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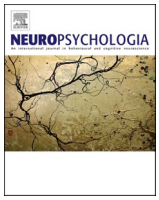

From past recall to future projection: What does verb tense production reveal about mental time travel in Alzheimer's disease?

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1. Introduction

Mental time travel (MTT) designates the complex cognitive faculty that enables us to mentally relive past personal events or pre-experience future ones (Suddendorf and Corballis, 1997; Tulving, 1985). This capacity to navigate backward and forward in time relies heavily on episodic memory and is markedly compromised in neurodegenerative diseases characterized by autobiographical memory deficits, such as Alzheimer's disease (AD) (El Haj et al., 2013; Moustafa and El Haj, 2018). MTT plays a crucial role in daily life, facilitating future-oriented decision-making and supporting the continuity and coherence of the self over time (Conway, 2005; D'Argembeau et al., 2011; Prebble et al., 2013).

A hallmark of MTT is the presence of various phenomenological details—such as perceptual, spatial, temporal, and emotional details—that create a vivid sense of (re)experiencing the retrieved or imagined event (D'Argembeau and Van der Linden, 2004; Johnson et al., 1988). Consequently, a widely adopted method for assessing MTT involves the analysis of these details within narratives produced during the recollection of past personal events or the simulation of future events across different epochs (for a systematic review, see Miloyan et al., 2019). Empirical investigations of MTT in AD have consistently demonstrated a dual impairment: not only are patients less capable of retrieving specific autobiographical events, consistent with the progressive deterioration of episodic memory, but the narratives they produce are significantly reduced in phenomenological details compared to those of control participants. This impoverishment is evident for both past episodic recall (Barnabe et al., 2012; Irish et al., 2011a, 2011b; Meulenbroek et al., 2010) and future event simulation (Addis et al., 2009; Irish et al., 2012; Moustafa and El Haj, 2018), suggesting that the core mechanisms supporting vivid MTT are compromised in the course of the disease. Moreover, some studies have shown that these difficulties in reliving past personal events may exhibit a temporal gradient, whereby events encoded earlier in life, particularly those from the early adulthood (i.e., 18-30 years old), are retrieved with greater vivid details than more recent memories (i.e. last years) (Barnabe et al., 2012; De Simone et al., 2016; Irish et al., 2011b; Müller et al., 2016). This gradient is thought to reflect the relative preservation of remote episodic memories, potentially supported by consolidation processes that render older memories more resistant to pathological degradation (Alvarez and Squire, 1994; Moscovitch et al., 2005).

While previous studies have predominantly focused on the phenomenological richness of recalled or imagined events, less attention has been paid to the linguistic mechanisms through which temporal information is conveyed during MTT. Yet, the ability to anchor events in time relies also on the use of specific linguistic markers that explicitly express temporal concepts (past, present, and future). Language provides indeed a range of temporal markers, including temporal adverbs (e.g. *yesterday, tomorrow*) and verb inflection (e.g. *was, will be*), which serve as fundamental tools for conveying the concept of time (Comrie, 1985; Klein, 2013). In tense-based languages (like French or English), verb inflection constitutes the primary mechanism for building a coherent temporal framework, enabling speakers to locate events in time and to establish temporal relationships between them. Beyond tense, another key component of time reference is grammatical aspect, which further refines the temporal perspective by specifying how an event is internally structured relative to a specific time (Comrie, 1976; Vetters, 1996). Like tense, aspect is typically expressed through verb morphology. A common distinction within grammatical aspect is that between perfectivity and imperfectivity: while perfectivity is used to express an action that must be seen as complete (e.g., *she wrote the letter*), imperfectivity highlights the internal temporal structure of the event, presenting it as ongoing or unfolding over time (e.g., *she was writing the letter*). Thus, tense locates events in time, while aspect shapes how their temporal unfolding is constructed. Through verb inflection, speakers situate events relative to the present moment of enunciation, which

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serves as a temporal anchor (Grisot, 2018; Reichenbach, 1947). Referring to past or future events therefore requires projecting oneself beyond the present into an alternative temporal framework while maintaining this anchor. This capacity to shift perspective is critical for linking speech time with event time. Investigating verb inflection in neurodegenerative conditions such as AD can therefore provide valuable insights into the cognitive mechanisms underlying time reference. Impairments in time perception and temporality (i.e. the subjective experience of time) are well-documented in AD, manifesting as disorientation (Weissberger et al., 2017), distortions in interval estimation (Carrasco et al., 2000; Papagno et al., 2004), and difficulties with MTT (Piolino et al., 2003; Rauchs et al., 2007). As a result, using verb inflection to refer to past or future events could be especially challenging for individuals with AD, given the demands such operations place on the ability to mentally project oneself in time.

Despite its theoretical importance, the study of verb inflection in AD remains limited, largely due to the scarcity of tasks specifically designed to elicit tense and grammatical aspect (Cortese et al., 2006; Fyndanis et al., 2013, 2018; Manouilidou et al., 2020; Schaffner et al., 2025a). While participants with AD generally perform below the level of control participants on such tasks, the underlying mechanisms driving their difficulties remain insufficiently understood. To date, the prevailing hypothesis attributes impairments in verb inflection primarily to deficits in verbal working memory and executive control (Cortese et al., 2006; Fyndanis et al., 2013, 2018). This explanation is supported by evidence from constrained tasks, such as sentence completion tasks (e.g., Fyndanis et al., 2013, 2018), which require participants to integrate linguistic and time conceptual information under strict structural constraints, placing significant demands on executive resources and working memory (see also Kok et al., 2007). Within this framework, grammatical aspect appears more demanding than tense (Manouilidou et al., 2020; Roumpea et al., 2019), as it entails a subjective choice between alternative temporal conceptualizations - perfective or imperfective - within the same timeframe (e.g., past events conceptualized as completed vs. ongoing). Schaffner et al. (2025a) showed that, in French-speaking participants with AD, performance in tense and aspect production through sentence completion tasks was influenced by executive functions (flexibility and inhibition) and working memory, with grammatical aspect being particularly impaired, with both perfective and imperfective forms similarly affected. While constrained tasks such as sentence completion tasks have provided important insights into how participants with AD manage verb inflection, their artificial and decontextualized nature, combined with high cognitive demands (see also Varlokosta et al., 2024), may limit their ecological validity. To overcome these limitations, narrative tasks offer a more naturalistic alternative for assessing participants' time reference abilities through verb inflection. Constructing a narrative, whether fictional or derived from one's experience, requires the speaker to organize events within a coherent temporal frame, aligned with or distinct from the moment of speech. Unlike constrained tasks, storytelling directly engages the cognitive and linguistic mechanisms involved in mentally situating events in time, potentially offering a more sensitive measure of temporal projection abilities in AD. In a storytelling-in-sequence task in which participants recounted short stories based on cartoon sequences, each anchored in a specific temporal frame (past, present or future), Schaffner et al. (2025b) showed that, compared to controls, participants with AD produced fewer temporally appropriate verb forms when narrating past or future stories, instead overusing the present tense. This pattern suggests a difficulty in building temporally coherent narratives when the temporal frame of the event diverges from the present, possibly reflecting a reduced ability to project oneself beyond the immediate moment – a key component of impaired temporality in AD.

Building on these findings, the present study aims to further investigate the link between verb inflection and MTT in AD. To this end, we analyse the use of verb tense and grammatical aspect within the framework of an adapted version of the Autobiographical Interview (AI; Levine et al., 2002), a well-established task designed to assess episodic and semantic characteristics of autobiographical memory and future thinking in an ecologically valid, narrative-based format. The AI prompts participants to retrieve or imagine personal events anchored in specific temporal contexts, thus offering a unique opportunity to examine how AD participants linguistically express time when mentally projecting themselves into the past or the future. A key strength of the AI lies in its capacity to distinguish between two types of narrative content: internal details, which reflect episodic, spatiotemporally grounded information typically used to assess MTT; and external details, which encompass semantic knowledge, commentary, or general information not tied to a specific time or place. Previous studies have shown that AD participants produced fewer internal and more external details than control participants, indicating a loss of episodic specificity (Irish et al., 2011a, 2011b, 2012). Interestingly, only one of these studies, also reported a greater use of present-tense verbs among AD participants when recalling past events (Irish et al., 2016). However, it remains unclear whether this atypical use of tense reflects a breakdown in temporal anchoring within internal content (internal details) or is merely a by-product of increased reliance on external, present-oriented discourse, as Irish's study (2016) combined both types of details when analysing tenses. Nevertheless, by separating tense and aspect usage according to the type of details, the AI provides an opportunity to examine more precisely how language reflects time projection in AD. This distinction is critical for understanding whether altered verb inflection patterns reflect a general linguistic impairment, or a disruption in the mental construction of time itself.

The present study builds on this framework to examine whether participants with AD show altered use of verb tense and aspect when recounting or imagining personal events situated in time. By focusing specifically on internal details, the narrative component most closely tied to MTT, we aim to determine whether verb inflection (tense and aspect) reflects a reduced ability to project oneself into the past or future. More broadly, we seek to clarify whether impairments in verb inflection in AD reflect broader deficits in temporal cognition, and more specifically, in the capacity for MTT. To address this question, the study is structured around two main objectives, each associated with a set of hypotheses, as detailed below.

2. Objectives and hypothesis

The first objective of the present study is to assess how French-speaking participants with AD and control participants manage time reference when mentally projecting themselves into their personal past and future to narrate events. To do so, we will examine the use of both tense and grammatical aspect, as these two markers of time reference have been shown to be challenging for individuals with AD to produce (Cortese et al., 2006; Fyndanis et al., 2013, 2018; Schaffner et al., 2025a).

Focusing on internal details elicited through an AI-adapted task (Levine et al., 2002), we will investigate the production of inflected verbs in three tense categories: past, present and future, during the recount of past events and the simulation of future personal episodes. Based on previous findings, we expect that participants with AD will produce fewer past-tense verbs than control participants when recounting past personal events, and fewer future-tense verbs when simulating future personal events. These reductions will be compensated by an increased use of present-tense verbs, reflecting a difficulty for participants with AD in disengaging from the present to mentally anchor events in another temporal frame.

In addition, we will explore how the use of past-tense forms varies according to the temporal distance of the past recalled event, specifically between remote past (i.e. young adulthood) and recent past (i.e. the last year). Given the temporal gradient often observed in AD, with relatively preserved access to remote memories in the early stages of the disease (Hou et al., 2005; N.Philippi et al., 2015), we expect that participants

with AD will produce fewer past-tense verbs for recent events than for remote ones, whereas no such difference is expected in the control group.

Regarding grammatical aspect (perfective vs. imperfective), although no clear pattern of impairment between the perfective or imperfective aspect has yet emerged in AD (Manouilidou et al., 2020; Roumpea et al., 2019; Schaffner et al., 2025a), we will explore its use within past-tense constructions across remote and recent recalled events. In French, aspect is grammatically encoded only in the past tense, offering a meaningful window into how participants conceptualize event boundaries over different periods of autobiographical time.

The second objective is to investigate the cognitive predictors of verb tense use during the narration of past and future events. Previous research suggests that executive functions, particularly mental flexibility and working memory, play a role in the use of appropriate tenses and aspect (Cortese et al., 2006; Fyndanis et al., 2013, 2018; Schaffner et al., 2025a). Although these findings largely stem from constrained tasks, we hypothesize that executive functions will partially predict the production of temporally appropriate verb forms (in both past and future contexts) in both groups. In addition, because the AI elicits richer and more contextually grounded narratives than decontextualized tasks, we also consider the role of cognitive capacities more closely related to temporality, such as episodic memory. We thus expect that, in the AD group, episodic memory will emerge as an additional predictor of appropriate tense use, reflecting its central role in supporting MTT.

3. Method

3.1. Population

Twenty-one French-speaking participants with a biologically confirmed diagnosis of typical amnestic AD were included. Biological confirmation was established through cerebrospinal fluid analysis or amyloid PET biomarkers. They were recruited from the Leenaards Memory Center of the Lausanne University Hospital (CHUV). Twenty-one French-speaking cognitively normal older adults strictly matched for age, gender and educational level were recruited in the community as control participants. The participant sample for this study was identical to that used in Schaffner et al.'studies (2025a, 2025b).

The general inclusion criteria for all participants were (1) being native or proficient French speakers (i.e., having completed compulsory school and training in French) and (2) having normal or corrected vision and hearing. For participants with AD, additional inclusion criteria required (1) biomarker evidence consistent with AD pathology according to the ATN classification (amyloid, tau, neurodegeneration; Jack Jr et al., 2018), (2) a diagnosis of probable AD as defined by the revised NINCDS-ADRDA guidelines (McKhann et al., 2011), (3) a global Clinical Dementia Rating (CDR; Morris, 1993) score ranging from 0.5 to 1, and (4) evidence of mild to moderate cognitive decline as measured by the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005).

Exclusion criteria for both groups included (1) a documented history of psychiatric conditions as outlined in the DSM-5 (American Psychiatric Association, 2022), (2) clinical manifestations of substance use disorders according to DSM-5 diagnostic criteria, and (3) focal brain lesions due to trauma or cerebrovascular events. For the control group, additional exclusion criteria were (1) any history of cerebral or neurological disorder and (2) evidence of cognitive impairment, defined as a MoCA score below 26/30 and performance below age- and education-adjusted norms on the *Dépistage des Troubles du langage chez l'Adulte et la personne âgée* (DTLA; Macoir et al., 2017). In addition, to ensure the absence of major language impairments that could interfere with the narrative task, participants underwent a series of language assessments from the GREMOTS battery (Bézy et al., 2016), the short version of the *Test Informatisé de Compréhension Syntaxique en français* (TICS-f-12; Python et al., 2013), and the *Batterie d'Évaluation de la Compréhension Syntaxique* (BCS; Bourgeois et al., 2019). Although some language measures revealed statistically significant differences between groups, mean scores were nevertheless very similar overall, with control participants achieving near-ceiling performance on several language assessments. A detailed overview of participants' sociodemographic characteristics and cognitive and language assessment scores is provided in Table 1.

This study received approval from the local ethics committee (Commission cantonale d'éthique de la recherche sur l'être humain du Canton de Vaud – CER-VD) in March 2021 and was conducted in strict accordance with the principles of the Declaration of Helsinki. All participants were thoroughly informed, both orally and in writing, about the study's objectives, potential risks, and possible benefits. To respect participants' autonomy and ensure informed consent, they were given sufficient time to reflect and to discuss their participation with relatives before providing written consent.

3.2. Material and procedure

3.2.1. General procedure

The present study is part of a larger research project investigating time reference abilities in AD. Within this project, participants completed a comprehensive cognitive assessment covering episodic, semantic and working memory, executive functioning (including inhibition and flexibility), and language abilities. The AI-adapted task (Levine et al., 2002) was administered after the cognitive assessment. Time reference abilities were further assessed using sentence completion tasks targeting tense and grammatical aspect, as well as a storytelling task (see Schaffner et al., 2025a, 2025b). The study protocol consisted of three sessions of 1.5–2 h for the AD group and two sessions of approximately 2 h for the control group. Sessions were conducted either at participants' homes or at the CHUV memory clinic, according to their preference.

3.2.2. The AI-adapted task

This task was adapted from the AI (Levine et al., 2002), a

Table 1
Sociodemographic, cognitive, and language characteristics of the AD and control groups.

Socio-demographic characteristics	AD group (n = 21)	Control group (n = 21)	W	*p*
Gender (F/M)	12/9	11/10	—	—
Age (years)	71.95 (9.09)	70.81 (8.96)	202	0.64
Education (years)	13.48 (2.44)	13.43 (2.42)	224	0.93
General cognitive functioning				
MoCA[a]	20.33 (3.81)	28.05 (1.56)	434.5	<0.001
DTLA[b]	87.74 (11.99)	97.90 (3.83)	264.5	<0.001
Language assessment				
GREMOTS[c]				
Naming (/36)	31.39 (3.38)	34.48 (2.60)	92	<0.001
Word repetition (/10)	9.78 (0.55)	9.95 (0.22)	188	0.27
Verb fluency	26.83 (10.07)	38.76 (11.95)	84	<0.01
Word reading (/30)	29.71 (0.56)	29.85 (0.48)	250.5	0.25
TICS-f-12[d] (/12)	10.76 (1.1)	11.76 (0.70)	357	<0.001
BCS[e]				
Representation of verb argument structure (/10)	9.71 (0.46)	9.95 (0.22)	273	<0.05

Note. Values are means with standard deviations in parentheses, except for Gender which shows frequencies (n). Group comparisons were performed using Wilcoxon rank-sum tests.

[a] MoCA = Montreal Cognitive Assessment (Nasreddine et al., 2005).

[b] DTLA = *Dépistage des Troubles du langage chez l'Adulte et la personne âgée* (Macoir et al., 2017).

[c] (Bézy et al., 2016).

[d] TICS-f = short version of the *Test Informatisé de Compréhension Syntaxique en français* (Python et al., 2013).

[e] BCS = *Batterie d'Évaluation de la Compréhension Syntaxique* (Bourgeois et al., 2019).

semi-structured interview designed to elicit narratives of past episodes and simulate future personal events. In the present study, participants were asked to recount four personal past experiences drawn from two distinct temporal periods: two events from the remote past (i.e., during young adulthood) and two events from the recent past (i.e., within the last year). In line with Levine's protocol, three phases were administered: (1) free recall of the memory, (2) general probes to ensure that participants had recounted all they could remember, and (3) specific probes targeting details relevant to coding (e.g., spatial, temporal, emotional information). To facilitate recollection, participants were provided with a list of potential life events (e.g., the first day at a new job, a wedding day). In addition, participants were instructed to imagine two plausible personal events in the near future (i.e., within the coming year). To support future-event narration, the examiner also provided oral examples.

For each condition (remote past, recent past, and future), participants were instructed to recount or imagine an event that: i) involved them personally, ii) was spatially and temporally anchored, and iii) could last several hours but less than a day. These instructions, together with the specified time periods, remained visible throughout the task. When participants encountered difficulties in recalling specific details or produced narratives lacking main coding dimensions of Levine's protocol such as spatial, temporal, and emotional details, the examiner provided additional support in the form of general prompts (e.g., "Can you recall something more specific about this event?" or "Can you tell me more about this event?"). Any details added in response to these prompts were incorporated into the narratives record.

3.2.3. Segmentation and categorization of narratives

All narratives were audio-recorded and transcribed verbatim. To analyse the inflected verbs associated with the episodic components of events, narratives were segmented into details units following the procedure described by Levine et al. (2002). Internal details (ID) referred to narrative segments constituting the main event, anchored in a specific spatio-temporal context. In contrast, external details (ED) referred to segments not directly related to the main event and consisted primarily of metacognitive statements about the task or event, as well as references to general knowledge. ED were excluded from subsequent analyses, as they do not rely on the recollection of temporally and spatially specific information and therefore do not engage MTT abilities. An example of narrative coding from a participant with AD in the remote past condition is presented below.

> On a fait le mariage civil et puis on n'a pas fait de mariage à l'église parce que ni l'un ni l'autre n'en ressentait le besoin (**external detail**). [*We had the civil wedding and then we did not have a church wedding because neither of us felt the need for it (**external detail**).*] On a fait une fête avec les amis en haut du village (**internal detail**) où habite le frère de mon mari (**external detail**), justement dans la grange, on avait tout aménagé et puis on a fait une fête là (**internal detail**). [*We had a party with friends up in the village (**internal detail**) where my husband's brother lives (**external detail**), in the barn, we had arranged everything and then we had the party there (**internal detail**)*] Y avait les grand-mères, y avait les cousines et les amis, on les avait tous invités dans la grange, c'était très sympa (**internal detail**). [*There were the grandmothers, the cousins, and the friends, we had invited them all to the barn, it was very nice (**internal detail**).*] Après, quand c'était fini, on a quand même emmené les adultes plus âgés dans un restaurant et on a fini au matin (**internal detail**). [*Afterwards, when it was over, we still took the older adults to a restaurant, and we ended in the morning* **(*internal detail*)**.]

In many narratives from the past condition (both remote and recent), participants produced elements related to the main event and situated in the same time period, yet lacking precise spatio-temporal anchoring. Such elements were often used to contextualize the event within a broader life period (e.g., "when I was 18 and lived with my parents") and also tended to appear when participants had difficulty retrieving the spatio-temporal context of a specific episode. According to Renoult et al. (2012, 2020) taxonomy, these elements correspond to one form of personal semantic – autobiographical fact – which combine personal content with a lack of precise episodic detail. We therefore classified them as a distinct category, labelled "Autobiographical fact" (AF), and retained in subsequent analyses because, although less temporally specific, they still engage mental time travel processes (see also, Strikwerda-Brown et al., 2019).

Inter-rater reliability for narrative coding across the three detail categories (ID, ED, and AF) was established using a second independent rater who coded 50% of the transcripts from both groups. Cohen's Kappa indicated excellent agreement between raters, with $\kappa = 0.84$ for the AD group and $\kappa = 0.91$ for the control group.

3.2.4. Extraction and coding of verb tenses

As the primary objective of our study is to examine the production of inflected verbs in autobiographical narratives, we extracted all inflected verbs produced by participants from the DI and AF segments. These verbs were categorized according to the tense category used (i.e., past, present and future tenses). Additionally, past-tense verbs were further classified based on grammatical aspect (perfective and imperfective).

More precisely regarding the French verbal inflection system, time is encoded through a set of inflected and periphrastic forms distributed across three temporal domains (past, present and future). Crucially, the perfective-imperfective opposition is primarily relevant in the past domain. In spoken narratives, past is mainly expressed through two forms: the *passé composé* (e.g., *il a marché* – "he walked"/"he has walked"), a compound form built with an auxiliary verb and a past participle, and the *imparfait* (e.g., *il marchait* – "he was walking"/"he used to walk"). These two main past tenses thus encode the aspectual distinction between perfective (*passé composé*) and imperfective (*imparfait*). For the expression of future time, French offers two main options: the periphrastic *futur proche* (e.g., *il va marcher* – "he is going to walk"), formed with the verb *aller* inflected at the present tense (*présent de l'indicatif*) followed by an infinitive, and the synthetic *futur simple* (e.g., *il marchera* – "he will walk"). The two forms were included in the future tense category. Finally, present time is mainly expressed through the *présent de l'indicatif* (il *marche* – "he walks" or "he is walking").

3.2.5. Cognitive assessment

Participants' cognitive functioning was assessed using a standardized battery of normed neuropsychological tests. **Verbal episodic memory** was evaluated using the French adaptation of the Free and Cued Selective Reminding Test (Van der Linden et al., 2004), with free delayed recall scores serving as the episodic memory index. **Short-term and working memory** were assessed using the Wechsler Memory Scale-Fourth Edition (WMS-IV; Wechsler, 2009). **Cognitive flexibility** was measured through two complementary tasks: (i) the total number of correct words produced with accurate category alternation in the Category Switching condition from the Verbal Fluency subtest of the Delis-Kaplan Executive Function System (D-KEFS; Delis et al., 2001), and (ii) the ratio of completion time for Trail Making Test Part B relative to Part A (B/A ratio; Tombaugh, 2004). Finally, **inhibitory control** was assessed using the Stroop Victoria test (Bayard et al., 2009), with interference scores calculated as the inhibition index.

3.3. Statistical analysis

Non-parametric Wilcoxon rank-sum tests were conducted in R (R Core Team, 2024) to: (1) verify group matching for age and education, and (2) compare cognitive performance between groups. This approach was selected after Kolmogorov-Smirnov tests confirmed non-normal data distribution.

For the first objective of our study, we fitted generalized linear mixed models (GLMMs) in R (R Core Team, 2024) using the *lme4* package

(Bates et al., 2015), with the number of inflected verbs as the dependent variable. The following independent variables were selected: i) the group (AD and control), ii) the time conditions (remote past, recent past and future) and iii) the interaction between these two variables. More precisely concerning the dependent variables, we used the occurrences of verbs inflected in the past, present and future tenses, as well as verbs inflected in the grammatical aspect of perfective and imperfective.[1] One model was performed for each tense and grammatical aspect, resulting in five separate models. As we processed count data, we used a Poisson distribution or a negative binomial distribution in case of overdispersion of the data. Moreover, given the variability in narratives length between participants, we added the number of words as a covariable in each model. Participants were systematically inserted as random intercepts but not items as random effects, due to the limited number of items (2 narratives per conditions, totalling 6 items). To assess the effect of our independent variables (group, time conditions and their interaction), we performed a likelihood ratio test (LRT) and retained only the variable that made a significant improvement to the model (Pinheiro and Bates, 2000). Post hoc analyses of significant interactions were conducted using the *emmeans* package (Lenth, 2025), applying Tukey's correction for multiple comparisons.

For the second objective, we used the same general procedure but with all cognitive tasks scores as independent variables to assess their contribution to inflected verbs production. We used the same dependent variables: the number of inflected verbs categorized by tense (past, present, future), resulting in 3 separate models. We also systematically assessed interactions between group and each cognitive task score to test whether differential effects of a specific cognitive competences might be observed between groups (e.g., a significant effect of working memory abilities on inflected verbs production only in the AD group).

For each model, the results section includes LRT outcomes, beta coefficients, standard errors, z-values, p-values, and odds ratios (OR). For each model, we also report Nakagawa's R^2 as an estimate of the variance explained by fixed effects (marginal R^2) and by the full model (conditional R^2; Nakagawa and Schielzeth, 2013).

Based on preliminary exploratory analyses, the “Autobiographical Facts” category was combined with internal details. This consolidation was justified by the low occurrence of autobiographical facts and the observation that statistical results remained identical. Subsequently, only the term “internal details” is used for clarity.

4. Results

4.1. Cognitive tasks

Table 2 displays cognitive tasks performance for both participant groups (AD and control), including statistical comparisons between groups. Participants with AD demonstrated lower performance than control participants on all cognitive measures.

4.2. AI-adapted task

The results of the AI-adapted task are presented according to the tense produced (past, present and future) and grammatical aspect (perfective and imperfective) produced. For each tense and grammatical aspect, we report the effects of group (AD vs control), time conditions (remote past, recent past and future), and of the interaction between the group and the time condition. Results from analyses examining cognitive predictors of verb tense use are reported at the end of this section.

[1] For the models conducted on grammatical aspect, only the narratives set in the past (remote and recent past) were considered as the opposition perfective/imperfective in French is uniquely valid in the past tenses.

Table 2
Mean scores (SD) for cognitive tests in AD and control groups with non-parametric comparison results.

Cognitive function	Test	AD group (n = 21)	Control group (n = 21)	W	*p*
Short-term memory	Digit Span Forward (max = 8)	5.62 (0.87)	6.24 (1.09)	302	<0.05
Working memory	Digit Span Backward (max = 8)	3.86 (0.73)	4.71 (1.31)	310	<0.05
Flexibility	Category Switching Fluency (D-KEFS)	9.05 (4.43)	16.05 (2.97)	402.5	<0.001
	TMT (B/A)	2.52 (1.35)	2.05 (0.65)	182.5	0.65
Inhibition	Stroop Interference Score	3.47 (1.92)	2.15 (0.44)	153.5	0.12
Verbal episodic memory	FCSRT (max = 16)	3.70 (3.06)	11.81 (2.78)	204	<0.001

Note. Values are means with standard deviations in parentheses. Group comparisons were conducted using Wilcoxon rank-sum tests. D-KEFS = Delis–Kaplan Executive Function System (Delis et al., 2001); TMT = Trail Making Test (Tombaugh et al., 2004); FSCRT = Free and Cued Selective Reminding Test (Van der Linden et al., 2004). The free delayed recall score from this test was used as the episodic memory index.

4.2.1. Past tense

Fig. 1 shows the proportion of past tense forms produced by each group (AD and control) across the three time conditions (remote past, recent past and future).

Results show a significant effect of time condition ($\chi^2(2) = 391.41$, $p < .001$) and a significant interaction between the group and the time condition ($\chi^2(2) = 11.75$, $p < .01$). No significant effect of group is observed (χ^2 (2) = 0.29, $p = .86$).

The effect of time condition reveals that more past-tense verbs were produced in narratives relating the remote and recent past, than in those concerning the future (respectively: $b = 1.79$ (SE = 0.08), $z = 22.69$, $p < .001$, OR = 0.16; $b = 1.67$ (SE = 0.08), $z = 21.02$, $p < .001$, OR = 0.18). The difference between the two past conditions is also significant ($b = 0.12$ (SE = 0.05), $z = 2.38$, $p = .04$, OR = 1.12), with a greater use of past-tense verbs in narratives situated in the remote past, compared to those in the recent past.

Interestingly, when the interaction is decomposed by group, the difference in the use of past-tense verbs between narratives set in the remote past and those in the recent past is marginally significant in the group with AD ($b = 1.15$ (SE = 0.06), $z = 2.28$, $p = .059$, OR = 3.15). Participants with AD tend to use more past-tense verbs when recounting events in the remote past (71%), compared to those in the recent past (56%). In addition, both groups of participants used significantly more past tenses in narratives set in the remote (AD: $b = 1.59$ (SE = 0.09), $z = 16.08$, $p < .001$, OR = 4.90; control: $b = 2.04$ (SE = 0.12), $z = 16.48$, $p < .001$, OR = 7.69) and recent past (AD: $b = 1.44$ (SE = 0.10), $z = 14.22$, $p < .001$, OR = 4.22; control: $b = 1.96$ (SE = 0.12), $z = 16.07$, $p < .001$, OR = 7.1) compared to those in the future. The decomposition by time conditions shows a significant difference between groups in the use of past tenses in narratives set in the future, with participants with AD using more past-tense verbs than control ($b = 0.46$ (SE = 0.14), $z = 3.22$, $p < .01$, OR = 1.58). No significant differences are observed between the groups for narratives set in the remote past ($b = 0.01$ (SE = 0.07), $z = 0.19$, $p = .84$, OR = 1.01) or in the recent past ($b = 0.05$ (SE = 0.07), $z = 0.77$, $p = .44$, OR = 1.05). Overall, the model explained 19.6% of the variance through fixed effects (marginal R^2), and 19.8% when random effects were also included (conditional R^2).

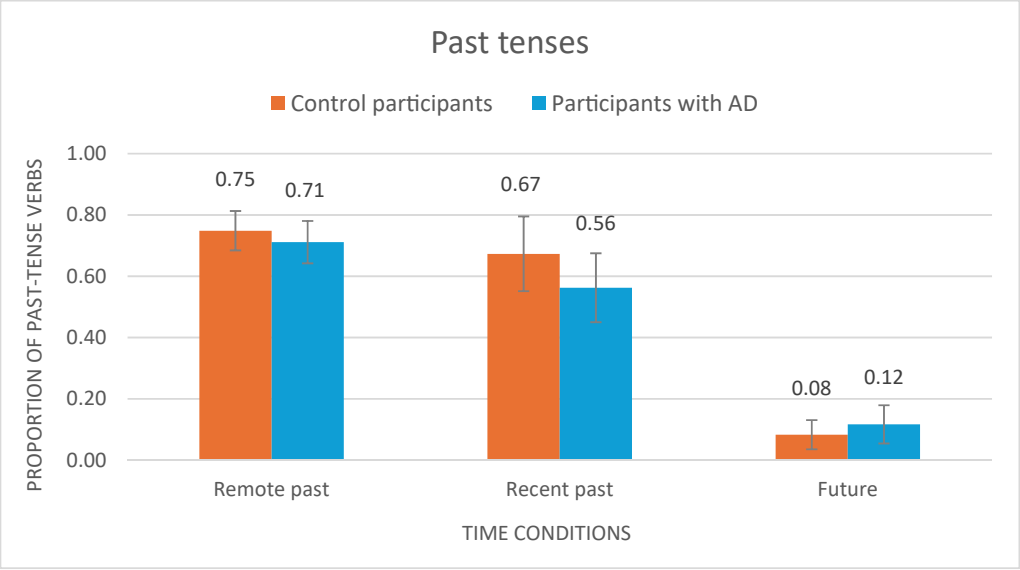

Fig. 1. Means and standard deviations of the proportions of past-tense verbs produced by each group (AD and control) across time conditions (remote past, recent past and future).

4.2.2. *Present tense*

Fig. 2 shows the proportion of present-tense verbs produced by each group (AD and control) across the three time conditions (remote past, near past and future).

Results show a significant effect of group ($\chi^2(1) = 5.66$, $p < .01$), a significant effect of time condition ($\chi^2(2) = 138.51$, $p < .001$), and a significant interaction between the group and the time condition ($\chi^2(2) = 7.89$, $p = .01$). Regarding the effect of group, participants with AD used globally more present-tense verbs than control participants ($b = 0.31$ (SE = 0.12), $z = 2.42$, $p = .01$, OR = 1.36). For the effect of time condition, more present-tense verbs are used for narratives set in the future condition compared to those in the remote and recent past (respectively: $b = 1.55$ (SE = 0.11), $z = 14.01$, $p < .001$, OR = 4.71; $b = 0.84$ (SE = 0.11), $z = 7.93$, $p < .001$, OR = 2.31). In addition, significantly more present-tense verbs are used for narratives set in the recent past condition, compared to those in the remote past condition ($b = 0.71$ (SE = 0.11), $z = 6.22$, $p < .001$, OR = 2.03).

Regarding the interaction effect, the decomposition by time condition shows that participants with AD used more present-tense verbs than control participants in both past time conditions (remote past: $b = 0.54$ (SE = 0.20), $z = 2.68$, $p < .01$, OR = 1.72; recent past: $b = 0.68$ (SE = 0.19), $z = 3.57$, $p < .001$, OR = 1.97). No significant difference between groups in the future condition is observed ($b = 0.11$ (SE = 0.18), $z = 0.66$, $p = .51$, OR = 1.11). The decomposition by group shows the same results than the decomposition of the single effect of time condition: both groups of participants produced more present-tense verbs in narratives set in the future than those in the past conditions (remote and recent). They used also significantly more present-tense verbs in narratives set in the recent past, compared to the remote past. Overall, the model explained 12.1% of the variance through fixed effects (marginal R^2), and 15.5% when random effects were also included (conditional R^2).

4.2.3. *Future tenses*

Fig. 3 below shows the proportion of future-tense verbs produced by each group (AD and control) across the three time conditions (remote past, recent past and future).

Results show a significant effect of time condition ($\chi^2(2) = 245.78$, $p < .001$), but no significant effect of group ($\chi^2(1) = 0.34$, $p = .56$), and no significant interaction between the group and the time frame ($\chi^2(2) = 2.85$, $p = .24$). Regarding the effect of time condition, more future-tense verbs are used in narratives set in the future condition, compared to those in the recent ($b = 3.89$ (SE = 0.30), $z = 12.86$, $p < .001$, OR = 48.91) and the remote past conditions ($b = 4.49$ (SE = 0.36), $z = 12.86$, $p < .001$, OR = 89.12). No significant difference in the use of future-tense verbs between the two past conditions is observed ($b = 0.58$ (SE = 0.46), $z = 1.27$, $p = .41$, OR = 1.78). Overall, the model explained 45.6% of the variance through the fixed effect of time condition (marginal R^2), and 46.9% when random effects were also included (conditional R^2).

4.2.4. *Grammatical aspect*

Fig. 4 below shows the proportion of verbs inflected for the imperfective and the perfective aspect by each group, across the remote and the recent past time conditions.

Regarding the use of imperfective aspect, results reveal a significant effect of time condition ($\chi^2(1) = 14.65$, $p < .001$), with a greater use of imperfective aspect in narratives set in the remote past compared to those in the recent past ($b = 0.26$ (SE = 0.06), $z = 3.92$, $p < .001$, OR = 1.29). However, there is no significant effect of group ($\chi^2(1) = 0.10$, $p = .75$), nor any interaction between group and time conditions ($\chi^2(1) = 1.30$, $p = .25$). The model explained a small proportion of variance: 0.5% through the fixed effect of time condition (marginal R^2) and 2% when including both fixed and random effects (conditional R^2).

Regarding the use of perfective aspect, results show no significant effect of group ($\chi^2(1) = 0.003$, $p = .95$), time conditions ($\chi^2(1) = 0.10$, $p = .74$) or any significant interaction ($\chi^2(1) = 0.002$, $p = .95$).

4.2.5. *Cognitive predictors of verb tense use*

None of the cognitive predictors, nor their interaction with the group showed a significant contribution to the use of inflected verb (past, present and future-tenses verbs). Table 3 below shows the results of the LRT tests for each cognitive predictor.

5. Discussion

The present study aimed to investigate how individuals with AD and healthy controls express time reference through verb inflection (tense and grammatical aspect) when mentally projecting themselves into their personal past and future. We used an adapted version of the AI (Levine et al., 2002), to elicit the recall of past personal episodes and the

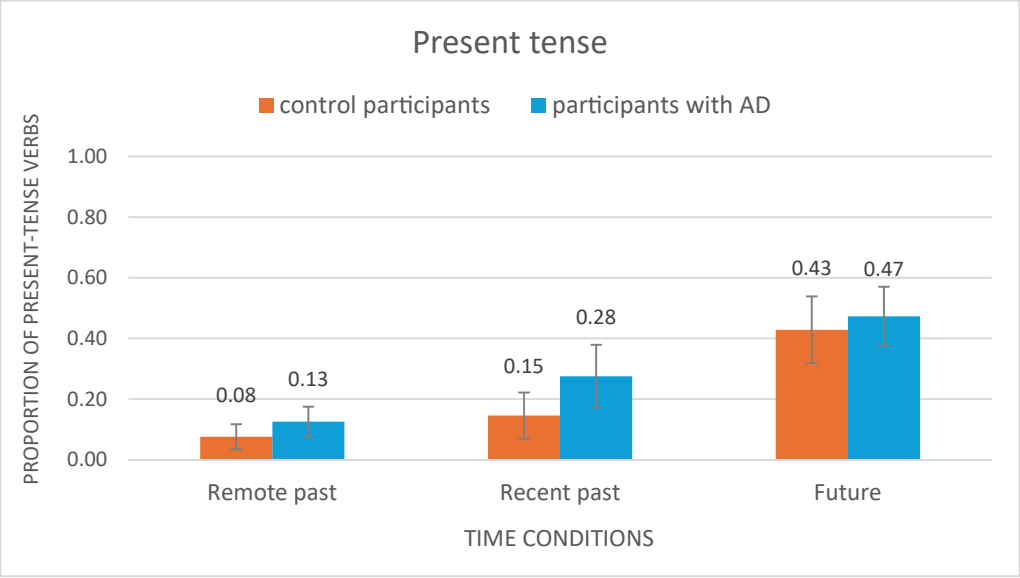

Fig. 2. Means and standard deviations of the proportions of present-tense verbs produced by each group (AD and control) across the three time conditions (remote past, recent past and future).

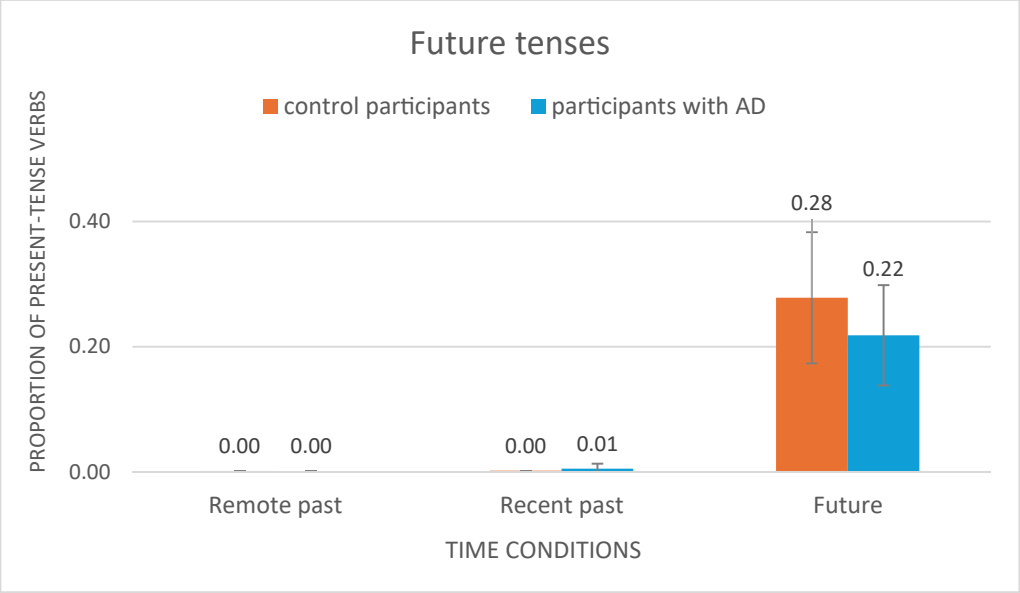

Fig. 3. Means and standard deviations of the proportions of future-tense verbs produced by each group (AD and control) across the three time conditions (remote past, recent past and future).

simulation of future events. Participants had to recount four personal past experiences: two from the remote past (i.e., during young adulthood) and two from the recent past (i.e. within the last year) and imagined two plausible future scenarios (within the coming year). To ensure that the analysis focused on temporal projection, only internal details– corresponding to the episodic components of the narratives - were used for subsequent analyses.

Our first objective was to examine how participants used verb tenses (past, present and future), and grammatical aspect (perfective and imperfective), across the three time conditions (remote past, recent past, and future).

First, regarding the use of past tenses, both groups produced significantly more past-tense verbs when recounting past episodes than when imagining future events. Descriptive analyses showed that within past narratives, the past tenses were used more frequently than either the present (see Fig. 2) or future tenses (see Fig. 3). Since only internal details were considered for the analysis of inflected verbs, these results indicate that participants were able to successfully project themselves into their personal past and anchor events accordingly. However, different patterns emerged across the two past conditions. Overall and for all participants, significantly more past-tense verbs were produced when recounting episodes from the remote past than from the recent past. Although the interaction effect was only marginally significant, this pattern appeared more pronounced in the AD group: participants with AD showed an approximate 15% reduction in past-tense usage between remote and recent past narratives, compared to a smaller difference of about 5% in controls. To further explore the link between present-tense usage and episodic memory processes, a post hoc analysis including only participants with AD was performed and reveals a significant increase in present-tense forms in the recent past, compared to

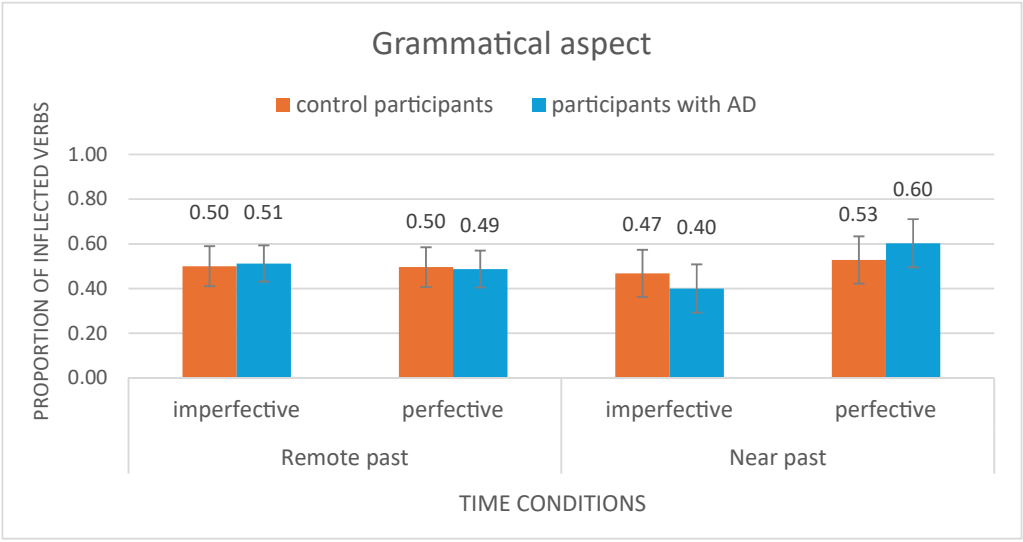

Fig. 4. Means and standard deviations of the proportions of inflected verbs for the grammatical aspect of perfective and imperfective produced by each group (AD and control) across the two past time conditions (remote and recent past).

Table 3
Likelihood ratio tests for cognitive predictors of verb tense production (past, present and future tense verbs).

Cognitive Function	Past tense verbs		Present tense verbs		Future tense verbs	
	χ^2	p	χ^2	p	χ^2	p
Flexibility (Category Switching)	0.15	0.69	1.54	0.21	0.01	0.90
Flexibility (TMT B/A ratio)	0.53	0.46	1.48	0.22	0.04	0.84
Inhibition	1.03	0.30	0.74	0.39	0.002	0.96
Short-term memory	0.13	0.71	0.17	0.68	0.05	0.81
Working memory	1.46	0.22	1.85	0.17	0.57	0.45
Verbal episodic memory	0.004	0.94	3.38	0.06	0.32	0.57

Note. All tests had df = 1. TMT = Trail Making Test.

the remote past condition.[2] This result confirms that the decrease in the past-tense usage across the two conditions is largely driven by participants with AD, who appear to struggle more when anchoring events in the recent past than in the remote past. This point will be addressed further below.

Second, participants with AD used significantly more present-tense verbs than control participants when recounting past events, though not when simulating future ones. This finding replicates previous results (Irish et al., 2016), but with an important nuance: in the present study, this overuse of the present tense was observed specifically within internal details, meaning that it cannot be attributed to the inclusion of external, present-oriented details. Importantly, this finding is not suggestive of a primary or generalized impairment in verb inflection. While subtle inefficiencies in non-memory domains have been reported even in amnestic MCI and early AD populations (e.g., Kramer et al., 2006; Economou et al., 2007), available evidence overall indicates that morphosyntactic processing of tense is relatively preserved in similar patient groups. In Schaffner et al. (2025a), participants with AD demonstrated preserved verb inflection abilities in sentence completion tasks across the three tenses examined (past, present, and future). Specifically, there was no significant effect of group, no effect of tense, and no Group × Tense interaction.[3] This pattern is consistent with the absence of a primary morphophonological or morphosyntactic deficit affecting verb inflection in AD. Following a reviewer's suggestion, we additionally examined syntactic complexity in the narrative productions to assess whether overall linguistic output was comparable between groups. We computed, for each participant, a ratio of the number of verbs produced to the total number of words. Despite slightly lower mean scores in the group with AD (M = 7.16, SD = 1.28) than in the control group (M = 8.18, SD = 2.85), performance remained within normal limits, as Z-scores ranged from −1.3 to 0.9 and did not reach clinically significant levels. Overall, these findings support the interpretation that the observed effects are not driven by language production impairment and are more compatible with a difficulty in maintaining a past temporal perspective during autobiographical recollection. Crucially, this difficulty appears to increase as the temporal distance between the recalled episodes and the present narrows. In other words, AD participants seem particularly prone to reverting to a present perspective when narrating episodes from the recent past compared to more distant periods. Combined with their reduced use of past tenses, these findings suggest that the past temporal framework of the narrative becomes less anchored as events are situated closer to the present, reflecting a progressive weakening of temporal anchoring.

This interpretation is consistent with previous studies showing that participants with AD recall fewer vivid and specific internal details for recent past events than for remote one (Barnabe et al., 2012; De Simone et al., 2016; Irish et al., 2011a; Müller et al., 2016). These differences have been linked to the neurocognitive profile of AD, in which hippocampal deterioration disproportionately affects the encoding and retrieval of recent experiences. In contrast, older memories rely more heavily on neocortical networks, which are more preserved in the earlier stages of the disease (Hou et al., 2005; N.Philippi et al., 2015). A recent study by Berntsen et al. (2022) further supports this view. The authors found a strong "reminiscence bump" in participants with AD, with autobiographical memories from young adulthood (ages 20-30) recalled more frequently and in greater details that those from other life periods. This pattern is echoed in the present data: the combined decrease in past tense usage and increase reliance on the present tense in recent past narratives observed in the group with AD (approximately 30%) suggests that temporal anchoring is particularly difficult when the past is temporally close to the present. Further studies investigating verb tense usage across more fine-grained periods of past life are needed to clarify this point.

Finally, regarding tense production in future-oriented narratives, no

[2] Significant effect of time conditions (remote vs recent past): $b = 0.76$ (SE = 0.16), $z = 4.78$, $p < .001$, OR = 2.14.
[3] Respectively: $p = .07$, $p = .17$, and $p = .28$.

significant difference was observed between the two groups in the production of future-tense verbs. Only a main effect of time condition emerged, with future-tense forms being used almost exclusively when participants were asked to imagine future events. Interestingly, however, future-tense category was not the dominant category produced in future-oriented narratives: for both groups, present-tense verbs accounted for approximately half of all inflected verb used (see Fig. 2). A closer analysis of the narratives highlights that participants frequently adopted a procedural narrative style, in which they described a sequence of actions as they might unfold (e.g., "I wake up, I take the train, I arrive …"). This narrative mode, which tends to describe general scripts or routines, typically lacks a well-defined temporal structure, and is commonly express in the present tense.

This tendency may reflect the greater cognitive challenge of imagining future events as opposed to remembering past episodes. Several studies have suggested that projecting oneself into the future might place greater demands on cognitive resources, particularly those related to executive processes. According to the episodic simulation theory (Schacter and Addis, 2007), future thinking requires the flexible recombination of elements from past experiences to construct plausible and personally relevant future scenarios. Executive functions, such as flexibility and working memory, as well as semantic memory, may be especially engaged in the mental simulation of future experiences (Addis et al., 2007; Irish and Piolino, 2016; Liu et al., 2021). Participants in our study may therefore have adopted a compensatory strategy by relying on generalized, atemporal semantic scripts to structure their future narratives, thus limiting the cognitive cost associated with constructing future events. This narrative mode, which tends to describe general scripts or routines, typically lacks a well-defined temporal structure, and is commonly expressed in the present tense. From a broader perspective, this pattern may also be interpreted in aspectual terms: such script-like descriptions rely less on bounded, event-specific representations and more on ongoing, generic or habitual processes, which are functionally closer to imperfective-like representations. Importantly, however, in French, the perfective/imperfective distinction is not morphologically marked in the future tense, which prevents a direct grammatical analysis of aspect in this condition. Rather, the present findings suggest a shift at the discourse level, whereby participants—particularly those with AD—may opt for semantically driven, atemporal script construction over the generation of specific, episodically grounded future events. Future work should examine whether differences appear in narrative structure or event representation, for example in the use of specific events versus more general, script-like sequences.

Our first objective also included an exploratory analysis of grammatical aspect, focusing on the use of perfective and imperfective verb forms in recounting past episodes. Previous studies suggest that aspect may pose an even greater challenge than tense for individuals with AD (Fyndanis et al., 2013; Schaffner et al., 2025a), as it requires adopting a specific temporal perspective from which the event is viewed - either as completed (perfective) or as unfolding over time (imperfective). However, no consistent evidence has yet emerged indicating that one aspectual verb form is more impaired than the other. To our knowledge, this study is the first to examine aspect use within a narrative task, rather than through constrained tasks.

Overall, participants with AD showed a similar pattern of aspect use to control participants, suggesting that, in a more ecological task, aspect may be less impaired than previously thought. The only significant difference was found across time conditions (remote vs. near past), with the imperfective verb forms used more frequently in narratives about the remote past than in those about the near past. Descriptively, the perfective verb forms appeared slightly more frequently in near past narratives, although this difference did not reach statistical significance. This distribution may reflect cognitive differences in temporal anchoring. The imperfective aspect is considered more demanding, as it requires the speaker to mentally situate themselves within the temporal unfolding of the event (including its beginning, middle, and end), thus anchoring the perspective fully in the past (Comrie, 1976; Grisot, 2018; Vetters, 1996). In contrast, the perfective aspect allows the speaker to view the event as a bounded whole, potentially from a present-oriented vantage point. The increased use of imperfective verb forms for remote past episodes may suggest that these memories are better consolidated, thereby facilitating participants' ability to shift temporal perspective within the remembered events. Importantly, this pattern was observed across both groups, as no significant Group × Time Condition interaction was found, suggesting that the observed increase in imperfective aspect for remote past events is comparable across groups, rather than being specific to AD. This is consistent with evidence that remote memories undergo semantic consolidation over time, which may support their preservation despite age- or disease-related cognitive changes (Berntsen et al., 2022; Janssen et al., 2005). As observed with the use of past tense, and consistent with the reminiscence bump for early adulthood events, the use of imperfective verb forms may reflect deeper projection into the remote past, and possibly a greater sense of reviviscence of the event. This theoretical proposition should, however, be interpreted with caution. To our knowledge, this study is the first to examine the expression of grammatical aspect within narratives. Additional observations, particularly using different narrative tasks, would provide better understanding of whether and how the use of grammatical aspect differs in participants with AD, compared to healthy aged participants.

Our second objective examined the cognitive mechanisms underlying time reference in AD. While previous research has linked verb inflection to executive and attentional processes (Cortese et al., 2006; Fyndanis et al., 2018; Schaffner et al., 2025a), recent findings suggest that these associations may be task-dependent (Varlokosta et al., 2024). Using an ecologically valid narrative task, we found no significant associations between cognitive predictors and the production of verb tenses. Although unexpected, this finding aligns with some prior research reporting weak or absent associations between neuropsychological performance and autobiographical interview measures in AD (Irish et al., 2010, 2013, 2016). However, this pattern stands in contrast to Schaffner et al. (2025b), where future-tense use was predicted by semantic memory and temporal abilities in a storytelling task. Since the same participants were involved, this discrepancy suggests that adapted-AI task engages cognitive processes that differ from those recruited by more structured laboratory assessments. In particular, autobiographical paradigms may place greater demands on self-referential and integrative processes, which are not fully captured by standard neuropsychological measures. Consistent with this interpretation, the lack of associations with episodic memory performance (FCRT) aligns with evidence that conventional memory tests engage different neural systems than those activated by ecological paradigms (Chen et al., 2017; McDermott et al., 2009). Notably, autobiographical recall and future simulation rely heavily on the default mode network, which supports self-referential processing, temporal integration, and event construction (Andrews-Hanna et al., 2014; Bellana et al., 2017; C. L. Philippi et al., 2015). In contrast, traditional neuropsychological tasks primarily tap domain-general executive and memory systems, which may explain their limited predictive value in narrative contexts. For instance, self-referential semantic knowledge, critical for future-oriented thinking (Strikwerda-Brown et al., 2022), may exert a stronger influence on future-tense usage than the traditional semantic memory measures used here. Taken together, these findings underscore the need for future studies on time reference in autobiographical recall to prioritize ecological paradigms over conventional neuropsychological measures in order to better capture the cognitive processes relevant to mental time travel.

5.1. Limitations

This study provides new insights into time reference management in AD and how projecting into personal past and future influences verb

tense usage. However, several methodological limitations should be acknowledged.

First, the relatively small sample size warrants cautious interpretation and limits the generalizability of our findings. Although our AD group included substantially more participants than previous studies using the AI in this population, the intrinsic heterogeneity of the pathology calls for larger samples to capture individual variability adequately. Additionally, including participants across different severity stages would have allowed examination of disease progression effects on time reference abilities. For this study, we prioritized homogeneous profiles characterized by mild to moderate impairment to ensure maximum group uniformity.

Second, a more fine-grained analysis of different past time periods could clarify the reminiscence bump effect observed here. Previous studies have produced inconsistent findings, partly due to varying levels of details in temporal divisions of the past (Barnabe et al., 2012). Future research should consider dividing remote past into multiple periods (e.g., childhood, early adulthood, middle adulthood) and recent past into finer intervals (e.g., within the last ten years), to which either confirm or refine the current results.

A further important avenue concerns time reference in future thinking. Participants with AD did not exhibit a differentiated tense usage profile when imagining future events in this study. Notably, this was the only condition in which expected tense forms were not predominant. This suggests that future simulation exhibits distinct properties compared to past recount (remote and recent past). One possibility may lie in the coding procedure used to extract the episodic parts of the narratives. Strikwerda-Brown et al. (2022) reanalysed future event narratives in AD using a refined taxonomy that differentiates semantic from episodic contributions (see also Strikwerda-Brown et al., 2019). They found that the initially reported decrease in internal details was counterbalanced by increased reliance on repeated, self-relevant past events, suggesting that individuals with AD may employ compensatory strategies when constructing novel episodic content. These results indicate that the standard AI-based internal detail metric as established by Levine et al. (2002), may underestimate the complexity of cognitive processes engaged during future thinking in AD. Applied to verb inflection, adopting a more fine-grained analysis of details within future narratives could reveal specific patterns of tense usage in AD compared to controls. In particular, re-coding the current future narratives using the refined taxonomy proposed by Strikwerda-Brown et al. (2022) could provide a more nuanced picture of tense usage in future narratives, by distinguishing between episodic future thinking, which is known to be impaired in AD, and more semantic or generic forms of future projection, which are less likely to be affected. Such a distinction may reveal whether verbal tense patterns specifically reflect the episodic future thinking difficulties experienced by individuals with AD — a question that the current coding scheme was not designed to address and that warrants systematic investigation in future work. Such an approach warrants systematic investigation to determine whether verbal tense patterns could reflect the underlying difficulties with episodic future thinking experienced by individuals with AD.

5.2. Conclusions and perspectives

Our findings provide novel evidence of time reference impairments in individuals with AD, extending these deficits to verb inflection within narrative discourse. By employing a mental time travel paradigm, our findings suggest that these impairments likely reflect disruptions in higher-order temporal processing rather than primary morpho-phonological deficits. Importantly, verb inflection may constitute promising linguistic correlate of MTT capacity in AD, offering a novel window into temporal processing deficits. Beyond their clinical significance, these findings contribute to the study of the brain–language relationship by showing how neurodegenerative changes associated with AD may disrupt linguistic mechanisms responsible for temporal anchoring in discourse. In this respect, grammatical tense and aspect appear to rely on neurocognitive systems that integrate language processing with episodic memory and self-projection in time. Extending this line of research to other neurodegenerative conditions may help clarify the specific contribution of MTT mechanisms to temporal language processing and verb inflection. In particular, future studies should examine whether similar findings emerge in other amnestic neurodegenerative diseases, such as frontotemporal dementia, to determine whether temporal marking deficits reflect episodic memory dysfunction or AD-specific pathology.

These findings also hold clinical implications. While further research is still required, alterations in verb tense usage within autobiographical narratives may serve as complementary linguistic indicators of cognitive deterioration and disease progression in AD. Incorporating systematic linguistic assessments that target temporal language features into clinical practice could provide valuable tools for longitudinal monitoring and evaluation of therapeutic outcomes.

Finally, combining ecological linguistic measures with neuroimaging approaches that capture the integrity of large-scale networks, such as the default mode network, may offer a more comprehensive understanding of how disruptions in self-referential and temporal processing systems contribute to language impairments in AD. More broadly, such an approach may help clarify how large-scale neural systems supporting temporal cognition and self-referential processing interact with language mechanisms during autobiographical discourse.

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CRediT authorship contribution statement

Mélanie Sandoz: Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Writing – original draft. **Evodie Schaffner:** Conceptualization, Data curation, Investigation, Methodology, Writing – original draft. **Gilles Allali:** Methodology, Writing – original draft. **Marion Fossard:** Conceptualization, Funding acquisition, Investigation, Methodology, Supervision, Writing – original draft.

Declaration of conflicting interests

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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