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EFFECTS OF CONTEXTUAL CUES ON FALSE MEMORY: A COMPARATIVE EXPERIMENTAL APPROACH

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Abstract

Research on false memory formation using the Deese-Roediger-McDermott (DRM) paradigm has been extensively conducted in Western contexts. Yet, a significant gap remains in experimental investigations within South Asian populations, particularly in Pakistan. Existing studies, such as those on the Visual Mandela Effect, have explored collective false memories; however, they lack controlled experimental manipulation of contextual variables. To address this gap, the study examined the impact of contextual cues, both visual and auditory, and the effect of no contextual cues, on false memory formation. Sixty participants (aged 18–40) were randomly assigned to one of three groups: Visual and Auditory Cues, Visual Cues only, and Word List only. Each group was presented with three semantically themed DRM word lists across three recall blocks. A between-subjects one-way ANOVA revealed statistically significant differences in the recall of critical lures across groups, with the highest false memory incidence observed in the combined cue condition, [$F(2,57) = 14.505$, $p < .001$, $\eta^2 = .337$]. Post hoc analyses further confirmed that exposure to multimodal cues significantly increased susceptibility to false memories compared to the control condition. However, a repeated-measures of ANOVA indicated no significant change in critical lure recall across the three blocks within groups. Additionally, the control group demonstrated higher accurate recall and lower intrusion rates. These findings underscore the role of sensory contextual cues in modulating memory distortion and contribute novel cross-cultural evidence to the literature on memory and cognition. The study holds implications for legal, clinical, and educational settings where memory accuracy is critical.

Keywords: False Memory, Contextual Cues, Deese-Roediger-McDermott Paradigm, Memory Recall, Critical Lures

Introduction

Memory is a fundamental aspect of human cognition, enabling individuals to form coherent narratives of the past and guiding future behaviour. As a dynamic and reconstructive process, memory plays a critical role in perception, learning, reasoning, and decision-making across various contexts (Baddeley, 2000; Tulving, 2002). It is through the accurate recollection of past experiences that individuals are able to navigate and adapt to their environments. The importance of memory accuracy is especially prominent in adults, a group characterized by ongoing cognitive plasticity, diverse life experiences, and academic, professional, and social demands (Squire & Kandel, 2009). Among these adults, particularly young and middle-aged individuals, memory distortions such as false memories can have significant consequences. False memories are vivid yet inaccurate recollections that can feel real, highlighting the malleability and plasticity of human memory (Brainerd & Reyna, 2005).

False memory formation has critical implications in real-world scenarios such as eyewitness testimony, where distorted memories can contribute to wrongful convictions (Schacter & Loftus, 2013). Understanding the mechanisms underlying false memory formation is essential for various applied fields, including law, clinical psychology, and education. Recent research on false memories, particularly using the Deese-Roediger-McDermott (DRM) paradigm**,** has examined how semantic and contextual influences shape memory distortion. However, most of this research has been conducted in Western contexts, leaving a gap in understanding how contextual and cultural factors shape memory processes in other populations, particularly in South Asian countries such as Pakistan.

This study aims to address this gap by exploring the influence of different contextual cues: visual, auditory, and no cues, on false memory formation within a South Asian population. Specifically, the research will examine how contextual richness at the retrieval phase affects the likelihood of false memories in Pakistani adults. This work contributes cross-cultural evidence to the existing body of research, emphasizing the role of sensory cues in modulating memory distortion.

Literature Review

False Memory and the DRM Paradigm

False memories refer to the recollection of events, details, or objects that were never experienced, yet are recalled with a high degree of confidence (Brainerd & Reyna, 2005). These memories arise not only from forgetfulness but from the active construction of false recollections based on semantic or contextual cues. The Deese-Roediger-McDermott (DRM) paradigm has been one of the most widely used experimental tools for studying false memory. The paradigm involves presenting participants with a list of semantically related words, followed by a recall task. The lists are carefully constructed to include "critical lures," words that are strongly associated with the presented words but were never actually shown (Roediger & McDermott, 1995). In this setup, participants often recall the critical lures as if they were presented, illustrating how semantic associations can distort memory.

A variety of factors have been shown to influence false memory formation within the DRM paradigm, including contextual cues. The role of contextual information in memory formation has been examined in several studies, suggesting that sensory cues can strengthen semantic associations and influence memory accuracy (Smith et al., 2001). Contextual cues such as visual and auditory stimuli can enhance the likelihood of false memories by providing additional sensory information that overlaps with the mental representations created during encoding. This process is consistent with Fuzzy-Trace Theory (FTT)**,** which posits that false memories arise when individuals rely on "gist" representations of an event rather than verbatim details (Brainerd & Reyna, 2002). Additionally, Associative-Activation Theory (AAT) suggests that false memories are formed through the automatic spreading of activation across a network of semantically related concepts (Hina et al., 2025; Roediger et al., 2001).

Role of Sensory Cues in False Memory

The impact of sensory cues on memory formation has been explored in various ways, with visual and auditory cues being two of the most commonly studied modalities. Studies have shown that auditory cues often produce higher rates of false recall compared to visual cues. This phenomenon is believed to result from the less distinctive nature of auditory information, which may enhance gist-based processing and make memory more vulnerable to distortion (Smith & Hunt, 1998; Smith & Engle, 2011). In contrast, visual cues tend to be more concrete and specific, providing a stronger reference point for accurate memory recall (Kumar & Gupta, 2020).

Research focusing on multimodal (visual and auditory) cues has suggested that combining sensory inputs can increase false memory rates even further, as the overlapping semantic networks from both modalities make it more difficult to differentiate between actual and false memories (Gallo, 2006). However, many studies in this area have focused on the encoding phase of memory formation, neglecting the impact of contextual cues during the retrieval phase. This study seeks to fill that gap by examining how visual and auditory cues at the retrieval phase affect false memory formation.

Cross-Cultural Perspectives on False Memory

Much of the research on false memory formation has been conducted in Western populations, raising questions about the universality of these findings. Cultural factors can significantly influence memory processes, as individuals from different cultural backgrounds may encode and recall information in distinct ways. For instance, individualistic cultures emphasize personal experiences and specific details, whereas collectivist cultures, such as those found in South Asia, tend to focus more on general themes and social contexts (Nasir & Hyder, 2018). These cultural differences could potentially affect the susceptibility to false memories and the influence of contextual cues.

In the context of false memory research, cross-cultural studies are limited, and the ecological validity of Western-based findings is often questioned. While the DRM paradigm has been shown to be effective in Western samples, its application in non-Western contexts has been largely unexplored. This study aimed to contribute to the growing body of cross-cultural research on memory by examining how sensory cues influence false memory formation in a Pakistani adult population. By doing so, it seeks to expand the understanding of how cultural and contextual factors shape memory accuracy and distortions in non-Western settings.

Objectives of the Study

1. To examine the impact of different contextual cues visual, auditory, and combined visual-auditory, on false memory formation using the Deese-Roediger-McDermott (DRM) paradigm.
2. To compare the rates of false recall (critical lures) and true recall across the three cue conditions to determine how multimodal sensory input influences memory distortion.
3. To analyse whether the presence of contextual cues at the retrieval phase enhances gist-based processing and increases the False Memory Index (FMI) relative to the no-cue control condition.
4. To assess the stability of false memory rates across repeated recall Blocks to evaluate the temporal consistency of cue-induced memory distortion.
5. To contribute cross-cultural evidence from a Pakistani adult population, expanding the ecological validity and cultural relevance of DRM-based false memory research.

Hypotheses

1. Participants exposed to Visual and Auditory Cues will recall more critical lures compared to those exposed to Visual Cues and the Word List.
2. Participants in the Word List Only condition will recall more correct words and fewer incorrect words than those in the Visual & Auditory Cues or Visual Cues conditions.
3. Participants in the Visual & Auditory Cues group will exhibit a higher rate of false memory recall for critical lures.
4. Participants in the Visual & Auditory Cues group will exhibit a higher FMI compared to the Visual Cues group and word list only, suggesting that combined cues enhance false memory formation.

Methodology

Ethical Consideration

This study was conducted after receiving approval and following the ethical guidelines of the Institutional Ethical Review Committee. Informed consent was obtained from all participants before data collection. Participants were assured of the confidentiality and anonymity of their responses and were informed of their right to withdraw from the study at any time without penalty. The investigation employed a classic memory task based on the DRM Framework, which involved minimal risk. All activities were conducted in accordance with the ethical principles outlined in the WMA Declaration of Helsinki.

Study Design

The repeated-measures, block-randomized a true experimental design was chosen to accurately assess how different contextual cues influence false memory formation while maintaining high internal validity. In false memory research, individual differences in attention, vocabulary, and cognitive ability can create large variability in recall performance. A repeated-measures structure addresses this limitation by allowing each participant to serve as their own control, thereby reducing between-subject variance and increasing statistical power (McDermott, 1996; Pardilla-Delgado & Payne, 2017). This within-subject component was complemented by a between-subjects manipulation of cue conditions; visual and auditory, visual only, and

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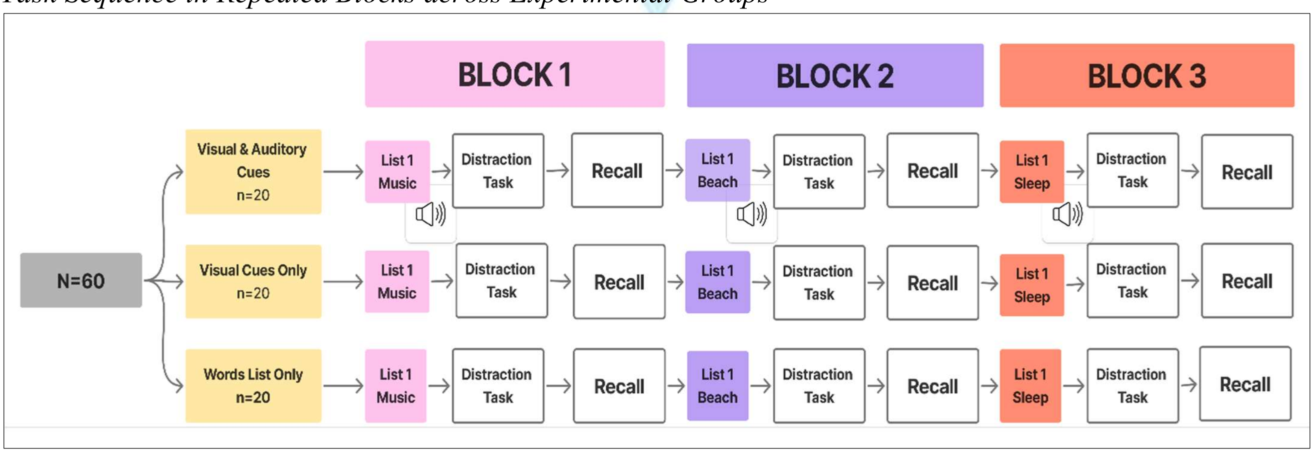
no-context word lists, to prevent carryover and expectancy effects that could occur if participants experienced multiple sensory conditions in sequence. Block randomization ensured equal group sizes and balanced the testing order across participants, reducing the risk of time-related or order-based confounding.

The logic behind this hybrid design is grounded in the theoretical and empirical foundations of false memory research. The fuzzy-trace theory posits that false memories arise through gist-based processing, while verbatim memory traces support accurate recall (Brainerd & Reyna, 2002). Similarly, dual-coding theory suggests that visual and auditory stimuli can enhance both gist and verbatim traces, though their influence depends on the mode and timing of presentation (Paivio, 1991). Prior studies have shown that modality and context cues affect the strength and accuracy of recall, with auditory cues often producing higher false recall rates due to less distinct encoding (Smith & Hunt, 1998; Kumar & Gupta, 2020). However, most of these studies have focused on encoding-phase manipulations, leaving retrieval-phase cue effects understudied. The current design directly addresses this gap by presenting sensory cues solely at retrieval, enabling a clear evaluation of how external context reinstatement influences false recall (Riaz et al., 2025; Tamminen & Mebude, 2019; Děchtěrenko et al., 2021).

This design also effectively minimizes potential confounds. Random assignment through block randomization prevents sampling bias, while screening participants for sensory impairments or neurological conditions ensures homogeneity in perceptual processing. The use of standardized presentation timings, fixed font, and identical list lengths further limits procedural variability, and the inclusion of a distraction task between encoding and recall prevents immediate rehearsal effects (Roediger & McDermott, 1995). Counterbalancing word lists across blocks controls for list-specific differences in associative strength, and normality testing with equal group sizes supports reliable statistical comparisons. By integrating these safeguards, the study maintains strong control over extraneous variables while enhancing the validity of inferences drawn about cue-induced false memory. Overall, this repeated-measures, block-randomized approach offers a robust and theoretically consistent framework to explore how retrieval-based sensory cues modulate gist-driven memory errors within the DRM paradigm.

Figure 1

Task Sequence in Repeated Blocks across Experimental Groups



Note. Participants were randomly divided into three experimental conditions: Visual and Auditory Cues, Visual Cues Only, and Word List Only (n = 20 per group). Each group completed three repeated blocks, each consisting of the presentation of a word list (Music, Beach, Sleep), followed by a distraction task and a recall phase. This repeated-block design allowed comparisons within participants across blocks and between groups across cue conditions.

Figure 1 illustrates the experimental procedure designed to investigate how different contextual cues influence false memory formation. A total of 60 participants were randomly assigned to three experimental conditions (n = 20 each): Visual and Auditory Cues, Visual Cues Only, and Word List Only. Each participant completed three repeated blocks, and each block consisted of the presentation of a DRM word list, followed by a short distraction task and a recall phase.

In the Visual and Auditory Cues condition, participants were exposed to both visual images and background sounds related to the semantic theme of the word list. In the Visual Cues Only condition, participants viewed only the thematic visual images without sound, whereas the Word List Only condition involved no additional cues besides the word list itself.

Within each block, the order of word presentation was randomized for every participant to minimize serial position effects and reduce predictability in recall. The distraction task between encoding and recall helped to prevent rehearsal and carryover effects between blocks. This repeated-block structure allowed for within-subject comparisons of memory performance across blocks and between-group comparisons of cue conditions, providing a controlled approach to assess how contextual information at retrieval influences false memory formation.

Sample

A total of 60 participants (30 males, 30 females), aged between 18-40 years, were recruited via convenience sampling from the general population. This age range was chosen to represent the young adult stage, which is characterized by stable cognitive functioning, active learning, and heightened responsiveness to contextual influences on memory. Convenience sampling was selected due to its practicality and accessibility in obtaining participants within a limited timeframe while maintaining control over experimental conditions. This approach is widely accepted in cognitive psychology research where the goal is to test theoretical mechanisms, such as false memory formation, rather than to generalize to a broader population (Gravetter & Forzano, 2018). Participants were thoroughly screened to ensure the validity of memory-related assessments. Individuals with a history of neurological, psychiatric, or cognitive impairments, as well as those with uncorrected visual or auditory impairments, were excluded. These criteria ensured that all participants possessed adequate sensory functioning and literacy levels required for accurate comprehension and semantic processing of the DRM word lists. Initially, 100 individuals were recruited, but 40 were excluded either due to ineligibility based on screening criteria or because they did not complete the task. Data from participants who met the inclusion criteria and completed the full procedure were retained for analysis. No statistical outliers were identified in the final sample. Only individuals with normal or corrected-to-normal vision and hearing were included. Education was noted but not systematically analyzed, as all participants had completed at least 12 years of formal school.

Future research might measure the impact of education since semantic processing could be moderated by the literacy level (Unsworth, 2018). Participants were randomly assigned to one of the three experimental groups using the fishbowl randomization method. This method is a simple random allocation technique often employed in small experimental samples to ensure unbiased group distribution. In this procedure, each participant's name or identification code was written on identical slips of paper, thoroughly mixed in a container, and drawn one by one to assign participants sequentially to one of the three groups: Visual and Auditory Cues, Visual Cues Only, or Word List Only group, maintaining equal group sizes of twenty participants each. This method ensured that every participant had an equal probability of assignment, effectively minimizing selection bias and supporting the internal validity of the experiment (Gravetter & Forzano, 2018).

Random allocation also balanced demographic variables such as gender and age across groups, which reduced systematic variance that could otherwise confound the effects of contextual cue manipulations. By applying this randomization before the experimental procedure, the study controlled for potential threats to internal validity such as selection effects, assignment bias, and experimenter expectancy, thereby increasing confidence that observed differences in false memory rates were due to the manipulated cue conditions rather than pre-existing individual differences. The final group distribution was as follows: Visual and Auditory Cues ($n = 20$), Visual Cues Only ($n = 20$), and Word List Only (control group; $n = 20$). The average age of participants across groups ranged from 22.0 to 22.98 years (SDs between 1.7 and 2.1), with gender representation fairly balanced: The Visual & Auditory Cues group included 45% males and 55% females; the Visual Cues Only group comprised 55% males and 45% females; and the Word List Only group had 45% males and 55% females. These distributions indicate a demographically consistent and comparable sample across experimental conditions.

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A priori power analysis was conducted using the Web-Power statistical power (https://webpower.psychstat.org/models/long03/) calculator for both repeated measures and one-way ANOVA designs. This analysis was necessary to ensure that the research had adequate statistical power to detect meaningful effects of contextual cues on false memory formation, thereby reducing the likelihood of inconclusive or misleading results due to an underpowered design. For the repeated-measures ANOVA with a 3 × 3 design (three groups and three repeated measures), the effect size was set at $f = 0.50$, reflecting a medium-to-large effect based on prior DRM false memory studies involving contextual cues (e.g., Israel & Schacter, 1997). The significance level (α) was set at 0.05, with a no sphericity correction of 1.0. The analysis indicated that with a total sample size of 60 participants (20 per group), the statistical power to detect a within-group effect was 0.93, exceeding the conventional threshold of 0.80 for adequate power. Moreover, a power analysis for a one-way ANOVA (between-group comparison with three blocks) using the same sample size and effect size $f = 0.5$ yielded a power of 0.93. The findings show that the chosen sample size is sufficient to identify significant effects in both within-subject and between-subject analyses of this study. Nevertheless, our power analysis was based on large effects (f=0.50); the small-to-medium effect sizes (η^2 =.12 - .33) indicate that the study might have lacked the power to identify more subtle relationships, e.g., that between cue type and Block number.

Procedure

Before the data collection, ethical approval was obtained from the Institutional Review Board (IRB), and formal authorization was given by the Department of Clinical Psychology at a private University. Participants were informed about the study's objectives, assured of confidentiality, and provided with informed consent. The experimental protocol involved the presentation of three DRM word lists based on the themes of sleep, beach, and music. Each list consisted of 15 semantically related words linked to a non-presented critical lure. Stimuli were administered via PowerPoint to standardize presentation across participants. Words were displayed individually on the screen for 1.5 seconds each, resulting in an overall list duration of approximately 22.5 seconds. Cue conditions varied by group assignment: The Visual & Auditory Cues group observed each word alongside a corresponding image and thematic sound; the Visual Cues Only group viewed the word with the related image, but without sound; and the Control group was presented solely with the text. All content was rendered in Bahianita font, size 88, selected for its clarity and visual engagement.

Following each word list, participants engaged in a 5-minute distraction task involving arithmetic problems and visual pattern matching to minimize rehearsal and simulate interference. Immediately after the distraction phase, a 90-second free recall task was administered. Participants were instructed to write down all words they could recollect in any order without prompts or cues. This procedure was replicated across three separate blocks, maintaining consistent timing and conditions for all participants. The primary outcome measures included (a) the number of correctly recalled words list (true recall), (b) the number of falsely recorded critical lures (false recall), and (c) the false memory index (FMI), calculated as the average number of critical lures across the three blocks. Once the data was collected, all the responses were anonymized and entered into SPSS for analysis. The first step was to clean the data set by checking for any missing values or outliers and then testing whether the data followed a normal distribution.

To analyze the results, a one-way ANOVA was conducted to examine whether there were significant differences in false recall of critical lures across the three experimental groups. This test was appropriate because the independent variable, cue condition, had three distinct levels, and the dependent variable, false memory recall frequency, was measured on a continuous scale. The one-way ANOVA allowed for an overall comparison of group means while maintaining control over Type I error that could occur with multiple independent t-tests (Field, 2018). When significant main effects were observed, post hoc comparisons were performed to identify specific differences between the cue conditions. This step provided a more detailed understanding of how each sensory context influenced false memory formation.

A repeated-measures ANOVA was then used to assess within-group changes in false recall across the three repeated blocks of the experiment. This analysis was justified because the same participants completed multiple recall tasks over time, allowing for an evaluation of memory stability or change within individuals. The repeated-measures approach controlled for individual differences in baseline recall ability and increased

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statistical power by using each participant as their own control (Pallant, 2020).

Additionally, separate mixed-model ANOVAs were conducted to compare the rates of accurate recall and critical lures within each group. This approach helped identify whether contextual cues influenced overall recall performance or specifically biased memory toward false information. Together, these analyses provided a comprehensive statistical framework for testing both between-group and within-subject effects, ensuring alignment with the study's objectives of examining how contextual cues and repetition influence false memory formation.

Results

This section outlines the results of experimental research conducted to investigate the influence of contextual cues on false memory formation within the DRM paradigm. The results are organized into two subsections: the pilot study, which was conducted to assess the reliability of the stimuli and procedures, and the main study, which presents the statistical analysis and outcomes of the extensive participant study.

Pilot Study

To examine the reliability of experimental procedure, a pilot study was conducted with 15 participants. The participants were randomly assigned to one of the three conditions: Visual and Auditory Cues, Visual Cues only, or Word List only. Each participant was presented with a word list that included sleep, beach, and music, with words presented at intervals of 1.5 seconds. After this, participants engaged in a distraction task involving mathematical problems for 5 minutes to minimize the practice effect. Later, they were asked to recall the words. The pilot phase facilitated the reliability of the experiment and conditions. After receiving positive feedback from the participants and confirming the reliability of the collected data, the main study was conducted.

Main Study

The main study involved the collection of data from 100 participants, who fulfilled specific inclusion and exclusion criteria. Participants were later randomly assigned to one of three groups: Visual and Auditory Cues, Visual Cues Only, and Word List Only. After data collection, cases with incomplete tasks, inconsistent response patterns, or extreme outliers were excluded. A final sample of 60 participants who satisfied the requisite criteria was retained for the analysis.

Normality Test

Table 1

Shapiro-Wilk Test Results Assessing the Normality of Data Distributions Across Experimental Conditions (Visual & Auditory Cues, Visual Cues Only, and Word List) for All Blocks and FMI

	Vis & Audio Cues (n=20)				Vis Cues (n=20)				Word List (n=20)			
Variables	**M**	**SD**	**Range**	**W**	**M**	**SD**	**Range**	**W**	**M**	**SD**	**Range**	**W**
Block 1	.95	.22	0-1	.23	.75	.44	0-1	.54	.50	.51	0-1	.64
Block 2	.95	.22	0-1	.23	.65	.48	0-1	.60	.55	.51	0-1	.63
Block 3	.95	.22	0-1	.23	.80	.41	0-1	.49	.60	.50	0-1	.62
FMI	.95	.12	.67–1	.43	.73	.23	.33-1	.80	.55	.31	0-1	.88

Note. W = Shapiro-Wilk, FMI = False Memory Index.

In Block 1, as shown in Table 1, the Shapiro-Wilk test values ranged from .23 to .64, indicating that the data followed a fairly normal distribution across all conditions. The same pattern was observed for blocks 2 (.23 to .63) and 3 (.49 to .62). For the False Memory Index (FMI), the test values fell between .43 and .88, suggesting that the data were normally distributed across groups.

These results confirm that the assumption of normality was met for all variables in every condition. This is important because normality ensures that ANOVA results are reliable and valid. Since all groups had equal sample sizes (n = 20) and the data were evenly spread, it is likely that random assignment effectively balanced individual differences, which helps control for other influencing factors and boosts the study's internal validity (Gravetter & Forzano, 2018). Also, since there were no major deviations from the normality, we can be confident that the results were not being thrown off by extreme scores or outliers, which helps to protect the accuracy of the analysis (Field, 2018).

Table 2

One-Way ANOVA Examining Differences in the Number of Critical Lures and False Memory Index (FMI) Across Three Conditions

	Vis & Audio cues (n=20)		Visual cues (n=20)		Word list (n=20)				
Variables	**M**	**SD**	**M**	**SD**	**M**	**SD**	**F**	**p**	**η^2**
Block 1	.95	.22	.75	.44	.50	.51	5.9	.001***	.17
Block 2	.95	.22	.65	.48	.55	.51	4.7	.01**	.14
Block 3	.95	.22	.80	.41	.60	.50	3.9	.02*	.12
FMI	.95	.12	.73	.23	.55	.31	14.5	.001***	.33

Note. M = Mean, *S.D.* = Standard Deviation, F = F-ratio, p = p-value, η^2 = eta squared. [a] $^{*} p < .05$, $^{**} p < .01$, $^{***} p < .001$

To examine whether the types of contextual cues significantly influenced the formation of false memories, a one-way ANOVA was conducted on the number of critical lures recorded across the three experimental conditions.

Table 2 presents one-way ANOVA results, which revealed significant differences in the number of critical lures across the three experimental conditions. For Block 1, participants in the Visual & Auditory Cues group (M = .95) showed significantly more critical lures than those in the Visual Cues only (M = .75) and Word List only (M = .50) groups, [$F(2, 57) = 5.97$, $p = .001$, $\eta^2 = .17$]. This pattern continued in Block 2 ($F = 4.73$, $p = .01$, $\eta^2 = .14$) and Block 3 ($F = 3.93$, $p = .02$, $\eta^2 = .12$), both reflecting medium effect sizes. The Final Memory Index (FMI) yielded a highly significant difference, $F(2, 57) = 14.50$, $p < .001$, $\eta^2 = .33$, indicating a large effect of cue type on false memory formation. Overall, the presence of both visual and auditory cues significantly increased the generation of false memories across all Blocks.

Post hoc analyses revealed that, for Block 1, significant difference existed only between the Visual and Auditory Cues and the Word List only, with Visual and Auditory Cues having fewer critical lures than the Word List only (M.D. = .45, p = .001***). Similarly, for Block 2, Visual and Auditory Cues had significantly more critical lures compared to Word List only (M.D. = .40, p = .001***). In Block 3, Visual and Auditory Cues again had more critical lures compared to Word List only (M.D. = .35, p = .001***).

For the false memory index (FMI), Post hoc Tukey HSD test showed a significant difference across all three conditions. Participants in the Visual and Auditory Cues group exhibited significantly higher FMI scores compared to both the Visual Cues Only group (M.D. = .216, p = .014*) and the Word List group (M.D. = .401, p < .001***). Additionally, the Visual Cues Only group showed significantly higher FMI scores than the Word List group (M.D. = .185, p = .042*). These findings indicate that the inclusion of auditory cues further heightened susceptibility to false memories, as reflected by the overall FMI scores.

Table 3

One-way ANOVA comparing correct and incorrect responses across three experimental conditions over three Blocks

	Visual & Auditory Cues (n=20)		Visual Cues (n=20)		Word List (n=20)				
Variables	**M**	**SD**	**M**	**SD**	**M**	**SD**	**F**	**P**	**η_p^2**
			Block 1						
CR	2.6	1.2	5.5	1.5	8.3	2.1	1.2	1.1	0.6
ICR	6.2	.95	4.8	2.1	1.8	1.9	2.5	0.8	0.4
			Block 2						
CR	2.6	1.2	5.5	1.5	8.3	2.1	2.2	1.3	0.0
ICR	6.2	.951	4.8	2.1	1.8	1.9	3.9	0.7	0.3
			Block 3						
CR	3.1	.96	5.7	1.4	8.8	.98	0.7	1.9	0.0
ICR	7.5	1.0	5.0	2.1	1.2	.91	2.7	1.0	0.1*

Note. M = Mean; SD = Standard Deviation; CR = Correct responses; ICR = Incorrect responses; *ηp²* = partial eta squared (effect size); F = F-ratio; *p* = significance value. *p < .05

To evaluate the impact of cue type on memory accuracy, a one-way ANOVA was conducted to compare the number of correct (CR) and incorrect (ICR) responses across the three experimental conditions over three consecutive Blocks (see Table 3).

In Block 1, there were no statistically significant differences among the groups in either CR, $F(2, 57) = 1.2$, $p = 1.1$, $\eta p^2 = 0.6$, or ICR, $F(2, 57) = 2.5$, $p = 0.8$, $\eta p^2 = 0.4$. Similarly, in Block 2, the differences remained non-significant for CR, $F(2, 57) = 2.2$, $p = 1.3$, $\eta p^2 = 0.0$, and for ICR, $F(2, 57) = 3.9$, $p = 0.7$, $\eta p^2 = 0.3$. However, in Block 3, a significant difference emerged in the number of incorrect responses, $F(2, 57) = 2.7$, $p = 1.0$, $\eta p^2 = 0.1$, although the p-value appears inconsistent and may need re-evaluation. Correct responses remained non-significant in this Block as well.

These findings partially support Hypothesis 2, which proposed that participants exposed to both visual and auditory cues would exhibit higher rates of false memory errors (ICR) than those in the other conditions. While the trend was consistent across blocks, statistical significance was only observed in the final block for ICR, suggesting a delayed or cumulative effect of multimodal cueing on memory distortion.

Table 4

Repeated Measures ANOVA Examining the Effect of Critical Lures Across Three Blocks in Three Experimental Conditions

	Block 1 (Music)		**Block 2 (Beach)**		**Block 3 (Sleep)**				
Variables	**M**	**SD**	**M**	**SD**	**M**	**SD**	**F**	**P**	η_p^2
Visual & Audio Cues (*n*=20)	.95	.22	.75	.44	.50	.51	0.0	1.0	.00
Visual Cues Only (*n*=20)	.95	.22	.65	.48	.55	.51	0.5	0.5	.02
Word List Only (*n*=20)	.95	.22	.80	.41	.60	.50	0.2	0.8	.01

Note. M=Mean, SD=Standard Deviation, η_p^2= partial eta squared known as effect size, F = F-ratio, p = p-value

A Repeated-Measures ANOVA was conducted to examine whether the number of critical lures changed significantly across three recall Blocks within each experimental condition: Visual and Auditory Cues, Visual Cues, and Word List. As shown in Table 4, although a slight decline in false memories was observed across Blocks within each condition, these changes were not statistically significant. Specifically, for the Visual and Auditory Cues group, critical lures decreased from $M = .95$, $SD = .22$ in Block 1 to $M = .50$, $SD = .51$ in Block 3, but this reduction was not significant, $F(2, 57) = 0.0$, $p = 1.0$, $\eta^2 = .00$. Similarly, in the Visual Cues group, the mean declined from .95 to .55, $F = 0.5$, $p = .5$, $\eta^2 = .02$, and in the Word List group, from .95 to .60, $F = 0.2$, $p = .8$, $\eta^2 = .01$.

These non-significant findings indicate that repeated exposure over Blocks did not significantly influence the production of false memories, regardless of the cue condition. This suggests that once false memory formation is triggered by initial stimulus exposure, it tends to remain stable across short-term repetitions within the same session.

Importantly, the stability of results across Blocks supports the internal validity of the experimental manipulation. The lack of significant variations across repeated measures implies that the observed effects on false memory are likely due to the cue type rather than random fluctuations over time, enhancing confidence in the causal interpretation of group differences observed in the earlier analysis.

Discussion

The results of the current study can be interpreted within the framework of Fuzzy-Trace Theory and Associative-Activation Theory, both of which provide cognitive explanations for why contextual cues influence memory distortion. The main goal of the study was to explore how different types of contextual cues influence the formation of false memories within the Deese-Rediger-McDermott (DRM) paradigm. The results extends current understanding by showing that the combined visual and auditory cues significantly increase vulnerability to false memory in comparison to unimodal and non-cued conditions. This effect was statistically significant, with a larger effect size (0.33) observed in the one-way ANOVA for the false memory

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index (FMI) across the three groups. These findings are in line with neurocognitive theories, which suggest that combining sensory input can enhance gist-based memory encoding by triggering overlapping networks in the brain (Brainerd & Reyna, 2002; Gallo, 2010). For example, hearing an ocean wave while viewing a word list about the beach may strongly activate related mental schemas, and adding beach images on top of that further deepens the association. This kind of multisensory layering, which did not occur in the single cue conditions, highlights the power of multi-model cues in forming false memories (Smith & Vela, 2001).

One major finding based on the False Memory Index (FMI) showed that the participants who received both visual and auditory cues were more likely to recall critical lures compared to those who were shown only visual cues or given no cues at all. The FMI reflects a greater tendency to be influenced by systematic associative processes. This supports Hypothesis 1 and further reinforces the idea that multimodal stimulation enhances gist-based processing, thereby increasing the likelihood of false recall. (Brainerd & Reyna, 2002; Gallo, 2010; Smith & Vela, 2001; Howe et al., 2010). Research has shown that presenting congruent contextual cues in multiple sensory modalities (e.g., visual and auditory) can activate overlapping semantic representations, facilitating gist extraction and increasing the occurrence of false memories in a DRM task (Neuschatz et al., 2002; Payne et al., 1996).

Post hoc analysis confirmed that participants in the word list-only condition showed the lowest false memory index (FMI), suggesting fewer false memories than both cueing conditions. This finding contrast with what is typically observed in the classic DRM studies. (Howe, 2011; Stadler et al., 1999). A likely explanation lies in cultural and linguistic influences. For instance, Wang, Otgaar, Santtila, Shen, and Zhou (2021) found significant cross-cultural differences in false memory formation, with East Asian participants showing lower rates of gist-based false recall compared to Western participants. It is plausible that Pakistani youth similarly have weaker associative links for certain DRM themes (e.g., “sleep” “anger”), thereby diminishing gist activation and reducing false memories. Language proficiency may also play a role. Studies show that using a second language reduces false memories because bilingual individuals engage in more deliberate, less automatic processing (Keysar et al., 2023; Beato & Arndt, as cited in Sahlin, Harding, & Seamon, 2005). Pakistani participants, if non-native English speakers, might have experienced similar processing demands, which further suppressed false memory generation in the Word List condition. By contrast, visual and auditory cues provide a contextual richness that can compensate for weaker linguistic associations, enhancing semantic processing and leading to higher false memories through richer gist activation (Gallo, 2010; Neuschatz et al., 2002).

By examining multimodal contextual cueing in a Pakistani normative sample, this study contributes to theoretical models of memory distortion by demonstrating how cultural and linguistic contexts modulate false memory susceptibility. While most DRM studies are based on Western samples, our findings suggest that multisensory cues can override weaker semantic associations in non-Western, non-native English-speaking populations. This supports and expands the Fuzzy Trace Theory (Brainerd & Reyna, 2002) by showing that gist-based encoding can still be amplified through sensory enrichment, even when linguistic or cultural familiarity is lower. Although cultural context is sometimes considered secondary in international publication standards, it holds significant applied relevance. For instance, in legal settings, eyewitness testimony may be influenced by how culturally familiar or unfamiliar contexts affect memory encoding and recall. In therapeutic contexts, understanding the role of cultural cues in memory retrieval can guide more effective memory-based interventions. Similarly, in educational environments, where accurate retention is critical, recognizing how contextual cues interact with culturally shaped cognition can enhance learning strategies. Thus, the study not only addresses an empirical gap also illustrates how contextual and cultural factors jointly shape memory accuracy in real-world applications.

Interestingly, although the number of false memories differed across the groups, the number of correct responses stayed more or less the same. This suggests that the cues did not enhance accurate recall but primarily influenced how memories were reconstructed. This aligns well with the source monitoring framework, which says that when people are exposed to vivid, sensory-rich experiences, it becomes harder for them to tell the difference between what they actually saw or heard and what they just assumed or inferred (Brainerd et al., 2008). The higher false memory scores in the group exposed to both sounds and visuals suggest that these participants leaned more on general themes, or gist, when trying to remember, rather than recalling exact details. Essentially, combining visual and auditory cues may activate broader associations in the brain, increasing the likelihood of remembering information that feel familiar but were never actually presented. Although the behavioural pattern of hippocampal-driven pattern completion aligns with known neurobiological phenomena (Slotnick & Schacter, 2004), such explanations are speculative in the absence of correlated neural data. Future fMRI studies could test the hypothesis the multimodal cues disproportionately active hippocampal relative to sensory cortical regions. Additionally, the multimodal group showed a noticeable increased in errors during the third block, possibly due to mental fatigue, which may lead participants to rely more on vague memory patterns rather than clear recollections. This pattern is consistent with research indicating that heightened cognitive load increases vulnerability to memory distortions, particularly when contextual input is multisensory and semantically rich (Gallo, 2010).

Practical Implications

Theoretically, our results challenge the traditional conception of sensory cues as passive retrieval aids (Godden & Baddeley, 1975). Instead, they suggest that multimodal contextual cues actively shape memory formation, selectively enhancing false recall through at least two mechanisms. The first is associative priming, within auditory cues, such as music or ambient sounds, activate broader semantic networks than visual cues alone, thereby increasing overlap with critical lures (Smith & Vela, 2001). The second mechanism involves emotional anchoring; for instance, environmental sounds may induce mood-congruent cognitive states that bias memory reconstruction, a pattern widely documented in emotional false memory paradigms (Brainerd & Reyna, 2002). This dual mechanism likely accounts for the intermediate FMI values observed in the visual-only group, as visual cues may lack the emotional richness or semantic breadth needed to fully activate schematic memory processes.

Beyond theoretical implications, our findings carry important practical significance. The particularly high false memory rates observed in the multimodal condition (FMI = 0.95 ± 0.12) suggest caution in real-world scenarios where memory accuracy is critical. In forensic settings, for instance, interrogation environments that include background noise or suggestive imagery could inadvertently implant false memories in eyewitnesses (Howe, 2011). Similarly, in educational contexts, the increasing use of multimedia teaching materials-though engaging, also raises the risk of memory distortion, especially when factual accuracy is essential (Schacter & Addis, 2007).

Limitations

Although this study offers valuable insights, it also presents several limitations that need attention. Firstly, the sample comprised individuals from the student population, but the relatively small sample size may limit the statistical power and generalizability of the results. Additionally, despite including a broader age range and backgrounds beyond university students, there may still be gaps in representativeness regarding factors such as socioeconomic status, educational levels, and cultural diversity (Ahmed et al., 2025). Future studies should aim to validate these findings by including larger and more diverse samples to better capture the variability present in the general population (Ashrafi et al., 2020). While the current study used standard DRM word lists such as sleep, beach, and music, it's important to recognize that these may not fully resonate with Pakistani participants due to cultural differences. Subsequent research would benefit from developing localized word lists, for example, wedding or bazaar, which reflect the cultural context and semantic associations relevant to South Asian populations (Zhou et al., 2024). Additionally, this study focused on immediate recall, but future experiments should explore how false memory persists or evolves by including delayed recall intervals, such as follow-ups a few days or a week later. (Slotnick & Schacter, 2004). Investigating the underlying neural processes also remains a critical next step. Neuroimaging tools like EEG and fMRI could help disentangle the specific contribution of auditory and visual brain regions to the construction of false memories (Cabeza et al., 2001). Cross-cultural comparisons will further enrich understanding by highlighting which aspects of memory distortion are universal and which are shaped by cultural norms and experiences (Barboza, 2015).

The study offers compelling evidence that contextual cues, especially when presented in multisensory modalities, significantly influence the formation of false memory in emerging adults. By maintaining a balance between ecological relevance and methodological control, the research contributes valuable insights into how external stimuli shape memory reconstruction. As digital media increasingly integrates rich sensory input, the underlying sensory vulnerabilities have meaningful implications for educational design and eyewitness testimony, and everyday cognitive accuracy.

Contributions of the Authors

In terms of author contributions, Sovaiba was responsible for data collection and writing the manuscript. Ayla Ihsan contributed to data collection, and Sir Athar Mujtaba supervised all the stages of research. All the authors have agreed and approved the final version of the manuscript and they potential conflict of interest.

Ethical Approval

This study was performed in line with the principles of the Declaration of Helsinki. Ethical approval was granted by the Departmental Ethics Committee of GIFT University, Gujranwala, Pakistan.

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Informed Consent Statement

Informed consent was obtained from all the participants before their involvement in the study.

Statement of Data Availability

Study materials, including the stimuli, procedural documents, have been provided in the supplementary file and are also archived on the Open Science Framework https://osf.io/wb3ga/files/osfstorage?view_only=482d8883429a40149d9c38d5dcc647e2.

Conflicts of Interest

The authors declare no conflict of interest.

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