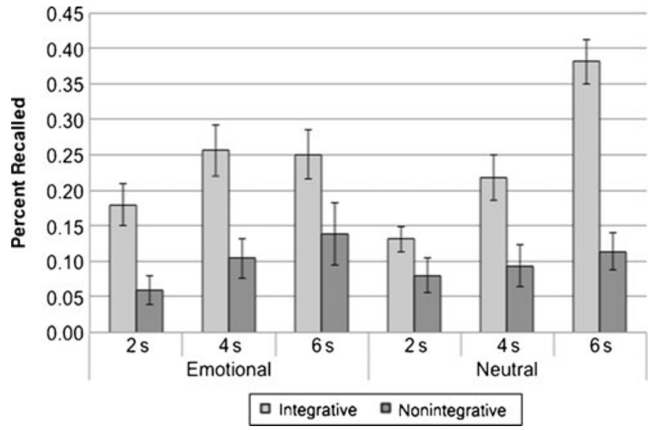

Fig. 2 Performance on the associative cued recall test in Experiment 2A. Error bars represent 95 % confidence intervals around the means

Associative cued recall

Cued recall rates for the right-handed neutral words that met the qualification criteria (i.e., part of a pair rated as a "3" or "4" at encoding) were submitted to a 3 (encoding time: 2 s, 4 s, 6 s) × 2 (emotional context: emotional cue, neutral cue) × 2 (study type: nonintegrative, integrative) repeated measures ANOVA. Consistent with Experiment 1, a significant main effect of study type was observed, $F(1, 22) = 60.35$, $p < .001$, partial $\eta^2 = 0.73$. Recall performance was significantly better for pairs studied in the integrative condition than in the non-integrative condition. As was expected, a significant main effect of encoding time was also observed, $F(2, 44) = 4.76$, $p = .01$, partial $\eta^2 = 0.18$, with memory performance increasing as encoding time increased.

Although no main effect of emotional context was observed, $F(1, 22) = 0.67$, $p > .4$, partial $\eta^2 = 0.03$, a significant three-way interaction was observed among emotional context, study type, and encoding time, $F(2, 44) = 4.38$, $p = .02$, partial $\eta^2 = 0.17$. As was seen in Fig. 2, the benefit from integration over nonintegration increased dramatically as encoding time increased for neutral words studied with other neutral words. Conversely, neutral words studied in an emotional context (Fig. 2) showed a numerical *decrease* in integrative benefit as encoding time increased. Additionally, in the 2-s study condition, neutral words showed a benefit from integration over nonintegration when studied with emotional words, but showed no such benefit when studied with other neutral words.

Experiment 2b

One concern may be that asking participants to make an item recognition judgment before their recall response may instantiate some testing effect that could contaminate the results. For instance, items that were recognized might be more available as targets on the cued recall test; conversely, the known presence of "lure" items may have prevented participants from performing a thorough memory search for some retrieval cues, which could confound the results of the subsequent recall judgment. In Experiment 2B, we employed the same study materials as in Experiment 2A, but participants performed only the associative cued recall task. In this way, we ameliorated any concern that the cued recall results of the previous two studied were affected by the preceding item recognition task.

Participants

Participants were 21 healthy young adults (11 female) of the ages 18–30 years (M = 19.1) as described for Experiment 2A. No participant who participated in Experiment 1 or Experiment 2A participated in Experiment 2B. Participant characteristics are available in Table 1.

Stimuli

The same study pairs from Experiment 2A were used in Experiment 2B. No new "lure" words were used, since Experiment 2B did not contain a recognition test component.

Procedure

The encoding phase of Experiment 2B was identical to that of Experiment 2A: Participants imagined 60 pairs using the nonintegrative imagery strategy, followed by 60 pairs using the integrative imagery strategy. One-third of the items in each imagery condition were presented for 2 s, one-third for 4 s, and one-third for 6 s. Participants were then given a 30-min break, during which they performed a series of pencil-and-paper tasks.

Following the 30-min break, participants performed only the associative cued recall test. All 240 studied words were cued in a randomized order. For each word, participants were instructed to record on a separate sheet of paper what word had been paired with the cue on the screen. They were encouraged to record a response for all words.

Results

Percentage of qualified pairs

The pair qualification data replicated that of Experiment 2A. A 3 (time: 2 s, 4 s, 6 s) × 2 (emotion: emotion, neutral) repeated measures ANOVA on pairs in the integrative condition revealed no main effect of emotion, $F(1, 20) = 0.89$, $p > .35$, partial $\eta^2 = 0.04$, with participants giving a "3" or "4" rating to 77.4 % ($SE = 2.3$ %) of all pairs containing an emotion word and 74.3 % ($SE = 2.4$ %) of all pairs containing a neutral word.

A main effect of time was observed, $F(2, 40) = 9.55$, $p < .001$, partial $\eta^2 = 0.32$, and this was qualified by a significant Emotion × Time interaction, $F(2, 40) = 4.48$, $p = .02$, partial $\eta^2 = 0.18$. As in Experiment 2A, encoding time did not affect participants' success ratings for pairs containing an emotion word, but the percentage of neutral pairs rated as "3" or "4" increased as encoding time increased.

Submitting the nonintegrative data to this 3 (encoding time) × 2 (emotion) repeated measures ANOVA revealed a main effect of emotion, $F(1, 20) = 4.63$, $p = .04$, partial $\eta^2 = 0.19$, with more pairs containing an emotion word qualifying ($M_{\text{emotion}} = 75.0$ %, $SE = 2.3$ %) than pairs containing two neutral words ($M_{\text{neutral}} = 70.6$ %, $SE = 3.1$ %). No effect of encoding time was observed, $F(2, 40) = 1.83$, $p > .15$, and emotion and time did not interact, $F(2, 40) = 0.15$, $p > .85$, partial $\eta^2 < 0.01$.

Associative cued recall

A 3 (encoding time: 2 s, 4 s, 6 s) × 2 (emotion context: emotional cue, neutral cue) × 2 (study type: nonintegrative, integrative) repeated measures ANOVA on the right-hand neutral words that met the qualification criteria revealed a significant main effect of study type, $F(1, 20) = 51.79$, $p < .001$, partial $\eta^2 = 0.72$. Recall performance was significantly better for pairs studied in the integrative condition than in the nonintegrative condition. A significant main effect of encoding time was observed, $F(2, 40) = 6.99$, $p = .002$, partial $\eta^2 = 0.26$, with memory performance increasing as encoding time increased. Consistent with Experiment 2A, no main effect of emotional context was observed, $F(1, 20) = 0.52$, $p > .48$.

Here, a significant interaction was observed between study type and encoding time, $F(2, 40) = 4.13$, $p = .02$, partial $\eta^2 = 0.17$, with memory performance in the integrative condition improving significantly at times greater than 2 s, but memory performance in the nonintegrative condition not differing across encoding times.

The three-way interaction among emotional context, study type, and encoding time approached significance, $F(2, 40) = 2.84$, $p = .07$, partial $\eta^2 = 0.13$. The nature of the trend was the same as the significant three-way interaction in Experiment 2A, with the integrative benefit increasing with time more dramatically for neutral words studied in a neutral context than for neutral words studied in an emotional context. The data for Experiment 2B are displayed in Fig. 3.

Discussion

The results of Experiments 2A and 2B offer evidence that successfully creating an integrated mental image of two neutral items takes longer and may require more effort than creating an integrated image of an emotional and a neutral item. This additional time on task, however, appears to produce a more salient memory trace. Although participants had high rates of self-reported success (i.e., rating a pair a "3" or "4" at encoding) for creating an integrated image of an emotional and neutral item after only 2 s, it took from 4 to 6 s to achieve that same level of success to integrate pairs containing two neutral referents. This is consistent with our hypothesis that integrating two neutral items with one another may require more elaborative effort than integrating an emotional and a neutral item. Importantly, this effect was observed for pairs only in the integrative condition; in the nonintegrative condition, participants' imagery success did not differ across the three time conditions, suggesting that the ability to imagine emotional items in isolation may

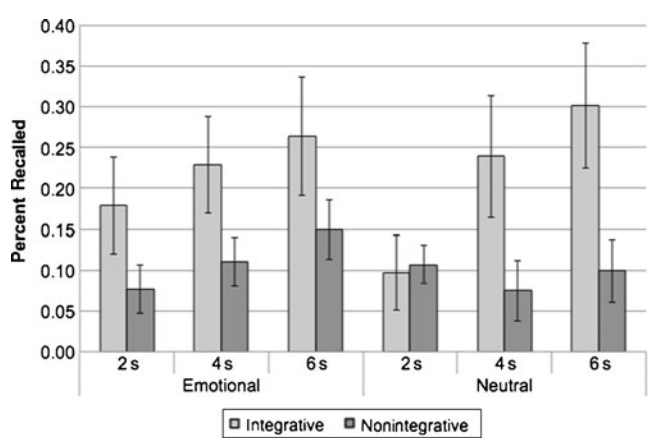

Fig. 3 Performance on the associative cued recall test in Experiment 2B. Error bars represent 95 % confidence intervals around the means

happen no faster than the ability to imagine neutral items. By contrast, it seems to be the *integration* of pairs containing an emotional item that benefits from a fast binding mechanism, making those pairs easier to integrate even when time is limited.

As we elaborate in the General discussion section, this pattern of results shares points of contact with the "binding theory" of MacKay et al. (2004), insofar as the present results point to a binding mechanism for neutral–emotional pairs that can be implemented more rapidly than for neutral–neutral pairs. It also is consistent with the "object based" framework of Mather (2007), in that the rapid binding occurred only when participants were asked to integrate the items into a coherent, single representation. However, these results break from both of those prior theories by showing that these seemingly beneficial effects of emotion on integrative processing at encoding do not always translate into enhanced long-term retention of the bound representation.

General discussion

Our aim was to investigate the effect on memory for neutral items depending on whether they were presented with an emotional word or with a neutral word, and depending on whether the items were imagined as an integrated unit or as two separate entities. Three experiments yielded data suggesting that it takes longer to integrate two neutral items than to integrate an emotional and a neutral item. The additional time and effort, though, resulted in a downstream mnemonic benefit for the neutral pairs: The relationship between two neutral items is better remembered than the relationship between an emotional and a neutral item. Although on average participants report similar subjective success at integrating emotional and neutral pairs (as measured by the number of "3" and "4" ratings at encoding), speeding the encoding time to 2 s produces a significant decrement in the number of neutral pairs successfully integrated. Such a result is suggestive that it takes more time or effort to construct plausible and vivid integrations of those items, whereas integrating an emotional with a neutral item can happen comparatively faster.

These data inform the debate over whether emotional information impedes or facilitates the binding of neutral details: Emotional information may indeed facilitate binding when the neutral information is well integrated with the emotional. Our data, therefore, offer a potential boundary condition for priority-binding theory (MacKay & Ahmetzanov, 2005; MacKay et al., 2004). If priority binding assumes that emotion will *always* enhance binding, then our data suggest that position may not be correct: In the nonintegrative condition, we see no disproportionate mnemonic advantage for nonemotional information that is studied with emotional information. On the other hand, when participants are instructed to integrate the emotional and nonemotional items into a single representation, we do see the type of enhancement that would be consistent with both the priority-binding and object-based (Mather, 2007) theories.

Additionally, our data offer an important additional interpretation of these theories: Although the presence of emotional information may indeed make it faster to form an integrated mental representation with neutral information, that quickness may come at the price of durable long-term memory for the association. When binding an emotional and neutral item, people may be more likely to over-rely on those fast binding processes and less likely to elaborate on the association. This may lead to a less resilient memory representation of the integrated pair. Conversely, when integrating two neutral items, no such prioritized processing is available and people must rely on more elaborative strategies to successfully integrate the items with one another; while more time consuming to create, this representation may leave a more durable or accessible trace in memory. These findings suggest that there may be differences between the processes that transiently bind emotional and neutral elements together during encoding in order to create a holistic representation of the episode and the processes that enable the bound representation to be stably stored in memory over time.

These results also emphasize the importance of considering the encoding task when attempting to resolve inconsistencies in the emotion and associative memory literature. Within this single study, we revealed no effect of emotion on associative memory (for the nonintegratively encoded items), an enhancing effect of emotion on associative memory (for the integrative pairs studied for only 2 s) and a detrimental effect of emotion on associative memory (seen most clearly in Experiment 1 and for the integratively encoded items studied for 6 s in Experiment 2A). Thus, even fairly subtle differences in task instructions (such as the precise length of time given to complete an encoding task) can fundamentally alter the way in which bound representations of emotional pairings are formed and stored in memory.

Limitations and future directions

Our findings offer several avenues for further investigation. First, it would be important to examine the extent to which the emotional differences observed on the recall test arise from an "integration"-specific process, or rather from an emphasis on associative memory in general. A productive follow-up study would be to vary the degree of integration required at encoding—for example, having a condition in which item information is emphasized (similar to our nonintegrative condition), an associative condition in which participants are instructed to associate the two items in some way (e.g., imagining the items next to each other, or in the same scene together), and a high-integration condition in which the items must be combined into a single, novel stimulus.[4]

Additionally, the apparent disparity in elaborative effort required between the neutral and emotional conditions should be explored in more detail. For example, one could investigate the degree to which implementing a divided attention task during the study phase further disrupts the integration of neutral and emotional pairs; if integrating an emotional and a neutral item is faster and less effortful, then one would expect dividing attention to differentially affect the emotional context conditions in a way similar to our encoding time manipulation.

It will also be important to explore how associations for emotional and neutral information differ in durability over a different study–test delay. Here, we find that emotion and encoding strategy interact when we test participants after a half-hour delay, but it is plausible that the nature of the interaction could depend on the delay between encoding and test. At the level of individual item memory, it has been shown that memory for neutral information decays faster than memory for emotional information (Sharot & Phelps, 2004). This may generalize to memory for well-integrated associations, as well: Although neutral integrations may be more memorable at a short delay, those integrations may begin to decay quickly as the study–test delay increases. On the other hand, integrated representations of emotional pairs may be more persistent over longer delays.

It is also possible that if stimuli with even higher arousal levels are used, this will lead to longer lasting effects on the memory for the bound representations. In order to have a sufficient number of positive and negative stimuli of similar arousal levels and of reasonable levels of concreteness (so that imagery was feasible), the present stimuli were by necessity only of moderate arousal. It is possible that if future studies use paradigms that enable presentation of very high-arousal stimuli, even emotional–neutral pairs studied for brief periods of time would have an associative advantage in long-term memory. However, we believe that it is interesting that despite the somewhat modest arousal levels of the stimuli used in the present study, we still saw a robust effect in the time it took to integrate the items and also in the cued recall data; in particular, even with these moderately arousing items, we still saw evidence for faster or more automatic integrative processing of emotional relative to neutral items.

[4] We thank an anonymous reviewer for suggesting this as a potential future investigation.

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Appendix: Figures and tables

Memory Results for Experiment 1 Pilot Data: Two Consecutive Integrative Study Blocks

Item Recognition

Study Block	Word Type	M	SE
First	Emotional	48.9%	(4.6)
	Neutral	50.6%	(4.4)
Second	Emotional	50.8%	(4.8)
	Neutral	52.0%	52.0% (4.1)

A 2 (emotion: emotional, neutral) × 2 (study block: first block, second block) revealed no main effect of emotion (F(1,11) = 0.28, $p > 0.6$, partial $\eta^2 = 0.03$) or study block (F(1,11) = 1.57, $p > 0.2$, partial $\eta^2 = 0.13$). Emotion and study block did not interact (F(1,11) = 0.04, $p > 0.85$, partial $\eta^2 < 0.01$). The lack of a main effect of emotionality is consistent with Experiment 1.

Associative Cued Recall of Neutral Word

Study Block	Pair Type	M	SE
First	Emotional	11.1%	2.7
	Neutral	17.1%	2.8
Second	Emotional	11.7%	2.8
	Neutral	21.5%	3.9

A 2 (emotion: emotional, neutral) × 2 (study block: first block, second block) revealed a main effect of emotion (F(1,11) = 5.95, $p = 0.03$, partial $\eta^2 = 0.35$), consistent with Experiment 1. There was no main effect of study block (F(1,11) = 1.30, $p > 0.25$, partial $\eta^2 = 0.11$). Emotion and study block did not interact (F(1,11) = 0.68, $p > 0.4$, partial $\eta^2 = 0.06$).

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