The Effect of Environmental Sound Effect on False Memory through the DRM Paradigm

Laith Jaroudi

Department of Psychological and Brain Science, University of California, Santa Barbara

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Dr. Melinda Baham

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Use of AI Statement

The help of Google Gemini was used during the initial brainstorming of the paper. The AI helped pave the direction for relevant studies and research related to the DRM task. Additionally, Google Gemini assisted in the writing of the abstract on December the 8th, 2025, by providing instructions for how to write a well-written abstract. The abstract was written and reviewed by me. Lastly, during the early weeks of the quarter, I asked Google Gemini to read and summarize Roediger & McDermott's (1995) paper and Israel and Schacter's (1997) paper. I asked for a summary *after* reading the paper myself, and only used the AI to make sure my general understanding was grasped

Abstract

The Deese-Roediger-McDermott (DRM) paradigm has been established to successfully induce false memories through simple word list tasks, presenting lists of semantically related words that lead participants to falsely recall a non-present "critical lure" word. While previous research has demonstrated that shifting the modality in which the word was presented (from a verbal delivery of the word to line drawings) led to a reduction in false memory rate in participants, the effect of non-verbal auditory cues remains uncharted. Through the framework of the Fuzzy Trace Theory (FTT), this study will explore the effects of environmental sound effects on participants' performance on the DRM task by either strengthening gist traces or enhancing verbatim traces. 67 undergraduate students from UCSB were randomly assigned to either an Audio + SFX or an Audio-only condition, and were then asked to perform a free-recall and recognition task for the word lists they studied alongside the inclusion of confidence as a moderator (Remember: High & Know: Low). A 2 x 2 ANOVA revealed a main effect of confidence ($p = 0.048$), with participants reporting more high confidence false memories in

comparison to low confidence, confirming the “real feel” of the false memories. However, no significant main effect was found for the mode of presentation nor a significant interaction effect. Contrary to our hypothesis, environmental SFX did not reduce false memory rates. Our results suggest that auditory cues may integrate into participants’ semantic gist rather than creating a verbatim tag, displaying the modality-specific nature of our memories’ reconstruction.

The Effect of Environmental Sound Effect on False Memory through the DRM Paradigm

During the early days of the field of Psychology, research led experts to believe that false memories were created only for complex and detailed memories, disregarding our memories' susceptibility to deception even in the slightest of tasks. This theory was argued against initially by Deese (1959), followed by Roediger and McDermott (1995), with both papers depicting the creation of false memories through a simple word list paradigm. Now coined as the famous (Deese-Roediger-McDermott) task, participants are asked to learn word lists that all have semantic similarities to a critical, non-present word (such as "sweet" and "chocolate" relating to the non-present "cake"), then are tested through free recall tasks and a recognition task to test for how many false memories were created. The task has been used plenty of times in modern research, due to its ability to address ecologically valid issues through a simple design. The understanding of these mechanisms provides us with insight into a socially significant phenomenon, as false memories play a crucial role from eyewitness testimony in legal settings to general social interactions where an accurate recall is required. The goal of this study is to observe how non-verbal auditory cues influence false memory.

Roediger and McDermott's paper (1995) replicated the findings from Deese's paper (1959) using similar methodologies. Essentially, they were able to use word-lists sharing words that were semantically related to a non-present critical lure word to elicit false memories in participants. After administering a free recall and recognition test, their results showed significantly high rates of both false recall and recognition across participants. This study helped spark the creation of a highly influential paradigm in memory research in psychology, with a plethora of research following suit to understand false memory through the DRM paradigm.

Following the original paper from Roediger and McDermott, researchers noticed a gap in the literature about the effects of presenting the DRM lists' words through different sensory modalities. One pivotal paper that addressed this concern was a paper conducted by Israel & Schacter in 1997, where they explored the effects of presenting the auditory stimuli both verbally and visually. Participants were shown simple line-drawings of words instead of hearing them from an experimenter (for example, participants would be shown a drawn picture of a cat instead of hearing the word cat being spoken to them). The researchers were able to find that line-drawings were able to reverse the effects of the standard DRM task, where participants that were shown line-drawings as opposed to spoken words had a significantly lower rate of false recall (Israel & Schacter, 1997). These findings show the significance of how the memory is presented has large implications for how false memories are created. We can better understand why these results differ from the original Roediger and McDermott paper through understanding the theoretical framework related to the DRM task that distinguishes memory from two different kinds of traces: the Fuzzy Trace Theory.

The Fuzzy Trace Theory is a dual processing model that splits our experience of remembering an event into two distinct mental traces: the gist trace and the verbatim trace (Reyna & Brainerd, 1995). The gist trace captures the broader and abstract trace of a memory, such as "I remember it being warm last Monday", while the verbatim trace captures more specific and precise traces of a memory, such as "I remember it being 80 degrees Fahrenheit last Monday morning". Following the FTT, the DRM task is meant to elicit a dominance in the gist trace of the participants' memory through the effects of the non-present critical lure word, which is why we see high rates of false recall and recognition within the DRM task.

This framework helps explain the reverse effect of Israel and Schacter's study (1997), where they were able to strengthen the verbatim trace through the increased visual details of the line-drawings and demonstrate that the modality of the stimuli influences the gist/verbatim traces. They argue that the line-drawings provided rich verbatim details, which elicited a distinctiveness heuristic amongst participants. This framework provides a solid foundation to help us explore how to elicit or inhibit the creation of false memories of the DRM task. There still holds unanswered questions about different modalities of the presentation of stimuli in the DRM task and false memory according to the FTT. The literature lacks an understanding on how non-verbal auditory cues (which in our studies' case is environmental sound effects) function in comparison to visual cues. While line-drawings were shown to strengthen the verbatim trace in participants' memory (Israel & Schacter, 1997), non-verbal auditory cues may integrate with the semantic gist of the word's meaning, failing to provide the same distinctive benefit as visual cues.

Furthermore, we will address the importance of how confident participants are in their answers to assess the strength of the false memories. Past research used the "remember/know" procedure, originally adopted by Roediger & McDermott (1995), to test for confidence within participants' judgements:"Know" judgements are supposed to relate to lower-confidence, gist-trace dominated memories while "Remember" judgements are supposed to relate to higher-confidence, verbatim-trace dominated memories. Research has shown that participants typically report higher confidence in false memories in comparison to low confidence, a phenomenon coined as "phantom recollection" by Brainerd & Reyna (2002). The inclusion of confidence as a moderator allows us to gain a deeper understanding of environmental SFX's effects on creating and inhibiting false memories amongst participants.

Rationale

The pursuit of discovering environmental SFX's effect on false memories is closely linked to how real-world false memories are created in contexts that often have background/environmental noise. We can infer that adding thematically-related sound effects creates theoretical ambiguity: the environmental SFX could reinforce the impact of the non-critical lure word (enhancing the gist trace and consequently increasing false memory recall and recognition rate), or they could offer participants a rich, specific event pairing to words (which helps enhance the verbatim trace and decrease false recall and false recognition rate).

We resolve this ambiguity by incorporating the Remember/Know task as a moderator, addressing Brainerd and Reyna's (2002) phantom recollection. Assessing confidence allows us to explore this mechanism deeper: if SFX act as cues to elicit a distinctiveness heuristic, they should disrupt high-confidence errors.

This allows us to better understand the interaction between verbatim traces and gist traces based upon their definitions in the Fuzzy Trace Theory, answering the question of "How do environmental sound effects influence gist vs verbatim based processing in memory recall, and do higher confidence ratings correspond to increased false recognitions?". We will address a gap in the research surrounding our understanding of auditory modalities and its influence on memory in comparison to visual modalities. We will be manipulating the presence of environmental SFX to see if false memories are increased or decreased.

Hypotheses:

1) We hypothesize that subjects that listen to the environmental SFX will show higher rates of false memories, and exposure to environmental SFX will elicit more false memories compared to those who were not exposed to environmental SFX.

2) We hypothesize that those who reported with high confidence will show higher levels of false memories compared to those who reported low confidence..
3) We hypothesize a significant interaction such that presence of environmental SFX will reduce the rate of high-confidence false memories, showing a smaller effect on the low confidence level.

Method

Design

Our study used 2 (Presentation Mode: Audio only vs Audio + SFX) x 2 (Confidence Level: High & Low) Between-subjects factorial design. Our independent variable was the mode in which the words were presented. Our moderator was participants' confidence level, operationalized by whether participants reported high or low levels of confidence. Our dependent variable was the rate of false memories, operationalized by the number of incorrect recall and recognition of words in the DRM task.

Participants

A total of 67 undergraduate University of California, Santa Barbara students that are over the age of 18 participated in this study. The participant pool consisted of students from the PSY120L class, using mild coercion due to the course credit they received for their participation in our study. Additionally, the rest of the participants volunteered to participate in the study through an anonymous link posted on social media. Participation was completely voluntary, with participants being able to withdraw from the study at any time without receiving a penalty. The study was approved by the course instructor Dr. Baham, who provided us IRB approval.

Measures and Apparatus

All participants conducted the study through an anonymous Qualtrics link, where participants were advised to use headphones throughout their completion of the experiment.

Auditory Manipulation (IV)

The Independent Variable was operationalized through a set of two audio recordings: an Audio-only condition containing lists of 10 words read aloud with equal spacing, and an Audio-SFX condition used the same vocal recording from the Audio-condition alongside a semantically related environmental sound effect (e.g. the word "chip" accompanied by the sound of a crunch").

False Memory Task

We used the DRM paradigm to assess false memory rate, where participants were asked to study 5 lists containing 10 words each. The study phase was followed by a free recall portion, where participants had 1 minute to write down as many words as they could remember before the timer was up.

Recognition and Confidence measure

After studying and performing free recall for all 5 lists, participants ended with a free recognition task, and were asked to differentiate between words that they had seen before or words they didn't. If participants selected the "old" option, they were presented with the option to select whether they "remember" seeing the word before or "knew" that they saw the word before, representing high and low confidence. A "remember" response represents the participant being able to recall specific details of seeing the word (high confidence), and the "know" response defined as a sort of familiarity of seeing the word (low confidence) (Roediger & McDermott, 1995).

Procedure

After opening up the Qualtrics link, participants were presented with the consent form, followed by instructions to listen to the audio clips containing lists of words that they had to remember for later. They were informed that after each list, they will have to complete a free recall task. Participants were advised to refrain from external distraction and to wear headphones. Participants were then randomly assigned to either the condition, Audio Only or Audio SFX, and the DRM task began. For every trial, participants listened to the first word list, presented either with or without SFX, immediately followed by the free recall task. Once this is repeated 5 times, participants received instructions for the recognition task. They were presented with a list of words and asked to identify if each word was on one of the previous lists or was not in one of the previous lists. If a participant responds "old," they were asked to answer if they “remember” seeing the word or “know” that they saw the word. Once this is complete, participants were thanked for their time and presented with the debriefing form. The form explained the purpose of the study, what the DRM paradigm and false memories are, and provided the contact information of the researchers for any questions/concerns.

Results

A 2 (Presentation Mode: Audio-only vs Audio + SFX presentation mode) x 2 (Confidence level: High vs Low) between-subject factorial ANOVA was conducted to show the effects of environmental SFXs and confidence on false memory rates.

The analysis revealed that the main effect of the presentation mode on false memory rate was not significant, $F(1, 65) = 0.69$, $p = .410$, $\eta^2 = .010$. This means that there was not a significant difference between participants' false memory rates when comparing those in the Audio-only presentation mode ($M = 0.43$, 95% CI [0.39, 0.47]) to those in the Audio-SFX presentation mode ($M = 0.45$, 95% CI [0.41, 0.50]).

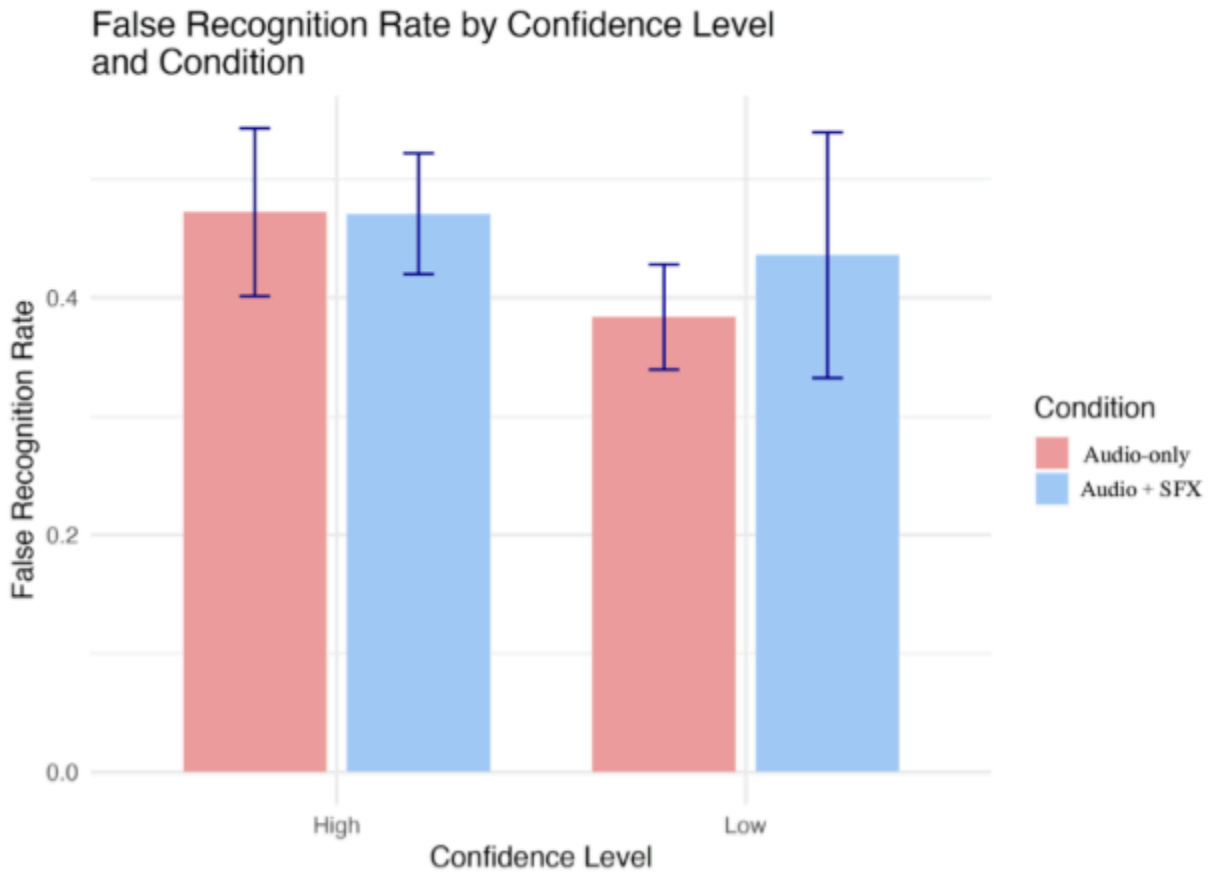
However, the ANOVA revealed that there was a significant main effect of confidence levels on false memory rates, $F(1, 65) = 4.06$, $p = .048$, $\eta^2 = .059$. Participants were significantly more likely to have a false memory and show higher levels of confidence by answering "remember" ($M = 0.47$, 95% CI [0.43, 0.52]) compared to those who had low confidence ($M = 0.41$, 95% CI [0.37, 0.45]).

The ANOVA revealed that there was no significant interaction effect between the mode of presentation and confidence levels, $F(1, 65) = 0.77$, $p = .385$, $\eta^2 = .012$. The analysis revealed that SFX had no differential impacts on high confidence false memories vs low confidence false memories (see Figure 1).

Lastly, a Pearson product-moment correlation was conducted to assess the relationship between confidence and false memory rates, and found a significant positive correlation, $r(67) = .28$, $p = .021$. This indicates that participants who reported higher confidence levels were more likely to be susceptible to false memories.

Figure 1

False Recognition Rate by Confidence Level and Presentation Condition



Discussion

This study aims to explore the effects of environmental sound effects and its ability to act as a cue to reduce or increase false memories within the DRM task. Our results showed mixed support for our specific hypothesis. First, we found that a significant main effect for confidence was present, with participants reporting higher levels of confidence ("Remember") compared to low levels of confidence ("Know"). This supports our second hypothesis regarding the phenomenological qualities of participants' false memories, replicating the original DRM task findings where participants' false memories were accompanied by vivid details under the term "phantom recollection" (Roediger & McDermott, 1995; Brainerd & Reyna, 2002). However, our first hypothesis was not supported, we did not find a significant main effect of presentation

mode, showing that environmental SFX did not increase false memory rates. Our third hypothesis regarding an interaction effect was also not supported, as the data revealed no significant interaction between environmental SFX and confidence level amongst participants.

The results from our study show an important contrast to Israel & Schacter's (1997) results on visual distinctiveness. The line drawings in their study elicited an increase in participant's verbatim-trace, allowing participants to utilize a distinctiveness heuristic to reject words they didn't recall seeing. On the contrary, the environmental SFX worked in a different manner in comparison to the line-drawings in reference to the Fuzzy Trace Theory. Instead of acting as a distinct verbatim tag, they likely integrated with the semantic gist of the words, where the sound was most likely processed as a feature of the concept itself and failing to trigger the distinctiveness heuristic the same way the visual cues did. The sound effects failed in stopping the creation of false memories.

This study possesses several limitations that may have contributed to these results. First, the nature of environmental SFX could differ to that of the line-drawing by being less instinctively obvious and more ambiguous. A line-drawing of a cat is typically concrete and well understood by a large majority of the general public. However, an audio clip of a cat's purr or meow may cause trouble in immediately eliciting a sense of familiarity in participants. The ambiguity of the sound effect could have caused confusion in participants and may have led to misinterpretation of the sound effect played. If the participant could not identify the sound, it is possible they would not have been able to accurately create a verbatim trace to use a distinct tag. Additionally, the line-drawings are modally different from the spoken word presented to

participants in Israel and Schacter's study (1997). Our study presents two different audio clips simultaneously, meaning that two audio clips at once could have caused a cognitive overload in participants when conducting the study. This could have caused divided attention and participants' inability to focus on two things at once, and the processing of the sound effect could have obstructed participants from processing the word itself, causing some participants to not hear the actual word altogether. Finally, because the study was conducted online, we lacked environmental control regarding the presentation of audio. There was an inconsistency in the type of headphones used amongst participants, meaning we could not confirm that participants were using high-quality headphones that (1) isolated noise to exclude background sounds and (2) make sure the headphones were able to project the audio clips accurately and not distort them. This could have influenced the clarity of our SFX manipulation, potentially interfering with the effectiveness of the sound.

Future research should explore the limitations mentioned above to better understand auditory processing in false memory within the DRM task. To address this, future studies should "norm" the sound effects prior to the experiment to ensure a base ability to identify common sounds amongst all participants. This could be operationalized by conducting a practice run with participants before the DRM starts, or providing them with 5 audio recordings and asking them to identify the sounds they hear to observe whether they possess pre-existing auditory or cognitive impairments. Additionally, future studies should explore both visual and non-verbal auditory cues within the same design. This would provide us with a definite and immediate comparison between the different modalities. This would allow us to more directly address the distinctiveness heuristic in the context of different modalities.

This study sought out to study whether the use of nonverbal auditory cues could mitigate the errors created from the DRM task and how environmental SFX performs compared to visual cues. While we were not able to find any significant increase or decrease in false memory rate, we were able to find that the creation of false memories was accompanied by a high confidence of the appearance of the word. Auditory cues were able to produce similar results compared to those of visual cues, suggesting the non-verbal auditory cues may integrate into the gist trace of the memory rather than enhancing the verbatim trace. Our research helps answer questions regarding the modality-specificity of our distinctiveness heuristic and observing the presentation of the words in the DRM task through different mediums. Future research must further explore false memories through different modalities to help explore how our memory can fault us in a practical setting.

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Appendix

DRM Word Lists

Participants were asked for study 5 DRM word lists containing 10 words each. Below are 6 lists of 15 words each.

Table A

SLEEP	SMOKE	CUP	RIVER	CAR	MUSIC
Bed	Cigarette	Mug	Water	Truck	Note
Rest	Puff	Saucer	Stream	Bus	Sound
Awake	Blaze	Tea	Lake	Train	Piano
Tired	Billows	Measuring	Mississippi	Automobile	Sing
Dream	Pollution	Coaster	Boat	Vehicle	Radio
Wake	Ashes	Lid	Tide	Drive	Band
Snooze	Cigar	Handle	Swim	Jeep	Melody
Blanket	Chimney	Coffee	Flow	Ford	Horn
Doze	Fire	Straw	Run	Race	Concert
Slumber	Tobacco	Goblet	Barge	Keys	Instrument
~~Snore~~	~~Stink~~	~~Soup~~	~~Creek~~	~~Garage~~	~~Symphony~~
~~Nap~~	~~Pipe~~	~~Stein~~	~~Brook~~	~~Highway~~	~~Jazz~~
~~Peace~~	~~Lungs~~	~~Drink~~	~~Fish~~	~~Sedan~~	~~Orchestra~~
~~Yawn~~	~~Flames~~	~~Plastic~~	~~Bridge~~	~~Van~~	~~Art~~
~~Drowsy~~	~~Stain~~	~~Sip~~	~~Winding~~	~~Taxi~~	~~Rhythm~~

Note: We decided not to include one of the word lists with critical-lure "sleep" and excluded 5 words from every list for the final experiment. On the first row of every column, the bolded word

represents the non-present critical lure word. This was not shown to participants. Additionally, the last 5 rows of every column did not make it into the final lists. These words were important to help test during out pilot runs