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Effects of emotion on memory specificity: Memory trade-offs elicited by negative visually arousing stimuli

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Abstract

Two different types of trade-offs have been discussed with regard to memory for emotional information: A trade-off in the ability to remember the gist versus the visual detail of emotional information, and a trade-off in the ability to remember the central emotional elements of an event versus the nonemotional (peripheral) elements of that same event. The present study examined whether these two trade-offs interact with one another when participants study scenes that elicit an emotional response due to the inclusion of a negative visually arousing object. Participants studied scenes composed of a negative or a neutral object placed on a background. Their memory was then tested for the "gist" and visual detail of the objects and the backgrounds. The results revealed that there is a pervasive memory trade-off for central emotional versus peripheral nonemotional elements of scenes. With some encoding tasks, a trade-off for gist versus visual detail also resulted, but this trade-off occurred only when memory for the nonemotional background of a scene was assessed. There was no gist/detail trade-off for the emotional objects in a scene.

Keywords: Emotion; Arousal; Memory; Gist; Detail; Scenes; Trade-off; Central; Peripheral; Visual

Individuals often believe that they remember negatively emotional experiences vividly (e.g., Dewhurst & Parry, 2000; Kensinger & Corkin, 2003; Ochsner, 2000), and at least some types of details are more likely to be remembered about negative items than about nonemotional ones (e.g., Doerksen & Shimamura, 2001; Kensinger & Schacter, 2006). However, numerous lines of research have suggested that memory is not enhanced for all aspects of negative, arousing experiences. Rather, memory for these events may be best described by *trade-offs*: Some aspects of an event are better remembered because of its emotional salience, whereas other aspects are more likely to be forgotten (reviewed in Buchanan & Adolphs, 2002; Reisberg & Heuer, 2004).

The exact nature of the memory trade-offs elicited by negative emotional arousal is unclear. Two predominant proposals have been put forth to describe the types of costs that may be associated with such memories. The first proposal is that negative arousal causes a narrowing of attention, such that details spatially and temporally associated with the emotional item are attended to and later remembered, while information peripheral (i.e.,

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not of central relevance)[1] to that item is likely to be forgotten (e.g., Easterbrook, 1959; Loftus, 1979; referred to here as the *central/peripheral trade-off*). For example, when an individual is shown a scene that includes a negative visually arousing element, they often remember the emotional aspect of the scene, but not the peripheral elements. Thus, individuals remember scenes as having been "zoomed in" on the emotional element (i.e., they believe the emotional element took up a larger proportion of the scene than it did in reality), likely because they remember the visually arousing information in the scene but not the information at the periphery (Safer, Christianson, Autry, & Osterlund, 1998). People also often show poorer recognition of information in the periphery if an emotional item was included in the scene than if only nonemotional items were present (e.g., Brown, 2003; Christianson & Loftus, 1991; Deffenbacher, 1983; Easterbrook, 1959; Kensinger, Piguet, Krendl, & Corkin, 2005; Pickel, French, & Betts, 2003; Shaw & Skolnick, 1994; Wessel & Merckelbach, 1997). A similar effect is thought to underlie the "weapon-focus" effect, in which an individual who is a witness to a crime often remembers the weapon used by the perpetrator but not other details such as the perpetrator's clothing or vehicle (e.g., Loftus, 1979; Loftus, Loftus, & Messo, 1987; Stanny & Johnson, 2000; Steblay, 1992): The information central to the source of arousal is remembered well, while peripheral information is forgotten.

The second proposed memory trade-off elicited by emotion focuses not on information's relevance to the emotional arousal, but rather on the level of detail remembered about the event (referred to here as the *gist/detail trade-off*). In particular, Adolphs and colleagues have suggested that emotion tends to enhance the likelihood that the "gist," or general theme, of an experience is remembered, while reducing the probability that specific visual details of that event are remembered. After showing participants emotional and neutral scenes, each accompanied by a short narrative, they have assessed "gist" memory by asking participants to recall or to recognize the verbal description of the scene (e.g., that a dead person had been found in the forest; Adolphs et al., 2001, Adolphs, Tranel, & Buchanan, 2005; Denburg, Buchanan, Tranel, & Adolphs, 2003). They have assessed memory for visual detail by asking participants to distinguish the studied image from foil images that have been altered (e.g., by changing the surface on which the dead body is lying; Adolphs et al., 2001; Denburg et al., 2003) or to choose the correct statement regarding the scene's visual details (Adolphs et al., 2005). Across these studies, emotion has enhanced performance on the tasks designed to assess "gist" memory, but has impaired performance on tasks requiring memory for the visual details of the studied images (Adolphs et al., 2001, 2005; Denburg et al., 2003).

The *gist/detail* trade-off, however, does not always seem to occur. In a prior investigation, we demonstrated that individuals can be *more likely* to remember specific visual details of emotional objects than of neutral objects (Kensinger, Garoff-Eaton, & Schacter, 2006). In that investigation, participants were presented with single objects (e.g., a snake, a chipmunk), each shown against a blank background. They later were better able to discriminate visually identical objects from similar (but not identical) objects when the items were negatively emotional than when they were neutral. In contrast, the studies that have revealed the *gist/detail* trade-off have assessed participants' memories of visual scenes (e.g., a dead body in a forest). It is possible that different processes act when individuals are presented with a complex scene containing an emotional object, rather than with a single emotional object in isolation. For example, gist-based extraction may be more likely to occur when participants encounter complex visual scenes that include many different components, rather than a single object (see Kensinger et al., 2006 for further discussion). Thus, perhaps individuals demonstrate a *gist/detail* trade-off for emotional items primarily when they are part of a broader visual scene, rather than when the emotional items are presented in isolation. It also is plausible that a *gist/detail* trade-off occurs primarily when participants are asked to focus on verbal descriptions of scenes or to follow a storyline regarding an emotional event, and that it is less likely to be elicited when participants process information in more of a visual manner (i.e., when the emotional response is elicited because of the presence of a visually arousing stimulus; see Laney, Campbell, Heuer, & Reisberg, 2004 for further discussion of the importance of distinguishing between "visual" and "thematic" evocation of emotional responses).

Another possibility is that the *gist/detail* trade-off may occur, but it may interact with the *central/peripheral* trade-off. This issue has remained relatively unexplored. The studies by Adolphs and colleagues, while separating gist from detail, have not examined memory for the gist and detail of the emotional aspect of the scene separately from memory for the gist and detail of information peripheral to the emotional aspect. In several of their studies, some details of the emotional object were manipulated (e.g., changing the orientation of the dead body) and other details associated with nonemotional elements of the scene were also altered (e.g., changing the forest floor on which the body was lying). In a more recent study (Adolphs et al., 2005), memory for "gist" was assessed primarily for the central emotional object, while memory for visual detail was ascertained primarily for the nonemotional peripheral elements.

[1] By "central" and "peripheral," we refer not to the information's spatial location in the scene, but rather to its relevance to the source of the emotional arousal (see Adolphs, Denburg, & Tranel, 2001 for further discussion).

Moreover, with one exception (Burke, Heuer, & Reisberg, 1992), the studies examining the *central/peripheral* trade-off have not teased apart contributions of gist memory versus memory for visual detail. The study by Burke and colleagues was designed to enhance our understanding of how "central" and "peripheral" details should be defined: based on spatial location, or based on the information's conceptual link to the scene or story. The findings provided empirical support for both definitions: Emotion improved memory for information tied either spatially or conceptually to the emotional meaning of a story. In other words, for aspects of a slide show that were closely tied to the emotional event, both gist memory and specific visual memory were enhanced.

Their study could not, however, easily distinguish "gist" and "specific visual" memory for the peripheral aspects of the scenes. Gist of the emotional narrative was focused on the emotional event; thus, Burke and colleagues did not have a mechanism to assess gist memory for background details. Moreover, the study by Burke and colleagues used a storyline, which may elicit more of a "thematic" induction of emotion. By investigating memory for the gist and the visual details of both the objects in scenes and the backgrounds on which the objects are placed, the present study allowed a critical extension of the study by Burke and colleagues. In particular, the present study assessed whether interactions between the specificity of memory (gist vs. detail) and the pertinence of information ("central" object vs. "peripheral" background) occur for stimuli that elicit emotional responses through the presentation of negative, visually arousing information.

We hypothesized that when presented with a complex visual scene that included a negatively arousing object placed on an otherwise nonemotional background (e.g., a dead body in a forest), participants would show a *central/peripheral* trade-off: They would be more likely to remember the negative arousing objects than the neutral objects, and less likely to remember backgrounds presented with negative arousing objects than those presented with neutral objects. However, we also hypothesized that this *central/peripheral* trade-off would interact with the *gist/detail* one. We hypothesized that participants would be more likely to remember both the "gist" and the specific details of emotional objects in the scenes than of neutral objects in scenes (e.g., that there was a dead body, and exactly what the dead body looked like). In contrast, we hypothesized that participants would be less likely to remember the visual details of backgrounds presented with negative arousing objects than with nonemotional ones, but would not show the same difficulty remembering the gist of the background presented with a negative arousing object. In other words, we hypothesized that the *gist/detail* trade-off would occur for nonemotional background (peripheral) elements of a scene, whereas both gist and visual detail would be remembered well for the emotional (central) object.

Present study

The present study assessed memory for "gist" and memory for visual detail separately for information central or peripheral to the emotional information in a complex visual scene. We created scenes by placing a negative arousing object (e.g., a snake) or a neutral object (e.g., a monkey) on a neutral background (e.g., a river, a jungle). By showing participants these scenes (e.g., a snake near a river; a monkey in a jungle), the present study examined how negative emotion impacted participants' abilities to remember the gist and visual detail of "central" objects (the snake or the monkey) and the "peripheral" backgrounds on which the objects were placed (the river or the jungle). In particular, participants studied a series of unrelated scenes, half with a negative arousing object on a background and half with a neutral object on a background (see Fig. 1A). At retrieval, participants were presented with a series of objects and backgrounds. Some of the objects and backgrounds were identical to those that participants had studied (*same*), others shared the same verbal label as an object or background that the participants had studied, but differed in any number of visual features (e.g., shape, orientation, color; *similar*) and other objects and backgrounds were novel (*new*). Participants were asked to indicate "same" if they had studied that identical object or background, "similar" if they had studied an object or background that shared the same verbal label (e.g., a monkey, a jungle) but that differed in any number of visual details from the exemplar presented on the recognition task, or "new" if they had not studied that type of object or background (see Fig. 1B). Although *similar* and *new* items were included on the recognition task so that participants would not be biased to consistently say "same," our main interest was in examining the effect of emotion on the responses to the *same* items[2] (i.e., to those items that, in reality, were identical to studied items).

[2] We chose not to focus on *similar* items because of the ambiguity in interpreting the precise cognitive processes associated with responses to these items. For instance, when a "similar" response is given to a *similar* item, it is unclear whether the participant recalls the visual details of the item (i.e., the participant has specific recognition for the originally studied item, and thus realizes that the *similar* item is not the "same") or if the participant finds the item familiar but has no memory for its visual details (i.e., the participant has memory for the gist of the item only, and therefore guesses that it is "similar" rather than the "same"). By contrast, responses to *same* items are much easier to interpret (see text).

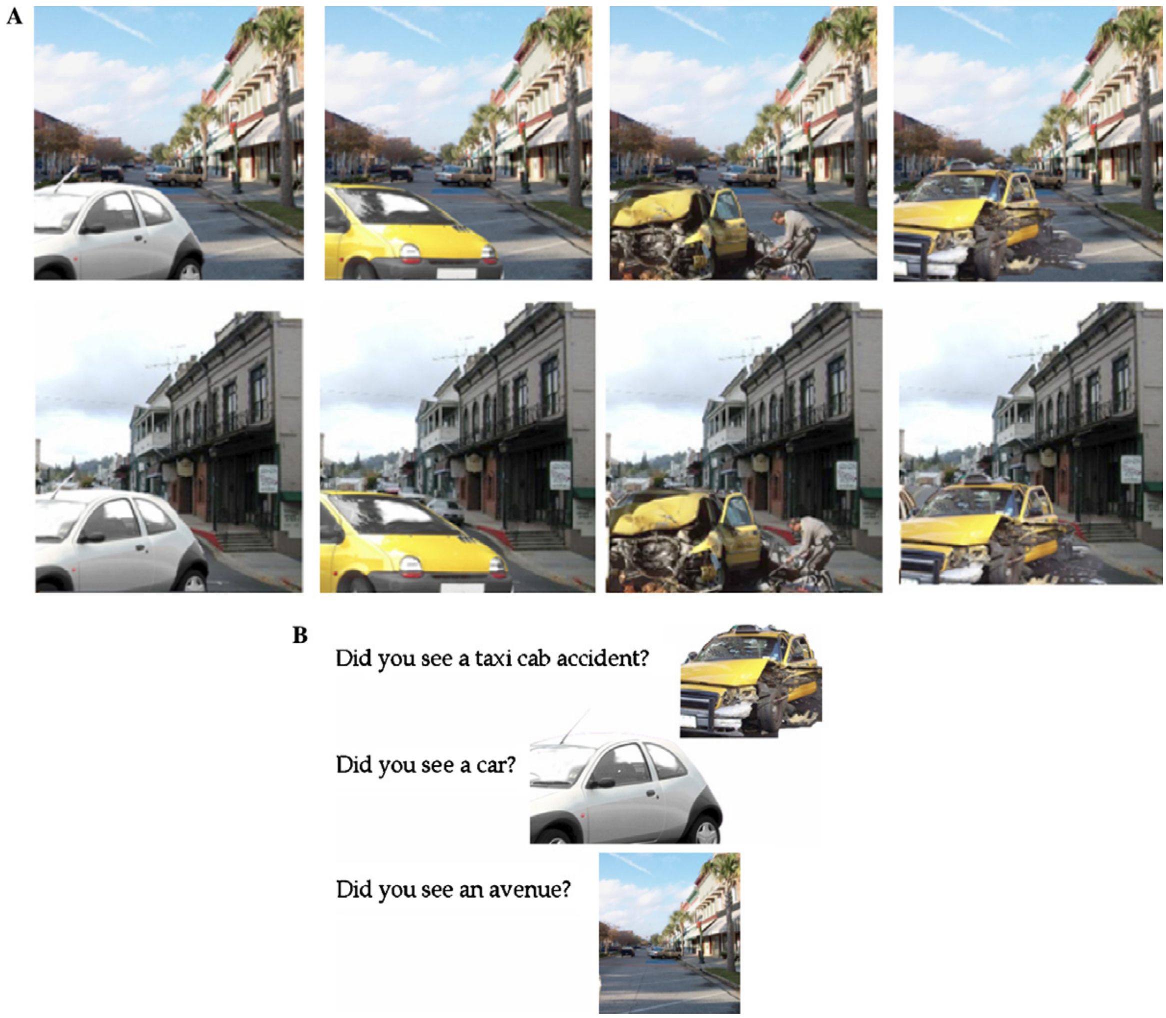

Fig. 1. For each of the 64 scenes, participants studied one of eight scene versions, each composed of a neutral background with a neutral or a negative object (A). At test, participants were presented with objects and backgrounds and indicated whether each was the "same" as a studied item, "similar" to a studied item (defined as an item that shared the same verbal label as something shown at study, but was not the exact exemplar), or was a "new" (nonstudied) item (B). The items on the recognition task were kept constant for all participants, while the scene versions that were studied were counterbalanced across participants.

Consistent with previous studies asking participants to make a "same" or "similar" distinction at retrieval (Garoff, Slotnick, & Schacter, 2005; Kensinger et al., 2006), we considered "same" responses to *same* items to reflect memory for the visual details of the studied object or background ("specific recognition"). *Same* items given either a "same" or a "similar" (and not a "new") response were considered to reflect memory for at least some aspects of the studied item ("general recognition"). That is, for *same* items given either a "same" or a "similar" response, participants had to remember at least that a particular type of object or background had been studied (e.g., that they had seen a monkey or a jungle) because otherwise they would have instead indicated that the item was "new." Thus, these general recognition scores reflect a participant's tendency to remember *at least* the gist of the items (with or without visual detail). Although this measure is consistent with prior investigations' examinations of emotion's effects on memory for gist, we also wanted to examine whether emotion increased the likelihood that participants remembered *only* the gist (and not the visual details) of an item. We therefore calculated "gist-only memory" as the proportion of *same* items not remembered with visual detail that also were not entirely forgotten (i.e., "similar" responses / ["similar" + "new" responses]). This calculation for gist-only memory, equivalent to "similar" responses/ (1-"same" responses), parallels the ''independent-know'' score often used in a Remember/Know paradigm (see Yonelinas & Jacoby, 1995), and takes into account the fact that the ''similar'' responses will be constrained by the number of ''same'' responses given (i.e., a ''similar'' response will be given only when the general object type is remembered, but its visual features are not).

This paradigm, therefore, allowed assessment of the effects of negative arousing content on memory for specific visual details (''specific recognition''), for *at least* the gist (''general recognition''), and for *only* the gist (''gist-only recognition''). Each of these types of memory was assessed separately for the ''central'' object (negative arousing or neutral) and for the ''peripheral'' background (always neutral). Thus, by comparing specific recognition for the objects and the backgrounds to general recognition or to gist-only recognition for those elements, we could examine whether the *gist/detail* and *central/peripheral* trade-offs interacted with one another.

Experiment 1

Method

Participants

Sixteen native English speaking adults (ages 18–35) participated for course credit or for pay. No participant was depressed nor was anyone taking medications that would affect the central nervous system. Informed consent was acquired in a manner approved by the Harvard University institutional review board.

Materials

Materials consisted of pairs of negative arousing objects (e.g., snakes), neutral objects (e.g., chipmunks), and backgrounds (e.g., rivers). Pairs were selected such that the two items of a pair shared the same verbal label (e.g., were both chipmunks) but differed in other perceptual features (e.g., color, shape, size, and orientation). Objects were taken from those used in a prior investigation (Kensinger et al., 2006) and were supplemented with additional images from photo clip art packages. Neutral backgrounds were taken from the IAPS set (Lang, Bradley, & Cuthbert, 1997) and from online image databases.

The objects and backgrounds were selected from a group of stimuli rated by a separate group of 8 young adults (ages 18–35). Negative objects all had been rated as having arousal ratings of greater than 4 on a 1–7 scale (with low numbers signifying a calming or soothing image and higher numbers signifying an exciting or agitating image) and valence ratings of lower than 3 (with lower numbers signifying a negative image and high values indicating a positive image). Neutral objects and background scenes all had been rated as nonarousing (arousal values lower than 4) and with valence ratings ranging between 3 and 5.

These objects and backgrounds were used to create scenes, by placing an object on a plausible background. Thus, each scene consisted of an object (which was either neutral or negative in valence) and a background (which was always neutral). For example, a neutral scene might show a chipmunk (neutral object) near a river (background), while a negative scene might show a snake (negative arousing object) near a river (background). Using both items from an object pair and both landscapes from a background pair, 8 versions of 96 scenes were created (4 versions with a negative arousing object and 4 versions with a neutral object, e.g., snake A with river A, snake A with river B, snake B with river A, snake B with river B, chipmunk A with river A, chipmunk A with river B, chipmunk B with river A, and chipmunk B with river B). All scenes were resized so that their longest edge was 700 pixels.

The negative and neutral objects were always of comparable size and were placed in the same approximate location on the scenes (see Fig. 1 for examples of stimuli). Pairs of stimuli (e.g., two snakes, two chipmunks) were selected to assure that the emotional and neutral object pairs were matched for (a) the overall similarity of the two items, (b) the dimensions (color, size, shape, orientation) that differed between the two items, and (c) the familiarity of the items (as explained below).

Overall similarity of each pair of objects or backgrounds was rated by 8 Harvard University undergraduate students, using a scale of 1 (members of a pair were incredibly similar to one another) to 10 (incredibly different). For the final pairs of objects and backgrounds selected, there was no difference between the similarity ratings for the emotional object pairs (mean = 5.1) and for the neutral object pairs (mean = 5.3; $p > .2$).

The degree of change in color, size, shape, and orientation was rated by 2 Harvard University undergraduate students, with a value of 0 indicating no change in a particular dimension (e.g., two cabbages that were both light green in color would receive a rating of 0 for color change), 0.5 indicating a slight change in a dimension (e.g., a dark brown dog versus a light brown dog would receive a rating of 0.5 in the color dimension) and 1 indicating a complete change in a dimension (e.g., a red shirt versus a blue shirt would receive a rating of 1 in the color dimension). For each dimension and for each pair, the scores from the two raters were averaged. Inter-rater reliability was high (all Cronbach's $\alpha > .85$). Emotional and neutral pairs were selected such that there was no significant effect of emotion on the ratings for change in any dimension, nor in the sum of change scores across all dimensions (all $p > .2$). Emotional and neutral objects also were selected so that the verbal labels of the items were of comparable frequency and familiarity (as reported in the MRC database, Coltheart, 1981, $p > .2$).

Procedure

Participants studied a set of 64 scenes (32 with a negative arousing object on a neutral background and 32 with a neutral object on a neutral background). The version of the scene shown at study (negative or neutral; and the particular object-background combination; see Fig. 1A) was counterbalanced across participants. Participants saw each scene for 2 s. Once the scene was removed from the screen, participants were asked to indicate whether they would want to approach or move away from the scene, using a 1–7 scale (1 indicating that they would move closer, 7 indicating that they would move away).

After a 30-min delay, participants performed a self-paced recognition task. (Debriefing indicated that no participant was expecting their memory to be assessed.) The order of items on the task was pseudorandomized for each participant. Participants were presented with objects and backgrounds separately. Some of these were identical to the scene components that they had studied (*same*), others were the alternate version of the object or background and therefore differed from the studied version in the specific visual details but not in the verbal label (*similar*), and still others were new objects or backgrounds that had not been studied (*new*). Participants saw either the *same* or the *similar* version of an item at test (never both versions). The items shown at recognition were kept constant for all participants; thus, whether an item was *same*, *similar*, or *new*, and whether a background had been shown with a negative or neutral object, was determined by the set of scenes that participants had studied (and was counterbalanced across participants). Each object or background was presented with a question (such as: "Did you see a snake?"). Participants were instructed to respond "same" if the answer to the question was "yes" and if the object or background shown at recognition was an exact match to what had been in one of the studied scenes (i.e., if they had seen a snake at study, and if the snake displayed at recognition was exactly the snake that had been in one of the study scenes). They were asked to respond "similar" if the answer to the question was "yes" but the object or background shown was not an exact match to the one presented at study (i.e., if they had seen a snake at study, but the snake shown at recognition was not that same snake). They were asked to respond "new" if the answer to the question was "no" (i.e., if they had not seen a snake at study). The questions were included on the recognition task to avoid ambiguity in participants' classifications of scenes. Pilot data had indicated that without the questions, some participants were very liberal in assigning "similar" rather than "new" responses—for example, having studied a picture of a forest, some would endorse a picture of a backyard as "similar" because both pictures included grass and trees, while others would classify the backyard as "new." The provision of the verbal labels in the questions removed this ambiguity. The recognition task included 32 *same* objects (16 negative, 16 neutral), 32 *similar* objects (16 negative, 16 neutral), 32 *new* objects (16 negative, 16 neutral), 32 *same* backgrounds (16 shown with a negative arousing object, 16 shown with a neutral object), 32 *similar* backgrounds (16 shown with a negative arousing object, 16 shown with a neutral object), and 32 *new* backgrounds.

Results

The raw data from Experiment 1 are presented in Table 1: The proportion of items given a "same," "similar," or "new" response are reported as a function of item type (*same, similar,* or *new*), scene component (object or background), and emotional content of the scene (negative or neutral). Note that the objects were negative or neutral, while the emotion of the backgrounds was defined by the type of object placed in the scene (i.e., a negative background indicates a back-

Table 1
Experiment 1: Mean responses (*SE*) for objects and backgrounds as a function of item type (*same, similar, and new*) and emotion type (neutral, negative)

	Same neutral	Same negative	Similar neutral	Similar negative	New neutral	New negative
Objects						
"Same"	.55 (.04)	.67 (.04)	.27 (.04)	.26 (.05)	.05 (.02)	.05 (.02)
"Similar"	.25 (.03)	.20 (.02)	.45 (.04)	.53 (.04)	.23 (.04)	.22 (.03)
"New"	.20 (.04)	.14 (.03)	.28 (.04)	.21 (.04)	.71 (.05)	.73 (.04)
Backgrounds						
"Same"	.54 (.05)	.39 (.04)	.23 (.04)	.23 (.04)	.02 (.01)	N/A
"Similar"	.23 (.03)	.27 (.04)	.43 (.04)	.41 (.05)	.17 (.03)	N/A
"New"	.23 (.04)	.33 (.04)	.34 (.04)	.36 (.05)	.81 (.03)	N/A

"Same" responses to *same* items reflect "specific recognition," while the sum of "same" and "similar" responses to *same* items reflects "general recognition."

ground that was presented with a negative arousing object). Because all backgrounds were nonemotional, there could be no *new* negative backgrounds.

Comparison of specific recognition and general recognition

An ANOVA with memory type[3] (general recognition, specific recognition), scene component (object, background), and emotion type (negative, neutral), as within-subject factors revealed a significant effect of memory type ($F(1,15) = 65.90$, $p < .001$, partial η-squared = .82), and an effect of scene component ($F(1,15) = 10.80$, $p < .01$, partial $\eta^2 = .42$) qualified by an interaction between emotion type and scene component ($F(1,15) = 18.31$, $p < .001$, partial $\eta^2 = .55$). As shown in Fig. 2, this interaction reflected the fact that specific recognition and general recognition were higher for negative arousing objects than for neutral objects, whereas both specific and general recognition were lower for backgrounds presented with negative arousing objects than for backgrounds presented with neutral objects. The ANOVA revealed no interaction between emotion type and memory type, nor a three-way interaction between emotion type, memory type, and scene component type (partial $\eta^2 < .02$); thus, while participants showed a *central/peripheral* trade-off, there was no evidence for a *gist/detail* trade-off.

Comparison of specific recognition and gist-only recognition

An ANOVA comparing the specific recognition and gist-only recognition scores, with memory type, scene component (object, background), and emotion type (negative, neutral), as within-subject factors revealed an effect of scene component ($F(1,15) = 39.25$, $p < .001$, partial $\eta^2 = .72$) qualified by an interaction between scene component and emotion type ($F(1,15) = 26.12$, $p < .001$, partial $\eta^2 = .64$). This interaction reflected the fact that participants showed better specific and gist-only recognition for negative arousing objects than for neutral objects, but poorer specific and gist-only recognition for backgrounds presented with negative arousing objects than for backgrounds presented with neutral objects (see Fig. 2). There was no interaction between memory type and emotion type, or between memory type, emotion type, and scene component (all partial $\eta^2 < .02$). Thus, the *central/peripheral* trade-off (for objects vs. backgrounds) existed both in memory for specific visual details and in memory for "gist," and there was no evidence of a differential effect of emotion on specific recognition versus gist-only recognition.

Discussion

Participants in Experiment 1 clearly demonstrated an emotion-induced memory trade-off for central versus peripheral scene components. They were more likely to remember the negative visually arousing objects than the neutral objects in scenes, and they were less likely to remember backgrounds shown with negative arousing objects than they were to remember backgrounds shown with neutral objects (consistent with the attentional narrowing hypothesis, e.g., Easterbrook, 1959). This central/peripheral trade-off occurred both when memory for visual details was assessed and also when memory for *at least* the gist or *only* the gist information was measured. Thus, there was no evidence of a gist/detail trade-off (in contrast to Adolphs et al., 2001, 2005; Denburg et al., 2003; see Fig. 2): Memory for both gist and detail was enhanced for the negative arousing objects and reduced for the backgrounds on which the negative objects had been placed.

Experiment 1, therefore, demonstrated that there are instances in which the critical emotional–memory cost can be related to the relevance of an item to the emotion depicted in the scene (the *central/peripheral* trade-off), rather than to the level of detail remembered about the scene (the *gist/detail* trade-off). This result does not, of course, imply that a *central/peripheral* trade-off would always be the dominant trade-off. One possibility is that the *central/peripheral* trade-off manifests itself primarily when participants are not given sufficient time to process all of the scene elements. If so, then the trade-off should be minimized (or eliminated) when participants are given additional time to view the scenes. However, there has been reasonable evidence to suggest that the *central/peripheral* trade-off may occur because of an automatic capture of attention by emotional information (see Reisberg & Heuer, 2004). To the extent that attention remains focused on the emotional elements of a scene for the entire time that it is presented, then the central/peripheral trade-off should not be reduced (and in fact could be enhanced) by increasing the presentation duration. Experiment 2 was designed to adjudicate between these alternatives.

Experiment 2

In Experiment 1, the *central/peripheral* trade-off did not interact with the *gist/detail* trade-off: The *central/peripheral* trade-off was equally strong for memory for visual detail (specific recognition), for *at least* the gist (general recognition), and for *only* the gist (gist-only

[3] Emotional content of the scene had no effect on the distribution of responses to the *new* items (i.e., on the false alarm and correct rejection rates). Therefore, for ease of presentation, all reported scores are uncorrected for false alarm rates. The qualitative nature of the data did not differ when scores were corrected for false alarm rates.

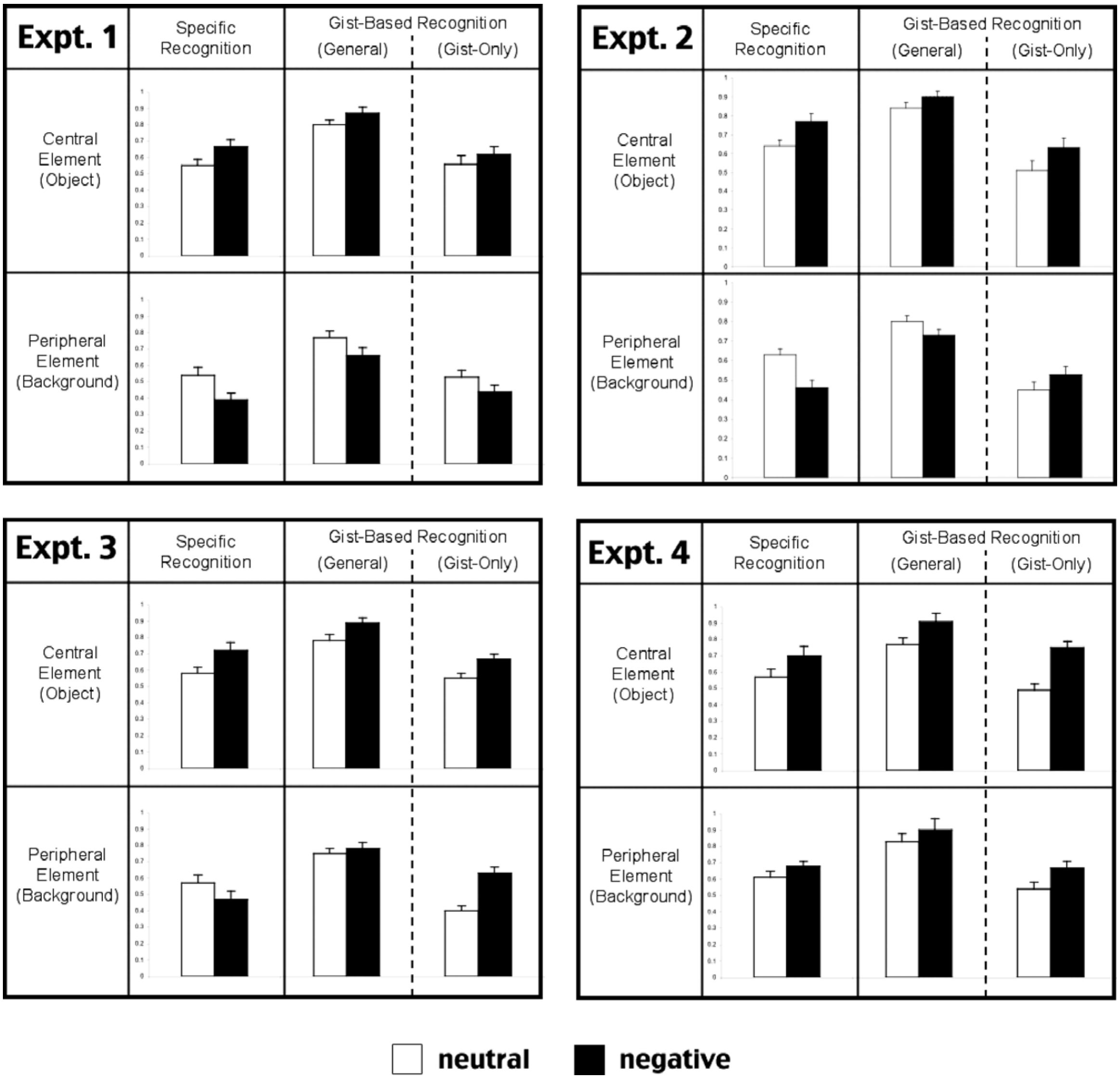

Fig. 2. To examine whether the *central/peripheral* and *gist/detail* trade-offs interacted with one another, memory for visual detail (specific recognition) and for gist-based information (general recognition, memory for *at least* the gist; gist-only recognition, memory for *only* the gist) was assessed for the "central" objects (black bar, negative; white bar, neutral) and the "peripheral" backgrounds (black, presented with negative object; white, presented with neutral object). See Table 5 for further information on encoding task manipulations in the four experiments.

recognition). In Experiment 2, we examined whether the *central/peripheral* trade-off would remain the dominant trade-off when participants were given additional time to process the stimuli.

Method

Participants

Sixteen adults (ages 18–35; 8 women) participated in the experiment for pay or course credit. Participants met the same criteria as outlined for Experiment 1.

Materials and procedure

The materials and procedure were identical to those of Experiment 1, except that participants viewed all scenes for 5 s (rather than for 2 s as in Experiment 1).

Results

The raw data for Experiment 2 are reported in Table 2. The proportion of items given a "same," "similar," or "new" response are reported as a function of item type (*same, similar,* or *new*), scene component (object or

Table 2
Experiment 2: Mean responses (*SE*) for objects and backgrounds as a function of item type (*same, similar, and new*) and emotion type (neutral, negative)

	Same neutral	Same negative	Similar neutral	Similar negative	New neutral	New negative
Objects						
"Same"	.64 (.03)	.77 (.04)	.22 (.03)	.22 (.03)	.05 (.01)	.04 (.01)
"Similar"	.20 (.03)	.13 (.02)	.55 (.04)	.59 (.04)	.22 (.02)	.21 (.03)
"New"	.17 (.02)	.11 (.03)	.23 (.04)	.19 (.03)	.73 (.03)	.76 (.03)
Backgrounds						
"Same"	.63 (.03)	.46 (.04)	.23 (.04)	.19 (.04)	.03 (.01)	N/A
"Similar"	.17 (.02)	.27 (.02)	.39 (.04)	.39 (.05)	.18 (.03)	N/A
"New"	.20 (.03)	.27 (.04)	.38 (.04)	.42 (.06)	.79 (.03)	N/A

background), and emotional content of the scene (negative or neutral).

Comparison of specific recognition and general recognition

An ANOVA with memory type (general recognition, specific recognition), scene component (object, background), and emotion type (negative, neutral) as within-subject factors revealed a significant effect of memory type ($F(1,15) = 120.93$, $p < .001$, partial $\eta^2 = .89$), an effect of scene component ($F(1,15) = 16.53$, $p < .001$, partial $\eta^2 = .52$), an interaction between emotion type and scene component ($F(1,15) = 24.54$, $p < .001$, partial $\eta^2 = .62$), between memory and scene component ($F(1,15) = 10.03$, $p < .01$, partial $\eta^2 = .40$) and among emotion, scene component, and memory ($F(1,15) = 22.55$, $p < .001$, partial $\eta^2 = .60$). This three-way interaction reflected the fact that the *central/peripheral* trade-off interacted with the *gist/detail* trade-off: The *central/peripheral* trade-off was stronger for specific recognition scores than for general recognition scores. However, ANOVAs conducted separately for the specific recognition and general recognition scores confirmed that both memory scores were influenced by the interaction between emotion and scene component ($F(1,15) = 42.93$, $p < .001$, partial $\eta^2 = .74$ for specific recognition; $F(1,15) = 7.38$, $p < .05$, partial $\eta^2 = .33$ for general recognition): Both specific and general recognition memory were enhanced for negative arousing objects compared to neutral objects and reduced for backgrounds presented with negative arousing objects compared to neutral objects (see Fig. 2).

Comparison of specific recognition and gist-only recognition

An ANOVA with memory type (gist-only, specific recognition), scene component (object, background), and emotion type (negative arousing, neutral), as within-subject factors revealed a significant effect of scene component ($F(1,15) = 6.81$, $p < .05$, partial $\eta^2 = .31$) qualified by an interaction between scene component and emotion type ($F(1,15) = 5.83$, $p < .05$, partial $\eta^2 = .28$) and by an interaction among emotion type, memory type, and scene component ($F(1,15) = 4.57$, $p < .05$, partial $\eta^2 = .23$). This three-way interaction reflected the fact that while both specific and gist-only memory were enhanced for negative arousing objects, emotion did not affect gist-only recognition of the backgrounds, whereas specific recognition was significantly worse for backgrounds with negative arousing objects than for those with neutral objects (see Fig. 2). Thus, a *gist/detail* trade-off was noted for the background elements of the scenes.

ANOVAs conducted separately for the specific recognition scores and the gist-only recognition scores confirmed that there was an interaction between scene component and emotion type for the specific recognition scores ($F(1,15) = 42.93$, $p < .001$, partial $\eta^2 = .74$) but not for gist-only recognition scores (partial $\eta^2 < .05$). In other words, participants showed a *central/peripheral* trade-off in specific recognition but not in gist-only recognition.

Discussion

Despite the longer presentation rate, the *central/peripheral* trade-off effect continued to be elicited in this experiment. However, while in Experiment 1 there had been no evidence of a *gist/detail* trade-off, the present study did provide evidence for an interaction between the two trade-offs. In particular, participants showed a strong *central/peripheral* trade-off when memory for visual detail was assessed (specific recognition), but showed a lesser *central/peripheral* trade-off when memory for *at least* the gist information was assessed (general recognition), and no trade-off when memory for *only* the gist information was assessed (gist-only recognition).

These results indicate that extending the encoding time does not result in equal memory for elements of negative and neutral scenes. Rather, even with additional processing time, participants continue to be more likely to remember the visual details of central emotional elements of scenes and less likely to remember the visual details of backgrounds presented along with an emotional object. However, it was the case that with additional study time, individuals were better able to process the general features of the background, thereby eliminating the *central*/*peripheral* trade-off for gist-only memory. These results emphasize a couple of features of the memory trade-off for central versus peripheral elements. First, the magnitude of the *central*/*peripheral* trade-off can differ depending on the specificity of memory that is assessed, and not all forms of recognition memory must simultaneously show the *central*/*peripheral* trade-off. Second, there clearly is a delicate interplay between processing time and effects of emotion on memory (see also Kensinger et al., 2006), whereby even a relatively minor increase in presentation duration can alter the types of memory scores that reveal a *central*/*peripheral* trade-off.

Unlike Experiment 1, Experiment 2 also revealed some evidence of a *gist*/*detail* trade-off. Thus, the results are somewhat consistent with the pattern described by Adolphs and colleagues (e.g., Adolphs et al., 2001), whereby gist memory is enhanced by emotion more than memory for visual detail. It may be that the *gist*/*detail* trade-off tends to emerge when participants are given relatively lengthy (5 s in this experiment; as long as 20 s in the studies by Adolphs and colleagues) periods of time to process the scenes but is less likely to emerge when processing time is reduced (as in Experiment 1).

However, the results emphasize the importance of distinguishing different scene elements: had the central emotional elements of the scenes not been analyzed separately from the peripheral nonemotional components, some critical memory characteristics would have been overlooked. Most importantly, the present results clearly demonstrate that the *gist*/*detail* trade-off does not occur for all scene elements. Rather, the *gist*/*detail* trade-off in the present experiment was revealed only for the background elements of the scene. In contrast, participants were more likely to remember both the gist and the visual detail of the negative arousing objects than they were to remember the gist and detail of the neutral objects.

In Experiments 1 and 2, participants passively viewed the scenes, and thus had no reason to attend to all aspects of the scenes. An essential question is to what extent the trade-offs that occur during this passive viewing can be manipulated by directing participants' attention toward other aspects of the scenes. To what extent can individuals "override" the attentional focus on emotional information in the environment: Can individuals strategically direct their attention toward other, nonemotional, aspects of the environment? Or is the focus on emotional information so automatic or so pervasive as to prohibit flexible deployment of attention?

Experiments 3 and 4 were designed to address these questions by examining the effect that manipulating encoding instructions would have on the trade-off effects demonstrated in Experiments 1 and 2. We hypothesized that changing the encoding instructions would reduce the *central*/*peripheral* trade-off. If this hypothesis were confirmed, the results would provide evidence that (a) attentional focusing during encoding plays an important role in elicitation of the trade-offs and (b) individuals are able to overcome some of this attentional focus.

Experiment 3

The results of Experiment 2 indicated that lengthening the presentation time does not lead to equated memory for negative arousing and nonemotional visual scenes. However, changing the presentation rate from 2 s (Experiment 1) to 5 s (Experiment 2) did alter the effects of emotion on memory: Most notably, with the longer presentation, individuals were better able to process the general features of the background, thereby eliminating the *central*/*peripheral* trade-off for gist-only memory.

In Experiment 3, we examined whether the characteristics of these emotion-induced memory costs could be further influenced by encoding strategies (see Table 5). A prior study (Kensinger et al., 2005) demonstrated that young adults were able to overcome a *central*/*peripheral* memory trade-off for emotional information when they were explicitly told that their memory for all aspects of a scene would be assessed, and thus that it was critical to attend to all elements of a scene. That prior study, however, did not tease apart memory for gist versus memory for detail. Moreover, because participants tend to adopt very different strategies when trying to remember information for a later memory task, the use of intentional encoding instructions prevented assessment of the types of encoding tasks that can lead to reductions in the *central*/*peripheral* trade-off. Experiment 3 examined whether the *central*/*peripheral* trade-off for both gist information and detailed information would dissipate when individuals were given encoding instructions that required them to process the scene in its entirety (Participants were asked to tell a story incorporating all elements of the scene). Prior studies (Laney et al., 2004) have suggested that the trade-off for central versus peripheral elements may be eliminated when emotion is evoked through a "thematic induction" procedure (such as hearing a story while watching movie slides). As Reisberg and colleagues have suggested (Reisberg & Heuer, 2004), individuals likely can use strategic processes to direct their attention during an emotional event. It is possible that asking participants to create a story (or to listen to one) incorporating the various event elements would be likely to elicit such a strategic deployment of attention, causing participants to focus not only on the central emotional element of a scene, but also on the background elements in the scene. However, an alternative possibility is that this type of strategic deployment of attention is possible only when the visual stimuli do not contain highly arousing visual elements: In the experiments by Laney and colleagues (2004), the emotion was elicited by the story script that participants listened to; there was nothing inherently arousing about the film slides that participants viewed. Experiment 3 examined whether story telling would be effective at eliminating the emotion-induced memory trade-offs for the scenes that contained a negative visually arousing element.

Method

Participants

Sixteen adults (ages 18–35; 9 women) participated in the experiment for pay or course credit. Participants met the same criteria as outlined for Experiment 1.

Materials and procedure

The materials and procedure were identical to those of Experiment 2, except that rather than passively viewing the scenes, participants were asked to "tell a brief story about each scene, incorporating all of the elements in the scene into the story."

Results

The raw data for Experiment 3 are reported in Table 3. The proportion of items given a "same," "similar," or "new" response are reported as a function of item type (*same, similar,* or *new*), scene component (object or background), and emotional content of the scene (negative or neutral).

Comparison of specific recognition and general recognition

An ANOVA with memory type (general recognition, specific recognition), scene component (object, background), and emotion type (negative arousing, neutral) as within-subject factors revealed significant effects of memory ($F(1,15) = 161.48$, $p < .001$, partial $\eta^2 = .92$), scene component ($F(1,15) = 25.033$, $p < .001$, partial $\eta^2 = .63$), and emotion ($F(1,15) = 6.74$, $p < .05$, partial $\eta^2 = .31$), with significant interactions between memory and emotion ($F(1,15) = 4.47$, $p = .05$, partial $\eta^2 = .23$), memory and scene component ($F(1,15) = 6.62$, $p < .05$, partial $\eta^2 = .31$), emotion and scene component ($F(1,15) = 14.09$, $p < .01$, partial $\eta^2 = .48$), and among emotion, memory, and scene component ($F(1,15) = 9.98$, $p < .01$, partial $\eta^2 = .40$). This three-way interaction reflected the fact that the *central/peripheral* trade-off was reflected in specific recognition scores (negative arousal boosting memory for objects but reducing memory for backgrounds) but not in general recognition scores (see Fig. 2). Separate ANOVAs conducted for the specific recognition and general recognition scores confirmed that there was a significant interaction between scene component and emotion types for the specific recognition scores ($F(1,15) = 21.15$, $p < .001$, partial $\eta^2 = .59$) but not for the general recognition scores (partial $\eta^2 < .05$).

Comparison of specific recognition and gist-only recognition

An ANOVA with memory type (gist-only, specific recognition), scene component (object, background), and emotion type (negative arousing, neutral) as within-subject factors revealed significant effects of scene component ($F(1,15) = 20.47$, $p < .001$, partial $\eta^2 = .40$), and emotion ($F(1,15) = 4.61$, $p < .05$, partial $\eta^2 = .13$), as well as interactions between memory and scene component ($F(1,15) = 4.52$, $p < .05$, partial $\eta^2 = .13$), between emotion and memory type ($F(1,15) = 13.41$, $p < .001$, partial $\eta^2 = .30$), between emotion and scene component ($F(1,15) = 13.97$, $p < .001$, partial $\eta^2 = .31$), and among emotion, scene component, and memory type ($F(1,15) = 8.41$, $p < .05$, partial $\eta^2 = .36$). This three-way interaction reflected the fact that a *central/peripheral* trade-off was demonstrated in specific recognition scores (higher for negative arousing objects than neutral objects, and lower for backgrounds with negative arousing objects than for backgrounds with neutral objects), whereas gist-only recognition was enhanced for

Table 3
Experiment 3: Mean responses (*SE*) for objects and backgrounds as a function of item type (*same, similar, and new*) and emotion type (neutral, negative)

	Same neutral	Same negative	Similar neutral	Similar negative	New neutral	New negative
Objects						
"Same"	.58 (.04)	.72 (.05)	.25 (.05)	.21 (.03)	.05 (.01)	.05 (.02)
"Similar"	.20 (.02)	.17 (.03)	.51 (.04)	.52 (.06)	.22 (.04)	.18 (.02)
"New"	.22 (.04)	.12 (.04)	.25 (.05)	.28 (.05)	.73 (.05)	.77 (.03)
Backgrounds						
"Same"	.57 (.05)	.47 (.05)	.20 (.03)	.22 (.05)	.01 (.01)	N/A
"Similar"	.18 (.02)	.31 (.03)	.43 (.05)	.39 (.05)	.14 (.03)	N/A
"New"	.25 (.04)	.22 (.05)	.37 (.05)	.39 (.05)	.84 (.03)	N/A

both negative arousing objects and backgrounds presented with negative arousing objects (see Fig. 2). ANOVAs conducted separately for the specific recognition and gist-only recognition scores confirmed that specific recognition scores were impacted by a significant interaction between emotion type and scene component ($F(1,15) = 21.15$, $p < .001$, partial $\eta^2 = .59$), whereas there was no comparable interaction relating to the gist-only recognition scores (partial $\eta^2 < .05$).

Discussion

The results of Experiment 3 provided strong evidence for an interaction between the *central/peripheral* and *gist/detail* trade-offs. For all memory assessments (both detailed and gist-based memory), recognition scores were enhanced for negative objects compared to neutral objects. In contrast, specific recognition was reduced, but gist-based memory measures (both general recognition and gist-only recognition) were enhanced, for backgrounds of scenes with negative visually arousing objects compared to backgrounds of scenes with neutral objects. Thus, the *central/peripheral* trade-off existed only for measures of specific recognition, and the *gist/detail* trade-off existed only when memory for background elements was assessed.

Unlike in Experiment 2, where the *gist/detail* trade-off for the backgrounds was apparent only when specific recognition was compared to gist-only recognition, the *gist/detail* trade-off for the backgrounds in Experiment 3 arose when specific recognition was compared either to gist-only recognition or to general recognition. Thus, this experiment provides stronger evidence for a *gist/detail* trade-off than either Experiment 1 or Experiment 2. Of note, this experiment's design also most closely parallels the encoding tasks used by Adolphs and colleagues (Adolphs et al., 2001, 2005; Denburg et al., 2003), which have led to a *gist/detail* trade-off. Their encoding tasks have tended to include the presentation of verbal descriptions, as well as visual depictions of scenes, similar to the story-telling condition used here (except that in their studies, the verbal descriptions were given by the experimenter, whereas the verbal descriptions in the present experiment were generated by the participants). Thus, the general similarity of results across these different studies may suggest that the *gist/detail* trade-off is particularly likely to occur when participants' encoding task focuses them on a verbal description of a visual scene. However, as in Experiment 2, the *gist/detail* trade-off was revealed only for the background elements of the scenes with the negative arousing object and not for the negative arousing objects themselves: individuals showed an enhanced ability to remember both the gist *and* the visual detail of negative arousing objects (consistent with Burke et al., 1992; Kensinger et al., 2006). These data underscore the importance of distinguishing between memory for different scene components and of assessing the level of detail remembered about scene elements when examining the effect of emotion on memory for complex visual scenes.

The results of Experiment 3 also emphasize that the nature of the *central/peripheral* trade-off effect can be manipulated by changing the encoding task. The results suggest that with the story-telling instructions, participants were able to process at least some parts of the backgrounds of the negative scenes; thus, they were no more likely to forget a background from a negative scene than they were to forget a background from a neutral scene. These data emphasize the important role of encoding processes in mediating the trade-off effects, and underscore the fact that individuals can use strategies to mitigate the attentional focus on emotional items.

This conclusion is broadly consistent with a prior study (Kensinger et al., 2005), demonstrating that the *central/peripheral* trade-off can be eliminated when encoding strategies are utilized. In that study, when participants were given intentional encoding instructions to remember all elements of a scene, they were no more likely to forget background components of scenes that had included a negative element than they were to forget background components of scenes that had been nonemotional. The results also are broadly consistent with studies by Laney et al. (2004), demonstrating that when emotion is generated in a thematic way (by listening to a narrative), trade-offs for central versus peripheral details can be reduced (as in the present experiment) or eliminated (as in the studies by Laney and colleagues).

Nevertheless, the results of Experiment 3 suggest that memory is still not equivalent for the negative and neutral scenes, even with the story-telling encoding task. Critically, specific recognition scores still showed the emotion-related *central/peripheral* trade-off. These results indicate that even when the overall recognition levels are comparable for elements of negative and neutral scenes, the amount of visual detail remembered about elements of those scenes can be different (see also Kensinger et al., 2006, for a similar finding when memory for single objects was assessed), and they emphasize the need to assess the level of detail remembered about emotional events as well as the overall recognition rates.

One plausible reason that the *central/peripheral* trade-off remained when specific recognition was assessed is that the story-telling condition most likely invoked verbal elaboration of the scenes. Perhaps this verbal processing was particularly useful in allowing participants to remember some aspects of the scene's backgrounds (e.g., that they had told a story about a canoe on a river), but not in enhancing their ability to remember the specific visual details (e.g., exactly what the river looked like). We hypothesized that a task that focused participants' attention on the visual details of the scene would be more likely to eliminate the central/peripheral trade-off in specific recognition. Experiment 4 examined this possibility.

Experiment 4

In Experiment 4, we examined whether an encoding task that required participants to pay attention to the visual details of a scene would cause a reduction in the *central/peripheral* trade-off for specific visual details (see Table 5). We reasoned that if any type of incidental encoding task was likely to eliminate this trade-off, it would be one that emphasized the visual details of the scene.

Method

Participants

Sixteen adults (ages 18–35; 10 women) participated in the experiment for pay or course credit. Participants met the same criteria as outlined for Experiment 1.

Materials and procedure

The materials and procedure were identical to those of Experiment 3, except that rather than telling a story about each scene, participants were asked to "describe the visual details of the scene, so that an artist could listen to this description and paint a picture that would look very similar to the scene that you are viewing." The scene remained on the screen for 5 s, but participants were informed that they could complete their description after the scene was removed from the screen.

Results

The raw data for Experiment 4 are reported in Table 4. The proportion of items given a "same," "similar," or "new" response are reported as a function of item type (*same, similar,* or *new*), scene component (object or background), and emotional content of the scene (negative or neutral).

Comparison of general recognition and specific recognition

An ANOVA with memory type (general recognition, specific recognition), scene component (object, background), and emotion type (negative arousing, neutral) as within-subject factors revealed a significant effect of memory type ($F(1,15) = 131.46$, $p < .001$, partial $\eta^2 = .92$) and of emotion type (negative arousing > neutral; $F(1,15) = 24.45$, $p < .001$, partial $\eta^2 = .67$). Critically, there was no interaction between memory type and emotion type, or among memory type, emotion type, and scene component (partial $\eta^2 < .05$). In this paradigm, there was an overall beneficial effect of emotion on both specific and general recognition, and this benefit was comparable for the objects and the backgrounds (see Fig. 2).

Comparison of specific recognition and gist-only recognition

An ANOVA with memory type (gist-only, specific recognition), scene component (object, background), and emotion type (negative arousing, neutral) as within-subject factors revealed only a significant effect of emotion type (negative arousing > neutral; $F(1,15) = 9.17$, $p < .01$, partial $\eta^2 = .43$) and no interactions. Unlike in Experiments 2 and 3, there was no interaction between emotion and scene component, or among emotion type, memory type, and scene component (partial $\eta^2 < .01$); the enhancing effect of emotion on gist-only and specific recognition was comparable for the objects and backgrounds (see Fig. 2).

Discussion

When participants' encoding task required them to attend to the visual details of the scene, all memory trade-offs for central versus peripheral detail (in specific recognition, general recognition, and gist-only recognition) were eliminated. These results indicate that participants can process the elements of a negative scene with the same level of specificity as they can process the elements of a neutral scene, but in order for them to do

Table 4
Experiment 4: Mean responses (*SE*) for objects and backgrounds as a function of item type (*same, similar, and new*) and emotion type (neutral, negative)

	Same neutral	Same negative	Similar neutral	Similar negative	New neutral	New negative
Objects						
"Same"	.57 (.05)	.70 (.06)	.25 (.05)	.29 (.05)	.06 (.02)	.06 (.02)
"Similar"	.20 (.02)	.21 (.04)	.48 (.05)	.49 (.05)	.23 (.02)	.19 (.03)
"New"	.23 (.03)	.09 (.03)	.27 (.03)	.22 (.03)	.71 (.03)	.75 (.04)
Backgrounds						
"Same"	.61 (.04)	.68 (.03)	.24 (.04)	.21 (.04)	.05 (.02)	N/A
"Similar"	.22 (.03)	.22 (.03)	.44 (.04)	.41 (.04)	.15 (.03)	N/A
"New"	.17 (.02)	.09 (.03)	.32 (.03)	.38 (.03)	.80 (.03)	N/A

Table 5
Summary of experimental design and results

Expt	Viewing time (s)	Encoding task[a]	Central/peripheral trade-off?	Gist/detail trade-off?	
				General vs. specific	Gist-only vs. specific
1	2	Passive Viewing	Yes Specific recog. General recog. Gist-only recog.	No	No
2	5	Passive Viewing	Yes Specific recog. General recog.	No	Yes Backgrounds
3	5	Tell story	Yes Specific recog.	Yes Backgrounds	Yes Backgrounds
4	5	Describe for artist	No	No	No

The central/peripheral trade-off column indicates the types of memory for which emotion enhanced memory for the "central" object but impaired memory for the "peripheral" background: specific recognition = memory for visual detail, general recognition = memory for *at least* the gist, and gist-only recognition = memory for *only* the gist. The gist/detail trade-off column denotes the types of scene elements (objects or backgrounds) for which emotion enhanced gist-based memory (as measured either by general recognition or gist-only recognition) but impaired specific recognition.

[a] In all experiments, participants were asked to indicate whether they would want to approach or move away from the scene.

so, the encoding task must guide their attention to the visual details of the scene. There also was no evidence of a *gist/detail* trade-off: While gist-only recognition was enhanced by emotion, there was no emotion-related impairment in specific recognition. Thus, when participants were asked to pay attention to the visual details of the scenes,[4] all detrimental effects of emotion were eliminated, and only a memory-enhancing effect of emotion remained. The implications of these results are discussed below.

General discussion

The results from the four experiments presented here suggest three primary conclusions. First, emotion does not enhance memory for all aspects of presented information; rather, there are emotion-induced memory costs as well as memory enhancements. Second, although the *gist/detail* trade-off can occur, it appears to interact with the *central/peripheral* trade-off: The *gist/detail* trade-off only occurred for background elements of emotional scenes, and was not apparent for the central emotional objects in a scene under any conditions. The most consistent emotion-induced memory trade-off appears to be for central versus peripheral elements of scenes: in three of the four experiments, memory was enhanced for negative aspects of scenes but reduced for nonemotional aspects included in a scene with a negative component. Third, the nature of the *central/peripheral* trade-off (whether it exists for memory for detail, for memory for *at least* the gist information, or for memory for *only* the gist information) can be altered by changing participants' encoding task (see Table 5).

With a two-second presentation time (Experiment 1), participants showed a *central/peripheral* trade-off in the likelihood of remembering the visual details of scene elements (specific recognition), in the likelihood of remembering *at least* the gist information (general recognition), and in the likelihood of remembering *only* the gist, but not the visual details, of scene elements (gist-only recognition). There was no evidence of a *gist/detail* trade-off. We suggest that with a 2 s presentation, participants' attention was likely to be focused on the negative aspect of a scene for nearly the entire duration of the scene's presentation, thus reducing the encoding of the nonemotional elements of the scene. This hypothesis is consistent with evidence indicating that emotion can influence the deployment of attention: For example, individuals are more likely to detect emotional objects in visual arrays (e.g., Ohman, Flykt, & Esteves, 2001; Phelps, Ling, & Carrasco, 2006) or during an attentional blink (Anderson & Phelps, 2001). It also is compatible with numerous prior studies demonstrating that emotional elements in a scene can be attended at the cost of information present in the periphery (e.g., Brown, 2003; Burke et al., 1992; Kensinger & Schacter, 2006;

[4] It also is possible that the additional processing time in the current condition—participants were allowed to finish their descriptions after the scene had been removed from the screen—also contributed to the elimination of emotion-related memory trade-offs. Regardless, the critical conclusion is that there are encoding conditions in which scenes with negative visually arousing elements can be encoded as well as scenes with only neutral elements.

Safer et al., 1998): In other words, encoding resources may be focused on the emotional item rather than on other information in the environment.

When the presentation duration was increased to 5 s per scene (Experiment 2), participants no longer showed a *central/peripheral* trade-off for gist-only recognition, but the *central/peripheral* trade-off for general recognition and specific recognition remained. These results suggest that, when given additional time, participants were able to divert some attention from the negative visually arousing object and thus to extract general features of the background, though perhaps at the cost of attending to the visual details of that background. Thus, when comparing gist-only recognition to specific recognition, a *gist/detail* trade-off was apparent for the background elements of the scenes (but not for the objects in the scenes). This experiment, therefore, provided some evidence for an interaction between the *central/peripheral* and the *gist/detail* trade-off.

Additional evidence for interactions between the *central/peripheral* and the *gist/detail* trade-offs occurred when the encoding task was switched from passive viewing to a more active task. In a condition in which participants were asked to focus on the theme of the scene (by telling a story incorporating all of the elements; Experiment 3), the presence of the negative arousing object did not prevent participants from being able to remember the gist of the backgrounds, but the participants did remain less likely to remember the specific visual details of those backgrounds. Thus, the *central/peripheral* trade-off remained only for specific recognition scores and not for gist-based recognition scores, and the *gist/detail* trade-off was present only for the background elements and not for the objects.

These emotion-related trade-offs were eliminated only when the encoding task required participants to focus on the visual details of the scene (Experiment 4). These results suggest that participants can use encoding strategies to overcome emotion-induced memory trade-offs (see also Kensinger et al., 2005). Thus, emotion-related enhancement for all aspects of an event can occur not only when emotion is elicited through a "thematic" induction (see Laney et al., 2004; Reisberg & Heuer, 2004) but also when emotion is elicited through the presence of a negative visually-arousing element. However, in this latter condition, participants appear to need substantial encoding support to help them direct their attention away from the visually arousing object and toward the other aspects of the visual stimulus. These results further suggest that the characteristics of the *central/peripheral* trade-off (i.e., whether it is limited to specific recognition, or also emerges when gist-based memory is assessed) can differ depending on whether participants are using primarily a verbal or a visual strategy to process scenes. Thus, not only are emotion's effects on memory modulated by the way in which the emotional response is elicited (e.g., by "visual" vs. "thematic" induction; see Laney et al., 2004), so too are they modulated by the particular cognitive processes that people use to process the emotional information.

Of course while the present study emphasizes that encoding effects are critical in influencing emotion-related memory trade-offs, it cannot rule out possible differences in retrieval access to the information encoded during study. An open question regards the effect of delay interval on the *central/peripheral* trade-off in young and older adults (see Denburg et al., 2003 for evidence of a *gist/detail* trade-off across short and long delays) and the effect of the retrieval instructions on memory for scene elements. The original proposal with regard to the trade-off for central and peripheral details (Heuer & Reisberg, 1990) was that arousal may impair memory for peripheral details with short delays, whereas the trade-off may not occur with longer delays. Because the present investigation used only short delays to assess memory, it is not known whether the trade-offs demonstrated here would differ if memory were assessed after a day or a week. Future investigations will be needed to examine whether the strength of these encoding manipulations on the memory trade-offs dissipate (or intensify) as the delay between study and test increases.

Another point worth notice is that across all four experiments, memory for the visual details of the negative aspect of the scene was enhanced. These results are consistent with a prior investigation (Kensinger et al., 2006), in which we presented participants with single objects (half negative, half neutral) and asked them to indicate whether they had previously studied a "same," "similar," or "new" object. Thus, regardless of whether visually arousing negative objects are presented in isolation or as part of a complex visual scene, individuals typically appear to remember more visual details of a negative item than of a nonemotional item.

In summary, the results of the present study demonstrate that individuals can show a *central/peripheral* trade-off for both the visual detail and the gist of a scene that includes a negative visually arousing object. The data also highlight the malleability of the effect: Changes in encoding methodology are sufficient to alter whether the *central/peripheral* trade-off is demonstrated, and if so, whether it is reflected only in memory for visual detail, or also in memory for gist-based information. Thus, it seems critical to carefully examine the encoding tasks used in studies that elicit a *central/peripheral* trade-off of differing magnitudes in order to more fully understand the range of encoding processes that may be used to elicit (or to overcome) the trade-off. Perhaps most importantly, the results suggest that when a *gist/detail* trade-off is elicited, it interacts with the *central/peripheral* trade-off. Thus, assessing memory for all elements of a negative or neutral scene with a single measure is likely to miss an essential influence on memory for emotional information: The *gist/detail* trade-off appears to be limited to elements peripheral to the negative visually arousing object in a scene, while the visually arousing objects themselves typically appear to be remembered with more gist, and also with more visual detail, than do neutral objects.

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