Modality Effects in Short-term Memory versus Long-term Memory within the Deese, Roediger and McDermott Paradigm

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Abstract

Roediger and McDermott (1995) created what is now known as the Deese, Roediger and McDermott (DRM) paradigm to elicit false memories based on semantic associations. There is evidence that false memories due to semantic associations occur in working memory and display an equal effect in short-term memory and long-term memory (Flegal et. al., 2010). Prior research using visual presentation versus audio presentation within this paradigm in long-term memory demonstrated conflicting results on which modality is superior. The current study used a combined short-term memory - long-term memory procedure with DRM lists presented in the auditory and visual modalities within subjects. The results showed higher rates of false alarms to associated probes than unrelated probes in both modalities and with both testing delays (immediate and with delay). In short-term memory, false memories were twice as frequent in the visual condition than in auditory condition. On the contrary, more memory errors were made in the auditory modality than the visual modality in long-term memory. This replicates findings of the visual modality leading to fewer memory errors in long-term memory and provides evidence to support the claim that the auditory modality is less susceptible to semantic distortions than the visual modality in working memory.

Keywords: false memories, semantic associations, short and long-term memory, modality

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As Mazzoni (2002) stated, studying memory distortions is important in understanding how memory processing works, learning the implications in legal practices that have damaging repercussions and studying the disturbing realizations in psychotherapy that may not have happened. Suggestion-dependent memory distortions imply that external influences lead to the memory error in the individual whereas naturally occurring memory distortions have implications about the perception of information and the internal memory process (Mazzoni, 2002). The current study focuses on naturally occurring distortions since unlike suggestion-dependent distortions, the memory error cannot be predicted unless there is a complete understanding of internal memory processing.

Why would errors be a systematic function of the memory system? One explanation is that the brain automatically organizes the perceptions into a meaningful structure, which can lead to an inaccurate account of an event (Musatti, 1931). Another possibility is the associative nature of information processing where, for example, seeing a word leads to activation of strongly associated words, which Underwood (1965) called implicit associative responses in memory. The fact is, memory is fallible and it is essential to study these distortions in order to obtain a complete picture of how memory works.

False Memory Phenomenon and the DRM Paradigm

Mentioned above, Underwood (1965) theorized that the false recall of a non-presented word was due to the implicit associative effect. Underwood used a continuous recognition task in which he presented a long series of words and after each word the participant decided whether or not the word was viewed previously in the list (i.e., old). If the participant identified a new critical word as old, Underwood labeled the response as a false alarm. Underwood found that false alarms depended on the number of prior associates of the non-presented critical word and on the relation between the associated word and the critical word.

A different theory about false memory phenomenon is the complex-feature hypothesis proposed by Anisfield and Knapp (1968). They posited that false recognition of a non-presented word was the result of decaying features that characterize a word. This means that any word can be recognized if semantic features from an old word are shared with a new word leading to a familiarity-based activation. These opposing theories received mixed support from subsequent studies such as Fillenbaum's study, Eagle's studies and Hall and Kozloff's study (Mazzoni, 2002). Fillenbaum (1969) supported the complex-feature hypothesis contrary to the findings of Grossman and Eagle (1970) and Cramer and Eagle (1972). Hall and Kozloff (1970) confirmed the role of implicit associative relation between words. Deese conducted a study (Deese, 1959) that utilized recall of words as opposed to recognition. He presented a group of words to participants that were all associated with a critical lure that was not presented and found that for particular lists, a high percentage of participants falsely recalled the non presented critical word. Deese (1959) believed that the false recall could be predicted due to the associative structure of the word list, meaning the degree of association that a word has to the critical word. Those results support the association theory and shows that the features of the word are not the cause of the memory error.

From Deese's word lists came the DRM paradigm. Roediger and McDermott (1995) created the DRM word lists based on results from Deese's (1959) study. Roediger and McDermott (1995) used the lists that had a high percentage of false recall to replicate Deese's findings and incorporated measures of recognition. Recall for non-presented critical words was significantly greater than recall for presented words occurring in the middle of the lists. In experiment 1, non-presented associates were recalled 40% of the time and were later recognized with high confidence. In experiment 2 with expanded lists, the false recall rate was 55% and on later recognition tests subjects made false alarms to these items at a comparable rate to the correct recognition rate. The most intriguing measure in this experiment was the use of remember-know judgments. A “remember” judgment is defined as one based on a strong recollective experience, whereas a “know” judgment is based on a sense of familiarity with the word (Mazzoni, 2002). Roediger and McDermott (1995) were surprised to see that many of the non-presented lures were accompanied by remember judgments showing a strong confidence in the memory error. Using this method as a foundation, considerable research has advanced our knowledge of the false memory phenomenon.

Modality Effects in Long-term Memory

In the context of the present study, we will be comparing the effects of visual presentation versus auditory list presentation on subsequent true and false memory. Several prior studies have examined modality effects on false memory. In the first experiment reported by Smith and Hunt (1998), they replicated Deese’s study (1959) in that a recall test was used with the additional manipulation of modality whereas their second experiment replicated Roediger and McDermott’s method (1995) with the modality manipulation. The result was that visual presentation reduced the rate of false memories compared to auditory presentations, and equivalent response recall of critical and studied items only occurred in the auditory condition (Smith & Hunt, 1998). Smith and Hunt (1998) theorized that the differential effects of modality were due to associated items coming to mind at study and test, or to the ability to differentiate between internal (words that come to mind due to activation) and external (words that were presented) cues in the visual modality. A third experiment was conducted to test the possibility that the modality difference is due to the implicit associative response, which is an explanation for the difficulty in distinguishing internal and external clues. Smith and Hunt (1998) repeated the first experiment with the additional requirement of a pleasantness ratings through which participants would be more like to focus on the meaning of the word. The modality effect was still evident, meaning the visual modality led to fewer false alarms when compared with the auditory modality, and the pleasantness rating further decreased the likelihood of a memory distortion in both modalities (Smith & Hunt, 1998). They propose that memory errors come from the critical word coming to mind at study, thus becoming a part of the encoding experience, and visual study provides a superior foundation of discriminating the stimuli that were presented from those that were only “thought of.”

Maylor and Mo (1999) utilized the DRM paradigm to study the modality differences in long-term memory as well. However, the result in this study directly contradicted Smith and Hunt’s findings. Maylor and Mo (1999) manipulated the modality of study and test words in the same manner that Smith and Hunt (1998) used in their study, as well as mismatching the modalities of study and test words. Mismatching the modalities refers to the method of using audio for stimulus words and then visual for test words and vice versa. The Roediger and McDermott (1995) original set-up was audio for study words and visual for test words in the recognition test, which may contribute to the number of false alarms. Maylor and Mo (1999) found evidence indicating that mismatching the modalities of study and test items led to more false alarms compared to when the study and test words were presented in the same modality. Another result was a higher false recognition rate following visual presentation compared to auditory presentation, which is contrary to the Smith and Hunt (1998) finding. However, Maylor and Mo (1999) used remember/know/guess[1] judgments and did not find evidence that remember judgments lead to more correct recognitions in any of the four conditions as compared to know judgments. The advantage they report when study and test modality match is a critical result, and one that is consistent with the encoding-specificity hypothesis (Maylor & Mo, 1999). The encoding-specificity hypothesis is the idea that retrieval varies directly with the compatibility of the stored information and the retrieval of information (Tulving & Thompson, 1973). The input of stimuli and the specific encoding operations determine the effectiveness of the retrieval cues.

Maylor and Mo (1999) discuss the contradiction of their findings and those of Smith and Hunt (1998). They first point out the difference in experimental design: Smith and Hunt (1998) did not use remember/know/guess judgments and the results were examined between subjects rather than within subjects as in Maylor and Mo (1999), which they assert is a weaker method. Maylor and Mo (1999) believe that the visual presentation lacks the perceptual and contextual detail that audio provides in sensory representation, hence the result that audio presentation leads to fewer false recognitions. Despite Maylor and Mo's confidence in their findings, studies have found that visual presentation leads to fewer memory errors in long-term memory such as Gallo, McDermott, Percer and Roediger (2001) who replicated Smith and Hunt's (1998) results.

Short-term Memory in DRM paradigm

Considerable evidence indicates that associative semantic processing is the province of long-term memory, and to the extent that false memories depend on associative processing, the question arises as to whether false memories might also be evident in short-term memory. To address this question, Atkins and Reuter-Lorenz (2008) conducted a series of experiments that modified the DRM task to assess false memories in working memory. To test working memory, four words were displayed individually for 1,200ms and after a 3000ms delay that had a math equation as a distracter task in some of the experiments, followed by a test word. The four words that were presented were semantically related to a critical lure that was also the test word in a proportion of the trials. The critical lures were mistakenly recognized as part of the memory set and if correctly rejected, the response time was longer than when rejecting unrelated lures. In Atkins and Reuter-Lorenz's (2008) second experiment, short-term memory semantic associations were also tested with recall as opposed to recognition and it was still found that semantic errors were more common than other types of errors[2]. Their evidence supports the theory that working memory may use similar mechanisms as long-term, episodic memory[3] at least with visual stimulus presentation.

Coane, McBride, Raulerson and Jordan (2007) conducted experiments for false memories in working memory as well. They used the activation-monitoring theory to explain their results, which coincide with Atkins and Reuter-Lorenz (2008) results. Coane and colleagues (2007) found an increase in reaction times for critical lures when compared to non-studied list items and unrelated probes. The extended reaction times for critical lures and studied items could be explained by the additional checking during the process of labeling the item as new or old. Associative activation occurs when a word is studied and the time to reject a critical lure takes longer due to monitoring needed to inhibit the associative activation that accompanies it.

Modality Effect in Short-term Memory

Penney (1989) integrates numerous sources of literature to explain that the auditory modality is superior in working memory. Penney theorizes that both modalities have the P code (phonological code), however, the auditory modality uses the A code (acoustic code) for processing while the visual stream of processing uses the visual code. The key difference is the separate processing streams as opposed to the earlier proposed separate memory stores.

Supporting evidence for the separate streams hypothesis is the data that stimuli presented to two modalities as opposed to one leads to greater performance on concurrent tasks and higher recall when two modalities are presented. There is also support of interference effects in both visual and auditory presentations, organization by modality is persistent, and there is evidence of modality-specific deficits in short-term memory (Penney, 1989). Crowder and Morton proposed the precategorical acoustic store, which put forward the idea that the acoustic store could hold unprocessed sensory information longer than the corresponding visual store (Crowder & Morton, 1969 as cited in Penney, 1989). Although there is not enough evidence to claim that these stores are the reason for modality effect in short-term memory, there is evidence that higher recall occurs with auditory stimuli presentation. Articulatory suppression demonstrates the modality effect in that articulatory suppression lowers visual memory span, with very little effect on auditory memory (Penney, 1989). This evidence, along with the automatic access to the A code, demonstrates that auditory information can be retained without continued attention and hence, is the superior processing stream in short-term memory.

Short-term Memory and Long-term Memory in DRM paradigm

Flegal, Atkins and Reuter-Lorenz (2010) compared short-term memory and long-term memory within subjects using the DRM paradigm. Based on theories that describe long-term memory as primarily semantic/associative and short-term memory as more sensory/perceptual-based, they expected short-term memory to have fewer false recognitions because sensory coding prevails over meaning-based coding. The results revealed that the false memory phenomenon was equally robust in short-term memory as well as long-term memory. This provided evidence that the processes forming false memory illusions may not be unique to long-term memory, supporting a newer notion that processes responsible for semantic memory errors are just as pervasive in short-term memory as they are in long-term memory. Perhaps there are separate processing streams as a function of modality that are the same throughout short-term memory and long-term memory.

Hypothesis and Predictions

The present study is tests the effects of stimulus input modality in short-term and long-term memory within subjects to see if the modality superiority characterizes short-term memory and long-term memory in the same manner. Based on the literature, the modality effect should differ in short-term memory and long-term memory within subjects due to the separate processing streams, which has yet to be tested. I hypothesize that the auditory presentation will lead to fewer false memories compared to visual presentation in short-term memory because of the idea that the auditory code represents memories with greater perceptual and contextual detail (Penney, 1989). Since the auditory code will be strong in short-term memory but decay over time, I expect to see a less robust effect of the false memory phenomena in short-term memory than in long-term memory with auditory study. I predict that visual study will lead to fewer false recognition rates as compared to auditory study in long-term memory because as stated, the auditory code will decay and the visual code will prevail.

Method

Participants

Forty-four subjects' ages 18-20 years participated in the experiment. They were all University of Michigan students enrolled in Psychology 111 and received credit for participating in this study. There were thirty-four female and ten male participants, all of whom were native English speakers and right-handed (one male was left-handed). Six participants were excluded due to an error in the program, two participants were excluded because many errors were admittedly due to exhaustion, two participants were excluded because there was no break before the long-term memory portion of the experiment, one participant was excluded because she read the visual items aloud and one participant was excluded because he required hearing aids, which affected his results. The University of Michigan Institutional Review Board approved this study.

Materials

In this experiment, there were 128 word lists that consisted of 4 semantically related words that were all associated to one theme word. These lists were obtained from the Flegal, Atkins and Reuter-Lorenz (2010) study in which 48 lists originated from the DRM paradigm (Roediger, Watson, McDermott & Gallo, 2001). The other 80 lists were created for the Flegal and colleagues (2010) study and confirmed to induce false recognition in both the Atkins and Reuter-Lorenz (2008) study as well as the Flegal and colleagues (2010) study.

As in the Flegal and colleagues (2010) study, the 128 lists were first divided into four groups of 32 lists and then divided again into sub groups of 16 word lists. Using this division, 32 different versions of the experiment were created using the E-prime software on Dell computers. Each list is presented following the possibility of three different probes: a related probe, an unrelated probe and a target. The related probe is the unstudied theme word associated with the list, the unrelated probe is the unstudied word that is not associated with the presented list, and the target is the theme word that was presented in the list (Flegal et. al., 2010).

Design and Procedure

Short-term memory task. Experiment A had 16 word lists for visual presentation and 16 word lists for auditory presentation with the structure of visual, auditory, auditory, visual (VAAV) while experiment A prime used the same presentation of the same word lists with the structure auditory, visual, visual, auditory (AVVA). Experiment A reverse would then use the 16 word lists that were for visual presentation in experiment A for auditory presentation and the 16 word lists used in auditory presentation in experiment A for visual presentation. The structure of A reverse is still VAAV but with the word list presentation is reversed. Experiment A reverse prime is composed of the same word lists in the same presentations, however the structure is AVVA. This structure is repeated for experiment B, II A, II B, III A, III B, IV A, and IV B.

For visual presentation, the participant saw one word at a time with a period of 100 ms between each word. After the fourth word, they see a green screen for 3000 ms during which the participant repeats the word “the” for articulatory suppression. Once the green screen disappeared, a test word appeared, which was one of the three types of probes described above. The participant pressed “M” on the keyboard if they recognized the test word as one of the four presented words and the participant pressed “Z” on the keyboard if they judged the test word not to be one of the four studied words. Sometimes instead of seeing a test word, the participant will see “X X” where they can press “M” or “Z.” These trials were later probed in long-term memory. Auditory presentation for short-term memory followed the same structure as visual presentation. The subject wore headphones (the same headphones for every subject with a set volume) and he or she hears four words with 100 ms in between each word. The screen stays blank through this time and once the four words have been presented the green screen is displayed for 3000 ms in which the participant repeats the word “the” out loud. Once the green screen disappears, the participant hears a test word and presses ‘M’ if they believe it was one of the presented words and ‘Z’ if they believe it was not one of the presented words.

Long-term memory task. After the four blocks that contain the 32 word lists, there are two more blocks composed of a very different structure. If the structure of the first part was VAAV, then the first LTM recognition block used auditory presentation and vice versa. For auditory presentation, the participant will hear 36 words and will have 3000 ms for each word to decide whether or not the word was presented in the first part. The first three words of this list were filler items that had not been presented nor were they associated with any theme words. The next thirty words consist of related lures, unrelated lures or targets. The last three words of the list, like the first three, are words that were not presented nor associated to a theme word.

Results

To determine whether the rate of false semantic memories differed between modalities and the type of memory, the proportion of *"yes"* responses was compared to related and unrelated probes using a three-way ANOVA with probe type (related, unrelated), modality (auditory, visual) and delay of test word (short-term memory, long-term memory) as repeated within subject factors (see table 1 for proportion of *"yes"* responses for each of the three probe types in each modality condition and across delay). There was a main effect of delay, indicating that more errors were made following the long delay, $F(1, 31) = 65.7$, $p < 0.001$, $\eta^2 = 0.67$. There was also a main effect of probe type indicating more errors to related lure probes than to unrelated probes, $F(1, 31) = 62.9$, $p < 0.001$, $\eta^2 = 0.67$. There was no main effect of modality, $F(1, 31) = 0.04$, $p = .80$. There was also a significant interaction between delay and probe type, $F(1, 31) = 12.2$, $p < 0.01$, $\eta^2 = 0.28$ and a marginal interaction between delay and modality, $F(1, 31) = 3.6$, $p = 0.06$, $\eta^2 = 0.1$. Critically, the three-way interaction between delay, modality and probe type was also significant, $F(1, 31) = 11.4$, $p < 0.01$, $\eta^2 = 0.27$. An interaction between delay and probe type was not significant, $F(1, 31) = 0.01$, $p = 0.90$.

To further explore these interactions we conducted 2 (modality: auditory, visual) x 2 (delay: short, long) ANOVA on *"yes"* responses to related lure probes. This analysis showed a main effect of delay, $F(1, 31) = 65.7$, $p < 0.001$, $\eta^2 = 0.67$. There was no main effect of modality,

$F(1, 31) = 0.04$, $p = 0.80$. An interaction between delay and modality was marginal, $F(1, 31) = 3.6$, $p = 0.06$, $\eta^2 = 0.10$. Subsequent *t*-tests showed that in the short delay condition the higher rate of false recognition in response to lure probes was revealed in visual modality than in auditory modality, $t(31) = 2.95$, $p < 0.01$, d = 0.53. In the long delay condition the higher rate of false recognition in response to lure probes was observed in auditory than in visual modality, $t(31) = -2.02$, $p = 0.05$, d = 0.35.

To determine whether accurate recognition of studied probes (*"yes"* responses to studied probes) differed due to delay and modality we conducted a two-way ANOVA with modality (auditory, visual) and delay (short, long) as repeated within subject factors. The analysis revealed a main effect of delay $F(1, 31) = 120.8$, $p < 0.001$, $\eta^2 = 0.8$ showing the higher accuracy following the short delay condition. There was no main effect of modality, $F(1, 31) = 1.56$, $p = 0.20$. An interaction between delay and modality failed to reach significance, $F(1, 31) = 2.86$, $p = .10$. Although the interaction was not significant the data suggest that veridical memory was better for the auditory short delay condition than for the visual short delay condition, $t(31) = -2.50$, $p < 0.05$, d = 0.40. In the long delay condition veridical memory between modalities remained equal, $t(31) = -0.10$, $p = 0.90$.

Signal detection analyses

We also performed analyses for sensitivity and response bias both for item specific memory and gist memory. The results are displayed in Table 2.

Item specific memory (studied probes compared to unrelated probes)

A 2 (modality: auditory, visual) x 2 (delay: short, long) repeated measures ANOVA on the *d'* measure for item-specific memory (hits) was conducted and showed a main effect of delay, $F(1, 31) = 117.9$, $p < 0.001$, $\eta^2 = 0.79$. There was no main affect of modality, $F(1, 31) =$

1.65, $p = 0.20$. There was no interaction between modality and delay, $F(1, 31) = 1.75$, $p = 0.20$. were revealed. Paired *t*-test showed marginally greater correct recognition in with audio compared with the visual condition in the short-term memory test, $t(31) = -1.90$, $p = 0.05$, d = 0.36. In the long-term memory test this difference was not significant, $t(31) = -0.20$, $p = 0.70$.

The same ANOVA was performed on response bias (*C*) and revealed only a main effect of delay, $F(1, 31) = 23.30$, $p < 0.001$, $\eta^2 = 0.43$ indicating more conservative criterion in the long delay condition than in the short delay condition . A main effect of modality, $F(1, 31) = 1.10$, $p = 0.30$. and an interaction between modality and delay, $F(1, 31) = 2.10$, $p = 0.20$. were not significant.

The data suggest that the participants used more conservative criterion in the visual condition than in the auditory condition in short-term memory tests. A *t*-test was performed to demonstrate a marginal difference in response bias between auditory and visual modality $t(31) = 1.97$, $p = 0.05$, d = 0.34.

Gist memory (related lure probes compared to unrelated probes)

A 2 (modality: auditory, visual) x 2 (delay: short, delay) repeated measures ANOVA performed on *d'* for gist revealed a main effect of delay, $F(1, 31) = 13.04$, $p < 0.01$, $\eta^2 = 0.29$. There is no main effect of modality was shown, $F(1, 31) = 0.01$, $p = 0.90$. The interaction between modality and delay was significant, $F(1, 31) = 6.10$, $p < 0.05$, $\eta^2 = 0.16$. T-tests were performed to show differences in sensitivity to gist between modalities in the short delay condition and in the long delay condition. In the short delay condition the participants relied more on gist in the visual than auditory conditions, $t(31) = 1.80$, $p = 0.07$, d = 0.31. In the long delay condition they depended more on prone in the auditory than visual condition, $t(31) = -1.80$, $p = 0.08$, d = 0.32.

The same ANOVA on *C* measure revealed a main effect of delay, $F(1, 31) = 55.27$, $p < 0.001$, $\eta^2 = 0.64$ showing more conservative response criteria in the short delay condition than in the long delay condition. No main effect of modality was obtained, $F(1, 31) = 0.20$, $p = 0.60$. The interaction between delay and modality was significant, $F(1, 31) = 4.90$, $p < 0.05$, $\eta^2 = 0.13$.

T-tests showed that participants in the short delay auditory condition were more conservative than in the short delay visual condition, $t(31) = -2.46$, $p < 0.05$, $d = 0.43$. No differences between modalities were revealed in the long delay condition, $t(31) = 0.90$, $p = 0.30$.

Discussion

The central issue of the present study was the investigation of the occurrence of false memory effects in short-term and long-term memory both in auditory and visual conditions. The experiment produces two data patterns of importance. First, there were false recognition effects in both short-term and long-term memory and in visual and auditory conditions. Second, in short-term memory, the superiority of the auditory modality was revealed, whereas in long-term memory visual presentation was superior.

The results replicated previous findings of the rapid distortions of verbal working memory (Atkins & Reuter-Lorenz, 2008; Coane et. al., 2007) showing that semantically related lures were falsely recognized after a few seconds following presentations. Moreover, results from auditory condition contribute to the literature on false working memories in the DRM paradigm by demonstrating that these memory distortions also emerge when study and test are conducted in the auditory modality.

Murdock (1967; 1968; 1969) and Penney (1989) present evidence that auditory stimuli presentations lead to superior verbal working memory. The auditory stream has a large capacity for storing sensory information and this auditory code will only be activated if the stimulus is actually heard and not when imagining a voice speaking the item (Penney, 1989). This coincides with the theory that auditory presentation uses more distinctive features and representations than visual presentation. This experiment supports that notion due to the observed fewer false alarms with auditory presentation in short-term memory as well as the higher correct recognition rates.

The results could be explained by focusing on the differences between the two stores of information, visual and auditory. Penney (1989) discusses the phonological code, the visual code and the auditory code. When a person hears an item he or she uses the phonological code and the auditory code while when a person sees an item he or she uses the visual code and the phonological code. The auditory code is more distinctive than the phonological and visual codes and lasts in working memory for a few seconds while the visual code decays in less than a second. The advantage of auditory presentation in working memory is that visual items require continuous attention to be maintained in short-term memory whereas auditory information creates sensory-based stores without continuous attention (Penney, 1989). Hence, the findings that the auditory presentation will lead to fewer false memories in the short-term memory are supported. Another explanation for the superiority effect of audio in short-term memory is using Baddeley's (1986; 1992) working memory model. This model contains a visuospatial sketchpad and a phonological loop for processing sensory information. Visual information uses the visuospatial sketchpad whereas for audio, the visuospatial sketchpad is not initially engaged and could be used to visualize the item that was heard. It is more difficult to reject related items with visual presentation because the original item lacks the perceptual detail that the auditory item contains. These theories are consistent with the findings that auditory information is more durable and distinctive than visual information within working memory.

The long-term memory results are consistent with Smith and Hunt (1998) findings that visual presentation leads to fewer memory errors than auditory presentation in long-term memory. The overall pattern was that less false recognition occurred under the auditory modality in short-term memory while less false recognition occurred under the visual modality in long-term memory. This is quite unlike the data from short-term memory where fewer false alarms accompanied better veridical memory with auditory presentation. There was no difference in veridical memory between the modalities in long-term memory, which further suggests that items are differentially processed based on the separate streams of modality.

The superiority of the visual condition in long-term memory may be explained by Baddeley's working memory model. Information in the phonological loop (the phonological code) is distinctive and durable; yet, information in the phonological loop needs to be continuously rearticulated to remain in working memory. This suggests that the auditory code deteriorates along with the phonological code and therefore, it would be difficult to correctly reject certain items after a long delay in the auditory condition. The requirement of phonological recoding could also explain why the visual presentation more effective in long-term memory because recoding will intensify the features of the item for easier retrieval after a delay. With this theory, the correct recognition rate for long-term memory in the visual condition should be greater than the correct recognition rate for auditory, yet the findings do not support that prediction.

In long-term memory where the benefit of visual presentation on correct recognition rates was not observed, decrease in false alarms may be associated with the distinctiveness heuristic, which can be used at retrieval (Schacter, Gallo & Kensinger, 2007). With this heuristic, it is easier to differentiate a lure from visually studied lists because according to the assumption that "thinking" of the lure is more similar to hearing it than to seeing it, the representation of the lure shares fewer common features with visually presented study items, and therefore can be successfully rejected.

Future Studies

Further analysis of this study could look at the gender differences due to the procedure of using a female voice in the auditory condition. A follow-up for this study would be to use remember/know/guess judgments with this exact experiment. This form of confidence rating could help to distinguish the similarities and/or differences in the false memories that are created in short-term memory versus long-term memory. Other studies might aim to analyze the importance of context effects in short-term memory and long-term memory using the DRM paradigm. Context differences could include the font of the text, the color of the text and background color, which could be used to vary the distinctiveness of items at encoding.

Footnotes

1. Remember judgments refer to recollecting the experience and being able to connect the experience of viewing or hearing the word with other physical aspects. Know judgments refer to a familiarity of the item, however not a complete memory of the experience. Guess judgments are simply when one does not remember at all, nor has any familiarity.
2. Types of errors include phonological errors, repeated words and words that were not related in either sound or meaning.
3. Episodic memory is a form of long-term memory that processes autobiographical events.

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Table 1

The Proportion of "Yes" Responses for Studied, Related and Unrelated Probes (standard error of the mean in parentheses).

	Short-term Memory		Long-term Memory	
	Task			
	Auditory	Visual	Auditory	Visual
	M (SEM)	M (SEM)	M (SEM)	M (SEM)
Lure probes	0.06 (0.01)	0.14 (0.03)	0.43 (0.04)	0.33 (0.03)
Unrelated probes	0.02 (0.01)	0.01 (0.01)	0.15 (0.04)	0.16 (0.03)
Studied probes	0.96 (0.01)	0.86 (0.03)	0.54 (0.04)	0.54 (0.04)

Table 2

Measures of Sensitivity (d') and Response Bias (C) for Item Specific Memory and Gist Memory as a Function of Modality and Delay.

	Short-term Memory				Long-term Memory			
	Item Specific Memory (true recognition)		Gist Memory (false recognition)		Item Specific Memory (true recognition)		Gist Memory (false recognition)	
	d'	*C*	*d'*	*C*	*d'*	*C*	*d'*	*C*
Auditory	3.18	0.04	0.14	1.56	1.3	0.52	0.96	0.7
Visual	2.78	0.21	0.46	1.37	1.24	0.51	0.62	0.82