RESEARCH REPORT

Encoding Modality Can Affect Memory Accuracy via Retrieval Orientation

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Research indicates that false memory is lower following visual than auditory study, potentially because visual information is more distinctive. In the present study we tested the extent to which retrieval orientation can cause a modality effect on memory accuracy. Participants studied unrelated words in different modalities, followed by criterial recollection tests that selectively oriented retrieval toward one study modality at a time. Memory errors were lower when oriented toward visual than toward auditory information, thereby generalizing the modality effect to an explicit source memory task. Moreover, these effects persisted independent of the test presentation modality, indicating that retrieval orientation overrode the potential cuing properties of the test stimulus. An independent manipulation check confirmed that visual recollections were subjectively experienced as more distinctive than auditory recollections. These results suggest that retrieval orientation is sufficient to cause a modality effect on memory accuracy by focusing monitoring processes on the recollection of studied features that are diagnostic of prior presentation.

Keywords: false recognition, modality, retrieval orientation

Recent research has highlighted the role of retrieval monitoring processes in the creation and avoidance of false memories. By retrieval monitoring, we refer to the various inference or decision processes that people use to enhance the accuracy of their memory judgments (see, e.g., Johnson, Hashtroudi, & Lindsay, 1993; Koriat & Goldsmith, 1996; Schacter, Norman, & Koutstaal, 1998). Much of the laboratory research on false memories and monitoring processes has used the Deese/Roediger-McDermott (DRM) procedure (Deese, 1959; Roediger & McDermott, 1995). In this paradigm, participants are induced to falsely remember nonstudied words (e.g., sweet) by presenting them with lists of associated words to memorize (e.g., candy, sour, sugar). Several theories have been proposed to explain this illusion (see Gallo, 2010, for a review). According to the activation/monitoring framework (e.g., Roediger, Watson, McDermott, & Gallo, 2001), studying a list of semantic associates may cause mental activation of the critical lure, and this activation may be confused with actual presentation if participants fail to correctly monitor the source of this activation. These monitoring processes are typically thought to occur during retrieval, although encoding factors also play an important role (Pierce, Gallo, Weiss, & Schacter, 2005).

Retrieval monitoring processes have been offered as one explanation of the finding that DRM false memories are affected by the presentation modality of the study lists. Smith and Hunt (1998)

This article was published Online First January 24, 2011.

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discovered that switching from auditory to visual presentation at study dramatically reduced false memories. They argued that visual presentation was more distinctive than auditory presentation, and this difference facilitated subsequent memory discrimination. For example, both modalities are likely to activate a phonological code, but only visual presentation is likely to activate an orthographic code. As argued by Gallo, McDermott, Percer, and Roediger (2001) and Kellogg (2001), these additional features from visual presentation might facilitate a monitoring process that suppresses false memory, such as the use of more conservative retrieval criteria (e.g., requiring the recollection of more distinctive features before endorsing a test item as studied; see Dodson & Schacter, 2002; Schacter, Israel, & Racine, 1999).

Although the modality effect on DRM false memory has been replicated several times (e.g., Cleary & Greene, 2002; Gallo et al., 2001; Kellogg, 2001; Pierce et al., 2005; Smith, Hunt, & Gallagher, 2008), complexities inherent in the DRM task make it difficult to definitely conclude that the effect is due to retrieval monitoring. For example, in contrast (or in addition) to the monitoring account described above, activation processes also might cause the modality effect in the DRM task. By this theory, the enhanced distinctiveness of visual presentation might reduce relational processing between the presented associates during study, thereby reducing associative activation of the nonstudied critical lure and subsequent false memory (Arndt & Reder, 2003; see also Hege & Dodson, 2004; McCabe, Presmanes, Robertson, & Smith, 2004). Although two DRM studies (e.g., Pierce et al., 2005; Smith et al., 2008) provided evidence that is consistent with a retrieval monitoring account, neither used tests that explicitly required or instructed participants to engage in such a process.

An additional complication is that test modality may matter. Gallo et al. (2001) found a modality effect with visual test cues but no effect when the test cues were auditory (also see Kellogg,

2001). Drawing from Marsh and Hicks (1998), Gallo et al. argued that test modality focused participants' retrieval orientation toward distinctive features that they could recollect, thereby facilitating a retrieval monitoring process. However, other studies are inconsistent with this test modality finding (Maylor & Mo, 1999; Nabeta & Kawahara, 2006; Rummer, Schweppe, & Martin, 2009). The effects of test modality on memory accuracy, as well as the role of retrieval orientation more generally, are still poorly understood.

The Criterial Recollection Task

The main goal of the current study is to more directly test the role of retrieval orientation in modality effects on memory accuracy. In doing so, we are not attempting to test between the retrieval monitoring and relational processing accounts of the DRM modality effect. Instead, our goal is to move beyond the DRM task, in order to investigate retrieval orientation processes without the potentially confounding influence of semantic or associative relatedness. In order to address this goal, we used the criterial recollection task.

The criterial recollection task is a special type of source memory task that was developed to more directly investigate retrieval monitoring processes than does the DRM task (Gallo, Weiss, & Schacter, 2004). Gallo et al. (2004) had participants study a list of unrelated words in a black font (black words); some of those words were followed by the same word in a red font (red words), and others were followed by a picture. Recollection was subsequently cued with black words, using different instructions across the test blocks. On the red word test, participants endorsed items that had been studied in red font, whereas on the picture test they endorsed items that had been studied as pictures. It is important that some items had been studied in both formats, so that the recall of one format did not exclude the item from having been presented in the criterial format (i.e., participants could not use a recall-to-reject strategy). Instead, participants had to adopt a specific retrieval orientation, selectively searching memory for red word recollections on the red word test and picture recollections on the picture test. Under these conditions, source misattributions were greater on the font test than on the picture test, consistent with the idea that orienting retrieval toward more distinctive pictures facilitated retrieval monitoring accuracy. Gallo et al. argued that this task was a more effective way to study retrieval monitoring, because using unrelated stimuli avoids the potential complications of study-based monitoring and relational processing effects that are inherent to the DRM task.

In the current study, participants studied a list of unrelated auditory or visual words and then took two different tests. On the auditory test they were instructed to endorse words that were studied auditorily, whereas on the visual test they were instructed to endorse words that were studied visually. As in prior work with this task, some items were studied in both formats so that participants had to selectively orient retrieval toward the to-be-recollected modality. If the orientation of retrieval toward different study modalities contributes to the false memory modality effect, then we would expect to find an effect of retrieval orientation in the criterial recollection task. Orienting retrieval toward more distinctive visual recollections should lead to more conservative decision criteria, thereby reducing source misattributions relative to when retrieval is oriented toward auditory recollections. Alter-

natively, if the modality effect is idiosyncratic to the DRM task (e.g., if it is caused by study-based monitoring of critical lures activated while the study lists are presented, or by reduced relational processing following visual presentation), then retrieval orientation should not influence performance on the criterial recollection task.

We also manipulated test modality in the current study, given that prior DRM results have been inconsistent with respect to the influence of test modality. These inconsistent results may have arisen from unforeseen interactions between test modality and activation processes in the DRM task, or because participants did not always consider study modality information when making test decisions. By using unrelated materials in the current experiment, and by explicitly orienting retrieval toward modality information at test, we provided a stronger test of the idea that test modality might serve as an additional retrieval cue for study modality information.

A final goal of the current study was to directly test the assumption that visual presentation leads to more distinctive recollections than does auditory presentation. Here we use "distinctiveness" to refer to the richness or complexity of the perceptual features of an event (cf. Gallo et al., 2004). Indeed, feature richness may be a better term for the construct that enhances retrieval monitoring. Although many previous studies of the modality effect have assumed that visual presentation leads to relatively more distinctive recollections than auditory presentation, we are unaware of any direct attempts to measure this hypothetical difference in recollective distinctiveness. In the absence of such a measure, appeals to distinctiveness to explain false memory modality effects run the risk of circularity. We therefore conducted a manipulation check experiment patterned after those used by Gallo, Meadow, Johnson, and Foster (2008) and Gallo, McDonough, and Scimeca (2010) in order to independently measure the relative number of details that are retrieved from recollected items. This experiment allowed us to directly test the assumption that memorial distinctiveness, as measured by the relative number of recollected details, is greater for visually than for auditorily studied items.

Method

Participants

The criterial recollection experiment had 96 participants, and the manipulation check experiment had 28 participants. All participants were undergraduate student volunteers from Texas A&M University. They received partial or extra course credit for participating.

Materials and Design

A total of 128 concrete words were taken from Gallo et al. (2004). Participants studied 96 words, with one third presented as

¹ Schacter et al. (1999) used the term *distinctiveness* to refer to a greater number of recollected details, but note that there could be cases in which fewer details could make an item more distinctive. For example, if all other items contained many details, an item with fewer details might be more distinctive. Given these other interpretations of the term *distinctiveness*, it should be emphasized that the main construct of interest in the current article is the number of recollected details.

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visual words printed in a red font (as in Gallo et al., 2004), one third presented as auditory words recorded in a female voice, and one third presented as both red words and auditory words (for a total of 128 events). The participants then took two test blocks, each containing items studied as only red words, items studied only as heard words, items studied as both red words and heard words, and nonstudied items. Retrieval instructions varied across the two test blocks (counterbalancing order), and test presentation modality was varied between participants. Items were counterbalanced across the study and test conditions, and study and test items were freshly randomized for each participant.

Criterial Recollection Procedure

Participants were told that they would study a series of words. They were told that some items would be printed in red letters on the computer screen, that other items would be spoken in a female voice through headphones, and that still others would be both seen as a red word at one time and heard through the headphones at another time. Red words were presented in lowercase letters using Kristen ITC 30-point font for 2,500 ms each. A 700-ms blank screen separated each visual or auditory word from the next word. Items were presented randomly during study. Participants were told to pay close attention to both the red words and the spoken words because they would later receive a memory test for the words (the exact nature of the tests was not revealed at this time).

After the study phase, participants were given instructions for the first criterial recollection test. For the red word test, they were told that their memory for words in red letters would be tested. They were instructed to respond "yes" if they remembered studying the word in red letters. They were further reminded that some red words also were studied as heard words, and other red words were never studied as heard words. Thus, it did not matter if they remembered hearing the word, as long as they remembered studying it in red letters. Instructions for the heard word test were similar, except participants were instructed to respond "yes" only to words that they had heard, and they were told that it did not matter if they remembered seeing the word in red letters, as long as they remembered hearing the word. These two retrieval orientation conditions were crossed with the modality used to present test items. For visual test presentation, test items were presented in the same red font that had been used at study, and for auditory test presentation, test items were presented in the same female voice that was used at study. All test decisions were self-paced, and the experimenter ensured that the participants understood each set of instructions.

Manipulation Check Procedure

The study phase of this experiment was identical to that used in the criterial recollection experiment. For the test phase, however, participants were not given separate criterial tests for the red words and the heard words. Rather, participants were instructed to judge whether they "actually recollected" an item (i.e., they remembered specifically how the word was presented at study), whether the word was "very familiar" (i.e., they thought that the word was studied but could not actually recollect the specific format), or whether the word was "new" (i.e., the item was not presented in the study phase). In addition, for each item that participants judged that they actually recollected, they were instructed to rate the level of details they could remember, on a scale ranging from 0 (no details) to 7 (many details). Participants were instructed to base their judgments on what they could recollect from the study phase, not how the item was presented at test.

The test was divided into two blocks, one of which consisted of visual test cues, the other consisting of auditory test cues. The order of the test blocks was counterbalanced across participants.

Results

Manipulation Check

Results from the manipulation check are shown in Table 1. The main goal of this manipulation check was to confirm that participants expected to remember more details for studied items in the visual modality. As in prior studies with this procedure, we were primarily interested in the subjective ratings of detail for items that were judged to be actually recollected. As expected, these judgments tended to be greater for items that were studied in both modalities compared with items studied in only one modality, which in turn were greater than items that were never studied. Considering only those items that were studied in a single modality, a study modality (heard vs. seen) X test modality (heard cues vs. seen cues) repeated measures analysis of variance on the number of recollected details revealed a main effect of study modality, F(1, 27) = 5.04, p = .033, $\eta_p^2 = .16$; no effect of test modality, F(1, 27) = 1.15, p = .294; and no interaction, F(1, 27) = .294(27) = .95, p = .339. The main effect of study modality indicates

Table 1
Subjective Responses for Each Item Type as a Function of Test Presentation Modality in the Manipulation Check Experiment

Item type	Visual test presentation			Auditory test presentation		
	p (AR)	p (VF)	Details	p (AR)	p (VF)	Details
Both	.62 (.05)	.26 (.04)	5.45 (.27)	.62 (.05)	.23 (.03)	5.22 (.24)
Seen words	.46 (.04)	.27 (.03)	5.42 (.24)	.38 (.04)	.33 (.04)	4.93 (.30)
Heard words	.46 (.05)	.30 (.04)	4.82 (.34)	.40 (.04)	.29 (.03)	4.72 (.32)
New words	.11 (.02)	.26 (.04)	3.09 (.47)	.07 (.01)	.25 (.04)	2.54 (.45)

Note. Standard errors of the mean are in parentheses. AR and VF responses reflect proportion of total items. Details recalled for actually recollected items were on a 0 (no details) to 7 (many details) scale. AR = actually recollect; VF = very familiar.

that visually studied words led to the recollection of more details (M=5.17, SD=1.44) than auditorily studied words (M=4.77, SD=1.72). This finding is consistent with the assumption that visually studied words lead to more distinctive recollections than auditorily studied words. Furthermore, this advantage in the number of recollected details for visually studied words was found regardless of the modality in which test cues were presented.

Although our primary interest was in subjective ratings of detail, we also report the overall rates of actually recollect and very familiar judgments in Table 1. Analysis of these judgments for items studied in only one modality revealed no effect of study modality, F(1, 27) = .05, p = .824, or test modality, F(1, 27) = .8243.04, p = .093, for actually recollect judgments. Likewise, there were no effects of study or test modality for very familiar judgments, F(1, 27) = .003, p = .957, and F(1, 27) = .30, p = .586, respectively. The finding that actually recollect judgments did not differ across modalities, whereas ratings of recollected details did differ, suggests that binary recollect/familiar judgments are not as sensitive to qualitative differences in recollection as are more fine-grained subjective ratings of detail (cf. Gallo et al., 2008). The finding that very familiar judgments did not differ indicates that the two modalities led to similar levels of familiarity at test. This finding is theoretically important because it suggests that any modality effects that are obtained on the criterial recollection task cannot be attributed to familiarity-based effects.

Criterial Recollection

Performance for the criterial recollection experiment replicated typical patterns with this task (see Table 2): Both-hits (items studied in each source) were greater than hits to items presented in the criterial source, F(1, 95) = 86.30, p < .001, $\eta_p^2 = .48$, which were greater than false alarms presented in the noncriterial source, F(1, 95) = 199.90, p < .001, $\eta_p^2 = .68$, which were greater than false alarms to nonstudied items, F(1, 95) = 169.78, p < .001, $\eta_p^2 = .64$. To test for retrieval orientation effects, we compared false alarms with studied items (i.e., source misattributions) across the two criterial recollection tests. This comparison revealed that source misattributions on the heard word test were greater than source misattributions on the seen word test, F(1, 94) = 21.73, p < .001

Table 2
Mean Recognition Performance for Each Item Type as a
Function of Test Type and Test Presentation Modality in the
Criterial Recollection Experiment

Item type	Visual test presentation	Auditory test presentation
Heard word test		
Both-hits	.77 (.02)	.73 (.02)
Heard word hits	.62 (.03)	.62 (.03)
Seen word FAs	.34 (.03)	.35 (.02)
New FAs	.15 (.02)	.11 (.02)
Seen word test	` ,	, ,
Both-hits	.74 (.02)	.73 (.03)
Seen word hits	.64 (.03)	.56 (.03)
Heard word FAs	.24 (.03)	.25 (.03)
New FAs	.12 (.02)	.11 (.02)

Note. Standard errors of the mean are in parentheses. FAs = false alarms.

.001, $\eta_p^2 = .19$ (i.e., a modality effect). This effect was the same when items were presented visually at test as when presented auditorily, F(1, 94) = .00, p = .996, suggesting that the modality effect depends more on the retrieval orientation that participants adopt than on the modality in which test items are presented. For nonstudied items, there was no difference in the false alarm rate between the heard word test and the seen word test, F(1, 94) = 1.32, p = .253, nor was there a criterial test by test modality interaction, F(1, 94) = .96, p = .331. Although some studies using the criterial recollection task have found retrieval orientation effects on nonstudied items (e.g., Gallo et al., 2004), they are not always found, potentially owing to floor effects (see McDonough & Gallo, 2008).

Analysis of hit rates indicated that both-hits were greater than heard word hits, F(1, 94) = 65.10, p < .001, $\eta_p^2 = .41$, and this effect did not differ as a function of test modality, F(1, 94) = .86, p = .355. Both-hits also were greater than seen word hits, $F(1, \frac{1}{2})$ 94) = 43.58, p < .001, $\eta_p^2 = .32$, and again, this effect did not differ as a function of test modality, F(1, 94) = 2.74, p = .101. For the two criterial recollection tests (the heard word test and the seen word test), hit rates for items presented only as heard words and only as seen words did not differ, F(1, 94) = .86, p = .357, and there was a marginally significant hit rate by test modality interaction, F(1, 94) = 3.25, p = .075. This interaction was driven by somewhat lower hit rates to seen words in the auditory test presentation condition. Overall, these findings are consistent with prior work with both the criterial recollection task and the DRM task, in that hypothetical differences in recollective distinctiveness were more likely to influence false alarm rates than hit rates.

Discussion

Our results provide direct evidence that modality effects on memory accuracy can be caused by differences in retrieval orientation and corresponding monitoring processes. Despite the fact that the same types of items had to be discriminated on each of our criterial recollection tests, participants were better at avoiding source misattributions when the retrieval instructions oriented participants toward visual information than toward auditory information. These results are consistent with prior work in the DRM task (e.g., Smith & Hunt, 1998) and generalize these findings beyond that task. As in the DRM task, the fact that our results were found in false alarm rates, as opposed to hit rates, suggests that responses to lures may be more sensitive to retrieval monitoring effects (see Gallo et al., 2004). Although hits (items studied in one modality and later judged to have been studied in that modality) and source misattributions (i.e., false alarms) should be affected by retrieval monitoring processes, hit rates might be less likely to reflect these processes because, unlike false alarms, they also are driven by retrieval success.

These results support the theoretical claims of Marsh and Hicks (1998), who argued that retrieval instructions could bias the features used to monitor memory. In fact, although Marsh and Hicks were not focused on false memory modality effects, their conclusions were partly based on a modality comparison that was similar to that used in the current study (e.g., lists of unrelated words and different instructions at test). They found that retrieval instructions selectively affected false alarms to nonstudied lures, so that these items were more likely to be correctly rejected when retrieval was

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oriented toward visual compared with auditory information (e.g., "Did you see?" vs. "Did you hear?" this item). However, two subsequent studies have found different results with this sort of manipulation. Leynes (2002) found that both true and false recognition were affected when retrieval was oriented toward visual information, and Humphreys et al. (2003) found that orienting retrieval toward auditory information led to fewer false alarms than visual information did. The current study was not designed to resolve the methodological differences between these studies, but one potentially critical factor is that all three of these studies used mutually exclusive presentation modalities at study. Thus, the recollection of one modality could have excluded the item as having been presented in the other modality, thereby providing some incentive to recollect both modalities at test. In the current study we went to greater lengths to manipulate retrieval orientation toward only one modality at a time, in order to provide a more direct test of the retrieval orientation hypothesis.

We also found evidence that the study modality effect was obtained regardless of the presentation modality used at test. As described in the introduction, the effects of test modality in the DRM task have been mixed, with some studies suggesting that visual modality at test enhances the study modality effect (e.g., Gallo et al., 2001; Kellogg, 2001), and others finding study-to-test congruency effects (e.g., Maylor & Mo, 1999; Rummer et al., 2009). Our results do not adjudicate between these positions, and the exact role of test presentation modality in DRM effects awaits further research with that task. The current results do indicate, though, that explicitly orienting retrieval toward study modality information can be sufficiently powerful to override any potential effects of test presentation modality. More generally, these results suggest that the retrieval expectations and intentions of the rememberer can have a larger influence on memory accuracy than the perceptual information contained in the retrieval cue itself. This conclusion makes sense from a functional perspective, because in many uses of memory outside the laboratory the modality of a retrieval cue (e.g., a verbal question) is likely to be very different from the types of information that one needs to recollect and monitor (e.g., an autobiographical event).

By emphasizing the importance of retrieval orientation, we do not intend to minimize the importance of encoding factors in the modality effect. In the current task, retrieval orientation is believed to have exerted an effect only because there were relative differences between the two study modalities. Using an independent assessment, we found that visual items were recollected in more detail than were heard items, providing converging evidence that visual presentation led to more distinctive recollections than auditory presentation. To our knowledge, ours is the first modality study to obtain an independent measure of the relative distinctiveness of visual and auditory presentation.

In conclusion, the current results add to a growing body of research demonstrating that orienting retrieval toward distinctive sources of recollections can reduce memory errors compared with less distinctive sources. This idea is consistent with the sourcemonitoring framework (Johnson et al., 1993; Marsh & Hicks, 1998), which emphasizes the importance of source differences and retrieval expectations. We have argued that the criterial recollection task avoids some of the theoretical ambiguities inherent to other tasks, such as the DRM task, but it is important to reiterate that our study modality effects were consistent with prior work

using the DRM task. The finding that the modality effect generalizes to the criterial recollection task is theoretically important, because it implicates a common retrieval mechanism that may operate in other situations as well. For example, Kellogg (2007) found that gist-based memory errors in Bartlett's (1932) "War of the Ghosts" task were reduced following visual presentation of the story compared with auditory presentation. An important question for future research will be to test the extent to which this effect is due to the same kinds of retrieval processes uncovered in the current study, as well as the extent to which the effect of modality on memory accuracy generalizes to more naturalistic stimuli.

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Received February 16, 2010
Revision received October 13, 2010
Accepted October 14, 2010