Neuropsychologia 201 (2024) 108943

Contents lists available at ScienceDirect

Neuropsychologia

journal homepage: www.elsevier.com/locate/neuropsychologia

Integrity of autobiographical memory and episodic future thinking in older adults varies with cognitive functioning

Audrey Li-Chay-Chung [a,b], Faryn Starrs [b], Jennifer D. Ryan [b,c], Morgan Barense [b,c], Rosanna K. Olsen [b,c], Donna Rose Addis [b,c,d,*]

[a] Department of Psychology, York University, Toronto, Canada
[b] Rotman Research Institute, Baycrest Academy for Research and Education, Toronto, Canada
[c] Department of Psychology, University of Toronto, Toronto, Canada
[d] School of Psychology, The University of Auckland, Auckland, New Zealand

ARTICLE INFO

Keywords:
Aging
Autobiographical interview
Episodic memory
Episodic simulation
Mild cognitive impairment
Montreal cognitive assessment MoCA

ABSTRACT

Research has documented changes in autobiographical memory and episodic future thinking in mild cognitive impairment (MCI) and Alzheimer's disease (AD). However, cognitive decline occurs gradually and recent findings suggest that subtle alterations in autobiographical cognition may be evident earlier in the trajectory towards dementia, before AD-related symptoms emerge or a clinical diagnosis has been given. The current study used the Autobiographical Interview to examine the episodic and semantic content of autobiographical past and future events generated by older adults ($N = 38$) of varying cognitive functioning who were grouped into High ($N = 20$) and Low Cognition ($N = 18$) groups based on their Montreal Cognitive Assessment (MoCA) scores. Participants described 12 past and 12 future autobiographical events, and transcripts were scored to quantify the numbers of internal (episodic) or external (non-episodic, including semantic) details. Although the Low Cognition group exhibited a differential reduction for internal details comprising both past and future events, they did not show the expected overproduction of external details relative to the High Cognition group. Multilevel modelling demonstrated that on trials lower in episodic content, semantic content was significantly increased in both groups. Although suggestive of a compensatory mechanism, the magnitude of this inverse relationship did not differ across groups or interact with MoCA scores. This finding indicates that external detail production may be underpinned by mechanisms not affected by cognitive decline, such as narrative style and the ability to contextualize one's past and future events in relation to broader autobiographical knowledge.

1. Introduction

Accruing evidence suggests that the pathological process of Alzheimer's disease (AD) begins years before the onset of clinically-detectable impairments required for a diagnosis of mild cognitive impairment (MCI) or dementia (Sperling et al., 2011). During this preclinical phase, there may be subtle neurocognitive changes (Caselli and Reiman, 2012; Han et al., 2017), including in the medial temporal lobes (MTL), even in the absence of subjective memory complaints. Specifically, Olsen et al. (2017) examined MTL integrity in a community sample of ostensibly cognitively healthy older adults with no subjective memory complaints or clinical diagnosis of MCI. They found that those individuals "at risk" of cognitive decline, as indicated by Montreal Cognitive Assessment (MoCA) scores that fell below the recommended cut-off, had significant volume reductions in anterolateral entorhinal cortex—a region in which Alzheimer's pathology is thought to originate (Khan et al., 2014). Moreover, these individuals showed subtle changes on tests of episodic memory (D'Angelo et al., 2016; Olsen et al., 2017). Recent work suggests that subtle alterations in autobiographical memory (AM) may also be evident early in the trajectory towards dementia, particularly for those at risk of developing AD (Bruus et al., 2021; Grilli et al., 2018; Grilli et al., 2021). Although, in MCI, deficits in AM for past events (Murphy et al., 2008) are strongly associated with an impaired ability to imagine future autobiographical events (Gamboz et al., 2010), less is known about the integrity of future imagination abilities in the preclinical phase. The aim of the current research was to investigate whether the ability to remembering the past and imagining the future is associated with cognitive functioning in older adults.

* Corresponding author. Rotman Research Institute, Baycrest Academy for Research and Education 3560 Bathurst St. Toronto ON, M6A 2E1, Canada.
E-mail address: draddis@research.baycrest.org (D.R. Addis).

https://doi.org/10.1016/j.neuropsychologia.2024.108943
Received 5 October 2023; Received in revised form 7 May 2024; Accepted 19 June 2024
Available online 20 June 2024

1.1. Remembering the past and imagining the future

AM refers to memory for self-related information that ranges in specificity from episodic AMs of specific past events to more general semantic knowledge about the self (Conway and Pleydell-Pearce, 2000). Episodic AMs contain high-fidelity contextual details about the specific time and place of the event, sensory-perceptual and emotional content experienced at the time, as well as the details of the event itself (people, action, dialogue, etc.; Conway and Pleydell-Pearce, 2000; Levine et al., 2002). These episodic details are typically interwoven with semantic information, including personal facts and general knowledge that are not tied to particular events (Levine, 2004; Renoult et al., 2012; Renoult et al., 2019). Thus, although episodic and semantic aspects of AM are considered distinct, they are simultaneously integrated in service of reinstating past events (Greenberg and Verfaellie, 2010; Horzyk et al., 2017; Irish et al., 2012; Irish and Piguet, 2013; Renoult et al., 2012), a process thought to be supported by the MTL (Cohen and Eichenbaum, 1993; Sheldon and Levine, 2016).

A capacity closely tied to remembering past events is the ability to imagine future events, also known as episodic future thinking (EFT; Atance and O'Neill, 2001; Schacter and Addis, 2007). A considerable body of research shows significant similarities between remembering and imagining events, including overlapping recruitment of the default mode network (DMN; Addis et al., 2007; Benoit and Schacter, 2015) and similar reductions of episodic content in the context of MTL damage (Hassabis and Maguire, 2007; Kwan et al., 2010; but see Squire et al., 2010). In light of these findings, the constructive episodic simulation hypothesis argues that remembering past episodes and simulating novel scenarios are supported by the same memory systems (Schacter and Addis, 2007; Addis et al., 2004). Like AM, simulating future events involves the integration of details from episodic memory with semantic knowledge (Addis, 2020; Atance and O'Neill, 2005; Irish and Piguet, 2013).

1.2. AM and EFT in healthy and pathological aging

A number of studies have examined AM and EFT in healthy and pathological aging using the Autobiographical Interview (AI) for past (Levine et al., 2002) and future (Addis et al., 2008) events. Critically, this measure quantifies the number of episodic details "internal" to the main event being described (e.g., event details, sensory details etc.), and the number of non-episodic details that are "external" to this event (including semantic details along with repetitions, meta-cognitive statements, details of other events, etc.). In line with findings of age-related deficits in episodic memory but sparing of semantic memory (Salthouse, 2004), older adults retrieve significantly fewer internal (episodic) details when remembering past events relative to younger adults, with a corresponding increase in the number of external (non-episodic) details (Acevedo-Molina et al., 2020; De Brigard, Rodriguez and Montañés, 2017; Levine et al., 2002; Devitt et al., 2017; Spreng et al., 2018, but see Wank et al., 2021; for a meta-analysis, see Simpson et al., 2023). Similar effects are evident for imagined future events (Addis et al., 2008, 2010; Schacter et al., 2013; Cole et al., 2013; Wank et al., 2021), and indeed, there are strong past-future correlations for both the number of internal ($r = .82$) and external ($r = .65$) details (e.g., Addis et al., 2008). Moreover, past internal detail scores have been found to predict future internal detail scores (Gaesser et al., 2011), in line with the notion that the ability to construct future events depends on the ability to access and recombine details stored in episodic memory (Schacter et al., 2007).

Although most studies have focused on the number of external details as a whole, there has been a shift to consider semantic details in particular. Of all the external detail subcategories, increases in semantic details could feasibly be reflective of a compensatory strategy to offset reduced access to episodic details. Devitt et al. (2017) conducted multilevel modelling of AI data from eight studies, and found that on trials for which fewer internal details were retrieved, more external, and specifically, semantic, details were produced. Although this negative relationship was evident for both younger and older adults, it was stronger and more consistent in older adults, interpreted as evidence of compensation for impoverished episodic content.

Compared to healthy older adults, individuals with AD show significant reductions in both the internal and external components of past and future events (Addis et al., 2009; see also, Bruus et al., 2021; El Haj et al., 2024; Irish et al., 2011; Meulenbroek et al., 2010), consistent with the progression of pathology beyond the MTL to involve lateral temporal regions mediating semantic aspects of AM (Irish and Piguet, 2013). In contrast, individuals with aMCI retrieved fewer internal details than healthy age-matched controls (see also Bruus et al., 2021; Buckley et al., 2014; Irish et al., 2010; Leyhe et al., 2009), but more semantic details when remembering past events (Murphy et al., 2008). Gamboz et al. (2010) replicated and extended this finding to future events. Importantly, in both AI studies, these changes could not be explained by differences in verbal output as the groups generated a similar number of details overall. The results were interpreted as a magnification of the aforementioned age-related alterations in AM (e.g., Levine et al., 2002) as a result of MTL pathology beyond changes associated with healthy aging that lead to reduced internal details, but with relatively more sparing of neocortical regions in aMCI as compared to AD (Frankenberg et al., 2021) that allowed for overgeneration of external details. A recent meta-analysis, however, suggests that the numbers of external details generated by individuals with MCI may be more comparable to healthy older adults than initially thought, at least for AM (Simpson et al., 2023). Whether this is the case for EFT remains unclear.

To date, few studies have investigated AM in the preclinical phase of AD, prior to development of aMCI. Bruus et al. (2021) examined the integrity of AM in participants with aMCI and AD as well as cognitively normal participants reporting subjective cognitive decline (SCD). This study found that, relative to healthy controls, individuals with SCD showed reductions in the ability to generate contextual episodic details on the Three Events Test using a scoring method analogous to the scoring of internal details on the AI. Interestingly, the SCD group performed similarly to the aMCI group, suggesting the changes to the integrity of AM may be indicative of being on a trajectory towards dementia. This study did not, however, quantify the amount of non-episodic detail generated by participants.

Grilli et al. (2018) compared middle-aged to older carriers of the apolipoprotein E (APOE) ε4 allele – a risk factor for AD – to age-matched non-carriers. Carriers were cognitively normal on neuropsychological testing but even so, recalled fewer internal details relative to non-carriers on the AI. Interestingly, carriers did not show an overproduction of external details, in contrast to the aforementioned findings in healthy older adults vs. young adults (Addis et al., 2008; Levine et al., 2002) and aMCI patients vs. healthy controls (Gamboz et al., 2010; Murphy et al., 2008). The same research group recently reported a similar pattern of findings for EFT in ε4 carriers (Acevedo-Molina et al., 2023). It is possible that the reduction of episodic details in these comparatively younger samples of older adults ($M \approx 67.5$ years of age) may not have yet reached a magnitude where it was necessary to compensate with an overproduction of non-episodic content. Moreover, external details were not broken down into subcategories, so whether there was a differential increase in semantic details is not known.

Finally, Peters and Sheldon (2020) examined AM in a sample of healthy older adults and found that the ability to generate internal episodic details correlated with inter-individual differences including cognitive status as measured by the MoCA. However, in that study, participants were only required to elaborate on one AM in detail, and the authors did not report on external details.

1.3. The present study

Although there is evidence to suggest that reductions in episodic AM may be a sensitive marker of early cognitive decline in preclinical AD (Bruus et al., 2021; Grilli et al., 2018; Peters and Sheldon, 2020), to date only one study has examined the integrity of EFT in early cognitive decline (Acevedo-Molina et al., 2023), and none have explored the question of whether the episodic content of EFT is predicted by the ability to retrieve past episodic details (cf. Gaesser et al., 2011). Moreover, these studies cannot speak to the question of whether an overproduction of *semantic* details is evident during this preclinical phase. The current pre-registered study (see https://osf.io/hg9zw) investigated this question in a sample of healthy older individuals without a clinical diagnosis or subjective memory complaints of varying cognitive functioning as estimated by their score on the Montreal Cognitive Assessment (MoCA); on this basis we grouped participants into High ($N = 20$) and Low Cognition ($N = 18$) groups[1] (Peters and Sheldon, 2020). As the sample was older than that in Grilli et al.'s study, we predicted that our group with lower cognitive performance would generate fewer internal details (across all internal subcategories) *and* more external details (particularly for semantic subcategories) in both their past and future events relative to age-matched controls.[2] We also predicted that performance on the past and future AI tasks would be correlated (Addis et al., 2008), and that the generation of internal details on the AI would correlate with scores on neuropsychological tests of episodic memory (Addis et al., 2008). Finally, drawing on Devitt et al.'s (2017) work suggesting that the increase in external semantic details reflects an overproduction of semantic content to offset declines in episodic content in healthy aging, we conducted two analyses. First, we correlated internal and semantic details at the participant level (i.e., collapsed across trials), as is done in most studies. However, as collapsing detail scores across trials can obscure relationships evident within individual trials, we also ran more sophisticated multilevel models recommended by Devitt et al. to explore whether increased semantic detail is generated on trials with fewer internal details.[3] Although we expected this pattern to be evident in both groups, we predicted it would be stronger in those with lower cognitive functioning. In addition to analyses splitting the sample into older adults with high and low cognitive functioning, where informative we also conducted supplemental analyses using the MoCA score as a continuous predictor. This included an exploratory mediation analysis examining whether the capacity to retrieve past internal details mediated the effect of MoCA scores on future internal details.[4]

2. Methods

2.1. Power analyses

Our sample size was constrained by the current sample size of the larger longitudinal study (Olsen et al., 2017) from which we were recruiting; nevertheless we conducted *a priori* power analyses using G*Power version 3.1 These analyses showed that a sample size of $N = 10$ was required to provide adequate power (0.95) to detect a Group x Detail Type interaction in a mixed ANOVA based on the effect size reported by Murphy et al. (2008; $\eta_p^2 = 0.33$, $d = 0.70$); based on the effect size reported by Grilli et al. (2018; $\eta_p^2 = 0.19$, $d = 0.48$), a sample of $N = 18$ was required. Additionally, sample sizes of $N = 11$ and $N = 21$ were required to provide adequate power (0.95) to detect the correlations of past and future AI performance reported by Addis et al. (2008) for internal ($r = 0.82$) and external ($r = 0.65$) details. Sample sizes of $N = 19$ to $N = 32$ were required for correlations of AI internal details with scores on neuropsychological tests of episodic memory, also based on effect sizes from Addis et al. (2008).

2.2. Participants

We recruited 42 community-dwelling older adults currently enrolled in a larger longitudinal study (Olsen et al., 2017)[5]; this cohort was originally recruited from participant databases at the Rotman Research Institute and the University of Toronto. All participants were fluent in English, had normal or corrected-to-normal vision, and did not have neurological or psychiatric disorders, strokes, brain trauma, colour blindness or diabetes. All participants provided written informed consent, and the study was approved by the Baycrest and University of Toronto Research Ethics Boards (REB). Participants received monetary compensation after each AI session, as per standard practices approved by the Baycrest REB.

Of our 42 participants, 3 dropped out midway through the study, and 1 was excluded due to their medical history of depression and antidepressant use. The final analytic sample included 38 older adults who ranged in cognitive functioning as estimated by the MoCA. We used a cutoff score of 26 on the MoCA (Nasreddine et al., 2005)—the standard threshold for primary care physicians to administer further testing for dementia (Damian et al., 2011)— to stratify the sample into Low Cognition (i.e., MoCA score of 19–25, $n = 18$, 13 female) and High Cognition groups (i.e., MoCA score of 26–30; $n = 20$; 14 female). Demographics are presented in Table 1. The groups did not differ significantly in age or years of education (at a Bonferroni-corrected α of .003, see Table 1), or in the number of females and males, $\chi^2_{(1)} = 0.02$, $p = .880$.

2.3. Materials

2.3.1. Adapted Autobiographical Interview (AI; Levine et al., 2002; Addis et al., 2008)

Participants completed an adapted version of the AI for which they retrieved past events as well as imagined future events. In the current study, conducted during the COVID-19 pandemic (during local lockdowns), participants completed six monthly AI sessions over the telephone as part of routine tracking of their cognitive and physical health for the larger longitudinal study. Each 30-min AI session involved completion of 4 trials (2 past, 2 future) blocked by temporal direction as in Addis et al. (2008) to reduce cognitive load and facilitate understanding of the instructions for each condition. Moreover, each event had to be within a specified timeframe (with instructions that it be either "the past few weeks" or "the past few years" from the present) to ensure that all participants generated events within a constrained time-frame that was similar for the past and future conditions (Addis et al., 2008). Specifically, each session comprised retrieval of one past event from the past few weeks and one from the past few years, and imagination of one event that could occur in the next few weeks and one in the next few years. The order of these trials was counterbalanced across each participant's sessions, and across participants.

On each 3-min trial, participants were instructed to generate and describe in detail an event consistent with the temporal direction and timeframe instructions. Each event had to be specific in time and place, so as to avoid generation of general events (e.g., routines, extended events). All events had to be autobiographical (i.e., events had to be ones

[1] In our preregistration plan, these groups were labelled "healthy" or "at-risk" of cognitive decline.

[2] Although preregistration plan does not make explicit reference to analysis by subcategories other than the semantic subcategory, we conducted analyses of internal and external subcategories to be consistent with the literature.

[3] Although in our preregistration plan we described running simple correlations to test this question, we also tested the relationship using more sophisticated multilevel models (Devitt et al., 2017), as described in the Methods.

[4] This analysis was not in the preregistration plan.

[5] Note that the participants currently enrolled do not overlap entirely with the original sample as reported in Olsen et al. (2017); $n = 20$ (8 in the High Cognition group, 12 in the Low Cognition group) are from the original sample and $n = 18$ (12 in the High Cognition group, 6 in the Low Cognition group) were subsequently enrolled due to attrition.

Table 1
Demographic and neuropsychological characteristics of the High and Low Cognition groups.

	High Cognition		Low Cognition		*t*	*df*	*p*	*d*
	M	SD	M	SD				
Demographics	*n* = 20		*n* = 18					
Age (years)	72.75	5.96	76.89	7.02	−1.97	36	.057	−0.64
Education (years)	15.20	2.29	16.00	2.54	−1.02	36	.314	−0.33
MoCA	*n* = 20		*n* = 18					
Total score* (/30)	27.10	0.85	23.72	1.60	7.99	25.30	**<.001**	**2.68**
Visuospatial/Executive* (/5)	4.80	0.41	3.89	0.83	4.21	24.22	**<.001**	**1.41**
Naming (/3)	3.00	0.00	2.89	0.32	1.46	17	.082	0.50
Attention (/6)	5.85	0.37	5.44	0.71	2.19	25	.019	0.73
Language (/3)	2.50	0.51	2.11	0.83	1.75	36	.044	0.57
Abstraction (/2)	1.75	0.44	1.56	0.51	1.25	33.93	.111	0.41
Memory* (/5)	3.10	1.12	1.83	0.22	3.01	36	**.002**	**0.98**
Orientation (/6)	5.95	0.22	6.00	0.00	−0.95	36	.175	−0.31
Neuropsychological battery	*n* = 19		*n* = 16					
TMT-A (scaled score)	9.47	2.34	10.19	2.11	−0.94	33	.177	−0.32
TMT-B (scaled score)	11.63	2.69	10.00	2.53	1.84	33	.038	0.62
WAIS-III Digit Symbol Coding (scaled score)	10.26	2.26	9.19	2.54	1.33	33	.097	0.45
Shipley-2 Vocabulary (Standard score)	109.89	6.34	104.88	10.30	1.77	33	.043	0.60
Phonemic fluency (FAS, *Z* score)	1.07	0.95	0.45	1.16	1.75	33	.045	0.59
Semantic fluency (animals, *Z* score)	0.77	1.03	0.38	1.58	0.87	33	.196	0.29
RAVLT Delayed recall (*Z*-score)	1.03	1.29	−0.04	1.66	2.15	33	.020	0.73
BVMT-R Delayed recall (*T*-score)	53.26	12.03	48.68	12.38	1.63	33	.056	0.55
Subjective memory	*n* = 20		*n* = 18					
MFQ Average rating (7-point scale)	4.82	0.74	4.91	0.60	−0.43	35	.373	−0.12

Note: *Significant group difference at Bonferroni-corrected alpha of .003 (uncorrected *p* value shown in bold). Maximum attainable for MoCA scores is provided in parentheses. BVMT-R = Brief Visuospatial Memory Test – Revised; MFQ = Memory Functioning Questionnaire; MoCA=Montreal Cognitive Assessment; RAVLT = Rey Auditory Verbal Learning Test; TMT = Trail Making Test; WAIS-III = Wechsler Adult Intelligence Scale III.

they had personally experienced or could imagine doing so). Future events also had to be novel scenarios that had not happened previously, but plausible given the participants' plans and thoughts about the future. The interviewer could provide probes as necessary to either encourage further description of details ("general" probes) or clarify the instructions to direct them back to the task ("redirect" probes). A set of cues (7 for each timeframe, e.g., celebrating a holiday; watching a performance) were available for participants if they required assistance in generating events on a given trial. All sessions were audio-recorded and trials were manually transcribed for scoring.

Following completion of each trial, participants completed a series of self-paced questions. They were asked to estimate the temporal distance of the event they had just described. They also rated a number of phenomenological aspects of the events: whether they (p)re-experienced the event primarily from a field or observer perspective (0 = field; 1 = observer), the amount of detail (1 = low detail, 5 = highly detailed), emotional intensity (1 = not emotional, 5 = highly emotional), and personal significance of the event (1 = not important, 5 = life changing).

Event transcripts were scored using the adapted AI scoring protocol (Addis et al., 2008) which was based on that originally developed by Levine et al. (2002). AI scoring involves first identifying a main event specific in time and place that occurred in a timeframe of 24 h or less; if more than one event meets this criterion, the one described in the most detail is selected as the main event. Using Autobiographical Interview Scoring software (SciToS; https://github.com/scientific-tool-set/scitos), the transcript is segmented into distinct details, or chunks of information, and then classified as either (1) internal episodic details specific to the main event (subcategories: event, time, place, perceptual, and thought/emotion details) or (2) external, non-episodic details that are not specific to the main event (subcategories[6]: personal semantic, general semantic, general events, other episodic events, repetitions and other non-mnemonic information such as meta-cognitive statements). Both total scores (total number of internal and external details), subcategory scores, and the total number of semantic details (i.e., sum of general semantic, personal semantic and generic event details) were computed. Five raters blind to participants' group membership were trained. Interrater reliability was established prior to scoring using a training set consisting of a total of 16 events drawn from Addis et al. (2008). Two-way random consistencies intraclass correlation (ICC) analyses demonstrated a high level of agreement across raters for both internal (Cronbach's α = 0.98) and external (Cronbach's α = 0.96) scores. ICC analyses indicated acceptable to high levels of agreement (LeBreton and Senter, 2008) for internal subcategory (Cronbach's α: event, 0.96; time, 0.90; place, 0.91; perceptual, 0.91; thought/emotion details, 0.94) and external subcategory (Cronbach's α: total semantic, 0.90, other episodic events, 0.74; repetitions, 0.87; other, 0.86) scores.

2.3.2. *Memory Functioning Questionnaire (MFQ; Gilewski et al., 1990)*

The MFQ was used to assess the presence of subjective memory complaints. The MFQ consists of 64 questions that evaluate self-awareness of memory difficulties by probing the frequency and seriousness of forgetting in daily life. Participants responded to each question using a 7-point Likert scale; responses are averaged across the 64 questions to yield an average MFQ score where low scores are associated with frequent and serious issues with forgetting while higher scores are associated with infrequent and minor forgetting, if any. Note that although $N = 1$ (Low Cognition group) withdrew from the study prior to completing the MFQ, the groups did not differ in their average MFQ scores (see Table 1). None of our participants indicated significant concerns about their memory; however, we cannot rule out the possibility that some individuals may have poor insight, or were not forthcoming about their memory concerns.

2.3.3. *Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005)*

The MoCA is a widely-used brief (10 min) cognitive screening tool that assesses visuospatial ability, multiple aspects of executive

[6] Note that in Levine et al.'s (2002) original scoring protocol, personal semantic, general semantic and general events were collapsed into one "semantic" category. Although not identical, this breakdown is similar to that used by Renoult et al. (2020).

functioning including attention and abstraction, short-term memory, confrontation naming and other language abilities, as well as orientation to time and place. With a total score of 30, a threshold of 26 is generally accepted as a cut-off for distinguishing cognitively normal participants from those who may be in the early stages of cognitive decline The stratification of our sample into High and Low Cognition groups resulted in a significant difference in the average MoCA scores, driven by significant reductions on the visuospatial/executive and memory subscores (at a Bonferroni-corrected α of 0.003, see Table 1); all of these effect sizes were in large (>0.98; Cohen, 1988).

2.3.4. Neuropsychological battery

Participants completed a brief neuropsychological battery to characterize cognitive performance (see Table 1). Note that $N = 3$ did not complete the battery; 1 Low Cognition group participant withdrew from the study, and 2 participants (1 from the Low and 1 from the High Cognition groups) declined to complete it. The following tests were administered: Trail Making Test (TMT) A and B (Reitan and Wolfson, 1985; Steinberg et al., 2005); Wechsler Adult Intelligence Scale III (WAIS-III) Digit Symbol Coding (Wechsler, 1997); Shipley-2 Vocabulary scale (Shipley et al., 2009); phonemic fluency (using letters FAS) and semantic fluency (using animals) (Tombaugh et al., 1999); Rey Auditory Verbal Learning Test (RAVLT; Schmidt, 1996); and Brief Visuospatial Memory Test – Revised (Benedict, 1997). For the RAVLT and BVMT, we report delayed recall scores as these scores are most relevant to the current study. Mean age-adjusted scores for both groups are presented in Table 1, along with results of independent samples *t*-tests (at a Bonferroni-corrected α of .003) and effect sizes. There were no significant group differences on any of these tests, and notably, mean performance for the Low Cognition group is within 1 standard deviation of the normative mean for their age. None of the participants in this study reported subjective memory concerns (based on the MFQ). Although none had a formal diagnosis of MCI, a registered clinical neuropsychologist reviewed the neuropsychological test results and, in line with the range of cognitive performance in the current sample, six participants were noted as showing very early signs of MCI.

2.4. Procedure

Researchers in the Olsen lab administered the MoCA, MFQ and neuropsychological test battery to participants enrolled in the larger longitudinal study. As the administration of these tests occurred within the context of this longitudinal study, the timing of administration relative to the first AI session varied across participants. Here we report the results from administrations closest to the first AI session. There were no group differences in the average absolute number of months that the first AI session was conducted before or after the MoCA (High Cognition, $M = 13.54$, $SD = 6.67$; Low Cognition, $M = 16.35$, $SD = 6.47$; $t_{(36)} = -1.31$, $p = .197$, $d = -0.43$), the MFQ (High Cognition, $M = 14.26$, $SD = 8.08$; Low Cognition, $M = 15.89$, $SD = 6.14$; $t_{(35)} = -0.68$, $p = .502$, $d = -0.22$) and the neuropsychological test battery (High Cognition, $M = 16.77$, $SD = 7.80$; Low Cognition, $M = 15.66$, $SD = 6.27$; $t_{(33)} = 0.46$, $p = .650$, $d = 0.16$). The mean delays (and SDs) are presented separately for participants in each group who completed these tests before or after the AI in Table 2. Note that participants who were enrolled into the larger longitudinal study during the COVID-19 pandemic completed the AI prior to the other testing sessions. Due to a 27-month moratorium on in-person testing at our institution during the COVID-19 pandemic, these participants experienced longer delays between the AI and neuropsychological testing, on the order of 19–20 months (relative to 12–16 months for those who completed the AI after the other testing sessions).

Telephone AI sessions were conducted monthly for six consecutive months by a research assistant (F.S.) who was blind to participants' group membership; the average number of days between sessions did not differ by group (High Cognition, $M = 30.72$, $SD = 2.34$; Low Cognition, $M = 31.06$, $SD = 1.93$; $t_{(36)} = -0.48$, $p = .635$, $d = -0.16$). Each AI session started with verbal consent and instructions, followed by the four AI trials.

Table 2
Mean delays in completion of the MoCA, neuropsychological testing and MFQ relative to the AI.

	Completed before AI		Completed after AI	
	High Cognition	Low Cognition	High Cognition	Low Cognition
MoCA				
N	16	16	4	2
Mean delay in months (SD)	12.04 (6.65)	16.04 (6.81)	19.55 (0.97)	18.85 (1.60)
Neuropsychological testing				
N	10	14	9	2
Mean delay in months (SD)	13.93 (6.27)	15.21 (6.58)	19.93 (8.44)	18.85 (1.60)
MFQ				
N	13	15	7	2
Mean delay in months (SD)	12.52 (6.10)	14.81 (6.53)	19.38 (9.62)	18.85 (1.60)

Note. AI = Autobiographical interview; MoCA = Montreal Cognitive Assessment; MFQ = Memory Functioning Questionnaire; SD = standard deviation.

2.5. Statistical analyses

Demographic, neuropsychological, and AI data, as well as data characterizing the events, were analyzed in SPSS (Version 28.0.0.0) using independent-samples *t*-tests, Chi-square tests, and mixed factorial analyses of variance (ANOVAs), as appropriate. The only exception were the counts of AI trials with an observer perspective which were submitted to Mann-Whitney *U* tests (confidence intervals for the difference between group medians was derived using the Hodges-Lehmann estimation). For all mixed ANOVAs Group (High vs. Low Cognition) was modelled as a between-subjects factor and Temporal Direction (Past, Future) as a within-subjects factor; significant main effects and interactions were examined using Bonferroni-corrected pairwise comparisons. Note that for brevity, the timeframe (years vs. weeks) was not included as a factor in the ANOVAs because this was not an experimental manipulation per se, but rather a way to constrain the temporal distance of generated events across groups given that distance can influence episodic detail (e.g., D'Argembeau and Van der Linden, 2004; Trope and Liberman, 2003; La Corte and Piolino, 2016). To this end, temporal distance did not differ across groups (see *Section 3.1*). However, we recomputed all ANOVAs on event phenomenology and AI total scores including timeframe as a factor and include these as Supplemental Materials (see *Section S1* for full results). We also computed Pearson's correlations between the number of internal, external and semantic details comprising past and future events, and between these scores and neuropsychological tests of episodic memory as well as the MoCA.

Shapiro-Wilk tests indicated that, for a small number of variables, normality assumptions were violated by the presence of outliers. However, given the small sample size, these outliers were considered as normal variation in the data and not indicators of performance or measurement error. Nevertheless, we repeated all analyses excluding the outliers and all the results remained the same (see Supplemental Materials *Section S2*) except for one pairwise comparison, as indicated in the Results. For all ANOVAs, if the assumption of sphericity was violated (as indicated by a significantly Mauchly's *W* test), degrees of freedom were adjusted using the Greenhouse-Geisser epsilon (Geisser and Greenhouse, 1958). Families of tests were corrected for multiple comparisons using a Bonferroni correction, where indicated.

To determine whether, on a trial-by-trial basis, increased semantic detail was generated on trials with fewer internal details, multilevel modelling analyses were conducted in R (Version 4.2.2; R Core Team, 2022). Data cleaning (transforming variables to their appropriate numeric format and subsetting the data by individual subject IDs) was conducted with the *psych* (Version 2.2.9; Revelle, 2022) and *dplyr* (Version 1.1.2; Wickham et al., 2023) R packages. Prior to analysis, group (High vs. Low Cognition) was dummy-coded, the number of internal details was grand mean-centered and the total number of external semantic details (i.e., sum of general semantic, personal semantic and generic event details) was computed. Using the *lme4* package (Bates et al., 2015), we built two-level random coefficient models (one for past events, and one for future events) for which the number of semantic details was the outcome variable. Participant and number of nternal details were modelled within-subjects, and internal details acted as our level 1 predictor. Group and the Group x Internal Detail cross-level interaction acted as level two predictors, allowing us to examine whether cognitive performance influenced the relationship between internal and semantic details. Slopes and intercepts varied across participants to account for any between-subjects variability. Normality of the residuals of the empty and two-level models revealed no significant outliers. We also recomputed this analysis using MoCA as a continuous measure of cognitive performance in place of group (see Supplemental Materials *Section S6*).

We computed an exploratory mediation analysis using PROCESS v4.3 for SPSS (Hayes, 2022). A simple mediation model was used, and a bootstrap confidence interval for the indirect effect was computed using 5000 bootstrap samples. The indirect effect was considered significant if the 95% CI did not contain zero.

3. Results

3.1. Qualities of past and future events

Group means for the qualities of past and future events are shown in Table 3. Note that one participant did not provide complete phenomenological data for four trials, and another participant for one trial; their means were computed excluding those particular trials.

3.1.1. Temporal distance of past and future events

First, to ensure that any group effects on the AI could not be explained by differences in temporal distance of events, we conducted a mixed 2 (Group: High Cognition, Low Cognition) x 2 (Temporal Direction: Past, Future) ANOVA on the estimated event dates (converted to days from the session date). There was a significant main effect of Temporal Direction, $F_{(1,\ 36)} = 8.32$, $p = .007$, $\eta^2_p = 0.19$, where past events were more temporally distant ($M = 473.87$, $SD = 195.48$) than future events ($M = 353.74$, $SD = 223.66$). Importantly, however, there was no main effect of Group, $F_{(1,\ 36)} = 0.03$, $p = .875$, $\eta^2_p < 0.01$, nor a significant Group x Temporal Direction interaction, $F_{(1,\ 36)} = 0.09$, $p = .769$, $\eta^2_p < 0.01$.

Table 3
Average qualities of past and future events.

	Past		Future	
	High Cognition	Low Cognition	High Cognition	Low Cognition
Temporal distance (days)	483.84 (209.47)	462.78 (184.12)	352.10 (221.73)	355.55 (232.20)
Observer Perspective†	0.14 (0.30)	0.27 (0.26)	0.42 (0.46)	0.32 (0.37)
Detail rating**	4.28 (0.38)	4.57 (0.25)	3.47 (0.52)	3.93 (0.63)
Emotional intensity rating	3.65 (0.69)	4.07 (0.51)	3.50 (0.69)	3.79 (0.67)
Personal significance rating*	3.80 (0.57)	4.14 (0.48)	4.08 (0.48)	4.38 (0.31)

Note. †Average number of trials on which observer perspective was reported. *Significant main effect of group ($p < .05$), **Significant main effect of group ($p < .01$). SD in parentheses. Ratings were made on a 5-point scale (1–5).

3.1.2. Phenomenology of past and future events

In line with task instructions to (p)re-experience events from a field perspective, the number of trials for which an observer perspective was reported was minimal for the 12 past and 12 future events (M values < 0.50, see Table 3). The frequency did not differ significantly across groups for future events ($U = 168.00$, $p = .740$, estimated difference between group medians = 0.00, 95% CI [−0.17, 0.33]), although for past trials it neared significance ($U = 246.50$, $p = .051$, estimated difference between group medians = −0.17, 95% CI [−0.33, 0.00]).

We examined whether subjective phenomenological ratings of detail, emotionality, and personal significance differed across groups and temporal directions. Separate mixed 2 (Group: High Cognition, Low Cognition) x 2 (Temporal Direction: Past, Future) ANOVAs were conducted on each of the three phenomenological ratings (detail, emotionality, and personal significance). For detail, there was a significant main effect of Group, $F_{(1,\ 36)} = 9.33$, $p = .004$, $\eta^2_p = 0.21$; the Low Cognition group ($M = 4.26$, $SE = 0.09$) rated their events as more highly detailed than the High Cognition group ($M = 3.87$, $SE = 0.09$). Moreover, past events ($M = 4.43$, $SD = 0.05$) were rated as more detailed than future events ($M = 3.70$, $SD = 0.09$), $F_{(1,\ 36)} = 71.13$, $p < .001$, $\eta^2_p = 0.66$. However, the Group x Temporal Direction interaction was not significant, $F_{(1,\ 36)} = 0.85$, $p = .363$, $\eta^2_p = 0.02$.

For emotionality, there was only a significant main effect of Temporal Direction, $F_{(1,\ 36)} = 6.02$, $p = .019$, $\eta^2_p = 0.14$, with past events ($M = 3.86$, $SE = 0.10$) being rated as more emotional than future events ($M = 3.64$, $SE = 0.11$). The main effect of Group, $F_{(1,\ 36)} = 3.53$, $p = .068$, $\eta^2_p = 0.09$, and the Group x Temporal Direction interaction, $F_{(1,\ 36)} = 0.53$, $p = .472$, $\eta^2_p = 0.01$, were not significant.

Finally, the analysis of personal significance revealed a main effect of Temporal Direction, $F_{(1,\ 36)} = 11.52$, $p = .002$, $\eta^2_p = 0.24$; future events were rated as more significant ($M = 4.23$, $SE = 0.07$) than past events ($M = 3.97$, $SE = 0.09$). There was a main effect of Group, $F_{(1,\ 36)} = 5.90$, $p = .020$, $\eta^2_p = 0.14$; the Low Cognition group rated their events as more significant ($M = 4.26$, $SE = 0.10$) than the High Cognition group ($M = 3.94$, $SE = 0.09$). However, the Group x Temporal Direction interaction was not significant, $F(_{1,\ 36)} = 0.06$, $p = .809$, $\eta^2_p < 0.01$.

In sum, past events were more temporally distant relative to future events yet more detailed and emotional, but future events were more personally significant. Critically, for our understanding of group differences on the adapted AI, the Low Cognition group rated their events overall as more detailed and more significant than did the High Cognition group.

3.2. AI performance

3.2.1. AI total scores

The number of cues provided to participants during AI trials was submitted to a mixed ANOVA with within-subjects factor Temporal Direction (Past, Future) and between-subjects factor Group (High Cognition, Low Cognition). This analysis showed that the average number of cues provided to participants on past (High Cognition: $M = 0.36$, $SE = 0.18$, Low Cognition: $M = 0.57$, $SE = 0.19$) and future (High Cognition: $M = 0.51$, $SE = 0.19$, Low Cognition: $M = 0.57$, $SE = 0.20$) trials did not differ by Group, $F_{(1,\ 36)} = 0.35$, $p = .556$, $\eta^2_p = 0.01$, or Temporal Direction, $F_{(1,\ 36)} = 0.26$, $p = .616$, $\eta^2_p < 0.01$. The Group x Temporal Direction interaction was also not significant, $F_{(1,\ 36)} = 0.31$, $p = .579$, $\eta^2_p < 0.01$.

Exploratory analyses examined whether the number of general and redirect probes varied by Temporal Direction (Past, Future) and Group (High Cognition, Low Cognition). A mixed ANOVA showed that the average number of general probes provided to participants on past and future trials differed by Group, $F_{(1,\ 36)} = 6.15$, $p = .018$, $\eta^2_p = 0.15$, with more general probing used when interviewing participants in the Low ($M = 0.60$, $SE = 0.08$) versus High ($M = 0.33$, $SE = 0.08$) Cognition groups. A significant effect of Temporal Direction, $F_{(1,\ 36)} = 4.62$, $p = .038$, $\eta^2_p = 0.11$, reflected slightly more general probing on future ($M =$

0.51, $SE = 0.06$) versus past trials ($M = 0.42$, $SE = 0.06$). The Group x Temporal Direction interaction was not significant, $F_{(1, 36)} = 0.17$, $p = .683$, $\eta_p^2 < 0.01$. For redirect probes, a mixed ANOVA showed that the average number of redirect probes provided to participants on past and future trials was higher for the Low versus High Cognition group, $F_{(1, 36)} = 7.63$, $p = .009$, $\eta_p^2 = 0.18$, and for future versus past trials, $F_{(1, 36)} = 32.22$, $p < .001$, $\eta_p^2 = 0.47$. These effects were qualified by a significant Group x Temporal Direction interaction, $F_{(1, 36)} = 7.63$, $p = .009$, $\eta_p^2 < 0.18$, whereby the difference between groups was larger in the future (High Cognition: $M = 0.15$, $SE = 0.14$, Low Cognition: $M = 0.38$, $SE = 0.21$) than past (High Cognition: $M = 0.07$, $SE = 0.11$, Low Cognition: $M = 0.17$, $SE = 0.22$) condition. Although these results indicate that the Low Cognition group required more support during the AI, particularly on future trials, it should be noted that on average, the numbers of both types of probes were relatively low, with on average fewer than 1 probe (of any type) used per trial for both groups.

We also ran exploratory correlations to examine whether the use of cues or probes was associated with cognitive status (MoCA) or with increased generation of internal and external detail. Full results are presented in Supplemental Materials (*Section S3*), but briefly the correlations were either non-significant or negative in direction, speaking against the possibility that cues or probes increased detail generation.

AI total scores were subjected to a mixed ANOVA with within-subjects factors of Session (1–6), Temporal Direction (Past, Future) and Detail Type (Internal, External) and a between-subjects factor of Group (High Cognition, Low Cognition). The main effect of Session did not reach significance, $F_{(3.83,\ 138.02)} = 2.39$, $p = .056$, $\eta_p^2 = 0.06$, and importantly, Session did not interact with Group, $F_{(5, 180)} = 0.70$, $p = 0.621$, $\eta_p^2 = 0.02$, Temporal Direction, $F_{(5, 180)} = 1.21$, $p = .304$, $\eta_p^2 = 0.03$, or Detail Type, $F_{(5, 180)} = 1.57$, $p = .170$, $\eta_p^2 = 0.04$, ruling out effects of session.

There was a significant main effect of Temporal Direction, with all participants producing more details for past ($M = 27.31$, $SE = 1.09$) than future trials ($M = 23.31$, $SE = 1.04$), $F_{(1, 36)} = 82.19$, $p < .001$, $\eta_p^2 = 0.70$. The main effect of Detail Type was also significant, $F_{(1, 36)} = 8.48$, $p = .006$, $\eta_p^2 = 0.19$, reflecting a higher number of external ($M = 28.38$, $SE = 1.78$) than internal ($M = 22.23$, $SE = 1.11$) details overall. These effects were qualified by an interaction of Temporal Direction with Detail Type, $F_{(1, 36)} = 113.67$, $p < .001$, $\eta_p^2 = 0.76$, whereby participants produced more internal details for past ($M = 28.18$, $SE = 1.26$) than future events ($M = 16.29$, $SE = 1.10$; $p < .001$) and more external details for future ($M = 30.32$, $SE = 1.96$) than past events ($M = 26.44$, $SE = 1.71$; $p < .001$; see Fig. 1a).

There was no significant main effect of Group, $F_{(1, 36)} = 2.72$, $p = .108$, $\eta_p^2 = 0.07$. However, there was a significant interaction of Group and Temporal Direction, $F_{(1, 36)} = 4.50$, $p = .041$, $\eta_p^2 = 0.11$, which reflected a larger group difference (High > Low Cognition) in the overall number of details generated for past events (High Cognition: $M = 29.49$, $SE = 1.50$; Low Cognition: $M = 25.13$, $SE = 1.58$; $p = .053$) than future events (High Cognition: $M = 24.56$, $SE = 1.43$; Low Cognition $M = 22.06$, $SE = 1.58$; $p = .236$), although neither group difference reached significance. Critically, however, there was a significant Group x Detail Type interaction, $F_{(1, 36)} = 5.11$, $p = .030$, $\eta_p^2 = 0.12$ (see Fig. 1b). Whereas the Low Cognition group generated significantly fewer internal details ($M = 18.13$, $SE = 1.60$) than the High Cognition group ($M = 26.34$, $SE = 1.52$; $p < .001$), both the Low ($M = 29.05$, $SE = 2.59$) and High ($M = 27.71$, $SE = 2.45$) Cognition groups generated comparable numbers of external details ($p = .709$). The three-way interaction of Detail Type, Group, and Temporal Direction was non-significant, $F_{(1, 36)} = 0.56$, $p = .458$, $\eta_p^2 = 0.02$, indicating that the aforementioned Group x Detail Type interaction was similar across past and future events. No other interactions were significant, p values > .458.

As expected, correlation analyses between MoCA and AI scores revealed a similar pattern of results as evident in the group analyses (see Fig. 2). MoCA scores were not significantly correlated with external details in either temporal direction (past: $r_{(37)} = -.07$, $p = .67$; future: $r_{(37)} = -.08$, $p = .66$). MoCA scores were significantly correlated with the mean number of internal details for past events, $r_{(37)} = .40$, $p = .012$, while for future events the correlation only approached significance, $r_{(37)} = .27$, $p = .10$), in keeping with the group difference in internal details being larger for past relative to future events. It is possible that although the correlation of cognitive functioning and the generation of future internal details was not significant, it nevertheless has an indirect influence via the capacity to retrieve past internal details. To explore this possibility, we computed a simple mediation analysis. This showed that the direct effect of MoCA on future internal details, controlling for the effect of past internal details, was not significant, $b = -0.24$, $t_{(36)} = -0.63$, $p = .53$. In contrast, the indirect effect was significant, $\beta = 1.20$, 95% CI [0.41, 2.43]. These results indicate that the degree to which participants can retrieve the internal details of past events fully mediates the relationship between MoCA and future internal details.

3.2.2. AI subcategory scores

We explored whether the High and Low Cognition groups differed in

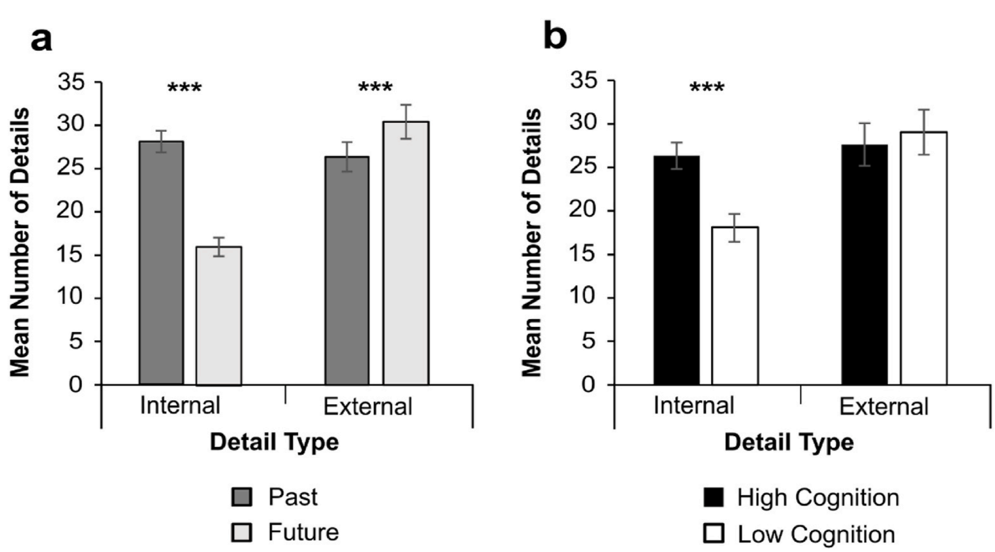

Fig. 1. Mean number of internal and external details per event generated (a) for past and future events, and (b) by High Cognition and Low Cognition groups on the Autobiographical Interview. Error bars are standard error of the mean. ***$p < .001$.

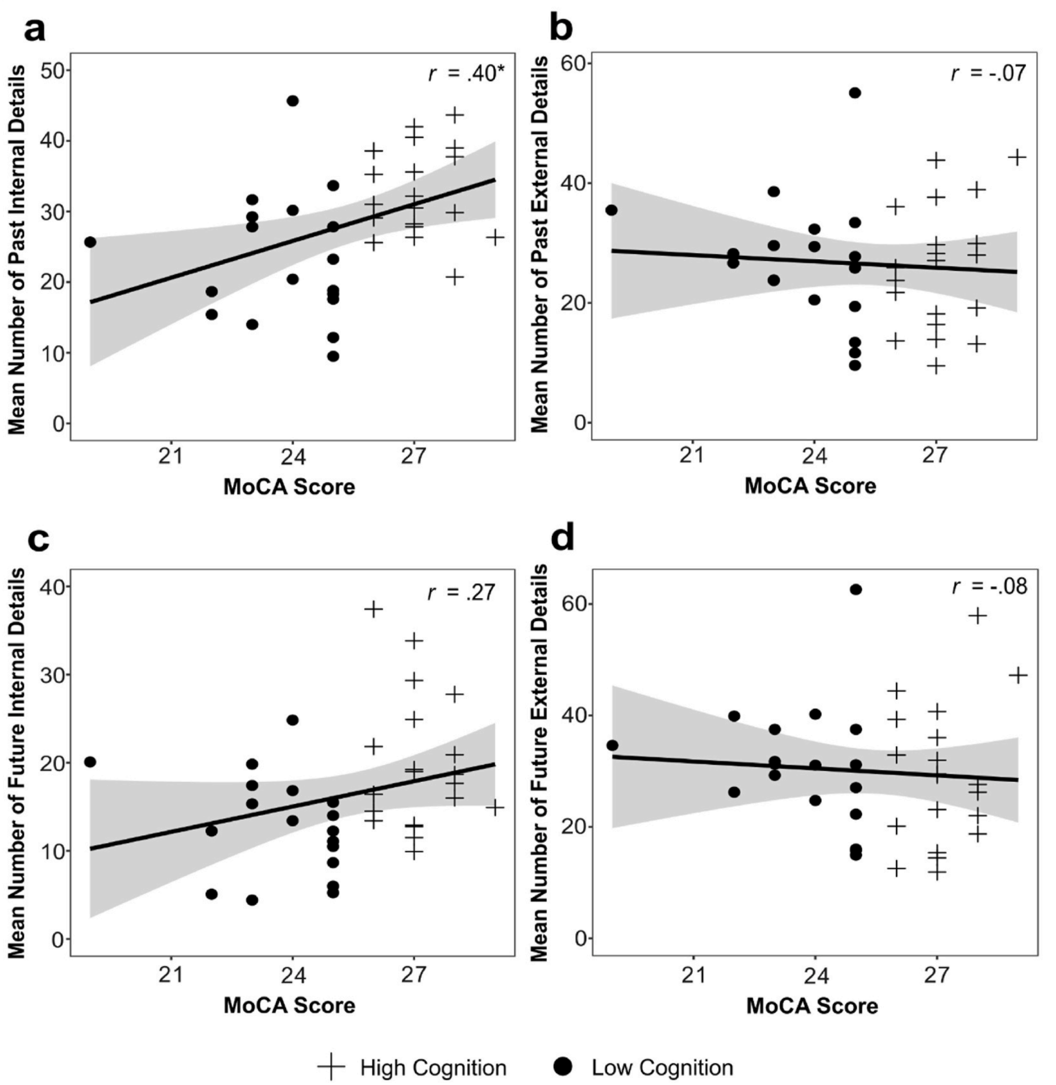

Fig. 2. MoCA scores correlated with the mean number of (a) past internal, (b) past external, (c) future internal, and (d) future external details. Note: Lines superimposed on the scatterplots are the lines of best fit for the whole sample, and the shaded areas are 95% confidence intervals.

terms of internal and external subcategory scores (see Table 4). For internal details, a mixed factorial 5 (Subcategory: event, place, time, perceptual, thought/emotion) x 2 (Group: High Cognition, Low Cognition) ANOVA was conducted. This analysis resulted in a main effect of Subcategory, $F_{(1.18,\ 42.48)} = 303.81$, $p < .001$, $\eta_p^2 = 0.89$, whereby more event details ($M = 15.12$, $SE = 0.80$) were generated than any other subcategory (p values $< .001$). There was also a higher number of thought/emotion details ($M = 2.19$, $SE = 0.14$) relative to time details ($M = 1.22$, $SE = 0.07$, $p < .001$), but not relative to place ($M = 1.67$, $SE = 0.12$, $p = .147$) or perceptual details ($M = 2.04$, $SE = 0.18$, $p > .999$). Whereas the number of perceptual details was similar to place details ($p = .203$), it was significantly higher than time details ($p < .001$).

There was also a main effect of Group for internal subcategories, $F_{(1,\ 36)} = 13.78$, $p < .001$, $\eta_p^2 = 0.28$, whereby the Low Cognition group ($M = 3.63$, $SE = 0.32$) generated fewer details per internal subcategory than the High Cognition group ($M = 5.27$, $SE = 0.30$), in line with the reduced generation of internal details overall. This group difference was qualified by a significant Subcategory x Group interaction, $F_{(1.18,\ 42.48)} = 11.68$, $p < .001$, $\eta_p^2 = 0.25$, which reflected the High Cognition group generating more internal details than the Low Cognition group for every subcategory (p values $< .009$) except for thought/emotion ($p = .862$).

For external details, the mixed factorial 4 (Subcategory: total semantic, episodic event, other, repetition) x 2 (Group: High Cognition, Low Cognition) ANOVA was conducted.[7] This analysis again revealed an effect of Subcategory, $F_{(1.69,\ 60.75)} = 86.81$, $p < .001$, $\eta_p^2 = 0.71$. The total

Table 4
Average Internal and External subcategory scores for High and Low Cognition groups.

AI Score	High Cognition	Low Cognition
Internal Subcategory Scores		
Event***	18.00 (4.90)	12.24 (4.98)
Place**	2.09 (0.86)	1.25 (0.59)
Time**	1.41 (0.45)	1.03 (0.37)
Perceptual**	2.63 (0.94)	1.45 (1.23)
Thought/Emotion	2.21 (0.95)	2.19 (0.87)
External Subcategory Scores		
Total Semantic	13.48 (6.86)	15.22 (6.99)
Episodic Event	7.25 (3.90)	6.30 (3.09)
Other	5.13 (1.99)	5.59 (1.96)
Repetition	1.88 (0.98)	1.94 (1.66)

Note. Significant main effect of group $^{**}p < .01$, $^{***}p < .001$. SD in parentheses.

[7] The same pattern of results was evident when the total semantic subcategory is broken down more finely (i.e., general semantic, personal semantic and general event). See Supplemental Materials (*Section S4*).

number of semantic details ($M = 14.35$, $SE = 1.13$) was greater than all other external subcategories (p values $< .001$). On the other hand, the number of repetitions ($M = 1.91$, $SE = 0.22$) was lower than all other subcategories (p values < 0.001). The number of external episodic details ($M = 6.77$, $SE = 0.58$) did not differ significantly from the other category ($M = 5.36$, $SE = 0.32$, $p = .216$). Importantly, there was no significant main effect of Group, $F_{(1, 36)} = 0.14, p = .714, \eta_p^2 < 0.01$, with the Low Cognition group generating a similar number of details per Subcategory ($M = 7.26$, $SE = 0.65$) as the High Cognition group ($M = 6.93$, $SE = 0.61$), and no Group x Subcategory interaction, $F_{(5,180)} = 0.980$, $p = .405$, $\eta_p^2 = 0.03$.

3.2.3. Correlational analyses

A series of Pearson's correlations were computed to examine the inter-relationships between numbers of details generated for past and future events, between the types of details, and between these scores and neuropsychological tests of episodic memory. All correlations were run across the full sample, and then separately within each group; a Bonferroni-corrected α of .0017 (correcting for a total of 30 correlations) was employed. First, to test whether the number of details generated for past and future events were correlated, as predicted by the constructive episodic simulation hypothesis (Schacter and Addis, 2007), we correlated (1) the mean number of past and future internal details, and (2) the mean number of past and future external details. As shown in Fig. 3a, there were strong positive correlations between mean past and future internal detail scores (full sample: $r_{(36)} = .81$, $p < .001$, 95% CI [.67, .90]; High Cognition group: $r_{(18)} = .76$, $p < .001$, 95% CI [.47, .90]; Low Cognition group: $r_{(16)} = .83$, $p < .001$, 95% CI [.59, .93]). Similar correlations were evident for mean past and future external detail scores (see Fig. 3b; full sample: $r_{(36)} = .89$, $p < .001$, 95% CI [.80, .94]; High Cognition group: $r_{(18)} = .89$, $p < .001$, 95% CI [.73, .96]; Low Cognition group: $r_{(16)} = .90$, $p < .001$, 95% CI [.74, .96]).

Pearson's correlations on the number of internal details with (1) the total number of external details and (2) the total number of semantic details (i.e., the sum of general semantic, personal semantic and general event details) were also computed for past and for future events. Whether computed for the full sample, or separately for the High and Low Cognition groups, none of these correlations were significant (r values $< .209$, p values $> .086$; see Supplemental Materials *Section S5* for full results; see Fig. 3c and d for correlations with total number of external details in the full sample). Finally, we correlated the number of internal details for past and future events with two neuropsychological

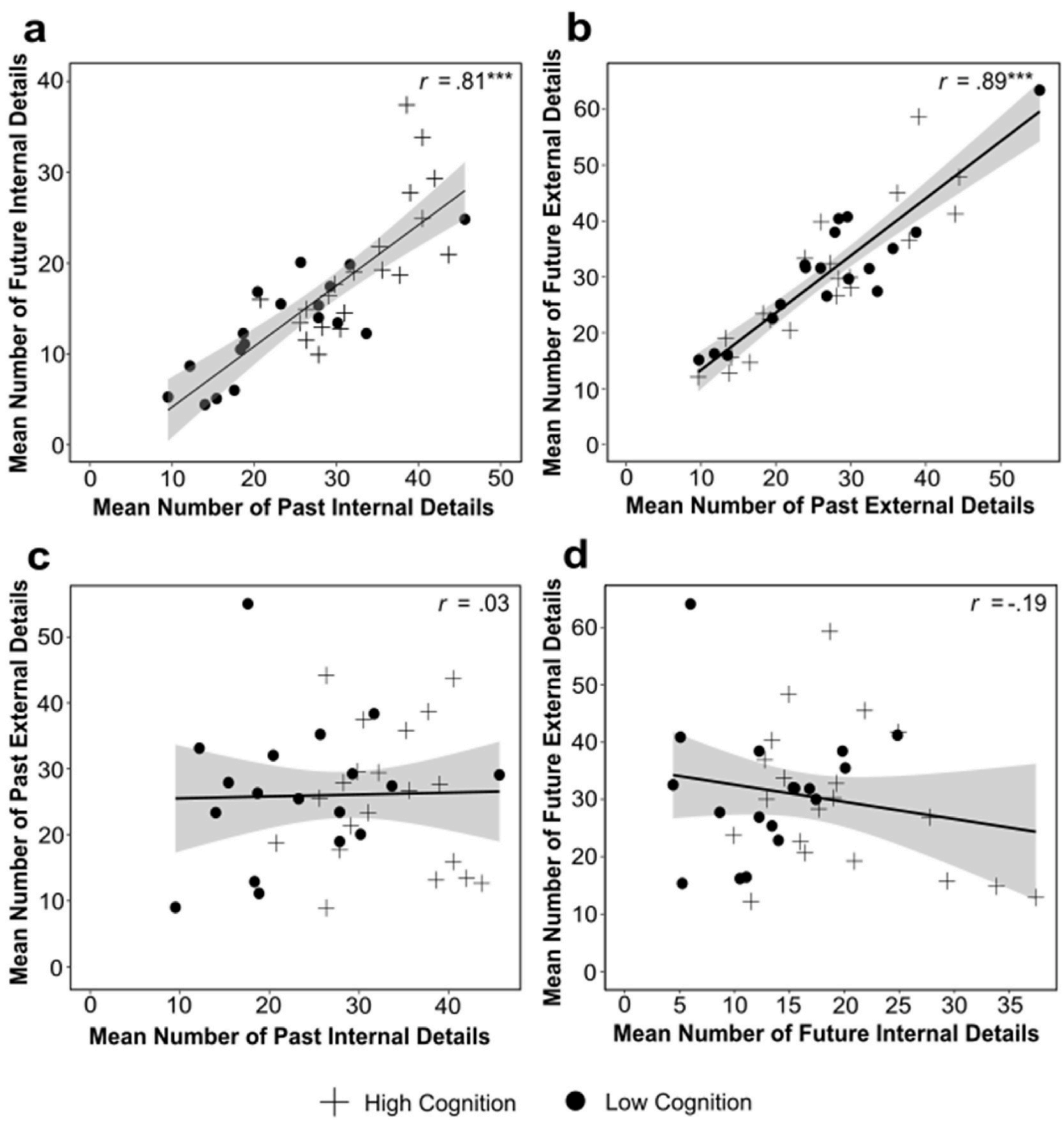

Fig. 3. Relationships of past and future (a) internal detail scores and (b) external detail scores and relationships between internal and external details in (c) past and (d) future events across both groups. Note: Lines superimposed on the scatterplots are the lines of best fit for the whole sample, and the shaded areas are 95% confidence intervals.

measures of episodic memory: delayed recall on the BVMT and the RAVLT. None of the correlations surpassed the corrected α threshold (r values < .32, p values > .033; see Supplemental Materials *Section S5* for full results).

3.2.4. Multilevel modelling analyses

Although the above correlations of the mean numbers of internal and external semantic details was non-significant for both past and future events, we examined this relationship on a trial-by-trial basis using multilevel modelling (Devitt et al., 2017). For both the past and future event models, an initial empty multilevel model was created with total external semantic details as the outcome variable. The intra-class correlation coefficients (ICCs) derived from the models indicated the suitability of multilevel modelling for the dataset. Both ICCs were above zero, revealing that a significant proportion of the variance in the number of semantic details was due to variation between participants (see Table 5). As such, multilevel modelling was deemed appropriate to use.

We then examined whether the number of internal details predicted the number of semantic details and whether this relationship differed according to cognitive functioning. For each temporal direction (past and future), a two-level model was run with number of semantic details as the level one outcome, number of Internal Details as a level one predictor, Group and Group by Internal Detail cross-level interaction as level two predictors. Statistics for each model can be found in Table 5. For both past and future events, the number of internal details generated was a significant negative predictor of semantic details (see Fig. 4). Neither Group nor the Group x Internal Detail interaction significantly predicted the number of semantic details comprising past or future events. A similar pattern of results was evident when we recomputed these analyses using MoCA as a continuous measure of cognitive performance in place of group. Briefly, these analyses showed the same pattern of results, with internal details being a significant predictor of semantic details, but with no significant effect of MoCA nor a MoCA x Internal Detail interaction (for full results, see Supplemental Materials *Section S6*).

4. Discussion

The current study investigated whether reductions in episodic details and corresponding increases in the semantic content of both AM and EFT are evident in the early stages of cognitive decline. As hypothesized, the Low Cognition group exhibited a reduction for internal details comprising both past and future events relative to the High Cognition group. However, the Low Cognition group did not show the expected overproduction of external details. Although the multilevel modelling demonstrated that trials lower in episodic content were higher in semantic content, this finding was evident in both groups, suggesting it reflects factors unrelated to cognitive decline.

Table 5
Statistics for multilevel models predicting the number of semantic details in past and future events.

Model	Parameter	ICC	β	*SE*	*t*	*df*	*p*
Empty models							
Past	Intercept	0.26	12.75	1.03	12.38	38	<.001
Future	Intercept	0.39	15.86	1.27	12.52	38	<.001
Two-level models							
Past	Internal	–	−0.39	0.06	−6.09	42.85	<.001
	Group	–	−1.69	2.04	−0.83	38.00	.413
	Internal x Group	–	0.09	0.08	1.18	35.29	.247
Future	Internal	–	−0.47	0.09	−5.30	51.77	<.001
	Group	–	−1.81	2.52	−0.72	38.03	.478
	Internal x Group	–	0.14	0.11	1.29	38.99	.205

Note. Internal = Internal Detail score; ICC = Intraclass correlation coefficient; SE = standard error of the mean.

4.1. Internal, but not external, detail generation is associated with cognitive functioning

The current study is the second to examine both the recollection of past events and the simulation of novel future events in older adults in the preclinical phase of AD, following Acevedo-Molina et al. (2023). Since it has been previously reported that aMCI patients generate fewer internal (episodic) details *and* more external (non-episodic) details in both their past and future events (Gamboz et al., 2010; Murphy et al., 2008), we hypothesized that participants with lower cognitive functioning in our sample would exhibit a similar pattern, although not as pronounced. The hypothesis was partially supported, with the Low Cognition group generating significantly fewer internal details than the High Cognition group. This finding is consistent with the other studies examining episodic AM and EFT in those at risk of MCI or AD (Acevedo-Molina et al., 2023; Bruus et al., 2021; Grilli et al., 2018; Peters and Sheldon, 2020). With respect to EFT, our exploratory mediation analysis demonstrated that this effect of cognitive functioning on EFT is fully mediated by episodic AM. In other words, the number of past internal details mediated the effect of the MoCA on the number of future internal details. This result is in line with the central tenet of the constructive episodic simulation hypothesis (Schacter et al., 2017), that in order to imagine the future, one has to access and recombine details from episodic memory.

This observation of reduced internal detail is consistent with findings of mild yet significant reductions in volume to MTL structures in participants at risk of or showing early signs of cognitive decline, given the role of MTL structures in episodic AM and EFT as demonstrated by neuroimaging (for a meta-analysis, see Benoit and Schacter, 2015) and hippocampal lesion studies (for a review, see Addis and Schacter, 2012; but see Squire et al., 2010). In a sample partially overlapping with that of the current study (8 in the High Cognition group and 12 in the Low Cognition group), Olsen et al. (2017) reported a significant reduction in MTL volume in the Low Cognition group, specifically in the anterolateral entorhinal cortex. Interestingly, activation proximal to this MTL region has been observed when remembering past and imagining future events (Addis et al., 2007, 2009). Although speculative, together, these results suggest that early dysfunction of anterolateral MTL at the preclinical stages of cognitive decline may underlie disruptions to the ability to generate episodic details when remembering and imagining events. However, given that other studies have linked internal detail generation with the dentate gyrus, CA2/3 and subiculum, albeit in young healthy adults (Palombo et al., 2018) or following encephalitis (Miller et al., 2017), research that specifically links anterolateral entorhinal volumes with reduced episodic detail generation in populations at risk of, or experiencing, early cognitive decline will be required to confirm this hypothesis.

Interestingly, however, we did not find that internal detail generation to be associated with objective measures of visual or verbal episodic memory, specifically delayed recall on the BVMT-R and RAVLT, in the full sample or in either group. We had based our hypothesis on prior findings in older adults (Addis et al., 2008); however in that study, the measure used was a test of relational memory (verbal paired associates) which may be more relevant for integrating internal details together to form coherent narratives of the past and future (Schacter and Addis, 2007; Hassabis et al., 2007). Moreover, the present groups did not differ significantly on these two memory measures, further suggesting that the mnemonic processes tapped by these standard neuropsychological measures do not explain the group difference in the ability to generate internal details. As pointed out by Grilli et al. (2018), the amount of episodic content in autobiographical events may be more sensitive to subtle changes in the early stages of cognitive decline, perhaps due to the reliance on multiple MTL-mediated cognitive mechanisms that might all be mildly affected.

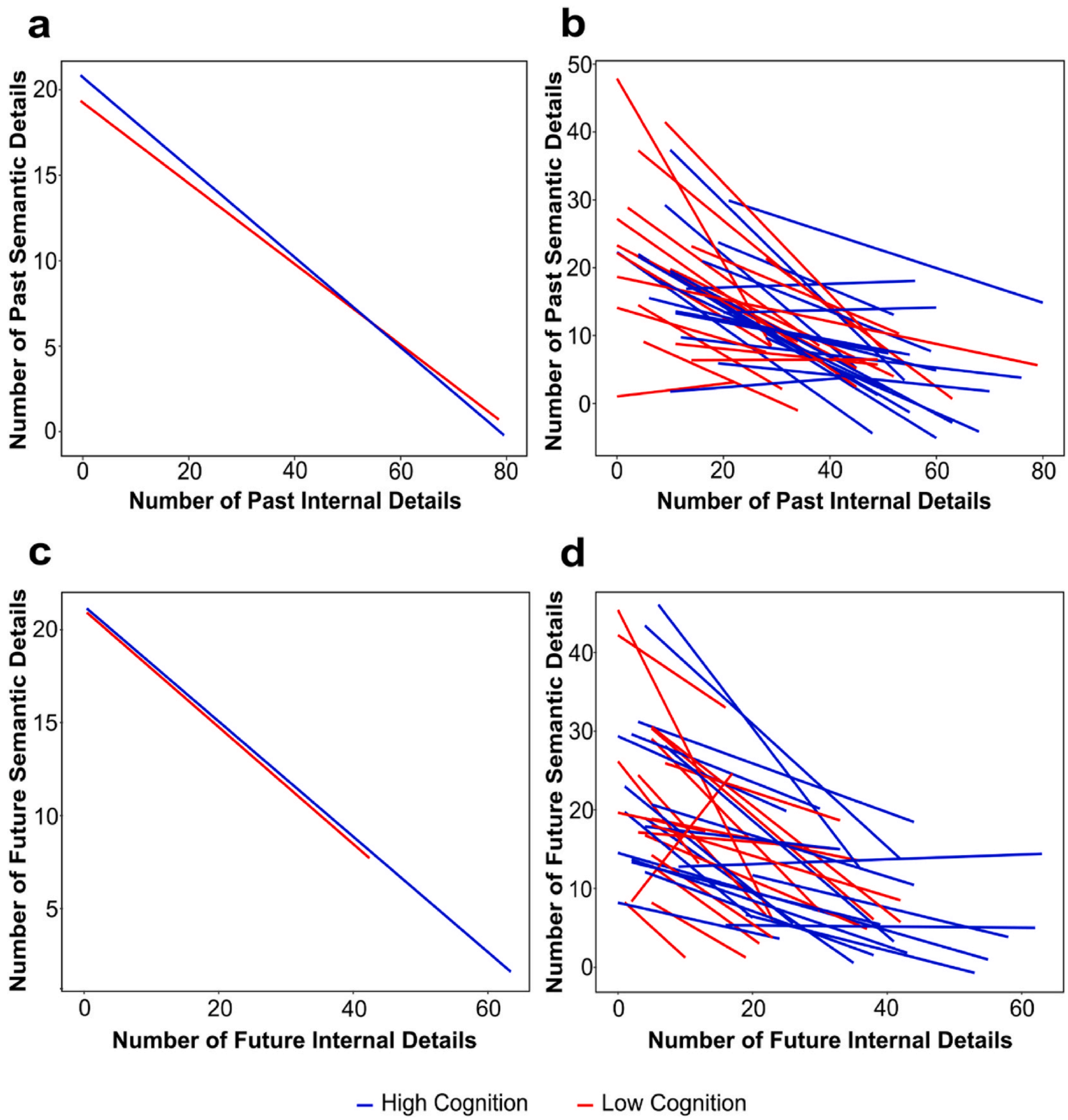

Fig. 4. Regression lines from multilevel models showing the relationship of the number of internal and semantic details for past events (top panels) and future (bottom panels) events. Overall group regression lines are in the left-hand panels, and individual participant regression lines are in the right-hand panels.

The observed reduction in episodic details in the Low Cognition group was evident for all internal subcategories except for thoughts/ emotions. It may be that, in contrast to the types of details comprising the event, time, place and perceptual subcategories, the thought and emotion details comprising one's inner experience during an event may not be as dependent on MTL regions, perhaps being more conceptual or gist-like in nature. Although these details are considered episodic in nature in that they were/will be experienced at the time of the event, it is possible that these details actually reflect thoughts and emotions experienced in the present moment that are then projected onto the remembered or imagined event. Future research examining whether thought and emotion details are fundamentally different in nature from other episodic details would be an interesting future direction.

The hypothesized corollary, that a reduction in internal details in the Low Cognition group would be accompanied by an overproduction of external details, was not supported. This finding is counter to AI studies of past and future events in aMCI (Gamboz et al., 2010; Murphy et al., 2008). However, there are two possible explanations for this result. First, the overproduction of external details in MCI could reflect, at least in part, an inability to inhibit the supress details that are not task-relevant. The absence of significant executive impairment in the Low Cognition group (other than a reduction in the MoCA Visuospatial/Executive domain, which was uncorrelated with levels of external and semantic detail, *r* values $< \pm .26$; *p* values $> .269$) may explain the difference from studies of MCI. Our results are, however, consistent with the findings of Grilli and colleagues (Grilli et al., 2018; Acevedo-Molina et al., 2023) who reported that carriers of the APOE ε4 allele—a risk factor for developing AD—recalled fewer internal details for past and future event compared to non-carriers but did not exhibit an overproduction of external details (see also Simpson et al., 2023). Here, we extend their finding to show that in a sample of older individuals with lowered cognitive functioning, some of whom are advancing toward, or may be in, the early stages of MCI, there is no overproduction of details in *any external subcategory* including semantic details, for either past or future events.

Second, it may be that, unlike individuals with advanced MCI, the episodic abilities of our participants with lowered cognitive functioning were not sufficiently compromised relative to healthy older adults to elicit this overproduction of external detail. Although our pre-registered correlations on total detail scores found no evidence of this hypothesized compensatory relationship, Devitt et al. (2017) showed that this standard approach of correlating total detail scores that are aggregates of multiple trials can obscure relationships evident at the trial level. In line with their recommendations, our multilevel models revealed that there was a negative relationship between the number of internal and semantic details at the level of individual trials not evident in the correlations. Specifically, past and future event narratives with fewer internal details had greater amounts of semantic detail, suggestive of a compensatory generation of semantic content when episodic content is low (Devitt et al., 2017). However, contrary to our hypothesis, this effect was not magnified in the Low Cognition group, despite their reduced capacity to generate internal episodic details. Similarly, this effect did not interact with MoCA scores. Though broadly consistent with our ANOVA results that the Low Cognition group and High Cognition group produced similar numbers of semantic details, this finding may also suggest that in the Low Cognition group, episodic content is not sufficiently impoverished to ramp up compensatory mechanisms to levels greater than is evident in healthy older adults with higher cognitive functioning.

Alternatively, these negative correlations might not reflect compensation per se. For instance, it could reflect an age-related semanticization of AMs related to increased reliance on crystalized cognition (Spreng et al., 2018) that is not affected by early cognitive decline. Moreover, it is possible that this inverse relationship is reflective of narrative preferences, such as a focus on non-episodic details at the expense of episodic content. Indeed, others have suggested that one's communicative goals, including the tendency to emphasize personal meaning and better contextualize specific events within broader knowledge structures, may influence the types of details included in narrative responses (e.g., Coupland and Coupland, 1995; Gaesser et al., 2011; James et al., 1998; Labouvie-Vief and Blanchard-Fields, 1982; Levine et al., 2002). Such effects have been observed by Mair et al. (2024) who found that older and young adults recalled more general non-episodic details when aiming to describe an event as an interesting story versus aiming to report the event in objective detail. In addition, they observed that older adults recalled a lower number of specific episodic details and prioritized the provision of contextualizing information compared to younger adults who favoured comprehensive descriptions. As such, narrative style and retrieval goals may underlie, at least in part, the proportion of episodic to non-episodic details, and this may be especially true for older adults. It is also possible that any effects of narrative style could be amplified by a paradigm that incorporates a time limit, as in the current study. Upon further examination of the AI transcripts, we observed that participants were cut off by the time limit on 65% of past trials (High Cognition group, 68%; Low Cognition group, 61%) and 53% of future trials (High Cognition group, 62%; Low Cognition group, 55%), suggesting that narrative style could play a role in these results. Disentangling narrative style from possible compensatory effects will be a particularly important question for future research.

4.2. Inflation of event phenomenology ratings with lowered cognitive functioning

Turning to the phenomenology of past and future events, the Low Cognition group rated their past and future events as more personally significant and subjectively more detailed than did the High Cognition group. There was also a trend for Low Cognition group to have an observer perspective on more trials than the High Cognition group, but this was only for past events and the frequencies overall were very low. The finding of higher detail ratings by the Low Cognition group is particularly notable, given their overall reduction in internal episodic detail. This decoupling of objective (AI scores) and subjective measures (ratings) of detail has been documented in other studies of age-matched samples, including temporal lobe epilepsy (Addis et al., 2007). It has been suggested that this phenomenon could reflect group differences in scale interpretation or criterion (Folville et al., 2022). If ratings for the amount of detail are made by estimating the total amount of detail generated, then the degree to which the detail rating matches the number of internal details will be a function of the proportion of internal-to-total details. Alternatively, it is also possible that these ratings are informed by the vividness of the (p)re-experience associated with internal details, and that the groups may differ systematically in the criterion they use (e.g., vividness vs. total amount of detail). A definitive answer is beyond the scope of this study, but is an important question for research in this field.

4.3. Correspondence of past and future events

We replicated prior results of similar patterns of performance across past and future events, consistent with the constructive episodic simulation hypothesis (Schacter and Addis, 2007). First, the group difference for internal, but not external, details was evident for both the past and future conditions; indeed, the significant Group x Detail Type interaction did not vary by temporal direction. Second, the number of internal and external details generated on past trials was significantly correlated with the numbers generated on future trials, and these past-future correlations were evident not only across the entire sample but within each group. Third, the multilevel models constructed for past and future events yielded the same pattern of results, specifically that the amount of internal detail predicted semantic detail. It should be noted that although correlated, we found that future events contained more external details than past events. This finding is broadly consistent with the notion that the imagination of episodic future events can be more cognitively demanding and difficult than remembering past events (D'Argembeau and Van der Linden, 2004; Wiebels et al., 2020).

We also found that past events were rated as more emotionally intense relative to future events, whereas future events were more personally significant. The finding that past events were more emotionally intense relative to future events is inconsistent with other reports of no difference on this dimension (e.g., D'Argembeau and Van der Linden, 2006; Rasmussen and Berntsen, 2013), although everyday past experiences may have taken on more emotional significance during the social isolation of ongoing COVID-19 lockdowns. More consistent with prior literature is the finding that future events hold more personal importance than past events (D'Argembeau and Van der Linden, 2006), likely reflecting the inherent links of future events to our goals (Lehner and D'Argembeau, 2016) and potential consequences (Rasmussen and Berntsen, 2013).

4.4. Limitations and future directions

This study was conducted amid lockdowns during the COVID-19 pandemic, which presented very real challenges to the feasibility and safety of in-person research. These restrictions, along with the nature of longitudinal research in which these participants were enrolled, meant that completion of the MoCA, neuropsychological testing and the AI were often spaced apart. As such, it is important to consider the possibility that a participants' true cognitive status as initially assessed by the MoCA may not have remained consistent by the time of their first AI session. An individual classified in the high cognition group with a longer time gap between their MoCA testing and AI data collection may have been classified in the low cognition group had the MoCA been administered at the same time as their first AI session. Critically, however, there were no group differences in these delays, and the delay between MoCA and the start of AI testing did not correlate with MoCA or AI total scores in either group or the full sample (r values $< \pm .23$; p values $> .201$). Additionally, the government-mandated restrictions and a 27-month moratorium on in-person testing at Baycrest Health Sciences (a geriatric hospital) meant that the AI procedure adopted in this study diverged from the standard administration, being conducted over the telephone with no face-to-face interaction, and over the course of six monthly sessions along other longitudinal testing. Any possible effects of remote administration on rapport and participant comfort with relaying detailed personal events was likely offset by the regular sessions during a time of relative isolation. Collecting data in shorter sessions alleviated concerns about fatigue and enabled us to measure AM and EFT across 12 trials of each type per participant, relative to 1–6 trials collected in other studies (Acevedo-Molina et al., 2023; Bruus et al., 2021; Grilli et al., 2018; Peters and Sheldon, 2020). Importantly, our analyses showed that there was not a significant effect of AI session and that session did not interact with any of the other factors examined, ruling out practice effects. Additionally, our findings are consistent with those of Grilli et al. who used a standard administration of the AI. Nonetheless, it will still be important to interpret these findings within the context of the pandemic, and to conduct replication studies once the effects of the pandemic have fully subsided.

4.5. Conclusion

In summary, in a sample of older adults of varying cognitive functioning, we found that individuals with lower cognitive functioning – as estimated by the MoCA – exhibited a deficit in their generation of all types of episodic details comprising past and future events except for thoughts and emotions, with no difference in non-episodic details. These findings are consistent with other studies of AM in the preclinical phase of AD, and importantly, we replicate Acevedo-Molina et al.'s (2023) recent finding that this pattern extends to EFT in line with the constructive episodic simulation hypothesis. In addition, our use of multilevel modelling demonstrated that on trials lower in episodic content, semantic content was significantly increased. Although suggestive of a compensatory mechanism, the magnitude of this inverse relationship did not differ across groups or correlate with MoCA scores. Taken together, the findings of this study support the notion that reductions in the episodic detail comprising autobiographical events are associated with lowered cognitive functioning early in the preclinical phase. Even so, the ability to contextualize autobiographical events in relation to broader non-episodic knowledge structures is preserved, enabling older adults to contextualize and bring meaning to the events in their personal past and future irrespective of cognitive functioning.

Funding

This research was supported by the Canada 150 Research Chairs Program (awarded to DRA), and the Canadian Institutes for Health Research (CIHR) PJT 162292 (awarded to RKO).

Data statement

Pre-registration of this study is available at https://osf.io/hg9zw. De-identified group level data and analysis code is available on the Open Science Framework (https://osf.io/9tem2/); transcripts and neuropsychological data are available on request.

CRediT authorship contribution statement

Audrey Li-Chay-Chung: Writing – review & editing, Writing – original draft, Visualization, Formal analysis, Data curation, Conceptualization. **Faryn Starrs:** Writing – review & editing, Investigation, Conceptualization. **Jennifer D. Ryan:** Writing – review & editing, Conceptualization. **Morgan Barense:** Writing – review & editing, Conceptualization. **Rosanna K. Olsen:** Writing – review & editing, Project administration, Investigation, Funding acquisition, Conceptualization. **Donna Rose Addis:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Methodology, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Data availability

Group level data and analysis code have been made available on OSF (https://osf.io/9tem2/); transcripts and neuropsychological data available upon request.

Acknowledgments

The authors would like to thank Dr. Natalia Ladyka-Wojcik, Niroja Balakumar, Anika Choi, Tanya Doshi, Nathanael Shing, Catherine Wang, and Xuan Zhang for data collection; Lydia Jiang and Jagruti Pershad for data organization and cleaning; Dr. Nicole Anderson for assistance in scoring and interpreting the neuropsychological test scores; Katerina Bekas, Ziming Cheng, Odysse Davis, and Riya Trikha for assistance with scoring; and Dr. Samuel Fynes-Clinton for assistance with data analysis. We extend our thanks to the participants for sharing their autobiographical narratives with us.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.neuropsychologia.2024.108943.

References

Acevedo-Molina, M.C., Matijevic, S., Grilli, M.D., 2020. Beyond episodic remembering: elaborative retrieval of lifetime periods in young and older adults. Memory 28, 83–93. https://doi.org/10.1080/09658211.2019.1686152.
Acevedo-Molina, M.C., Thayer, S.C., Horn, K., Nkulu, H., Ryan, L., Andrews-Hanna, J.R., Grilli, M.D., 2023. Past and future episodic detail retrieval is reduced among clinically normal older adults at higher genetic risk for late-onset Alzheimer's disease. Neuropsychology 37 (2), 194–203. https://doi.org/10.1037/neu0000866.
Addis, D.R., 2020. Mental Time Travel? A Neurocognitive Model of Event Simulation. Rev. Philos. Psychol. 11, 233–259. https://doi.org/10.1007/s13164-020-00470-0.
Addis, D.R., McIntosh, A.R., Moscovitch, M., Crawley, A.P., McAndrews, M.P., 2004. Characterizing spatial and temporal features of autobiographical memory retrieval networks: a partial least squares approach. Neuroimage 23, 1460–1471. https://doi.org/10.1016/j.neuroimage.2004.08.007.
Addis, D.R., Musicaro, R., Pan, L., Schacter, D.L., 2010. Episodic simulation of past and future events in older adults: evidence from an experimental recombination task. Psychol. Aging 25, 369–376. https://doi.org/10.1037/a0017280.
Addis, D.R., Sacchetti, D.C., Ally, B.A., Budson, A.E., Schacter, D.L., 2009. Episodic simulation of future events is impaired in mild Alzheimer's disease. Neuropsychologia 47, 2660–2671. https://doi.org/10.1016/j.neuropsychologia.2009.05.018.
Addis, D.R., Wong, A.T., Schacter, D.L., 2008. Age-related changes in the episodic simulation of future events. Psychol. Sci. 19, 33–41. https://doi.org/10.1111/j.1467-9280.2008.02043.x.
Addis, D.R., Schacter, D.L., 2012. The hippocampus and imagining the future: where do we stand? Front Hum Neurosci 5, 173. https://doi.org/10.3389/fnhum.2011.00173.
Addis, D.R., Wong, A.T., Schacter, D.L., 2007. Remembering the past and imagining the future: Common and distinct neural substrates during event construction and elaboration. Neuropsychologia 45, 1363–1377. https://doi.org/10.1016/j.neuropsychologia.2006.10.016.
Atance, C.M., O'Neill, D.K., 2001. Episodic future thinking. Trends Cognit. Sci. 5, 533–539. https://doi.org/10.1016/S1364-6613(00)01804-0.
Atance, C.M., O'Neill, D.K., 2005. The emergence of episodic future thinking in humans. Learn. Motiv. 36, 126–144. https://doi.org/10.1016/j.lmot.2005.02.003.
Bates, D., Mächler, M., Bolker, B., Walker, S., 2015. Fitting linear mixed-effects models using lme4. J. Stat. Software 67, 1–48. https://doi.org/10.18637/jss.v067.i01.
Benedict, R.H.B., 1997. Brief Visuospatial Memory Test—Revised. Psychological Assessment Resources.
Benoit, R.G., Schacter, D.L., 2015. Specifying the core network supporting episodic simulation and episodic memory by activation likelihood estimation. Neuropsychologia 75, 450–457. https://doi.org/10.1016/j.neuropsychologia.2015.06.034.
Bruus, A.E., Waldemar, G., Vogel, A., 2021. Impairment of episodic-specific autobiographical memory in individuals with subjective cognitive decline and in patients with prodromal or mild Alzheimer's disease. J. Alzheim. Dis. 84, 1485–1496. https://doi.org/10.3233/JAD-215113.
Buckley, R.F., Saling, M.M., Irish, M., Ames, D., Rowe, C.C., Villemagne, V.L., Lautenschlager, N.T., Maruff, P., Macaulay, S.L., Martins, R.N., Szoeke, C., Masters, C.L., Rainey-Smith, S.R., Rembach, A., Savage, G., Ellis, K.A., 2014. Autobiographical narratives relate to Alzheimer's disease biomarkers in older adults. Int. Psychogeriatr. 26, 1737–1746. https://doi.org/10.1017/S1041610214001136.
Caselli, R.J., Reiman, E.M., 2012. Characterizing the preclinical stages of Alzheimer's disease and the prospect of presymptomatic intervention. J. Alzheim. Dis. 33 (s1), S405–S416. https://doi.org/10.3233/JAD-2012-129026.
Cohen, J., 1988. Statistical Power Analysis for the Behavioral Sciences. Lawrence Erlbaum Associates.
Cohen, N.J., Eichenbaum, H., 1993. Memory, amnesia, and the hippocampal system. The MIT Press.
Cole, S.N., Morrison, C.M., Conway, M.A., 2013. Episodic future thinking: Linking neuropsychological performance with episodic detail in young and old adults. Q. J. Exp. Psychol. 66, 1687–1706. https://doi.org/10.1080/17470218.2012.758157.

Conway, M.A., Pleydell-Pearce, C.W., 2000. The construction of autobiographical memories in the self-memory system. Psychol. Rev. 107, 261–288. https://doi.org/10.1037/0033-295X.107.2.261.

Coupland, N., Coupland, J., 1995. Discourse, identity, and aging. In: Nussbaum, J.F., Coupland, J. (Eds.), Handbook of Communication and Aging Research. Lawrence Erlbaum Associates, Inc, pp. 79–103.

Damian, A.M., Jacobson, S.A., Hentz, J.G., Belden, C.M., Shill, H.A., Sabbagh, M.N., Caviness, J.N., Adler, C.H., 2011. The Montreal Cognitive Assessment and the Mini-Mental State Examination as screening instruments for cognitive impairment: Item analyses and threshold scores. Dement. Geriatr. Cognit. Disord. 31, 126–131. https://doi.org/10.1159/000323867.

D'Angelo, M.C., Smith, V.M., Kacollja, A., Zhang, F., Binns, M.A., Barense, M.D., Ryan, J. D., 2016. The effectiveness of unitization in mitigating age-related relational learning impairments depends on existing cognitive status. Aging Neuropsychol. Cognit. 23 (6), 667–690. https://doi.org/10.1080/13825585.2016.1158235.

D'Argembeau, A., Van der Linden, M., 2004. Phenomenal characteristics associated with projecting oneself back into the past and forward into the future: influence of valence and temporal distance. Conscious. Cognit. 13, 844–858. https://doi.org/10.1016/j.concog.2004.07.007.

D'Argembeau, A., Van der Linden, M., 2006. Individual differences in the phenomenology of mental time travel: the effect of vivid visual imagery and emotion regulation strategies. Conscious. Cognit. 15, 342–350. https://doi.org/10.1016/j.concog.2005.09.001.

De Brigard, F., Rodriguez, D.C., Montañés, P., 2017. Exploring the experience of episodic past, future, and counterfactual thinking in younger and older adults: a study of a Colombian sample. Conscious. Cognit. 51, 258–267. https://doi.org/10.1016/j.concog.2017.04.007.

Devitt, A.L., Addis, D.R., Schacter, D.L., 2017. Episodic and semantic content of memory and imagination: a multilevel analysis. Mem. Cognit. 45, 1078–1094. https://doi.org/10.3758/s13421-017-0716-1.

El Haj, M., Moustafa, A.A., Antoine, P., Chapelet, G., 2024. Relationship between future thinking and prospective memory in Alzheimer's disease. Journal of Alzheimer's disease reports 8 (1), 33–42. https://doi.org/10.3233/ADR-230144.

Folville, A., Simons, J.S., D'Argembeau, A., Bastin, C., 2022. I remember it like it was yesterday: age-related differences in the subjective experience of remembering. Psychonomic Bull. Rev. 29, 1223–1245. https://doi.org/10.3758/s13423-021-02048-y.

Frankenberg, C., Pantel, J., Haberkorn, U., Degen, C., Buchsbaum, M.S., Herold, C.J., Schröder, J., 2021. Neural correlates of autobiographical memory: evidence from a positron emission tomography study in patients with mild cognitive impairment and Alzheimer's disease. Front. Psychiatr. 12, 730713 https://doi.org/10.3389/fpsyt.2021.730713.

Gaesser, B., Sacchetti, D.C., Addis, D.R., Schacter, D.L., 2011. Characterizing age-related changes in remembering the past and imagining the future. Psychol. Aging 26 (1), 80–84. https://doi.org/10.1037/a0021054.

Gamboz, N., De Vito, S., Brandimonte, M.A., Pappalardo, S., Galeone, F., Iavarone, A., Sala, S.D., 2010. Episodic future thinking in amnesic mild cognitive impairment. Neuropsychologia 48, 2091–2097. https://doi.org/10.1016/j.neuropsychologia.2010.03.030.

Geisser, S.W., Greenhouse, S., 1958. An extension of Box's results on the use of the F distribution in multivariate analysis. Ann. Math. Stat. 29, 885–891. https://doi.org/10.1214/aoms/1177706545.

Gilewski, M.J., Zelinski, E.M., Schaie, K.W., 1990. The Memory Functioning Questionnaire for assessment of memory complaints in adulthood and old age. Psychol. Aging. 5, 482–490. https://doi.org/10.1037//0882-7974.5.4.482.

Greenberg, D.L., Verfaellie, M., 2010. Interdependence of episodic and semantic memory: evidence from neuropsychology. J. Int. Neuropsychol. Soc. 16 (5), 748–753. https://doi.org/10.1017/S1355617710000676.

Grilli, M.D., Wank, A.A., Bercel, J.J., Ryan, L., 2018. Evidence for reduced autobiographical memory episodic specificity in cognitively normal middle-aged and older individuals at increased risk for Alzheimer's disease dementia. J. Int. Neuropsychol. Soc. 24, 1073–1083. https://doi.org/10.1017/S1355617718000577.

Grilli, M.D., Wank, A.A., Huentelman, M.J., Ryan, L., 2021. Autobiographical memory fluency reductions in cognitively unimpaired middle-aged and older adults at increased risk for Alzheimer's disease dementia. J. Int. Neuropsychol. Soc. 27, 905–915. https://doi.org/10.1017/S1355617720001319.

Han, S.D., Nguyen, C.P., Stricker, N.H., Nation, D.A., 2017. Detectable neuropsychological differences in early preclinical Alzheimer's disease: a meta-analysis. Neuropsychol. Rev. 27, 305–325. https://doi.org/10.1007/s11065-017-9345-5.

Hassabis, D., Kumaran, D., Vann, S.D., Maguire, E.A., 2007. Patients with hippocampal amnesia cannot imagine new experiences. Proc. Natl. Acad. Sci. USA 104, 1726–1731. https://doi.org/10.1073/pnas.0610561104.

Hassabis, D., Maguire, E.A., 2007. Deconstructing episodic memory with construction. Trends Cognit. Sci. 11, 299–306. https://doi.org/10.1016/j.tics.2007.05.001.

Hayes, A.F., 2022. Introduction to Mediation, Moderation, and Conditional Process Analysis: A Regression-Based Approach, third ed. Guilford Press.

Horzyk, A., Starzyk, J.A., Graham, J., 2017. Integration of semantic and episodic memories. IEEE Transact. Neural Networks Learn. Syst. 28, 3084–3095. https://doi.org/10.1109/TNNLS.2017.2728203.

Irish, M., Addis, D.R., Hodges, J.R., Piguet, O., 2012. Considering the role of semantic memory in episodic future thinking: evidence from semantic dementia. Brain 135, 2178–2191. https://doi.org/10.1093/brain/aws119.

Irish, M., Hornberger, M., Lah, S., Miller, L., Pengas, G., Nestor, P.J., Hodges, J.R., Piguet, O., 2011. Profiles of recent autobiographical memory retrieval in semantic dementia, behavioural-variant frontotemporal dementia, and Alzheimer's disease. Neuropsychologia 49, 2694–2702. https://doi.org/10.1016/j.neuropsychologia.2011.05.017.

Irish, M., Lawlor, B.A., O'Mara, S.M., Coen, R.F., 2010. Exploring the recollective experience during autobiographical memory retrieval in amnestic mild cognitive impairment. J. Int. Neuropsychol. Soc. 16, 546–555. https://doi.org/10.1017/S1355617710000172.

Irish, M., Piguet, O., 2013. The pivotal role of semantic memory in remembering the past and imagining the future. Front. Behav. Neurosci. 7, 27. https://doi.org/10.3389/fnbeh.2013.00027.

James, L.E., Burke, D.M., Austin, A., Hulme, E., 1998. Production and perception of "verbosity" in younger and older adults. Psychol. Aging 13 (3), 355–367. https://doi.org/10.1037/0882-7974.13.3.355.

Khan, U.A., Liu, L., Provenzano, F.A., Berman, D.E., Profaci, C.P., Sloan, R., Mayeux, R., Duff, K.E., Small, S.A., 2014. Molecular drivers and cortical spread of lateral entorhinal cortex dysfunction in preclinical Alzheimer's disease. Nat. Neurosci. 17, 304–311. https://doi.org/10.1038/nn.3606.

Labouvie-Vief, G., Blanchard-Fields, F., 1982. Cognitive ageing and Psychological growth. Ageing Soc. 2 (2), 183–209. https://doi.org/10.1017/S0144686X00009429.

Kwan, D., Carson, N., Addis, D.R., Rosenbaum, R.S., 2010. Deficits in past remembering extend to future imagining in a case of developmental amnesia. Neuropsychologia 48, 3179–3186. https://doi.org/10.1016/j.neuropsychologia.2010.06.011.

La Corte, V., Piolino, P., 2016. On the role of personal semantic memory and temporal distance in episodic future thinking: the TEDIFT model. Front. Hum. Neurosci. 10 https://doi.org/10.3389/fnhum.2016.00385.

LeBreton, J.M., Senter, J.L., 2008. Answers to 20 questions about interrater reliability and interrater agreement. Organ. Res. Methods 11, 815–852. https://doi.org/10.1177/1094428106296642.

Lehner, E., D'Argembeau, A., 2016. The role of personal goals in autonoetic experience when imagining future events. Conscious. Cognit. 42, 267–276. https://doi.org/10.1016/j.concog.2016.04.002.

Levine, B., 2004. Autobiographical memory and the self in time: brain lesion effects, functional neuroanatomy, and lifespan development. Brain Cognit. 55, 54–68. https://doi.org/10.1016/S0278-2626(03)00280-X.

Levine, B., Svoboda, E., Hay, J.F., Winocur, G., Moscovitch, M., 2002. Aging and autobiographical memory: dissociating episodic from semantic retrieval. Psychol. Aging 17, 677–689. https://doi.org/10.1037/0882-7974.17.4.677.

Leyhe, T., Müller, S., Milian, M., Eschweiler, G.W., Saur, R., 2009. Impairment of episodic and semantic autobiographical memory in patients with mild cognitive impairment and early Alzheimer's disease. Neuropsychologia 47, 2464–2469. https://doi.org/10.1016/j.neuropsychologia.2009.04.018.

Mair, A., Poirier, M., Conway, M.A., 2024. Nonepisodic autobiographical memory details reflect attempts to tell a good story. Psychol. Aging. https://doi.org/10.1037/pag0000805.

Meulenbroek, O., Rijpkema, M., Kessels, R.P.C., Rikkert, M.G.M.O., Fernández, G., 2010. Autobiographical memory retrieval in patients with Alzheimer's disease. Neuroimage 53, 331–340. https://doi.org/10.1016/j.neuroimage.2010.05.082.

Miller, T.D., Chong, T.T.-J., Aimola Davies, A.M., Ng, T.W.C., Johnson, M.R., Irani, S.R., Vincent, A., Husain, M., Jacob, S., Maddison, P., Kennard, C., Gowland, P.A., Rosenthal, C.R., 2017. Focal CA3 hippocampal subfield atrophy following LGI1 VGKC-complex antibody limbic encephalitis. Brain 140, 1212–1219. https://doi.org/10.1093/brain/awx070.

Murphy, K.J., Troyer, A.K., Levine, B., Moscovitch, M., 2008. Episodic, but not semantic, autobiographical memory is reduced in amnestic mild cognitive impairment. Neuropsychologia 46, 3116–3123. https://doi.org/10.1016/j.neuropsychologia.2008.07.004.

Nasreddine, Z.S., Phillips, N.A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., Cummings, J.L., Chertkow, H., 2005. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J. Am. Geriatr. Soc. 53, 695–699. https://doi.org/10.1111/j.1532-5415.2005.53221.x.

Olsen, R.K., Yeung, L.-K., Noly-Gandon, A., D'Angelo, M.C., Kacollja, A., Smith, V.M., Ryan, J.D., Barense, M.D., 2017. Human anterolateral entorhinal cortex volumes are associated with cognitive decline in aging prior to clinical diagnosis. Neurobiol. Aging 57, 195–205. https://doi.org/10.1016/j.neurobiolaging.2017.04.025.

Palombo, D.J., Bacopulos, A., Amaral, R.S.C., Olsen, R.K., Todd, R.M., Anderson, A.K., Levine, B., 2018. Episodic autobiographical memory is associated with variation in the size of hippocampal subregions. Hippocampus 28, 69–75. https://doi.org/10.1002/hipo.22818.

Peters, S., Sheldon, S., 2020. Interindividual differences in cognitive functioning are associated with autobiographical memory retrieval specificity in older adults. GeroPsych: The Journal of Gerontopsychology and Geriatric Psychiatry 33, 15–29. https://doi.org/10.1024/1662-9647/a000219.

Rasmussen, A.S., Berntsen, D., 2013. The reality of the past versus the ideality of the future: emotional valence and functional differences between past and future mental time travel. Mem. Cognit. 41, 187–200. https://doi.org/10.3758/s13421-012-0260-y.

Reitan, R.M., Wolfson, D., 1985. The Halstead–Reitan Neuropsycholgical Test Battery: Therapy and clinical interpretation. Neuropsychological Press.

Renoult, L., Armson, M.J., Diamond, N.B., Fan, C.L., Jeyakumar, N., Levesque, L., Oliva, L., McKinnon, M., Papadopoulos, A., Selarka, D., St Jacques, P.L., Levine, B., 2020. Classification of general and personal semantic details in the Autobiographical Interview. Neuropsychologia 144, 107501. https://doi.org/10.1016/j.neuropsychologia.2020.107501.

Renoult, L., Davidson, P.S.R., Palombo, D.J., Moscovitch, M., Levine, B., 2012. Personal semantics: at the crossroads of semantic and episodic memory. Trends Cogn. Sci. 16, 550–558. https://doi.org/10.1016/j.tics.2012.09.003.

Renoult, L., Irish, M., Moscovitch, M., Rugg, M.D., 2019. From Knowing to Remembering: The Semantic-Episodic Distinction. Trends Cogn. Sci. 23, 1041–1057. https://doi.org/10.1016/j.tics.2019.09.008.

Revelle, W., 2022. Psych: Procedures for Psychological, Psychometric, and Personality Research (Version 2.2.9) [Computer software]. https://CRAN.R-project.org/package=psych.

R Core Team, 2022. R: A Language and Environment for Statistical Computing (Version 4.2.2.) [Computer software]. http://www.R-project.org.

Salthouse, T.A., 2004. What and when of cognitive aging. Curr. Dir. Psychol. Sci. 13, 140–144. https://doi.org/10.1111/j.0963-7214.2004.00293.x.

Schacter, D.L., Addis, D.R., 2007. On the constructive episodic simulation of past and future events. Behav. Brain Sci. 30, 331–332. https://doi.org/10.1017/S0140525X07002178.

Schacter, D.L., Addis, D.R., Buckner, R.L., 2007. Remembering the past to imagine the future: the prospective brain. Nat. Rev. Neurosci. 8, 657–661. https://doi.org/10.1038/nrn2213.

Schacter, D.L., Benoit, R.G., Szpunar, K.K., 2017. Episodic future thinking: mechanisms and functions. Current Opinion in Behavioral Sciences 17, 41–50. https://doi.org/10.1016/j.cobeha.2017.06.002.

Schacter, D.L., Gaesser, B., Addis, D.R., 2013. Remembering the past and imagining the future in the elderly. Gerontology 59, 143–151. https://doi.org/10.1159/000342198.

Schmidt, M., 1996. Rey Auditory Verbal Learning Test: A Handbook. Western Psychological Services.

Sheldon, S., Levine, B., 2016. The role of the hippocampus in memory and mental construction. Ann. N. Y. Acad. Sci. 1369, 76–92. https://doi.org/10.1111/nyas.13006.

Shipley, W.C., Gruber, C.P., Martin, T.A., Klein, A.M., 2009. Shipley-2 Manual. Western Psychological Services.

Simpson, S., Eskandaripour, M., Levine, B., 2023. Effects of healthy and neuropathological aging on autobiographical memory: a meta-analysis of studies using the autobiographical interview. J. Gerontol. B Psychol. Sci. Soc. Sci. 78 (10), 1617–1624. https://doi.org/10.1093/geronb/gbad077.

Sperling, R.A., Aisen, P.S., Beckett, L.A., Bennett, D.A., Craft, S., Fagan, A.M., Iwatsubo, T., Jack, C.R., Kaye, J., Montine, T.J., Park, D.C., Reiman, E.M., Rowe, C.C., Siemers, E., Stern, Y., Yaffe, K., Carrillo, M.C., Thies, B., Morrison-Bogorad, M., et al., 2011. Toward defining the preclinical stages of Alzheimer's disease: recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. Alzheimer's Dementia 7, 280–292. https://doi.org/10.1016/j.jalz.2011.03.003.

Spreng, R.N., Lockrow, A.W., DuPre, E., Setton, R., Spreng, K.A.P., Turner, G.R., 2018. Semanticized autobiographical memory and the default-executive coupling hypothesis of aging. Neuropsychologia 110, 37–43. https://doi.org/10.1016/j.neuropsychologia.2017.06.009.

Squire, L.R., Van Der Horst, A.S., McDuff, S.G.R., Frascino, J.C., Hopkins, R.O., Mauldin, K.N., 2010. Role of the hippocampus in remembering the past and imagining the future. Proc. Natl. Acad. Sci. USA 107, 19044–19048. https://doi.org/10.1073/pnas.1014391107.

Steinberg, B.A., Bieliauskas, L.A., Smith, G.E., Ivnik, R.J., 2005. Mayo's older Americans normative studies: age- and IQ-adjusted norms for the trail-making test, the stroop test, and MAE controlled oral word association test. Clin. Neuropsychol. 1, 329–377. https://doi.org/10.1080/13854040590945210.

Tombaugh, T.N., Kozak, J., Rees, L., 1999. Normative data stratified by age and education for two measures of verbal fluency: FAS and animal naming. Arch. Clin. Neuropsychol. 14, 167–177. https://doi.org/10.1016/S0887-6177(97)00095-4.

Trope, Y., Liberman, N., 2003. Temporal construal. Psychol. Rev. 110, 403–421. https://doi.org/10.1037/0033-295X.110.3.403.

Wank, A.A., Andrews-Hanna, J.R., Grilli, M.D., 2021. Searching for the past: exploring the dynamics of direct and generative autobiographical memory reconstruction among young and cognitively normal older adults. Mem. Cognit. 49, 422–437. https://doi.org/10.3758/s13421-020-01098-2.

Wechsler, D., 1997. Technical Manual for the Wechsler Adult Intelligence Test, third ed. The Psychological Corporation.

Wickham, H., François, R., Henry, L., Müller, K., Vaughan, D., 2023. Dplyr: A Grammar of Data Manipulation (Version 1.1.2) [Computer software]. https://github.com/tidyverse/dplyr.

Wiebels, K., Addis, D.R., Moreau, D., Van Mulukom, V., Onderdijk, K.E., Roberts, R.P., 2020. Relational processing demands and the role of spatial context in the construction of episodic simulations. J. Exp. Psychol. Learn. Mem. Cognit. 46, 1424–1441. https://doi.org/10.1037/xlm0000831.