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# Enhancing Long-Term Sequential Memory through the Timeline Technique: Evidence from Reporting Modalities and Implications for Educational and Forensic Contexts

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**Abstract: Objective:** This study examined whether different Timeline Technique (TLT) reporting modalities improve long-term sequential memory accuracy and recall speed among university students. **Methodology:** A between-subjects experiment involved 140 female undergraduates at Qatar University (ages 19–53), randomly assigned to written TLT, hand-drawing TLT, hand-drawing with captions TLT, verbal TLT, or free-recall control. After placing six objects in specified locations across naturalistic scenes, participants recalled object identity, location, chronological sequence, and completion time. Reports were manually scored and analyzed using one-way ANOVA and planned independent-samples t-tests. **Key Findings:** Groups did not differ in learning accuracy, $F(4, 133) = .87$, $p = .48$, $\eta^2 = .025$. Reporting modality significantly affected object recall, $F(4, 135) = 3.26$, $p < .05$, $\eta^2 = .088$; verbal TLT outperformed free recall, $t(50.77) = -2.49$, $p < .01$, $d = -.63$, as did drawing with captions, $t(56.46) = -2.19$, $p < .05$, $d = -.57$. Sequential accuracy also differed, $F(4, 114) = 7.44$, $p < .001$, $\eta^2 = .21$, with verbal TLT superior to control, $t(48.80) = -3.63$, $p < .001$, $d = -.94$. Location accuracy was not significantly affected, $F(4, 129) = 2.30$, $p = .062$, $\eta^2 = .066$. Recall time differed across conditions, $F(4, 124) = 21.33$, $p < .001$, $\eta^2 = .41$; verbal TLT was faster than control, $t(29.91) = 6.28$, $p < .01$, $d = 1.77$. **Conclusions:** Verbal TLT most consistently enhanced object and sequential recall while reducing reporting time; drawing with captions also supported object recall. **Recommendations:** Educational and forensic applications should prioritize verbal timeline reporting and test it in more diverse samples using standardized, multi-rater scoring.

**Keywords:** Timeline Technique, Sequential Memory, Long-term Memory, Recall Accuracy, Quality Education (SDG 4), Peace, Justice and Strong Institutions (SDG 16).

# تعزيز الذاكرة التسلسلية طويلة المدى باستخدام تقنية الخط الزمني: دلالات تطبيقية في السياقات التعليمية والجنائية

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**الملخص الهدف:** هدفت الدراسة إلى اختبار أثر أنماط التقرير المختلفة لتقنية الخط الزمني في دقة وسرعة استرجاع الذاكرة التسلسلية طويلة المدى لدى طالبات جامعيات. **المنهجية:** استُخدم تصميم تجريبي بين المجموعات شمل 140 طالبة في جامعة قطر، تراوحت أعمارهن بين 19 و53 سنة، وُزعن عشوائيًا على خمس حالات: السرد الكتابي باستخدام الخط الزمني، والرسم اليدوي، والرسم مع تعليقات كتابية، والسرد اللفظي، والاسترجاع الحر دون التقنية. بعد وضع ستة أشياء في مواقع محددة داخل مشاهد طبيعية، استرجعت المشاركات هوية الأشياء ومواقعها وتسلسلها الزمني، وسُجل زمن الإنجاز. صُححت التقارير يدويًا، وحُللت البيانات باستخدام تحليل التباين الأحادي واختبارات ت للعينات المستقلة

**أهم النتائج:** لم تختلف المجموعات في دقة التعلم، $F(4, 133) = .87$, $p = .48$, $\eta^2 = .025$. وظهر أثر دال لنمط التقرير في دقة استرجاع الأشياء، $F(4, 135) = 3.26$, $p < .05$, $\eta^2 = .088$؛ إذ تفوقت مجموعة السرد اللفظي على المجموعة الضابطة، $t(50.77) = -2.49$, $p < .01$, $d = -.63$، كما تفوقت مجموعة الرسم مع التعليقات، $t(56.46) = -2.19$, $p < .05$, $d = -.57$. واختلفت دقة التسلسل دالًا، $F(4, 114) = 7.44$, $p < .001$, $\eta^2 = .21$، لصالح السرد اللفظي مقارنة بالضابطة، $t(48.80) = -3.63$, $p < .001$, $d = -.94$. ولم يظهر أثر دال في دقة المواقع، $F(4, 129) = 2.30$, $p = .062$, $\eta^2 = .066$. كما اختلف زمن الاسترجاع، $F(4, 124) = 21.33$, $p < .001$, $\eta^2 = .41$، وكان السرد اللفظي أسرع من الاسترجاع الحر، $t(29.91) = 6.28$, $p < .01$, $d = 1.77$.

**الاستنتاجات:** كان السرد اللفظي باستخدام الخط الزمني الأكثر اتساقًا في تحسين استرجاع الأشياء والتسلسل وتقليل زمن التقرير، كما دعم الرسم مع التعليقات استرجاع الأشياء. **التوصيات:** توصي الدراسة بإعطاء الأولوية للتقرير اللفظي المنظم زمنيًا في التطبيقات التعليمية والجنائية، واختباره على عينات أكثر تنوعًا باستخدام تصحيح معياري متعدد المقيمين. **الكلمات المفتاحية:** تقنية الخط الزمني، الذاكرة التسلسلية، الذاكرة طويلة المدى، دقة الاسترجاع، التعليم الجيد (الهدف 4 من أهداف التنمية المستدامة)، السلام والعدل والمؤسسات القوية (الهدف 16 من أهداف التنمية المستدامة).

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## Background

Recent cognitive psychology literature emphasizes that memory is not a passive record of past experience, but an active and reconstructive process shaped by attention, context, and retrieval conditions (Morales-Calva & Leal, 2025). Memory allows individuals to encode, retain, and retrieve information across time; however, recall accuracy may be affected by forgetting, interference, reconstruction, and the absence of effective retrieval cues. Early experimental work also established that memory weakens over time without effective rehearsal or retrieval support (Ebbinghaus, 1913).

This issue is especially important in educational and forensic contexts, where individuals are often required to remember not only isolated details, but also the order, location, and meaning of events. In classroom learning, students may need to recall procedures or historical sequences, whereas in investigative interviews witnesses may need to reconstruct actions in their correct chronological order. Therefore, improving the structure through which information is retrieved remains an important concern in applied memory research, particularly when recall accuracy has practical consequences for learning, testimony, and decision-making (Foudil et al., 2021; Torres-Morales & Cansino, 2024).

Long-term memory involves the retention and later retrieval of information after the immediate processing period has ended, and it includes memory for items, locations, events, and temporal relations (Morales-Calva & Leal, 2025). Within this broader system, episodic memory refers to the recollection of experienced events within their spatial and temporal contexts, whereas sequential or serial-order memory refers more specifically to the ability to remember items, actions, or events in the order in which they occurred. Recent models of serial memory suggest that order recall depends on contextual and positional cues that help individuals move from one remembered element to the next (Logan & Cox, 2021, 2023). This distinction is central to the present study because many real-life situations require people to remember what happened, where it happened, and in what sequence it happened. Thus, long-term sequential memory should be examined as a distinct recall outcome rather than treated simply as a general form of episodic memory (Lohnas, 2025; Ward & Beaman, 2025).

Contemporary theories of serial and sequential memory provide useful explanations for how ordered information is encoded and retrieved. Retrieved-context models suggest that each item in a sequence becomes linked to a changing temporal context, and this context later serves as a cue for recall (Lohnas, 2025). Similarly, recent serial-order accounts argue that people may rely on both item-dependent and item-independent contextual cues when reconstructing a sequence (Logan & Cox, 2023). From a working-memory perspective, sequential recall may become more difficult when individuals must simultaneously remember the relevant items, organize their order, and produce a response in a demanding format. Cognitive-load theory therefore suggests that external supports may improve performance when they reduce unnecessary processing demands and allow cognitive resources to be directed toward the core retrieval task (Paas & van Merriënboer, 2020). In this sense, structured reporting formats such as timelines may support sequential recall by providing an external temporal scaffold that helps organize remembered information more efficiently (Ward & Beaman, 2025). Working-memory research further shows that maintenance depends on limited-capacity resources, selective attention, and the organization of material into manageable units (Gathercole, 1994; Lepsien et al., 2011; Thalmann et al., 2019). Recent evidence also indicates that temporal processing and sequential shifts of attention are especially relevant to preserving serial order, whereas spatial processing may make a different contribution (Attout et al., 2026; Li & Saiki, 2014).

The Timeline Technique (TLT) has been proposed as a structured reporting method that may support memory retrieval by organizing recalled information along a temporal framework (Hope et al., 2019). Unlike free

recall, which requires individuals to decide independently where to begin and how to organize their account, the TLT provides a visible or conceptual temporal structure that can guide the reporting process. This structure may reduce the cognitive burden associated with organizing complex information while allowing individuals to move flexibly across the timeline and add details as they become accessible. Recent research has also shown that the usefulness of the TLT may depend on the reporting context and the characteristics of the participants, including cultural and communication factors (Hope et al., 2026). Therefore, examining different forms of TLT reporting is necessary to determine whether the technique is equally effective across written, verbal, drawing-based, and combined modalities (Kontogianni et al., 2021).

Previous research has provided evidence that timeline-based reporting can improve memory performance in applied contexts. Hope et al. (2013) showed that using a timeline format helped participants report more correct details and reduced sequencing errors when recalling a complex event. Later, Hope et al. (2019) demonstrated that a timeline approach could improve recall of conversational information, including who said what and when. More recently, Kontogianni et al. (2021) found that combining timeline reporting with additional retrieval supports could facilitate recall and particularization of repeated events. However, recent cross-cultural evidence also indicates that the benefits of the TLT may not be uniform across all groups or contexts, suggesting that cultural background and reporting norms may influence how participants use the technique (Hope et al., 2026). Together, these studies suggest that TLT is a promising structured recall tool, but they also show the need for further research on its effectiveness across different memory tasks and reporting modalities. Timeline-interviewing research also suggests that self-generated cues and open follow-up prompts can facilitate access to additional event information (Kontogianni et al., 2018, 2020).

## Study Problem

Despite these contributions, an important research problem remains. Most previous studies on the Timeline Technique have focused on episodic event recall, eyewitness accounts, repeated events, or conversational memory (Hope et al., 2019; Kontogianni et al., 2021). Although these studies included elements of temporal organization, they did not primarily examine long-term sequential memory as a distinct form of recall. This distinction matters because sequential recall requires individuals to remember not only the identity of items, but also their correct order within a temporal structure. Recent models of serial memory emphasize that sequence recall depends on contextual and order-based cues that may differ from those involved in general item recall (Logan & Cox, 2023; Lohnas, 2025).

Moreover, object identity, spatial location, and temporal order may rely on partly different cognitive and neural processes, which means that a technique supporting temporal recall may not necessarily improve spatial recall to the same degree (Torres-Morales & Cansino, 2024). Therefore, it remains unclear whether TLT improves all components of long-term sequential memory equally, or whether its benefits are stronger for specific outcomes such as object recall, location recall, sequence accuracy, or recall time. In addition, limited evidence is available regarding which reporting modality—written narrative, hand-drawing, hand-drawing with captions, or verbal narrative—is most effective in supporting long-term sequential memory recall. Accordingly, the present study addresses this gap by examining the effect of different TLT reporting modalities on long-term sequential memory among university students.

## Research Questions

The present study was guided by the following research questions:

1. Does the reporting modality significantly affect object recall accuracy after controlling for baseline learning accuracy?

2. Does the reporting modality significantly affect memory sequence accuracy after controlling for baseline learning accuracy?
3. Does the reporting modality significantly affect location recall accuracy after controlling for baseline learning accuracy?
4. Does the reporting modality significantly affect recall time after controlling for baseline learning accuracy?
5. Which Timeline Technique reporting modality is most effective in enhancing long-term sequential memory recall compared with free recall?

## Study Significance

Addressing this problem is important for both theoretical and applied reasons. Theoretically, studying TLT in relation to long-term sequential memory can clarify whether external temporal scaffolds support recall by strengthening contextual organization, reducing cognitive load, or improving access to item-order associations (Lohnas, 2025; Logan & Cox, 2023). This contributes to memory research by extending the application of TLT beyond episodic event recall and eyewitness reporting to a more specific form of memory: long-term sequential recall. It also helps clarify whether the benefits of structured retrieval are general across memory outcomes or more strongly related to particular components such as item recall and temporal order.

Practically, identifying the most effective reporting modality may be useful in educational contexts, where students often need to remember ordered material such as historical events, procedural steps, scientific processes, and narrative sequences. Cognitive-load theory suggests that learning and retrieval may improve when instructional or reporting formats reduce unnecessary demands on working memory (Paas & van Merriënboer, 2020). In forensic and investigative contexts, the ability to recall actions and events in their correct chronological order is also important for eyewitness accounts and structured interviews. At the same time, recent research on drawing-based learning indicates that visual production can support memory, but its effectiveness depends on task design, learner support, and the effort required to generate drawings (Dechamps & Skulmowski, 2025; Zhang & Fiorella, 2021). Therefore, comparing different TLT modalities may provide useful evidence for selecting appropriate memory-support strategies in educational and forensic settings. Research on writing media and note-taking further indicates that the response medium can shape retention and recall in educational tasks (Lee, 2021; Schoen, 2012).

## Study Objectives

The main objective of this study was to examine the effect of different Timeline Technique reporting modalities on long-term sequential memory recall among university students. Specifically, the study aimed to:

1. examine differences between reporting modalities in object recall accuracy;
2. examine differences between reporting modalities in memory sequence accuracy;
3. examine differences between reporting modalities in location recall accuracy;
4. compare recall time across different reporting modalities;
5. determine whether TLT-based reporting formats produce better recall outcomes than free recall; and
6. identify which TLT reporting modality provides the strongest support for long-term sequential memory recall.

## Research Hypotheses

Based on previous research on timeline reporting, multi-modal recall, and memory retrieval, the study was guided by the following hypotheses:

1. Participants using any TLT reporting format will demonstrate more accurate sequential recall than participants using free recall without TLT.

2. Participants using a multi-modal TLT format, specifically hand-drawing with written captions, will show better long-term recall accuracy than participants using a single-modality TLT format.
3. Participants using visual TLT formats, including hand-drawing and hand-drawing with captions, will access and report long-term sequential memory more accurately and more quickly than participants using verbal or written reporting formats.

## Methods

### Study Design

This study employed a between-subjects experimental design to examine the effect of different Timeline Technique (TLT) reporting modalities on long-term sequential memory recall. The independent variable was the reporting modality, which included five conditions: TLT with written narrative, TLT with hand-drawing, TLT with hand-drawing plus written captions, TLT with verbal narrative, and free recall without TLT. The dependent variables were object recall accuracy, memory sequence accuracy, location recall accuracy, and recall time.

### Participants and Setting

A total of 151 undergraduate students were initially recruited from Qatar University. Eleven participants were not included in the final sample because they self-reported a history of mental health conditions during the screening stage of the study. The final sample consisted of 140 female undergraduate students aged between 19 and 53 years. At the time of data collection, participants were enrolled in Psychology and/or English Literature programs.

Participants were recruited from different academic years through several channels, including email invitations, class announcements, word of mouth, and direct messages. Participation was voluntary, and no language-based exclusion criterion was applied. All participants received standardized instructions before beginning the experiment, and the study was conducted under controlled conditions in a computer laboratory to reduce environmental variability and ensure consistency in data collection.

### Inclusion and Exclusion Criteria and Randomization Procedure

Participants were eligible for inclusion if they were female undergraduate students enrolled at Qatar University during the period of data collection, were enrolled in Psychology and/or English Literature programs, were able to understand and follow the experimental task instructions, and voluntarily agreed to participate in the study. Participants were excluded if they self-reported a history of pre-existing mental health conditions during the screening stage. Eleven participants were excluded on this basis, resulting in a final sample of 140 participants. No language-based exclusion criterion was applied.

After eligibility screening, the remaining participants were randomly assigned to one of the five reporting conditions: TLT with written narrative, TLT with hand-drawing, TLT with hand-drawing plus written captions, TLT with verbal narrative, and free recall without TLT. This random assignment was conducted before the recall phase to reduce selection bias and to support comparability between the experimental and control conditions. All participants received standardized task instructions, and the experiment was implemented under controlled laboratory conditions to ensure consistency across groups.

## Experimental Conditions

Participants were randomly assigned to one of five reporting conditions. In the written TLT condition, participants used a timeline format and provided their recall in written narrative form. In the hand-drawing TLT condition, participants used a timeline format and reported their recall through drawings. In the hand-drawing plus captions condition, participants combined drawings with short written captions. In the verbal TLT condition, participants reported their recall orally using a timeline-based verbal narrative. In the control condition, participants completed a free recall task without using the Timeline Technique.

## Procedure

The experiment was completed in a computer laboratory. At the beginning of the session, participants received on-screen instructions explaining the task requirements. They were first asked to report whether they had any pre-existing mental health conditions. Participants who answered "Yes" were excluded from the final sample. The remaining participants proceeded to the experimental task.

After completing a practice session, participants were asked to complete an online memory task. During this task, they dragged six objects to highlighted locations within different naturalistic scenes, such as a café, carnival, and living room. Participants were given seven minutes to complete this task. The purpose of this stage was to allow participants to encode the identity of each object, its location, and its position within a sequence.

Following the online task, participants were instructed to recall the identity of each object, its location within the scene, and the exact chronological order in which the objects had been placed. Depending on their assigned condition, participants completed the recall task using one of the five reporting formats: written TLT, hand-drawing TLT, hand-drawing plus captions TLT, verbal TLT, or free recall without TLT. The recall phase had no time limit. Participants were allowed to ask for clarification regarding the instructions before submitting their recall reports.

## Outcome Measures and Scoring

Recall performance was assessed using four outcome measures. Object recall accuracy referred to the number of objects correctly recalled by each participant. Location recall accuracy referred to the number of object locations correctly recalled within the scenes. Memory sequence accuracy referred to the accuracy with which participants recalled the chronological order in which the objects were originally placed. Recall time referred to the total time required by each participant to complete the recall report.

Participants' recall reports were timed and manually scored by a single researcher. The researcher counted the number of correctly recalled objects, the number of correctly recalled locations, and whether the sequence of objects in each scenario was correctly reported. These scores, together with the time required to complete each recall report, were recorded in an Excel spreadsheet before statistical analysis.

## Statistical Analysis

The data were processed and analyzed using R statistical software. Descriptive statistics were used to summarize participants' performance across the five reporting conditions. One-way analysis of variance (ANOVA) was conducted to examine differences between reporting modalities in learning accuracy, object recall

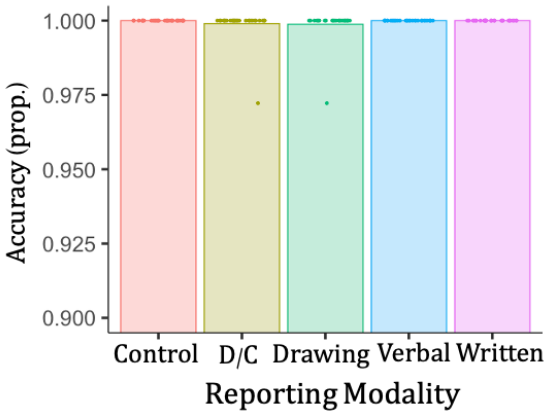
accuracy, memory sequence accuracy, location recall accuracy, and recall time. Planned independent-samples t-tests were then conducted to compare specific TLT conditions with the free recall control condition. Effect sizes were reported using eta squared ($\eta^2$) for ANOVA results and Cohen's d for t-test comparisons. Statistical significance was set at $p < .05$.

Given that the present study employed a between-subjects experimental design rather than a pretest–posttest design, and because the dependent recall outcomes were measured only during the recall phase, ANCOVA was not applied. Instead, one-way ANOVA was considered appropriate for comparing the five independent reporting conditions. To assess baseline equivalence, learning accuracy during the encoding task was compared across groups, and the results showed no statistically significant differences, indicating comparable initial encoding performance across conditions.

## Results

First, a one-way analysis of variance (ANOVA) was performed to compare participants' average accuracy (dependent variable) across the different reporting formats (independent variable) during the learning task. There was no significant difference in learning accuracy between the five different groups, $F(4, 133) = .87$, $p = .48$, $\eta 2 = .025$. This indicates that participants in all conditions accurately encoded the presented information during the online task.

**Figure 1** *Scores of Learning Accuracy*




*Note.* The mean number of objects recalled accurately for each reporting modality (i.e., control/free recall, drawing + caption, drawing, verbal, written).

To measure object recall accuracy, an analysis was performed using a one-way ANOVA, with TLT type as the independent variable, $F(4, 135) = 3.26$, $p < .05$, $\eta 2 = .088$. Planned, one-way, unpaired samples t-tests were used to reveal the following relationships: Participants were more accurate at object recall after using the verbal TLT than those who engaged in free recall, $t(50.77) = -2.49$, $p < .01$, Cohen's $d = -.63$. Also, object recall was significantly more accurate in the drawing + caption TLT condition than in the control condition, $t(56.46) = -2.19$, $p < .05$, Cohen's $d = -.57$.

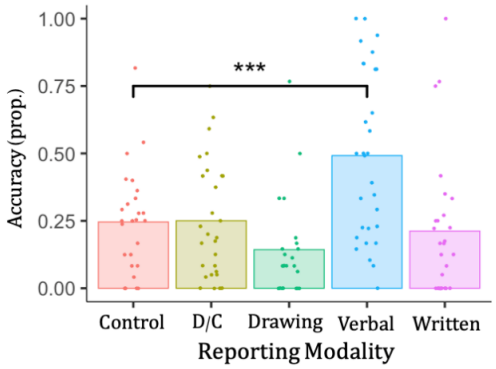



**Figure 2 :** *Scores of Object Recall Accuracy*

*Note.* The mean number of objects accurately recalled for each reporting modality.

To measure sequential recall accuracy, this study conducted a one-way ANOVA, with reporting format as the independent variable. There was a significant effect of reporting format on the accuracy of sequential order memory, F(4, 114) = 7.44, p <.001, η2=.21. Planned, one-way, unpaired samples t-tests were used to explore the nature of effects involving TLT type. The sequential recall was significantly more accurate for participants who used a verbal TLT compared to those in the control group, t(48.80) = -3.63, p <.001, Cohen's d = -.94.

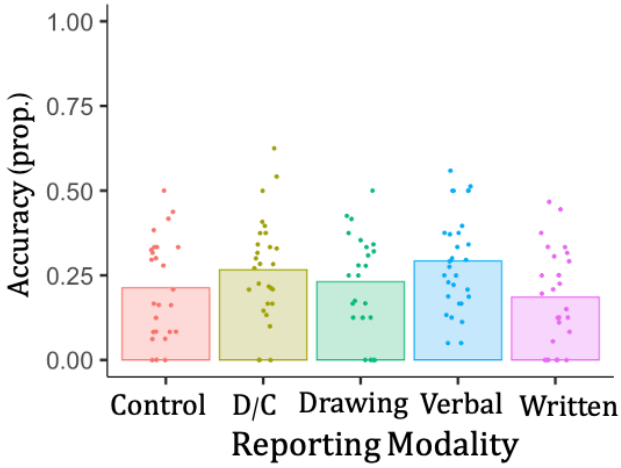



**Figure 3:** *Scores of Memory Sequence Accuracy*

*Note.* The mean of correct memory sequence accurately for each reporting modality. To evaluate location report accuracy, this study conducted a one-way ANOVA, with reporting format as the independent variable. The results revealed no significant effect of reporting format on location report accuracy F(4, 129) = 2.30, p = .062, η2=.066.

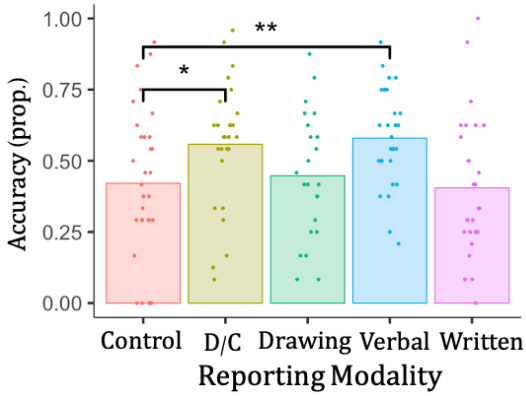



**Figure 4:** *Scores of Location Recall Accuracy*

*Note.* The mean number of locations accurately recalled for each reporting modality.

To analyze the relative recall speed, a one-way ANOVA was conducted, with reporting format as the independent variable. There was a significant effect of reporting format on recall time, F(4, 124) = 21.33, p < .001, $\eta^2$ = .41. Planned, one-way, unpaired samples t-tests were used to explore the nature of effects involving reporting format. The recall was significantly faster for participants in the verbal TLT condition compared to those in the control group, t(29.91) = 6.28, p <.01, Cohen's d = 1.77.

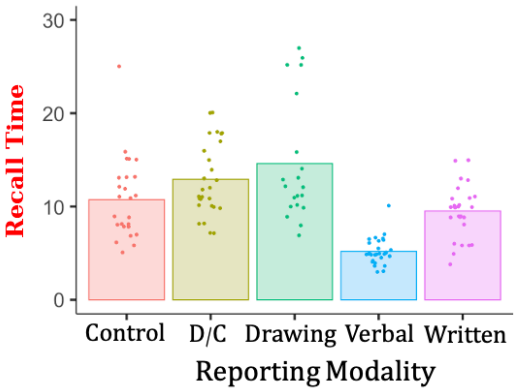



**Figure 5 :** *Scores of Recall Time*

*Note.* The mean recall time for each reporting modality.

## *Discussion*

The present study examined the effect of different Timeline Technique (TLT) reporting modalities on long-term sequential memory recall. Building on previous research showing that timeline-based formats can support event and conversation recall (Hope et al., 2019; Kontogianni et al., 2021), this study compared four TLT modalities—written narrative, hand-drawing, hand-drawing with written captions, and verbal narrative—with a free recall condition. The findings provide partial support for the study hypotheses and suggest that the benefits of TLT vary according to the specific memory outcome being assessed. In particular, verbal TLT appeared most useful for sequential recall and recall speed, while drawing plus captions appeared beneficial for object recall. These results are consistent with recent views that memory retrieval depends on the interaction between contextual cues, reporting demands, and the structure provided during recall (Lohnas, 2025; Ward & Beaman, 2025).

The first important finding is that there were no significant differences between the five groups in learning accuracy. This suggests that participants across conditions encoded the experimental material at a relatively similar level before the recall phase. From a methodological perspective, this strengthens the interpretation that later differences in recall were more likely related to the reporting modality than to unequal initial learning. This interpretation is important because memory performance can be influenced by both encoding and retrieval conditions (Morales-Calva & Leal, 2025). Since the groups did not differ significantly during the learning stage, the observed advantages of verbal TLT and drawing plus captions are more plausibly interpreted as effects of retrieval structure and response format. This supports the view that structured retrieval cues can influence recall even when initial encoding is comparable across participants (Foudil et al., 2021; Lohnas, 2025).

The results showed that the verbal TLT condition produced the strongest effect on sequential memory recall. Previous studies have shown that timeline reporting can improve the recall of complex events and conversations by helping individuals organize information according to temporal relations (Hope et al., 2013, 2019). In the present study, participants who used the verbal timeline format recalled the sequence of objects more accurately than those in the free recall condition, suggesting that the verbal TLT may also support long-term sequential memory. This finding extends prior TLT research beyond eyewitness and episodic event recall by showing its relevance to a more specific memory outcome: the reconstruction of item order after a delay. Recent serial-order models help explain this result because they emphasize that ordered recall depends on contextual and positional cues that guide transitions between remembered items (Logan & Cox, 2023; Lohnas, 2025). Thus, the verbal timeline may have provided a useful temporal scaffold that helped participants reconstruct the

object sequence more accurately than free recall.

The superiority of the verbal TLT format may be explained by its relatively low production demands. Cognitive-load theory suggests that performance may improve when unnecessary demands on working memory are reduced, allowing individuals to focus on the essential task of retrieving and organizing information (Paas & van Merriënboer, 2020). In this study, verbal reporting may have allowed participants to express remembered information quickly without spending additional cognitive resources on handwriting, spelling, spatial arrangement, or drawing production. This is important because sequential recall already requires the participant to retrieve object identity, maintain order information, and organize the sequence coherently. Compared with written or drawing-based reporting, verbal TLT may therefore have reduced extraneous production demands while preserving the benefits of temporal organization. This interpretation is consistent with recent work suggesting that serial recall depends on both memory representations and the retrieval context in which those representations are accessed (Ward & Beaman, 2025; Lohnas, 2025). This account is consistent with earlier evidence that spoken and written recall can differ because the two reporting modes impose different production requirements (Bekerian & Dennett, 1990), and with capacity models emphasizing the working-memory demands of composing written responses (McCutchen, 1996).

The finding that the verbal TLT group completed the recall task more quickly than the free recall group further supports the cognitive-efficiency interpretation. In retrieved-context models, recall is guided by contextual cues that help initiate and organize access to stored information (Lohnas, 2025). The verbal timeline may have helped participants move through the remembered sequence with less hesitation because the temporal structure was already available as an organizing framework. In contrast, participants in the free recall condition may have needed to spend more time deciding how to begin, how to arrange remembered objects, and how to check the order of the sequence. Faster recall in the verbal TLT condition should therefore not be interpreted simply as speed, but as a possible indicator of more efficient retrieval organization. This explanation is consistent with cognitive-load theory, which suggests that reducing irrelevant task demands can improve the efficiency of learning and performance (Paas & van Merriënboer, 2020; Wylie & Evans, 2023).

The results also showed that both the verbal TLT and the hand-drawing plus caption TLT conditions improved object recall accuracy compared with free recall. Research on drawing and memory suggests that drawing can support recall by encouraging visual, motor, and semantic processing of information (Roberts & Wammes, 2021). In the present study, however, the strongest drawing-related benefit appeared when drawing was combined with written captions, rather than when drawing was used alone. This suggests that the captions may have strengthened the connection between the visual representation and the verbal identity of each object. Recent studies on learning by drawing indicate that drawing is not automatically beneficial in all circumstances; rather, its effectiveness depends on the level of support provided and the cognitive demands of the task (Zhang & Fiorella, 2021; Dechamps & Skulmowski, 2025). Therefore, the drawing plus caption condition may have improved object recall because it provided multiple retrieval cues—visual, verbal, and temporal—within the same reporting format (Navratil & Kühl, 2023). The drawing advantage has been reported in free recall, although its strength depends on whether drawing, doodling, or

writing is used and on the task conditions (Meade et al., 2019; Wammes et al., 2016). Related enactment research likewise shows that active production can influence later recall, but that its benefit is conditional rather than universal (Steffens et al., 2015).

However, the findings did not fully support the hypothesis that visual TLT formats would be superior to verbal or written formats. Although drawing has been shown to enhance memory in some contexts, recent research indicates that drawing-based learning and recall are sensitive to task complexity, learner support, and the quality of the generated visual representation (Zhang & Fiorella, 2021). In the present study, the purely visual drawing condition did not produce the strongest sequential recall performance. One possible explanation is that drawing during retrieval imposed additional visuomotor and organizational demands, especially because participants had to remember object identity, location, and order at the same time. Dechamps and Skulmowski (2025) similarly note that drawing can be beneficial when appropriately designed, but it may become less effective when the drawing task itself consumes excessive cognitive resources. Therefore, while drawing may help strengthen memory for object identity, it may not be the most efficient method for reconstructing temporal sequence unless supported by verbal labels or captions (Navratil & Kühl, 2023).

The absence of a significant effect of reporting modality on location recall accuracy is also noteworthy. Episodic memory includes information about what happened, where it happened, and when it happened, but recent research suggests that spatial and temporal contextual information may rely on partly distinct cognitive and neural processes (Torres-Morales & Cansino, 2024). In the present study, TLT primarily provided a temporal structure, which may explain why it was more effective for sequence recall than for precise location recall. Remembering where an object was placed within a scene may depend more heavily on spatial binding and scene-based memory than on temporal organization alone. This interpretation is consistent with recent work showing that space and time are both central to episodic memory, but they may not be retrieved through identical mechanisms (Foudil et al., 2021). Therefore, the findings suggest that TLT should not be treated as a general tool that improves all memory components equally; instead, its effectiveness may depend on whether the target outcome is temporal, spatial, or item-based.

From a theoretical perspective, the findings contribute to research on sequential memory by supporting the importance of temporal organization in recall. Serial-order models argue that remembering a sequence involves more than retrieving separate items; it requires reconstructing relations among items within a contextual framework (Logan & Cox, 2021, 2023). In the present study, the TLT may have acted as an external temporal scaffold that helped participants organize recalled objects according to their original order. This interpretation is also compatible with retrieved-context models, which propose that recall is guided by contextual cues that help access and transition between stored representations (Lohnas, 2025). By showing that verbal TLT improved sequential accuracy, the study suggests that structured temporal reporting can support the retrieval of ordered information. Thus, the findings extend the theoretical relevance of TLT from general event recall to the more specific domain of long-term sequential memory (Ward & Beaman, 2025).

The current study also has practical implications for educational and forensic contexts. In education, students are often required to remember information in sequence, such as historical timelines, procedural steps,

scientific processes, or narrative events. Cognitive-load theory suggests that structured supports can improve performance when they reduce unnecessary processing demands and help learners focus on essential information (Paas & van Merriënboer, 2020). Therefore, verbal TLT may be useful as a classroom or revision strategy when students need to organize and retrieve sequential material. In forensic and investigative contexts, timeline-based reporting has already shown promise for helping witnesses organize complex event information (Hope et al., 2019; Kontogianni et al., 2021). However, recent evidence also suggests that the usefulness of the TLT may vary across cultural and reporting contexts (Hope et al., 2026). Accordingly, the present findings support the potential value of verbal timeline reporting, but they also indicate the need for further testing in more diverse and naturalistic settings before broad professional application.

Nevertheless, the results should be interpreted with caution. The sample consisted only of female undergraduate students from Qatar University, which limits the generalizability of the findings to broader populations, particularly because recent research on self-administered timeline reporting suggests that memory reporting may vary across cultural and communication contexts (Hope et al., 2026). In addition, the scoring process was conducted manually by a single researcher, which may introduce subjectivity or scoring bias. Reliability research emphasizes the importance of using clear scoring criteria and reporting agreement between raters when human judgment is involved in coding or scoring responses (Koo & Li, 2016). Future studies should therefore include more diverse samples in terms of gender, age, educational background, and cultural context, and should use standardized scoring protocols, multiple independent raters, and inter-rater reliability checks to strengthen the reliability and reproducibility of the findings. In addition, future research should examine not only whether participants recalled the correct objects, locations, and sequence, but also the level of detail, specificity, and qualitative richness of their reports, as previous work on timeline-based and multi-method interviewing has shown the importance of distinguishing between general recall and more detailed, particularized memory reports (Kontogianni et al., 2021).

Overall, this study provides evidence that the Timeline Technique can enhance long-term sequential memory recall, particularly when implemented through verbal narration or through a combined drawing-and-caption format. Previous research has established the value of TLT in eyewitness and conversation recall, but the present study extends this evidence by applying the technique to long-term sequential memory (Hope et al., 2019; Kontogianni et al., 2021). The findings suggest that the effectiveness of TLT depends not only on the presence of a timeline structure, but also on the modality through which recall is reported. Verbal TLT appears especially useful for sequential recall because it combines temporal structure with low production demands, while drawing plus captions may be more helpful for object recall because it provides both visual and verbal retrieval cues. This pattern is consistent with recent memory and learning research showing that retrieval depends on the match between task demands, cognitive resources, and available cues (Lohnas, 2025; Dechamps & Skulmowski, 2025). Therefore, the study highlights the potential value of TLT as a structured recall tool while also showing that its benefits are modality-specific rather than uniform across all forms of memory recall.

Taken together, these findings suggest that the effectiveness of the Timeline Technique depends not only on whether a temporal

structure is provided, but also on how participants are required to report the remembered information. This interpretation is consistent with serial-order and retrieved-context models, which emphasize the role of contextual and temporal cues in organizing ordered recall (Logan & Cox, 2023; Lohnas, 2025). Verbal TLT may be particularly effective because it combines temporal organization with relatively low production demands, allowing participants to focus more directly on retrieving and sequencing information rather than on the additional effort required for writing or drawing (Paas & van Merriënboer, 2020; Wylie & Evans, 2023).

In contrast, drawing-based formats may provide useful visual cues, but they may also require additional cognitive and motor effort, especially when participants must simultaneously recall object identity, location, and order (Zhang & Fiorella, 2021; Dechamps & Skulmowski, 2025; Navratil & Kühl, 2023). This distinction is important for both educational and forensic applications, as previous research has shown that timeline-based reporting can support the organization and retrieval of complex event information (Hope et al., 2019; Kontogianni et al., 2021). Therefore, the present findings support a more nuanced understanding of TLT as a modality-sensitive recall strategy rather than a uniformly effective technique across all memory outcomes.

**Limitations**

Although the present study provides useful evidence regarding the role of the Timeline Technique (TLT) in enhancing long-term sequential memory recall, several limitations should be acknowledged. First, the study sample was relatively homogeneous, as all participants were female undergraduate students from Qatar University and were enrolled in Psychology and/or English Literature programs. This limits the generalizability of the findings to wider populations with different gender profiles, age groups, educational backgrounds, cultural contexts, and levels of cognitive or academic experience. Future studies should therefore recruit more diverse samples to determine whether the observed effects of TLT are consistent across different demographic and educational groups.

Second, the scoring of participants' recall reports was conducted manually by a single researcher. Although manual scoring allowed for close examination of the responses, the absence of multiple independent raters and inter-rater reliability assessment may have increased the possibility of subjective judgment or scoring bias. Future research should employ standardized coding procedures, blinded scoring, and multiple raters to enhance the reliability and reproducibility of the findings.

Third, the study focused primarily on the accuracy of object recall, location recall, sequential recall, and recall time. It did not assess the qualitative richness or level of detail in participants' recalled information. For example, a participant who recalled an object using a general label may have been scored similarly to another participant who provided a more specific and detailed description. Future studies should examine not only whether information is recalled accurately, but also the precision, completeness, and descriptive quality of recalled details.

Finally, the experimental task was conducted in a controlled laboratory setting using structured visual scenes and object-placement tasks. While this design strengthened experimental control, it may not fully reflect the complexity of real-world memory situations, such as classroom learning, eyewitness reporting, or forensic interviews. Future research should examine the effectiveness of TLT in more

naturalistic contexts to better understand its practical applicability.

### *Conclusion and Implications*

The present study contributes to the growing body of research on the Timeline Technique by extending its application from episodic memory to long-term sequential memory recall. The findings indicate that TLT can support memory retrieval, but its effectiveness varies according to the reporting modality and the type of memory outcome being assessed. In particular, the verbal TLT format was the most effective in improving sequential recall accuracy and reducing recall time when compared with free recall. In addition, both the verbal TLT and the hand-drawing plus caption format improved object recall accuracy. However, the reporting modality did not significantly affect location recall accuracy.

These findings suggest that verbal timeline-based reporting may provide an efficient cognitive structure for retrieving information in the correct order. By allowing participants to organize recalled information verbally within a temporal framework, verbal TLT may reduce the cognitive demands associated with written or drawing-based reporting. The hand-drawing plus caption format also appears to offer benefits for object recall, possibly because it combines visual representation with verbal labeling and therefore provides multiple retrieval cues.

The results have important implications for educational and forensic contexts. In educational settings, TLT may be used as a learning and revision strategy to help students organize and recall sequential information, such as historical events, procedural steps, scientific processes, or narrative structures. In forensic and investigative contexts, the findings suggest that verbal timeline reporting may be useful when accurate recall of the order of events is essential, such as in eyewitness accounts or structured interviews. However, further empirical research is needed before applying these findings broadly in professional practice.

Overall, this study highlights the potential value of TLT as a structured recall tool for enhancing long-term sequential memory. The findings suggest that the effectiveness of TLT depends not only on the presence of a timeline structure, but also on the modality through which recall is reported. Verbal and multi-modal TLT formats appear especially promising and should be examined further in future research.

### *Future Research Directions*

Future research should address several important areas. First, studies should include more heterogeneous samples in terms of gender, age, academic background, cultural context, and educational level. This would help determine whether the benefits of TLT observed in the present study can be generalized beyond female university students.

Second, future studies should develop and apply standardized scoring protocols for evaluating recall reports. The use of multiple independent raters, blinded assessment, and inter-rater reliability statistics would strengthen the credibility and replicability of the findings.

Third, future research should examine the quality and specificity of recalled information in addition to accuracy. This would allow researchers to distinguish between general recall and detailed recall, which is particularly important in applied contexts such as education and eyewitness testimony.

Fourth, further studies should test TLT in more ecologically valid settings. For example, future research could examine whether verbal TLT

improves students' recall of lecture content, textbook material, or historical sequences. Similarly, forensic-oriented studies could investigate whether verbal timeline reporting enhances the accuracy and completeness of eyewitness recall in simulated or real investigative interview contexts.

Finally, future research may compare immediate and delayed recall conditions to determine whether different TLT modalities have short-term and long-term effects on memory retention. This would provide a more comprehensive understanding of how timeline-based reporting supports memory over time.

### *Ethical Approval and Consent to Participate*

All procedures involving human participants were conducted in accordance with the ethical standards of Qatar University and the applicable regulations governing research involving human subjects. The study was reviewed by the Qatar University Institutional Review Board (QU-IRB) and was determined to be exempt from full IRB review. The exemption was granted under QU-IRB Reference No. QU-IRB 168/2024-EM, with a decision date of August 19, 2024. Participation was voluntary, and informed consent was obtained from all participants before data collection. Participants were informed about the study purpose, the nature of participation, the right to withdraw at any stage, and the confidentiality of their responses.

### *Availability of Data and Materials*

The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

### *Author Contributions*

Ali Shakir Al-Fatlawi and Sara Mohammed Al-Khayarin jointly contributed to the study conception and design, data collection and interpretation, manuscript drafting, and critical revision. Both authors read and approved the final manuscript.

### *Conflict of Interest*

The authors declare that they have no relevant financial or non-financial conflicts of interest related to this study.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### *Thesis Derivation Statement*

This study is not derived from a master's thesis or doctoral dissertation.

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