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Prospective Memory in HIV-Associated Neurocognitive Disorder: A Systematic Review and Meta-Analysis

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Systematic Review

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Abstract

Prospective memory (PM) is the ability to remember and execute intended actions in the future. It Involves encoding, retention, and retrieval of information at a specific time (Time-based prospective memory) or based on a specific cue (Event-based prospective memory). Deficits in prospective memory are prevalent among people with HIV Associated Neurocognitive Disorder (HAND), with direct implications for medication adherence and everyday functional independence. This systematic review and meta-analysis were conducted in accordance with PRISMA guidelines and included searches of PubMed, ScienceDirect, ProQuest, PsycINFO, and Google Scholar for quantitative studies, specifically controlled studies comparing PM performance in HAND with that of seronegative or HIV-positive comparison groups. Five independent studies (total N = 677; 244 HAND, 433 comparison) yielded 9 independent effect sizes; 9 were pooled using robust variance estimation to account for within-study dependency, with the remaining 2 retained for qualitative synthesis. A random-effects meta-analysis showed a significant, moderate pooled effect (Hedges' g = 0.53, 95% CI [0.27, 0.68], $p < .001$; $\tau^2 = 0.02$), indicating worse overall PM performance in HAND relative to comparison groups. Subtype analysis across three studies reporting both time-based and event-based types showed a larger deficit for time-based PM (g=-0.72) than for event-based PM (g=-0.35), a difference that was significant after cluster-robust correction ($p = 0.043$). However, these findings are based on only three studies and should therefore be interpreted cautiously. These findings provide quantitative confirmation that PM deficits in HAND are moderate in magnitude and disproportionately concentrated in time-based PM, supporting a PM-targeted, strategy-based intervention as part of rehabilitation and medication-adherence-focused medical care for people living with HAND.

Introduction

Prospective memory (PM) involves individuals making a conscious decision to perform a task on a future basis; they form an intention or plan to perform the task and remember to act on the formed action after a delay, either at a specified time (time-based PM) or in response to a particular target event (event-based PM) [1]. PM is also defined as the ability to plan, retain, and retrieve an intention as planned [2]. The major processes involved in encoding and during the retention interval are crucial for the PM [3] because they jointly determine whether an intention is successfully formed, maintained and later retrieved at the right moment. Specific encoding, clear cue-action links, and if-then plans make the intention more robust and easier to retrieve. Together, these phases shape whether the intention survives long enough to be spontaneously or strategically retrieved when needed [4]. PM plays a significant role in everyday cognitive functioning and has profound ecological significance in HIV-associated neurocognitive disorder (HAND), relating to medication adherence, attending doctors' appointments [5], fulfilling social commitments and maintaining the complex multistep routines of daily life [6]. Unlike retrospective memory, PM requires an individual to self-initiate the retrieval of an intention, often simultaneously engaged in unrelated ongoing activity [7–9]. Nevertheless, PM and Working Memory (WM) are separate but linked in a way that both depends on overlapping executive and attentional resources to protect goal-relevant information from distraction, with WM operating over short, task-immediate intervals and PM operating over longer retention intervals during other activities [9, 10]. This aspect makes PM one of the most ecologically yet cognitively demanding forms of memory, which is closely linked with everyday behaviours ranging from taking medication at the correct time, attending a scheduled appointment, remembering to relay a message or returning a phone call, all dependent on how intact our PM is. Consistent works with this ecological centrality, PM impairments in clinical populations are not merely laboratory curiosities, as mentioned earlier, they are crucially linked to poor medication adherence, greater dependence on instrumental activities of daily living, unemployment and reduced health-related quality of life [11–13].

HAND consists of a range of cognitive impairments resulting from the neuroinvasion of HIV, currently affecting nearly 30–50% of individuals [14, 15]. HAND is diagnosed using the Frascati criteria [15], which include three subtypes (graded): asymptomatic neurocognitive impairment (ANI), mild neurocognitive disorder (MND), and HIV-associated dementia (HAD), depending on the severity of neuropsychological impairment and its impact on everyday functional activities and independence. Even though cART has significantly lowered mortality rates among people living with HIV (PLHIV) in developed nations [16] maintaining long-term clinical stability necessitates rigorous adherence to these medication regimens [17]

The dominant theoretical account of PM is McDaniel and Einstein's (2000) multiprocess theory, which proposes that successful prospective remembering can be supported by both automatic and strategic cognitive processes and that the balance between these processes relies on the structural features of the PM task itself. It states that there are two cognitive routes that can lead to successful prospective memory retrieval: one is through effortful monitoring and the other through spontaneous retrieval. Effortful monitoring pathways require top-down attentional control, where individuals have to maintain the prospective memory intention, and they have to actively scan their environment for relevant cues so that they can retrieve the information. This monitoring is resource-intensive and produces observable costs in the ongoing task performance. But when it comes to spontaneous retrieval, it is a relatively automatic route; it can trigger when a string of associative or perceptual links exists between cue and action. Particularly if the prospective memory cue is focal, as in being processed as part of an ongoing task. In contrast to effortful monitoring, spontaneous retrieval typically incurs minimal costs on ongoing task performance [18].

PM has received relatively little systematic investigation compared to retrospective memory or executive functions. Recent empirical evidence indicates that PM deficits serve as early markers of decline and predict functional outcomes in HAND [11]. These impairments are further associated with poor medical adherence [19]. However, the specific mechanisms across HAND stages and their growing influence on the daily functioning of PLHIV remain underexplored. Despite the extensive use of combination antiretroviral therapy (cART), which has helped result in a decline in the incidence of the most severe form of neurocognitive impairment, such as HIV-associated dementia, neurocognitive impairment continues to affect PLHIV, even among those who are virologically well controlled [20]. In the past two decades, there have been works which have tested this prediction, generally confirming that PLHIV with HAND self-reports more frequent PM failures in daily life and performs more poorly on laboratory-based PM measures than seronegative comparison groups and PLHIV without HAND [21, 11]. However, this body of literature has evolved considerably beyond simple group comparisons to interrogate the specific boundary conditions under which HAND-related PM deficits emerge, and the cognitive mechanisms associated with them. For instance, studies using the Memory for Intentions Screening Test (MIST) have shown that HAND-related PM deficits are disproportionately evident at longer (15-minute), but not shorter (2-minute), ongoing task delay intervals, and are most evident for TBPM cues, implicating strategic dyscontrol rather than a generalised encoding or retrospective

memory failure [22]. Another study by Doyle et al. (2013), quantifying clock checking behaviour during PM tasks has demonstrated that individuals with HAND monitor external cues significantly less frequently than seronegative peers, particularly as the target execution time approaches, and that reduced time monitoring is associated with executive dysfunction and verbal fluency deficits. Related findings indicate that basic time estimation and production abilities are also mildly to moderately impaired in HAND and are correlated with attention and episodic memory rather than executive function per se, suggesting that both perceptual-attentional and strategic monitoring mechanisms may contribute to TBPM failure.

In addition to these delays, monitoring-based experimental manipulation of task importance has given us the idea that emphasising the relative priority of the PM task over a competing ongoing task can normalise PM accuracy in adults with HAND, suggesting that at least part of the observed deficits reflects a resource allocation failure that is amenable to remediation under certain conditions of heightened strategic engagement [23]. Similarly, research on spontaneous compensatory strategy use such as note taking while during laboratory PM tasks has found that strategy deployment is strongly associated with better PM performance, particularly for TBPM and may serve as a marker of broader compensatory strategy use in daily life among older adults with HAND, even though HAND status itself does not appear to reduce the likelihood of spontaneous strategy use [24]. Subsequently, metacognitive research has revealed that individuals with HAND are not simply impaired in PM performance but are also inaccurately overconfident in their predicted ability to complete TBPM tasks, and that this overconfidence is associated with executive dysfunction and with nonadherence to antiretroviral therapy, pointing to a clinically consequential dissociation between subjective and objective PM competence [25].In the cognitive neuropsychological profile of HAND, there is a primary dissociation between time-based and event-based prospective memory. TB tasks require executing an action at a specific time or after a precise duration. Because no external trigger prompts the individual, successful execution depends on internal, self-initiated strategic time monitoring. Individuals must interrupt ongoing activities to monitor the time elapsed [21]. Conversely, event-based tasks present an explicit environmental trigger. When event-based cues are focal, such as the ongoing tasks naturally direct attention focus to the target feature, the cue detection occurs relatively automatically via spontaneous retrieval, and performance in HAND is relatively spared. Nonetheless, when event-based cues are non-focal or semantically unrelated to the ongoing activity, target detection demands strategic attentional monitoring, exposing substantial PM impairment in HAND [21].

A limited study has systematically synthesised these findings to quantify the overall magnitude of PM impairment associated with HAND or formally to test across studies whether effect sizes are systematically moderated by task characteristics such as cue type (event-based versus time-based), delay interval length, diagnostic characteristics or PM modality- despite the clear theoretical prediction from multi-process theory that such moderators should matter, and notwithstanding the direct clinical relevance of identifying which PM parameters carry the greatest risk for functional decline particularly in ART nonadherence.

The present systematic review and meta-analysis, therefore, aimed to synthesise the existing literature examining PM performance in older adults with HAND relative to HIV-seronegative comparison groups and PLHIV without HAND. The primary aim of the present meta-analysis was to quantify the nature and extent of PM deficits in the HAND population compared with people living with HIV (PLHIV). Secondary objectives were to determine whether EBPM and TBPM are differently affected by HAND. By integrating findings across the available body of controlled studies, this review seeks to provide a pioneering quantitative, moderator-based account of prospective memory impairment in HAND.

Measurement of PM Across the Empirical Studies

PM has been operationalised across empirical studies using examination of behavioural meta-cognitive and temporal processing paradigms. The failures of PM in HAND are not uniform; rather, they reflect in selective disruptions within the frontostriatal circuits that govern strategic monitoring, attention allocation and self-initiated intention retrieval [26]. Measuring PM requires constructing dual-task paradigms wherein a primary ongoing task is interrupted by the self-initiated retrieval and execution of a delayed intention. Empirical literature situated across HAND and PM has been quantified using standardised clinical batteries aligned with Frascati criteria of HAND, computerised dual-task paradigms with various manipulations on instructions, automated time-monitoring software, meta-cognitive predictions and temporal estimation tasks. Morgan et al (2012) used the Memory for Intentions Screening Test (MIST) as a primary PM measure along with cue modalities, such as TBPM and EBPM, delay intervals on short (2-minute) and long delay (15-minute), using a standardised word search puzzle as an ongoing distractor task, and measured error type coding including omission errors, loss of time errors, loss of content errors, task substitution errors, post-test recognition task, PRMQ complaints scale along with Time Estimation probe at 15s, 30s, 45s and 90s. Matchanova et al. (2020) used measures of the Cambridge Prospective Memory Test (CAMPROMPT), along with 3 Time-Based (TB) trials, 3 Event-Based (EB) trials, and Variable delay intervals. For the ongoing task, includes paper-and-pencil puzzles, the Spontaneous Strategy Scoring System (1–5 ordinal scale combining note count, qualitative rating, and self-report), and the Memory Functioning Questionnaire (MFQ). Doyle et al. (2013) incorporated MIST with Automated Clock Checking and used modalities of the TB and EB subscales, with delay intervals of 2-minute, 15-minute, and 24-hour naturalistic delays. For the ongoing task, a Standardised Word Search Puzzle, which includes Web-based SQL, time-monitoring software (keypress reveals a digital clock for 6s), Clock checks tracked across six 4-min intervals. Casaletto et al. (2014) introduced the MIST Metacognitive Prediction Paradigm, including the modalities of Time-Based (TB) subscale, Event-Based (EB) subscale, and ongoing tasks, such as the Standardised Word Search Puzzle and measures including Pre-test Likert performance predictions, Continuous Meta-PM score, and Categorical Meta-PM (overconfident, underconfident, accurate) and 30-day MEMS cap electronic cART tracking. Woods et al. (2014) established a Computerised Non-Focal EB PM Task (Experimental Dual-Task Paradigm) integrating Non-focal EB cue (syllable "TOR") requiring "Q" keypress, 5 target cues embedded per 100-trial block and ongoing tasks as Lexical Decision Task (LDT) embedded with Word vs. Non-word categorisation, and measured Instructional Task Importance Manipulation (Ongoing Important vs. PM Important), Ongoing LDT Reaction Time (RT) cost tracking, and Post-block target cue recognition test.

Standardised Assessments

As mentioned above, the Memory for Intentions Screening Test (MIST) incorporated eight PM trials administered over a thirty-minute period while participants were engaged in an ongoing distraction task of a standardised word search puzzle. The items are counterbalanced across three dimensions, such as short (2-minute) versus long (15-minute) delay intervals, time-based versus event-based cues, and verbal versus physical action response modalities. Each item scores 0–2 points, giving 1 point for retrieving the correct intention and 1 point for executing the response within the temporal window (± 1 minute for 2-minute delays; ±2 minutes for 15-minute delays) or upon completion of the cue. Subscale scores range from 0 to 8, and the overall score is from 0 to 48. MIST also has an error-coding framework designed to categories PM failure. Omission errors occur when a response is omitted in response to a cue. Loss of time errors are errors that are made in the execution of an intention correctly, but outside of the time window. Task substitution errors occur when a different action or response modality is performed. The loss-of-content errors indicate that there is some awareness that there is something to answer, as well as a failure to retrieve the content itself. An eight-item post-test recognition task then tests whether prospective failure is due to a failure of strategic monitoring or to a failure in retrospective memory. Naturalistic PM was assessed as another component of PM, using a 24-hour delay trial where participants called the clinic the next day and reported the amount of sleep they had obtained in a two-hour period.

The Cambridge Prospective Memory Test (CAMPROMPT) is a dual-task prospective memory test that combines ongoing paper-and-pencil puzzles. It contains six different PM tasks, half of which are time-based and half event-based, with subscale scores ranging from 0 to 18 [23].

Experimental Paradigms

To isolate attentional monitoring processes, experimental paradigms are designed to include PM targets within computerised ongoing tasks, including the Lexical Decision Task (LDT) (Woods et al., 2014). Subjects compare presented letter strings as words or non-words and respond as promptly and accurately as they can. PM targets consist of non-focal cues, such as words containing a specific syllable, such as “TOR”, requiring a unique keypress. These tasks manipulate instructional task importance across 100 trial blocks; there was a baseline condition in which LDT's ongoing performance without PM demands is assessed. Another condition is the ongoing task importance condition where PM demands are introduced, but instruction explicitly direct participants to priorities speed and accuracy on the primary LDT over detecting target cues, and the PM task importance condition, where the instruction explicitly direct participants to priorities cue detection over ongoing LDT performance. By measuring ongoing tasks, RT costs are defined as LDT response slowing during PM blocks relative to baseline, and the experimenter can track the allocation of strategic attentional resources to prospective cue monitoring [22].

To capture dynamic monitoring behaviours during delay intervals, specialised software tracks clock checking activity during the task. Participants may press a key on the keyboard to display a digital clock for 6 seconds. Software records exact timestamps for every clock check. To quantify spontaneous deployment of compensatory strategies, a standardised coding system evaluates note-taking behaviour on CAMPROMPT. While paper and pencils are available, examinees may take notes if they wish. Strategy use is scored on an integrated scale ranging from 1 to 5, combining elements of total note count, examiner qualitative rating assessing clarity and elaborateness and retrospective self-report.

Methods

Search Strategy

A systematic search strategy was performed from 2007 to March 2026, since the Frascati criteria were established in 2007, across databases such as MEDLINE PsycINFO, PubMed, Web of Science, ScienceDirect, ProQuest, and Google Scholar. Search terms combined across concept blocks using with Boolean operators: "prospective memory" OR "time-based prospective memory" OR "event-based prospective memory") AND ("HIV/AIDS" OR "human immunodeficiency virus") AND ("neurocognitive" OR "HAND" OR "HAD" OR "ANI" OR "MND" OR "cognitive impairment". Search results were imported to Rayyan, and duplicates were removed. Study selection proceeded in two stages. In stage one, titles and abstracts were independently screened against the eligibility criteria, and in stage two, the full text of all records deemed potentially eligible was independently assessed for inclusion. The study selection process is summarised in a PRISMA 2020 flow diagram (Fig. 1).

Selection of Studies

The inclusion criteria were as follows:

1. Published articles included reported measures of event-based or time-based prospective memory abilities in patients with HAND.
2. These studies additionally assessed PM in a group of healthy participants or people living with HIV as a comparison group.
3. These studies used quasi-experimental, quasi-controlled, and cross-sectional employing quantitative measures of PM.
4. These studies contained sufficient information to calculate at least one effect size.

The Exclusion criteria were as follows:

1. Other systematic reviews, scoping reviews, and meta- analysis
2. Editorials, letters to editors and commentaries
3. Case reports and single-subject designs
4. Studies without a quantitative measure of PM
5. Studies not available in the English language

Data extraction

Data extraction was conducted by a single reviewer using Rayyan software to manage and screen the included records. For each eligible study, the extracted data includes sample means, standard deviations, sample sizes (HAND and comparison groups), effect sizes (Hedges' g,) and study design details.

Statistical Analysis

As the studies used different tasks of PM, we opted for the standardised mean difference as an estimator of the effect size of accuracy in PM tasks (Hedges' g, Cohen's d) between HAND and comparator groups, which was used as a common metric across studies.

Meta-analytic approach

All the analysis was performed using JASP. Because some studies contributed multiple effect sizes (separate time-based and event-based PM outcomes), a random-effect multilevel meta-analysis was conducted to account for the dependence among effect sizes within studies. Models were estimated using restricted maximum likelihood (REML), with the within-study correlation among effect sizes specified at .80. Heterogeneity was evaluated using Cochran's Q Test and the estimated between study variance, $\tau 2$. JASP supports meta-analytic estimation using restricted maximum likelihood and standard heterogeneity indices.

Table 1
characteristics of studies including PM among the HAND and the comparison group

Study	Study ID	PM Outcome	Cue-type	Comparison	N_HAND	N _Control	M_HAND	SD_HAND	M_ Control	SD_ Control	Hedg g
Longer ongoing task delay intervals exacerbate prospective memory deficits in HIV-associated neurocognitive disorders (HAND)	Morgan et al. (2012)	TB PM (15-min)	TB	HAND vs HIV−	49	78	1.71	1.15	2.38	1.25	0.55
Longer ongoing task delay intervals exacerbate prospective memory deficits in HIV-associated neurocognitive disorders (HAND)	Morgan et al. (2012)	EB PM (15-min)	EB	HAND vs HIV−	49	78	2.00	1.20	2.80	1.10	0.22
Prospective memory and spontaneous compensatory mnemonic strategy use in the laboratory and daily life in HIV-associated neurocognitive disorders	Matchanova et al.(2020)	TB PM	TB	HAND vs HIV−	53	62	8.8	3.2	11.8	3.0	0.64
Prospective memory and spontaneous compensatory mnemonic strategy use in the laboratory and daily life in HIV-associated neurocognitive disorders	Matchanova et al.(2020)	EB PM	EB	HAND vs HIV−	53	62	13.0	3.10	13.5	3.0	0.12
Prospective memory in HIV-associated neurocognitive disorders (HAND): The neuropsychological dynamics of time monitoring	Doyle et al.(2013)	TB subscale (MIST)	TB	HAND vs HIV−	55	108	4.30	1.70	5.80	1.50	0.95
Prospective memory in HIV-associated neurocognitive disorders (HAND): The neuropsychological dynamics of time monitoring	Doyle et al.(2013)	EB subscale (MIST)	EB	HAND vs HIV−	55	108	5.40	1.90	6.30	1.60	0.48
Self-Predictions of Prospective Memory in HIV-Associated Neurocognitive Disorders: Evidence of a Metamemory Deficit	Casaletto et al. (2014)	TB PM (MIST z-score)	TB	HAND vs HIV−	72	150	−0.55	0.92	0.17	0.85	0.72
Self-Predictions of Prospective Memory in HIV-Associated Neurocognitive Disorders: Evidence of a Metamemory Deficit	Casaletto et al. (2014)	EBPM(MIST Event-Based z-score)	EB	HAND vs HIV−	72	150	-0.21	0.90	0.12	0.88	0.41

Study	Study ID	PM Outcome	Cue-type	Comparison	N_HAND	N _Control	M_HAND	SD_HAND	M_ Control	SD_ Control	Hedg g
Task Importance Affects Event-Based Prospective Memory Performance in Adults with HIV-Associated Neurocognitive Disorders and HIV-Infected Young Adults with Problematic Substance Use	Woods et al. (2014)	EB PM accuracy (ongoing cond.)	EB	HAND vs HIV+	15	35	45.00	28.00	69.00	30.00	0.78

Index- HAND-HIV Associated Neurocognitive Disorder, Prospective Memory, TBPM-Time-Based Prospective Memory, EBPM-Event-Based Prospective Memory,

Results

A total of 9 effect sizes across 5 independent primary publications [22-26] were identified during data extraction (Table 1). Among these, k = 9 effect sizes were provided with matrices of means, standard deviations, and standard errors required for quantitative meta-analysis. The primary studies included group sizes ranging from 49 to 78 participants per group.

Hedges' g across individual prospective memory outcomes ranges from g = 0.12 (SE = 0.187, Matchanova et al., 2020) to g = 0.95 (SE = 0.173, Doyle et al., 2013). Positive effect sizes indicate worse prospective memory performance in the HAND cohort than in the control cohort.

Meta-Analytic Estimates

			95% CI		95% PI	
	Estimate	Standard Error	Lower	Upper	Lower	Upper
Pooled effect	0.53	0.059	0.38	0.66	0.038	0.66
τ	0.19	0.091	0.00	0.47		
τ^2	0.03	0.034	0.00	0.22		

Table 2. pooled estimates of PM

A random-effects meta-analysis revealed a statistically significant pooled effect size, indicating moderate prospective impairment in the HAND group relative to controls (0.53; SE=0.059; p<0.001), with a confidence interval suggesting strong evidence of decreased PM performance in HAND. In addition, prediction intervals suggest that, despite potential population-level variation, prospective memory performance will consistently remain worse in the HAND population across comparable future study settings.

Publication Bias

The publication bias is addressed using funnel plot. It is a simple scatter diagram that compares the impact estimates from individual studies to some Parameters of study size and precision. This plot showed that the observed effect sizes were consistently positive and were generally distributed within the expected funnel region. However, given the number studies included (k = 9) is less require a careful interpretation. Given that, the potential publication bias cannot be reliably excluded.

Time-based and Event-based Multilevel Meta-regression

Figure 3 graphs showing TB, EB and pooled results of EBPM &TBPM meta regression.

The time-based deficit (−0.728) is larger than the event-based deficit (−0.358) in all three studies with matched TB/EB Hedges' g. The difference is significant under the cluster correction but is at the boundary of what is considered statistically defensible with independent studies and with df as low as ~1; another set of 5 studies could determine the opposite result. The direction and the size of the TB > EB gap is a more reliable conclusion to draw than the significance test, per se.

Figure 4 Forest plot of the included studies. Including effect sizes and their confidence intervals across multiple studies in a meta-analysis.

A multilevel meta-regression with cluster-robust standard errors (clustering by study, small-sample correction) tested cue type as a moderator of the HAND PM. Effects here are mentioned as Hedges' g, The event-based effect was moderate but not statistically distinguishable from zero given the available degrees of freedom, g = −0.35, 95% CI [−2.38,1.62], t (1.00) = −2.42, p = .250, while the time-based effect was substantially larger, g −0.72. The difference between cue types reached significance under the cluster-robust correction, b = −0.35, 95% CI [−0.65,-0.03], F (1, 1.46) = 47.66, p = .043, consistent with the theoretical prediction that HAND disproportionately impairs time-based prospective memory. The pooled effect across both cue types was moderate but only marginally significant once clustering was accounted for, g = −0.59, 95% CI [−1.30, 0.13], p = .069. Given that this test is based on only three independent studies (residual df 1–2 after the small-sample cluster correction), these results should be interpreted as suggestive rather than conclusive; the consistency

of the direction and magnitude of the TB > EB gap across all three studies is a more stable finding than the formal significance test itself. Residual heterogeneity was not significant, $Q_{\square}(3) = 4.48$, $p = .215$.

Discussion

Across the five studies, HAND sample sizes ranged from 15 participants in Woods et al. (2014, Experiment1) to 72 participants in Casaletto et al. (2014). Comparison groups included HIV- seronegative adults; however, Doyle et al. (2013) did not include HIV-positive group without HAND, and Woods et al. (2014, Experiment 2) compared younger adults living with HIV according to substance-use risk rather than HAND status. HAND diagnoses were uniformly derived using Frascati criteria (Antinori et al.,2007), though the proportion of syndromic (MND/HAD) versus asymptomatic (ANI) HAND varies across samples from 0% HAD and 40% MND, 60% ANI in Doyle et al. (2013).

The five studies broadly address why PM fails in HAND and under what conditions, mapping more closely to the stages of the multiprocess model (encoding, delay-interval monitoring, cue detection, retrieval, and execution). Investigating secondary mechanisms like delay interval, Morgan et al. (2012) provided substantial evidence for HAND x delay interval interaction, which showed that a PM performance did not differ between HAND and seronegative groups at a 2-minute delay but varied considerably at a 15-minute delay ($d = 0.48$ overall, $d = 0.56$ for TB items specifically), with the effect driven primarily by omission and loss of time errors rather than by recognition of failures, which gives evidence against a general encoding or retrospective memory account and in favour of a delay-dependent strategic monitoring account. In time monitoring, Doyle et al. (2013), using a novel clock checking paradigm using a keystroke logged clock checking mechanism embedded in the MIST, found that people with HAND checked the clock significantly less often than the controlling group across four of six 4-minute intervals, particularly failing to show the expected escalation in clock checks as the target execution time approached (i.e., a blunted J-shaped monitoring curve). Frequency of clock checking correlated with TB PM performance and was unrelated to normal time estimation, suggesting that reduced monitoring, rather than an inability to judge elapsed time, may drive the TB PM deficit. Looking into the accounts of time perception.

Woods et al. (2014) offer the most direct causal test of the strategic-monitoring account: when instruction explicitly prioritised the PM task over the competing ongoing task, PM accuracy in HAND improved substantially relative to the condition where the ongoing task was prioritised. This is a theoretically important result. A deficit that is sensitive to instructional emphasis is, by definition, not a hard ceiling capacity it indicates that at least part of the observed impairment reflects how attentional resources are allocated between competing task demands, not merely how much capacity is available in an absolute sense. This finding is also evidence in the included literature that HAND-related PM impairment may be partially remediable through relatively simple environmental or instructional scaffolding. Matchanova et al. (2020) extend this remediability picture from the instructional level to the strategic level, spontaneous strategy use (e.g., note-taking) during PM tasks was strongly associated with better performance, particularly for TB items, and critically, HAND status did not reduce the likelihood that participants spontaneously deployed such strategies. In other words, the deficit in unaided, self-initiated monitoring does not appear to reflect a loss of the underlying compensatory capacity itself; individuals with HAND can and do use external strategies effectively when they choose to, at rates comparable to those of controls. This dissociates the monitoring impairment from a more general strategic or executive collapse, and points toward compensatory strategy training as a plausible intervention target. Casaletto et al. (2014) close the loop on this account, which is the most clinically relevant finding in the set: the individuals with HAND are not only objectively impaired on TBPM tasks but are also inaccurately overconfident about their own predicted performance, and this overconfidence itself is associated with executive dysfunction and with nonadherence to antiretroviral therapy. This is a critical addition to the monitoring account above, because it identifies a plausible mechanism by which an objectively remediable deficit [23, 24] may nonetheless go uncompensated in daily life; if individuals with HAND do not accurately anticipate their own PM failures, they have correspondingly less reason to engage the compensatory strategies they are otherwise capable of using. This metacognitive dissociation, impaired performance paired with preserved or even inflated confidence, is a pattern with direct implications for how adherence-support interventions should be designed. These studies converge on a specific and theoretically coherent profile; HAND impairs PM primarily by degrading the self-initiated, strategic monitoring processes that time-based and non-focal event-based tasks depend on, while leaving basic encoding, recognition and the capacity to deploy compensatory strategies comparatively intact. The impairment is graded by delay length, is sensitive to instructional and strategic scaffolding, and is compounded rather than caught early by inaccurate metacognitive self-monitoring.

The dissociation between TBPM and EBPM impairments underscored by a consistent pattern of greater TBPM than EBPM deficits across three matched-subscale studies. TB tasks provide no external retrieval trigger and are therefore maximally dependent on the self-initiated strategic monitoring that HAND appears to compromise, whereas the focal EB tasks can rely on relatively spared spontaneous, cue-driven retrieval. This dissociation is consistent with and provides a quantitative anchor for the qualitative claim in the individual primary studies that HAND-related PM impairment is not generalised but boundary-conditioned by task structure. Clinically, it suggests that everyday demands with no external prompt (e.g., "Remember to take your medication at 8 p.m.") should be more vulnerable to HAND-related failure than demands with a salient environmental trigger (e.g., "Take your medication when you get home from the clinic"), a distinction with direct implications for how adherence supports are designed. We note again, however, that this moderator estimate is built on only three independent study clusters, and the associated significance test ($p = .043$) sits close to the edge of what a small-sample cluster-robust correction can support with confidence. We report it because the direction and magnitude of the TB > EB gap were remarkably consistent across all three contributing studies, despite their use of different PM instruments (MIST vs. CAMPROMPT) and different comparison groups — a form of convergent validity that we consider more persuasive than the formal p-value alone. Nonetheless, this should be treated as a well-motivated hypothesis rather than a definitive conclusion.

The pattern of results carries several implications for clinical management of PLHIV. First, because the deficit is concentrated in time-based, self-initiated tasks, the same structure as most medication adherence demands, routine cognitive screening for PM (rather than relying solely on general neurocognitive batteries that may not isolate PM-specific impairment) could help identify patients at elevated risk of nonadherence before adherence failures accumulate clinically. Second, the remediability of the deficit with increased task importance cues [23] and the maintenance of spontaneous strategy use for compensation [24] indicate that relatively low-cost interventions, external reminder systems, alarm-based cueing, and cueing based on salient anchors in the

daily environment may be feasible targets for intervention as opposed to speculations. Third, the overconfidence in metacognition that was noted by Casaletto et al. (2014) suggests that adherence intervention strategies based on patient reports of likely adherence difficulty (e.g., "Do you think you'll remember to take this?") might systematically underestimate risk in this patient population and that objective PM screening may provide a more accurate basis for triaging adherence intervention than subjective adherence assessment.

Strength and Limitation

The notable strengths of this review are, to our knowledge, the first quantitative synthesis of HAND-PM literature; the only prior systematic review in this area [27] was more of a narrative synthesis para and did not report pooled effect sizes. We used robust variation estimation to appropriately account for the dependent effect sizes contributed by studies reporting separate TBPM and EBPM outcomes from the same sample. Several limitations including small and non-independent evidence base, single reviewer data extraction, heterogenous operation of PM and underpowered publication bias assessment.

Conclusion

This meta-analysis provides the first quantitative evidence that prospective memory impairment in HAND is real and moderate in magnitude, within time-based deficits consistently exceeding event-based deficits. These patterns give us understanding about impaired strategic monitoring, rather than encoding failure, as the core mechanism. These findings also give evidence that PM impairment is a modifiable risk factor with direct relevance to medication adherence, rather than a fixed consequence of decline. Given the small, non-independent evidence base, this synthesis should be treated as an initial benchmark warranting confirmation in larger longitudinal studies.

Declarations

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Competing Interests

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Figures

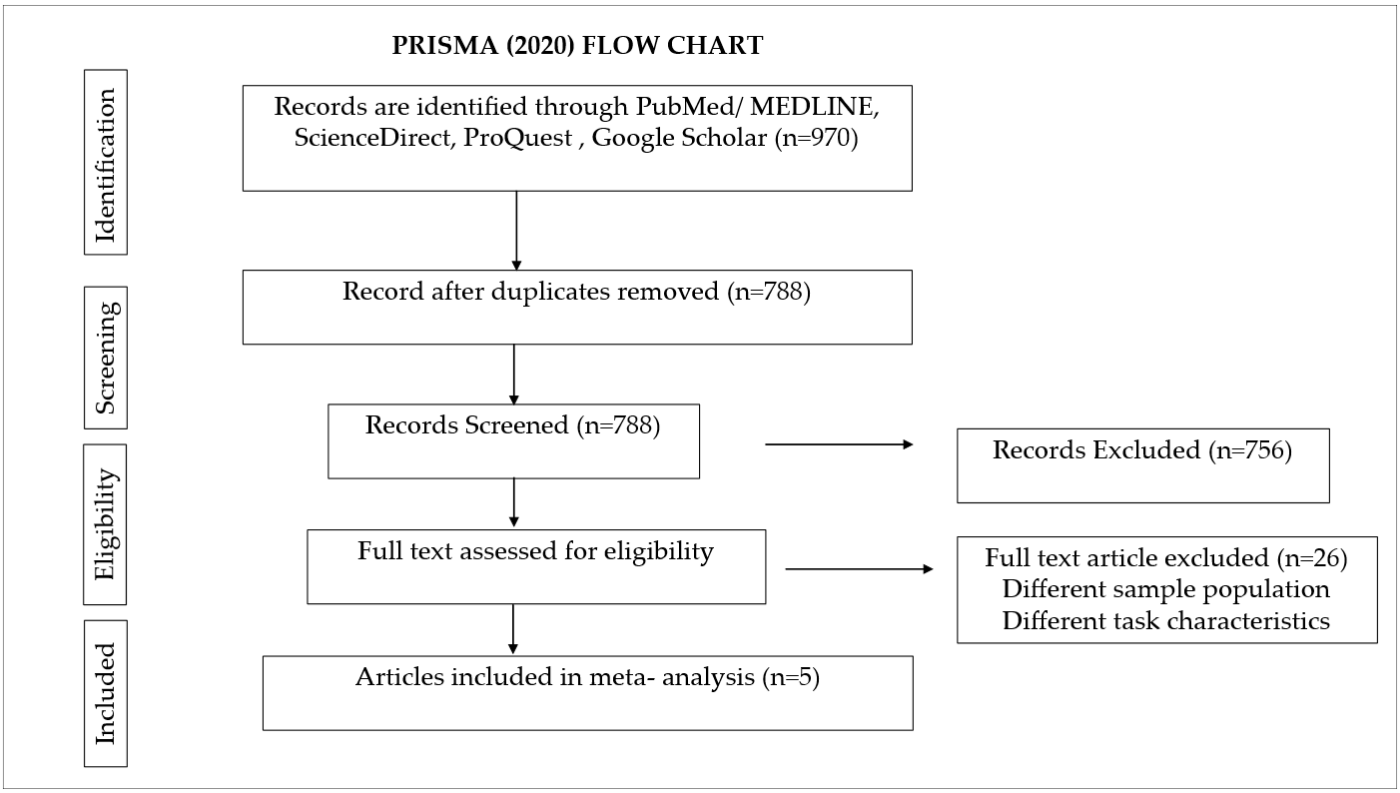


Figure 1

Flowchart of the studies included in the systematic review and meta-analysis

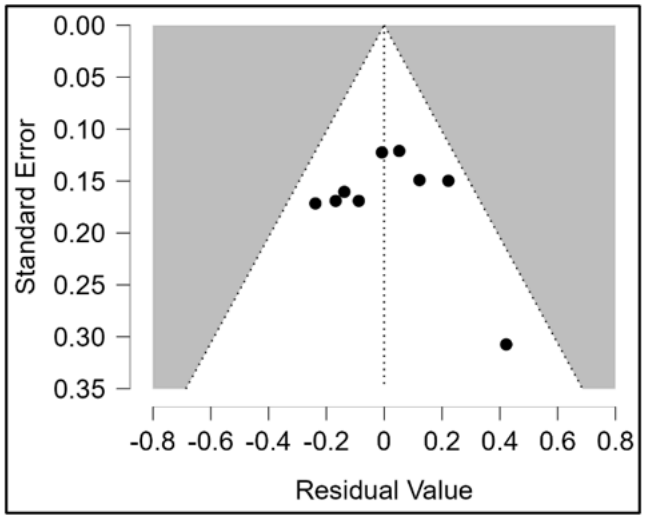


Figure 2

Residual Funnel plot of effect size across the studies

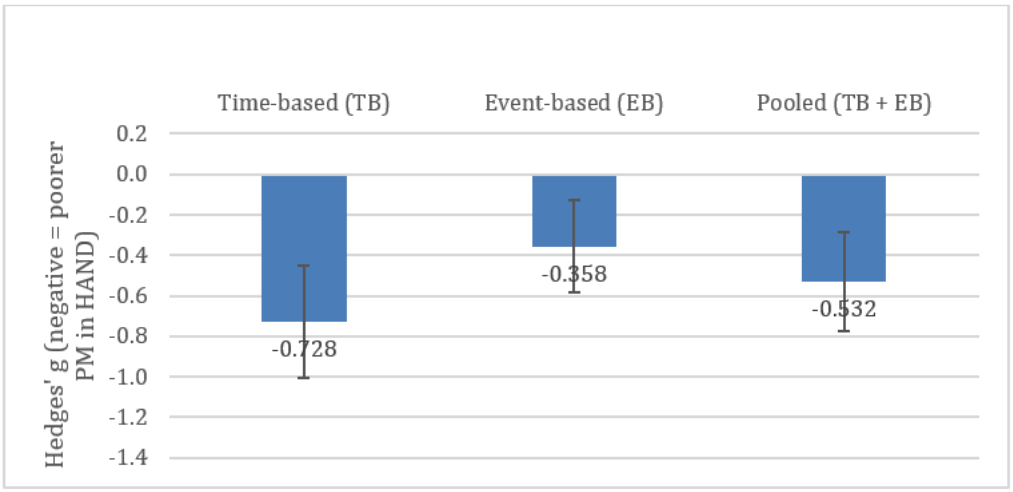


Figure 3

graphs showing TB, EB and pooled results of EBPM &TBPM meta regression.

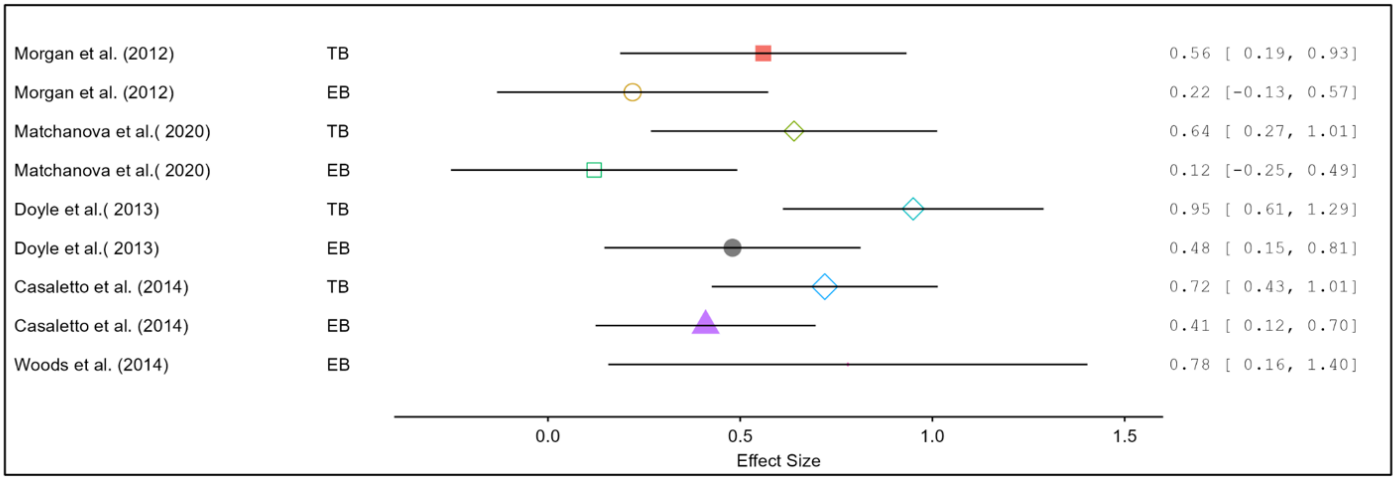


Figure 4

Forest plot of the included studies. Including effect sizes and their confidence intervals across multiple studies in a meta-analysis.