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Event-Based Prospective Memory and Verbatim–Gist Recall in A6utism Spectrum Disorder

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Abstract

This study examines the effects of cueing conditions (full cue vs. no cue) on event-based prospective memory (PM) performance in individuals with Autism Spectrum Disorder (ASD). It specifically investigates how individuals with ASD encode and retrieve event-based intentions and whether their reliance on verbatim memory affects PM execution. Addressing inconsistent findings in previous research, the study explores whether external cueing can improve PM performance by compensating for spontaneous retrieval difficulties and reduced gist-based processing.

A total of 102 participants took part in the study, including 50 high-functioning ASD individuals (M = 20.71, SD = 2.70) and 52 typically developing controls (M = 21.75, SD = 1.97). Participants performed a multi-trial, multi-list event-based PM task under full cue and no cue conditions. They were required to detect pre-specified PM targets while recalling studied items, allowing assessment of PM accuracy and cue-based facilitation.

Results showed that ASD participants had significantly lower PM performance in the no-cue condition, indicating difficulty in spontaneous intention retrieval. Full cue conditions enhanced PM performance but did not fully mitigate challenges. Findings support Fuzzy Trace Theory, suggesting that ASD individuals rely heavily on verbatim memory and benefit from structured, salient cues that support retrieval when gist processing is limited.

Introduction

Autism Spectrum Disorder (ASD) is a neurodevelopmental condition characterized by persistent deficits in reciprocal social communication and social interaction across multiple contexts, alongside restricted, repetitive patterns of behavior, interests, or activities (American Psychiatric Association, 2013). Individuals with ASD often encounter significant challenges beyond social interaction and communication difficulties, profoundly affecting cognitive processes such as memory encoding, storage, and retrieval (Miller et al., 2014; Boucher et al., 2012). Among these cognitive challenges, prospective memory (PM), the ability to remember and execute a delayed intention, plays a crucial role in independent living and goal-directed behavior (McDaniel & Einstein, 2007).

PM deficits have substantial real-world implications for ASD individuals, impacting their ability to complete daily activities such as remembering appointments, taking medications, or responding appropriately to situational cues (Williams et al., 2014; Altgassen et al., 2009). PM can be categorized into time-based PM, which requires self-initiated recall at a specific time (e.g., remembering to make a phone call at 5 PM), and event-based PM, in which an external cue prompts retrieval of the intended action (e.g., giving a message when seeing a particular person) (McDaniel & Einstein, 2000).

While research has consistently shown that time-based PM is significantly impaired in ASD, findings regarding event-based PM remain inconsistent, leading to debate about whether ASD individuals exhibit preserved or impaired event-based PM. Moreover, differences in memory encoding strategies,

specifically, the preference for verbatim versus gist recall, may further explain the observed variability in event-based PM performance.

Several studies suggest that individuals with ASD perform comparably to neurotypical (NT) controls in event-based PM, particularly when external cues are highly salient and do not require complex strategic monitoring.

Altgassen et al. (2010) conducted a study examining event-based PM in children with ASD and neurotypical controls. Participants were asked to perform an ongoing working memory task while remembering to execute a delayed action upon encountering a predefined event cue. The researchers manipulated cue salience, ensuring that cues were highly distinct and easily recognizable. The findings indicated that ASD children performed similarly to NT controls when cues were explicit and externally provided, reducing the demand for self-initiated monitoring. This suggests that event-based PM deficits may not be an inherent feature of ASD but may emerge when tasks require strategic cue detection and response flexibility.

Williams et al. (2014) extended these findings by conducting a study on adults with ASD, using a more naturalistic event-based PM task. Participants were required to remember to press a specific key whenever they saw a particular stimulus embedded in a computer-based task. When the cue was highly distinct and signaled, ASD participants performed as well as neurotypical individuals. However, when cues were more subtly embedded in the task environment, PM execution in ASD individuals declined. The authors concluded that cue salience plays a crucial role in event-based PM performance in ASD, and difficulties arise primarily when cues require associative processing rather than direct stimulus-response recognition.

Sheppard and Altgassen (2021) further examined the role of cue distinctiveness in ASD event-based PM performance. Their study tested ASD and NT participants on event-based PM tasks with varied cue salience levels, from isolated, highly visible cues to embedded, more conceptually demanding cues. Their findings reinforced prior studies: ASD participants performed successfully when cues were perceptually distinct but struggled when cues required inferential processing or were contextually embedded. The study concluded that individuals with ASD rely more on direct perceptual cues than on inferential cue-linking strategies.

In contrast, other studies argue that event-based PM is significantly impaired in ASD, particularly when tasks require flexible cognitive strategies, inferential reasoning, or associative linking. Yi et al. (2014) conducted a study in which ASD participants were required to detect contextually embedded event cues rather than explicit visual signals. The study involved a naturalistic paradigm where the cue was conceptually associated with the target action rather than a simple visual marker. The results showed that ASD individuals performed significantly worse than NT participants, suggesting that event-based PM impairments in ASD may arise when retrieval depends on flexible associative processing rather than direct stimulus-response matching.

Similarly, Dehnavi & Khan (2024) found that event-based PM execution was significantly lower in ASD individuals when tasks involved dynamically changing contexts. Participants completed an event-based PM task in which cue-action pairings varied across trials. The results indicated that individuals with ASD struggled to adjust their retrieval strategies to match new contextual information, leading to higher omission errors and lower accuracy compared to NT controls. The authors concluded that while individuals with ASD can retrieve PM intentions under rigid, rule-based conditions, they struggle with adapting retrieval strategies in dynamic or unpredictable environments.

Moreover, to better understand the memory deficits observed in ASD, we turn to Fuzzy Trace Theory (FTT), a comprehensive framework that explains memory and cognitive development across the lifespan (Reyna & Brainerd, 1995). FTT has been operationalized through well-established process models (Brainerd et al., 2009; Odegard et al., 2008; Rivers et al., 2008), which have been shown to reliably assess fundamental memory processes in individuals ranging from young children to older adults. FTT posits that memory operates through two distinct but interacting processes: verbatim memory, which encodes precise, detailed information, and gist memory, which captures the general meaning or conceptual framework of an experience (Reyna & Brainerd, 1995). Typically, neurotypical individuals flexibly engage both memory systems depending on the demands of a given task (Brainerd et al., 2009). However, growing evidence suggests that individuals with ASD demonstrate a distinct pattern of memory processing characterized by an over-reliance on verbatim memory at the expense of gist-based encoding. This pattern aligns with Weak Central Coherence (WCC) theory (Frith, 1989; Frith & Happé, 1994), which describes a cognitive processing style in ASD that prioritizes local details over global meaning.

Multiple studies have documented this memory bias in ASD. Miller et al. (2014) found that individuals with ASD excel at recalling precise factual details but struggle to extract broader conceptual themes. Similarly, Bowler et al. (2010) reported that ASD participants could retain fine details of presented information but failed to integrate those details into a coherent, higher-level representation. This suggests that ASD may struggle to generalize learned information to novel contexts, a key component of flexible memory use.

Bennetto et al. (1996) and Boucher et al. (2012) further support this notion, demonstrating that while ASD individuals perform comparably to neurotypical individuals on rote memory tasks, they exhibit impairments when asked to recall meaningful, relational aspects of an event. The findings of Gaigg et al. (2008) reinforce this trend, revealing that ASD participants show a preference for surface-level details in story recall while failing to extract overarching narratives.

If individuals with ASD predominantly encode memories in a verbatim format, their ability to detect and respond to PM cues becomes rigid and dependent on exact matches. For instance, if an ASD individual encodes an event-based PM cue in a highly specific form (e.g., "When I see a red notebook, I will submit my assignment"), they may struggle to generalize this intention to slightly altered but conceptually equivalent situations (e.g., "When I see my professor holding a stack of papers, I will submit my

assignment"). Neurotypical individuals, by contrast, are more likely to encode the task using gist-based memory (e.g., "When I see something related to class, I will remember to submit my assignment"), making them more flexible in retrieving the intended action.

Empirical support for this hypothesis comes from research on PM in ASD. Henry et al. (2014) found that ASD participants performed significantly worse than neurotypical controls on event-based PM tasks, particularly when the cue required some degree of flexible interpretation. Williams et al. (2013) demonstrated that ASD individuals exhibit PM deficits primarily when retrieval demands exceed simple recognition and require generalization.

Moreover, Altgassen et al. (2012) highlight that while individuals with ASD can perform comparably on PM tasks with explicit reminders, their performance declines in situations requiring spontaneous retrieval. This aligns with the idea that verbatim-dependent encoding strategies impair the ability to recognize cues unless they appear in an identical format to the stored memory representation.

In conclusion, understanding event-based PM in ASD is crucial, as memory encoding biases impact daily functioning. FTT suggests that ASD individuals rely more on verbatim recall, making event-based PM retrieval rigid and cue-dependent. While they may perform well with explicit cues, difficulties arise when cues require generalization or inference. This study bridges a critical gap by examining how verbatim vs. gist encoding affects event-based PM in ASD, with implications for cognitive training, adaptive interventions, and improved daily independence.

Method

The study consisted of a total of 102 participants, divided into two groups: 50 individuals with high-functioning ASD and 52 typically developing controls. The ASD group comprised 52% males and 48% females, with an age range of (M = 20.708, SD = 2.696), while the control group included 50% males and 50% females, with an age range of (M = 21.750, SD = 1.973). This study focused on individuals with high-functioning ASD, indicating that participants did not have intellectual or language impairments. The ASD diagnosis was confirmed by a state-registered clinician (psychologist or multidisciplinary clinical team) based on DSM-5 (2013) criteria, ensuring that all participants met the diagnostic standards for ASD. Although observational measures such as ADOS were not utilized, clinical diagnosis was confirmed through professional evaluation.

The study specifically excluded individuals with intellectual disabilities or severe cognitive impairments that could interfere with task comprehension. Additionally, participants with co-occurring psychiatric conditions such as ADHD, anxiety disorders, or other neurodevelopmental disorders were not included, ensuring a relatively homogeneous ASD sample. For the non-ASD group, participants were recruited voluntarily without a history of psychiatric disorders, neurological diseases, or current use of psychotropic drugs. Participants with visual impairments or other physical issues that might hinder their ability to take the test were excluded from the study. Any participant with visual, auditory, or motor impairments that could interfere with completing the memory tasks was also excluded. Participants who

did not complete both experimental sessions were removed from the final analysis. All the methods in this study were approved by the Ethics Committee at the INDIAN INSTITUTE OF TECHNOLOGY BOMBAY *633(PROPOSAL NUMBER IITB-IEC/2024/038_IEC, office of R&D), and informed consent was obtained from all participants.

Materials

The present study employed a multi-trial, multi-list free-recall task, following Tulving's (1962) framework. It was designed to assess event-based PM execution and recall accuracy under two different cueing conditions: No-Cue Condition and Full-Cue Condition. The task was designed to evaluate the accuracy of event-based PM execution within an ongoing memory retrieval context, specifically investigating how external cueing influences the ability to detect and respond to PM targets. Additionally, the study examined correct recall accuracy and the specificity of memory retrieval, as measured by verbatim vs. gist recall. The experiment was implemented as a computer-based task using E-Prime, ensuring precise stimulus presentation, response logging, and automated data collection. Each trial consisted of two interwoven tasks:

1. A free-recall task, where participants studied and later attempted to recall a list of words.
2. An event-based PM task requiring participants to execute a keypress response whenever they recalled a word from a pre-specified target category.

Each participant completed multiple trials, experiencing both cueing conditions in a counterbalanced order to control for potential order effects. The word stimuli were drawn from six predefined semantic categories: Fruits (e.g., apple, banana, mango), Animals (e.g., lion, elephant, rabbit), Furniture (e.g., chair, table, bed), Clothing (e.g., jacket, trousers, scarf), Tools (e.g., hammer, screwdriver, wrench), Transportation (e.g., bus, bicycle, train).

Each word list contained 24 words, ensuring an equal number of words from each category. Before the start of each trial, participants were informed that one of these six categories would serve as the PM target category for that trial. However, how this information was presented varied based on the cueing condition.

In the no-cue condition, participants had to encode, store, and retrieve words entirely through self-initiated memory processes, as no external cues were provided at any stage of the task. In the encoding phase, participants were presented with 24 words, one at a time, each displayed for 2000 milliseconds (ms) with an inter-stimulus interval (ISI) of 500 ms. Words were displayed in random order, and no category labels were provided to assist in semantic organization.

Before encoding, participants were informed that one category (e.g., "Animals") would serve as the PM target category. However, this category was not displayed again during recall, requiring participants to retain and retrieve the PM task independently.

Recall Phase and Event-Based PM Execution (No-Cue)

Following encoding, participants were instructed to recall and type as many words as possible from the studied list. The event-based PM task required them to press a designated key (e.g., "A" for Animals) before typing a word belonging to the PM target category. Since no category labels were provided at recall, participants had to self-monitor their recall process to correctly execute the PM task.

In addition to correct event-based pm execution (no-cue), recall accuracy was analyzed based on: 1) correct recall accuracy (no-cue) – the number of correctly recalled words from the studied list. 2) verbatim recall (no-cue) – the number of words recalled exactly as presented during encoding. 3) gist recall (no-cue) – the number of words recalled as semantically related alternatives (e.g., recalling "coat" instead of "jacket"). Each participant completed multiple trials in this condition, ensuring repeated measurement of PM execution and recall performance.

In the full-cue condition, participants received maximum external support for PM execution, with semantic category labels displayed during encoding and recall phases. During the encoding phase, the study list structure, word presentation duration, and ISI were identical to the no-cue condition. However, category labels were displayed before each word appeared on the screen. For example, before "lion" was presented, the label "Animals" was displayed, assisting participants in categorizing words during encoding.

As in the no-cue condition, participants were informed of the PM target category before encoding, but unlike the No-Cue Condition, this category label was also displayed during recall, serving as a retrieval cue.

Recall Phase and Event-Based PM Execution (Full-Cue)

During recall, category labels were displayed on the screen, guiding participants toward category-based retrieval. The event-based PM task remained the same: Participants had to press the designated key before typing a word from the PM target category. However, in this condition, category labels explicitly reminded participants of the PM target category, facilitating Correct event-based PM execution (full-cue). In addition to PM execution, recall accuracy was analyzed based on: 1) correct recall accuracy (full-cue) – the number of correctly recalled words. 2) verbatim recall (full-cue) – the number of exact matches to the originally presented words. 3) gist recall (full-cue) – The number of semantically related but non-identical recalled words. Each participant completed multiple trials under this condition, ensuring that cueing effects were assessed across repeated retrieval attempts.

The study measured the following dependent variables:

1. Correct event-based pm execution: full-cue (the number of times participants successfully pressed the assigned key before typing a PM target category word). And no-cue (the number of times participants successfully pressed the assigned key before typing a PM target category word without cueing support).

2. Correct recall accuracy (full-cue: the number of correctly recalled words under the full-cue condition). no-cue: (the number of correctly recalled words under the no-cue condition).
3. Verbatim vs. gist recall: verbatim recall (the proportion of words recalled exactly as presented). and gist recall (the proportion of words recalled as semantically related alternatives).

Procedure

Participants were tested individually in a controlled, quiet environment to minimize distractions. Before each task condition, they received detailed, standardized instructions read aloud by the experimenter to ensure consistency. They were encouraged to perform well across tasks and were provided with a comfortable, well-lit, noise-free environment to support focus. The testing area was carefully arranged, with unnecessary items removed and electronic devices turned off to prevent distractions. Glare from windows or other sources was controlled for clear stimulus visibility, and participants were seated with an unobstructed view of the screen.

To verify ASD diagnoses, medical records from the SANTOSH Institute for Mentally Challenged Children and OM Creation Trust (developmental disability institutions in Mumbai, Maharashtra, India) were reviewed before the experiment. If institutional records were unavailable, parents provided medical documentation for confirmation. Control participants were volunteers recruited from IIT Bombay (Maharashtra, India). All participants provided informed consent, and ASD participants obtained additional assent from caregivers when applicable. Participants who did not complete both experimental sessions were excluded from the final analysis. This setup ensured that all participants engaged with the tasks under optimal conditions, reducing external variables that could influence performance.

Design

The present study employed a 2 × 2 mixed factorial design to examine event-based PM performance and recall specificity (verbatim vs. gist), where the within-subjects factor is cuing condition (full cue vs. no cue), and the between-subjects factor is disorder (ASD vs. non-ASD). The dependent variables are: correct recall accuracy (full cue, no cue), correct event-based execution (full cue, no cue), verbatim recall (full cue, no cue), and gist recall (full cue, no cue).

Result

Table 1 presents the descriptive statistics for correct recall accuracy, event-based execution, verbatim recall, and gist recall across the two cueing conditions (full-cue, no-cue) and two groups (ASD, control) (*see* Fig. 1). The result for correct recall accuracy: in the full-cue condition, the ASD group (M = 11.78, SD = 2.54) performed significantly lower than the control group (M = 17.61, SD = 4.79), with an overall mean of M = 14.75, SD = 4.83. In the no-cue condition, ASD participants exhibited a lower mean recall accuracy (M = 5.58, SD = 1.75) compared to the control group (M = 14.69, SD = 3.42), resulting in a total mean of M = 10.22, SD = 5.32.

For correct event-based execution, in the full-cue condition, ASD individuals (M = 2.76, SD = 1.13) performed significantly worse than the control group (M = 7.55, SD = 2.04), with a total mean of M = 5.20, SD = 2.92. In the no-cue condition, ASD participants (M = 2.04, SD = 1.04) also showed lower execution rates compared to the control group (M = 4.94, SD = 2.27), with an overall mean of M = 3.51, SD = 2.29.

In verbatim recall: for the full-cue condition, the ASD group demonstrated lower verbatim recall (M = 4.18, SD = 1.08) compared to the control group (M = 8.65, SD = 2.41), leading to a total mean of M = 6.46, SD = 2.92. In the no-cue condition, ASD individuals (M = 2.66, SD = 1.58) recalled fewer verbatim details than the control group (M = 8.09, SD = 1.71), with a total mean of M = 5.43, SD = 3.18.

In gist-recall: in the full cue condition, the ASD group (M = 4.46, SD = 1.12) demonstrated lower gist recall than the control group (M = 9.17, SD = 1.93), with an overall mean of M = 6.86, SD = 2.84. In the no-cue condition, ASD participants (M = 1.80, SD = 0.92) exhibited significantly lower gist recall performance than the control group (M = 7.34, SD = 2.15), leading to a total mean of (M = 4.62, SD = 3.24).

Overall, these descriptive statistics suggest that ASD individuals performed worse across all measures, with cueing conditions playing a crucial role in performance differences between the two groups.

Table 1
Descriptive statistic, Mean, SD of performance scores on the “Multi-Trial, Multi-List Free Recall Task” on Disorder (ASD vs. non-ASD)

The correct recall accuracy Full-cue	**Mean (ASD) N = 50**	**SD (ASD)**	**Mean (Control Group) N = 52**	**SD (Control Group)**	**Mean Total**	**SD Total**
	11.78	**2.54**	**17.61**	**4.79**	**14.75**	**4.83**
The correct recall accuracy No-cue	5.58	1.75	14.69	3.42	10.22	5.32
The correct event-based Execution Full-cue	2.76	1.13	7.55	2.04	5.2	2.92
The correct event-based Execution No-cue	2.04	1.04	4.94	2.27	3.51	2.29
Verbatim recall full-cue	4.18	1.08	8.65	2.41	6.46	2.92
The verbatim recall no-cue	2.66	1.58	8.09	1.71	5.43	3.18
Gist recall full-cue	4.46	1.12	9.17	1.93	6.86	2.84
The gist recall no-cue	1.8	0.92	7.34	2.15	4.62	3.24

Between-subjects effects revealed a significant main effect of disorder (ASD vs. Control) across all dependent variables. For correct recall accuracy, individuals with ASD performed significantly worse than

the control group ($F(1, 100) = 232.4$, $p < .001$, $\eta^2 = 0.69$), indicating a large effect size. Similarly, for correct event-based Execution, a significant effect of disorder was found ($F(1, 100) = 236.5$, $p < .001$, $\eta^2 = 0.70$), suggesting that ASD individuals exhibited lower event-based execution performance.

Furthermore, a significant between-subjects effect was found for verbatim recall, with ASD participants recalling significantly fewer verbatim details compared to the control group ($F(1, 100) = 341.8$, $p < .001$, $\eta^2 = 0.77$). The largest effect was observed in Gist Recall, where ASD individuals showed substantial impairments in recalling conceptual information compared to controls ($F(1, 100) = 421.4$, $p < .001$, $\eta^2 = 0.80$), indicating that the ASD group exhibited a strong reliance on verbatim recall over gist recall.

In the within-subjects effects, a significant main effect of cue condition (full cue vs. no cue) was found across all dependent variables. For correct recall accuracy, participants demonstrated better recall in the full-cue condition ($F(1, 100) = 104.7$, $p < .001$, $\eta^2 = 0.51$), showing that external cueing substantially improved memory retrieval. Similarly, the cueing effect was significant for correct event-based execution ($F(1, 100) = 51.9$, $p < .001$, $\eta^2 = 0.34$), indicating that cues facilitated better execution of event-based PM tasks.

For verbatim recall, the effect of cue condition was also significant ($F(1, 100) = 20.94$, $p < .001$, $\eta^2 = 0.17$), suggesting that external cues supported accurate verbatim memory retrieval. Additionally, a strong effect of cue condition was found for gist recall ($F(1, 100) = 120.3$, $p < .001$, $\eta^2 = 0.54$), indicating that cueing particularly enhanced gist-based retrieval performance.

For the interaction effects (cue condition × disorder), the interaction between cue condition and disorder was significant for correct recall accuracy ($F(1, 100) = 13.51$, $p < .001$, $\eta^2 = 0.11$), suggesting that the ASD group benefited differently from cueing compared to the control group. Similarly, a significant interaction was observed for correct event-based execution ($F(1, 100) = 16.76$, $p < .001$, $\eta^2 = 0.14$), indicating that while cueing improved event-based execution in both groups, the effect size varied between ASD and control participants.

For verbatim recall, the interaction effect was smaller but still significant ($F(1, 100) = 4.49$, $p = .036$, $\eta^2 = 0.04$), suggesting that while both groups benefited from cueing, ASD individuals relied more on verbatim memory encoding. Finally, a significant but small interaction effect was found for gist recall ($F(1, 100) = 4.14$, $p = .044$, $\eta^2 = 0.04$), indicating that while both groups showed increased gist recall with cueing, the effect was more pronounced in the control group.

In summary, the results indicate that cueing significantly enhanced memory retrieval and event-based PM execution, with ASD participants showing overall weaker performance compared to controls. Additionally, while both groups benefited from cueing, ASD individuals relied more on verbatim recall strategies and had greater difficulty in utilizing gist-based recall. The significant interaction effects suggest that the extent to which cueing improved performance varied between ASD and neurotypical individuals, highlighting differences in memory encoding and retrieval strategies across groups.

Table 2
Multivariate Tests of Between-Subjects and Within-Subjects Effects for Cue Condition and Interaction with Disorder

Source	Measure	Sum of Squares	df	Mean Square	F	Sig.	η²⍰
Between-Subjects Effects							
Disorder	Correct Recall	2847.68	1	2847.68	232.4	p < .001	0.69
Error	Correct Recall	1225.29	100	12.25			
Disorder	Correct Event-Based Execution	755.65	1	755.65	236.5	p < .001	0.7
Error	Correct Event-Based Execution	319.5	100	3.19			
Disorder	Verbatim Recall	1251.67	1	1251.67	341.8	p < .001	0.77
Error	Verbatim Recall	366.23	100	3.66			
Disorder	Gist Recall	1341.44	1	1341.44	421.4	p < .001	0.8
Error	Gist Recall	318.3	100	3.18			
Within-Subjects Effects							
Cue-Condition	Correct Recall	1060.78	1	1060.78	104.7	p < .001	0.51
Cue-Condition	Correct Event-Based Execution	141.78	1	141.78	51.9	p < .001	0.34
Cue-Condition	Verbatim Recall	55.01	1	55.01	20.94	p < .001	0.17
Cue-Condition	Gist Recall	256.59	1	256.59	120.3	p < .001	0.54
Cue-Condition * Disorder	Correct Recall	136.86	1	136.86	13.51	p < .001	0.11
Cue-Condition * Disorder	Correct Event-Based Execution	45.78	1	45.78	16.76	p < .001	0.14
Cue-Condition * Disorder	Verbatim Recall	11.8	1	11.8	4.49	p < .05	0.04
Cue-Condition * Disorder	Gist Recall	8.84	1	8.84	4.14	p < .05	0.04

Source	Measure	Sum of Squares	df	Mean Square	F	Sig.	η²⊠
Error (Cue-Condition)	Correct Recall	1012.84	100	10.12			
Error (Cue-Condition)	Correct Event-Based Execution	273.19	100	2.73			
Error (Cue-Condition)	Verbatim Recall	262.65	100	2.62			
Error (Cue-Condition)	Gist Recall	213.33	100	2.13			

Pairwise comparisons, adjusted using the Bonferroni correction for multiple comparisons, revealed significant differences between the ASD and control groups across all memory measures, confirming that individuals with ASD performed significantly worse than neurotypical controls in correct recall, event-based execution, verbatim recall, and gist recall (Table 3).

For correct recall accuracy, the control group outperformed the ASD group, with a significant mean difference of 7.47 (SE = 0.49, $p < .001$). This finding indicates that cueing strategies were significantly less effective for ASD individuals in enhancing overall recall accuracy.

Similarly, correct event-based execution was significantly lower in the ASD group compared to controls, with a mean difference of -3.85 (SE = 0.25, $p < .001$). This suggests that ASD individuals had more difficulty detecting and executing event-based PM tasks, even in the presence of external cues.

For verbatim recall, a significant mean difference of -4.955 (SE = 0.268, $p < .001$) was observed between groups, with control participants demonstrating higher accuracy in recalling the exact details of the studied words. This finding aligns with prior research suggesting that ASD individuals struggle with encoding and retrieving precise verbatim details, particularly under conditions that require flexible recall strategies.

The largest difference between groups was found in gist recall, where ASD participants performed significantly worse than controls, with a mean difference of -5.13 (SE = 0.25, $p < .001$). This suggests that ASD individuals exhibit a stronger reliance on verbatim memory encoding, making it difficult to retrieve conceptual or meaning-based information in recall tasks.

Overall, these results indicate that while both cueing conditions improved memory performance, the extent of improvement was significantly lower in the ASD group across all memory domains. The deficits in event-based execution and gist recall in ASD individuals suggest underlying difficulties in cognitive flexibility, retrieval monitoring, and strategic memory processing, reinforcing the need for tailored interventions that support adaptive memory strategies in ASD populations.

Table 3
Pairwise Comparisons of Disorder Groups (ASD vs. Control) for Memory Measures

Measure	(I) Disorder	(J) Disorder	Mean Difference (I-J)	Std. Error	Sig.
Correct Recall	ASD	Control group	-7.474	0.49	p < .001
Correct Recall	Control group	ASD	7.474	0.49	p < .001
Correct Event-Based Execution	ASD	Control group	-3.85	0.25	p < .001
Correct Event-Based Execution	Control group	ASD	3.85	0.25	p < .001
Verbatim Recall	ASD	Control group	-4.955	0.268	p < .001
Verbatim Recall	Control group	ASD	4.955	0.268	p < .001
Gist Recall	ASD	Control group	-5.13	0.25	p < .001
Gist Recall	Control group	ASD	5.13	0.25	p < .001

Discussion

The present study aimed to investigate the effects of cueing on event-based PM performance and recall accuracy in individuals with ASD. By examining how individuals with ASD retrieve information under different cueing conditions (full cue vs. no cue) and how they rely on verbatim vs. gist recall, this study provides a deeper understanding of the cognitive processes underlying memory retrieval in ASD. The findings highlight significant memory impairments in ASD, particularly in gist recall and event-based execution, and emphasize the crucial role of external cueing in memory facilitation.

A primary finding of this study is that individuals with ASD exhibited pronounced deficits in event-based PM execution and recall accuracy. These deficits were observed across both cueing conditions, but they were particularly pronounced in the absence of external cues. This aligns with previous research indicating that individuals with ASD struggle with the independent retrieval of memory-based intentions, particularly when retrieval demands require flexible cognitive control and associative memory binding (Williams et al., 2014; Altgassen et al., 2009). The difficulties in event-based PM suggest underlying impairments in executive function, monitoring, and self-regulation, which are critical for recognizing and responding to PM cues in real-world situations.

The literature on event-based PM performance in ASD has been inconsistent. Some studies suggest that individuals with ASD perform comparably to neurotypical controls when the event-based PM cue is

highly salient and requires minimal strategic monitoring (Altgassen et al., 2010; Williams et al., 2014). However, other research indicates significant deficits in event-based PM, particularly when cues require associative linking, inferential reasoning, or broader contextual integration (Dehnavi & Khan, 2024; Yi et al., 2014). The present study supports the latter perspective, demonstrating that cueing improves event-based PM performance in ASD but does not fully compensate for underlying difficulties in retrieval monitoring and execution.

These findings suggest that the variability in previous studies may be attributed to differences in cue salience, task complexity, and the degree of cognitive flexibility required for retrieval. When event-based cues are distinct and match the way the memory was encoded, ASD individuals may retrieve the information more effectively. However, when cues are subtle, embedded within broader contexts, or require flexible associative linking, retrieval failures are more likely. This reinforces the need to consider how memory encoding strategies in ASD affect their ability to retrieve event-based intentions under different conditions.

One of the most striking findings of this study was the pronounced difficulty that individuals with ASD exhibited in gist recall, particularly in the absence of external cues. The preference for verbatim over gist recall in ASD has been well documented in the literature and is often linked to WCC theory (Frith, 1989; Frith & Happé, 1994) and FTT (Reyna & Brainerd, 1995). These frameworks suggest that while neurotypical individuals balance the use of precise (verbatim) and conceptual (gist) memory retrieval depending on the task demands, ASD individuals rely heavily on surface-level details while struggling to extract broader meanings and conceptual connections. Consistent with previous research, this study found that ASD individuals retained specific factual details but struggled to generalize or integrate information into meaningful conceptual representations (Miller et al., 2014; Bowler et al., 2010). This memory profile has been observed in multiple cognitive domains, including narrative comprehension, autobiographical memory, and inferential reasoning (Miller et al., 2018). The difficulty that individuals with ASD face in extracting higher-order meanings from stored memories suggests that their memory deficits are not simply due to poor retrieval but rather reflect fundamental differences in how information is encoded and processed.

Contradictory evidence exists regarding the extent to which individuals with ASD struggle with verbatim recall. Some studies report intact or even superior verbatim memory in ASD, particularly in tasks that emphasize rote learning and structured recall formats (Bowler et al., 2010; Miller et al., 2018). However, our findings suggest that even in verbatim recall tasks, individuals with ASD performed worse than controls, particularly in event-based PM contexts. This suggests that while ASD individuals may encode information with great specificity, retrieving these details in a PM framework presents additional challenges. These challenges may stem from difficulties in self-monitoring, memory updating, and linking stored information to retrieval cues.

A key finding of this study was the significant impact of cueing on memory retrieval, with cueing substantially improving recall accuracy, event-based PM execution, and both verbatim and gist recall.

The benefits of full cue conditions suggest that structured external support serves as an effective retrieval facilitator for individuals with ASD. These findings align with previous research demonstrating that explicit, highly structured cues help ASD individuals access stored memory traces more effectively (Sheppard & Altgassen, 2021).

However, while cueing improved memory retrieval in ASD, the extent of improvement was notably smaller than that observed in the control group. This suggests that external support, while beneficial, does not fully compensate for ASD-related deficits in PM and recall processes. The interaction effect between cueing and disorder group indicates that neurotypical individuals can more effectively integrate external cues into their retrieval strategies, while ASD individuals exhibit a more limited response to cue-based facilitation.

These findings are consistent with research showing that ASD individuals benefit most from explicit, structured reminders rather than inferential or ambiguous cues (Landsiedel et al., 2017). The results suggest that cueing mechanisms should be tailored to match the specific encoding strategies used by ASD individuals, ensuring that retrieval prompts align with verbatim-based memory traces rather than requiring flexible inferential recall.

These findings have important theoretical and practical implications. Theoretically, the study reinforces the predictions of FTT, providing further evidence that ASD individuals struggle to encode and retrieve gist-based memory representations. It also extends research on event-based PM deficits in ASD, highlighting the role of cue distinctiveness and memory encoding biases in shaping retrieval success.

From a practical perspective, these findings highlight the need for targeted interventions that support structured and explicit memory retrieval in ASD individuals. Since they rely on verbatim recall and struggle with flexible retrieval, effective strategies should include clear visual or verbal cues that align with how information was originally encoded. Scaffolded learning approaches can also help integrate gist-based processing alongside their natural preference for detail-oriented recall. Additionally, technology-assisted memory tools, such as AI-driven reminders and adaptive prompts, can provide personalized support to enhance memory retrieval. Given the challenges ASD individuals face with self-initiated retrieval in PM tasks, future interventions should focus on training programs that strengthen monitoring skills and strategic recall, ultimately improving independence in daily life.

While this study provides valuable insights into cueing effects on PM and recall in ASD, several important research directions remain. For example, neuroimaging studies could further explore the neural mechanisms underlying retrieval monitoring and cue-based recall in ASD. Prior research suggests that ASD individuals exhibit altered prefrontal and hippocampal activation during memory tasks, which may contribute to difficulties in linking intentions with retrieval cues (Urbain et al., 2015). Future work should examine whether cueing interventions alter neural activation patterns in ASD and whether training programs can enhance cognitive flexibility in memory retrieval.

In conclusion, this study provides strong evidence of memory impairments in ASD, particularly in event-based PM execution and gist recall, while also highlighting the role of external cueing in improving retrieval performance. The findings suggest that memory deficits in ASD are not uniform but are highly dependent on cue availability, retrieval demands, and encoding-retrieval interactions. Future research should continue to explore how cueing mechanisms can be optimized to support cognitive adaptability in ASD, to develop targeted interventions that enhance PM and recall abilities in real-world settings.

Conclusion

In summary, research suggests that individuals with ASD exhibit a strong preference for verbatim encoding, often at the expense of gist-based memory. This bias may contribute to event-based PM deficits by making retrieval too dependent on the exact match between the encoded and encountered cue. Given the importance of PM in daily functioning, further research is needed to explore strategies that promote more flexible, gist-based memory processing in ASD individuals. Understanding these mechanisms will be key in designing effective interventions that enhance memory retrieval and improve real-world task execution for individuals with ASD.

Declarations

Declaration of Funding:

The authors declare that no funding was received for the study.

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

Author Contributions Statement

F.D. conceptualized the study, designed the experiments, conducted the data collection, performed the analysis, and drafted the manuscript. S.I. provided guidance on the research design, supervised the overall project, and offered critical revisions on the manuscript. Both authors reviewed and approved the final version of the manuscript.

Human Ethics and Consent to Participate declarations:

The Clinical trial number is not applicable. Ethical clearance was obtained from the Institute Ethics Committee (IITB-IEC/2024/026).

Consent for publication

Informed consent was obtained from all participants for data collection, and they were informed that the results might be published anonymously.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Declaration of conflict of interest:

The authors declare no conflict of interest concerning this article's research, authorship, and/or publication.

Ethical Declaration:

The authors confirm that all methods followed relevant guidelines and regulations under the Institute Ethics Committee (IITB-IEC/2024/026) (Indian Institute of Technology Bombay).

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Figures

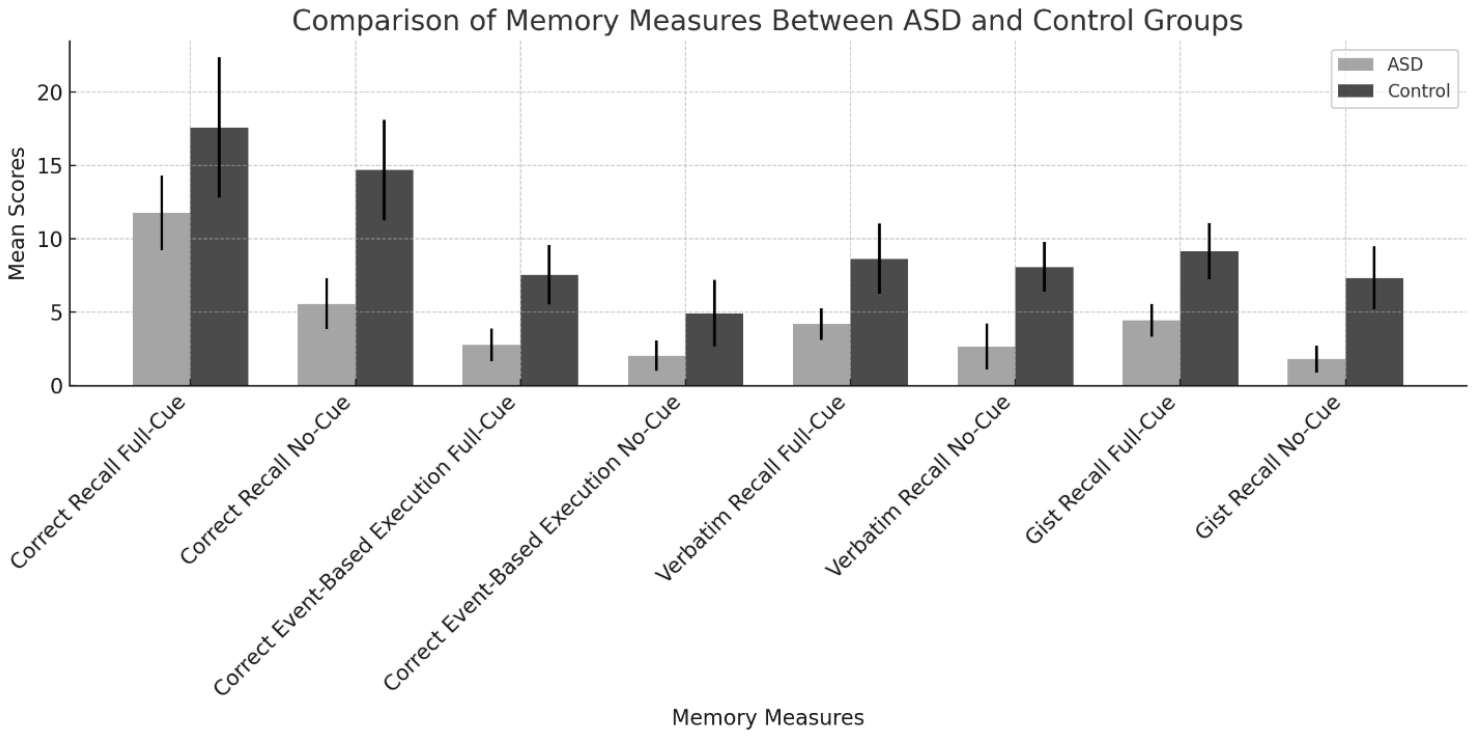


Figure 1

Comparison of Memory Performance Between ASD and Control Groups Across Cueing Conditions