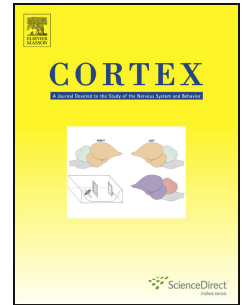


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Impaired capacity for auto-noetic reliving during autobiographical event recall in mild Alzheimer's disease

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The capacity to mentally travel back in time and relive past events via auto-noetic consciousness has been shown to be compromised even in the early stages of Alzheimer's disease (AD). To further understand the unravelling of the recollective experience in pathological ageing, we investigated autobiographical memory (ABM) using the Episodic Autobiographical Memory Interview (EAMI) in thirty middle-aged and thirty healthy elderly controls, and twenty patients with mild Alzheimer's disease. Of key interest was the recall of contextual details and the behavioural markers predictive of auto-noetic reliving. AD patients exhibited significant difficulties in recalling contextual details across all life epochs on the EAMI manifesting in a negative temporal gradient from the Early Adulthood epoch onwards. Overall there was a low incidence of auto-noetic consciousness during ABM recall across all participant groups and life epochs when compared with previous studies. AD patients showed a compromised capacity to mentally relive past memories (AD < Healthy Elderly < Middle-aged Controls), across all life epochs on the EAMI. AD patients tended to recall past events as semanticised accounts divested of rich sensory-perceptual imagery. The impoverished capacity to generate egocentric or self-referential imagery resulted in the production of fragmented and depersonalised accounts of formerly evocative events and likely stems from medial temporal and frontal pathology exhibited from early stages of the disease.

Keywords: Alzheimer's disease, Autobiographical memory, Auto-noetic consciousness, Episodic memory, Imagery.

## 1. Introduction

The phenomenon of auto-noetic (self-knowing) consciousness has been expounded as a necessary correlate of episodic memory (Tulving, 1985), permitting mental time travel to relive past autobiographical events. Autobiographical memory (ABM) refers to personally relevant memories encompassing knowledge at different levels of abstraction, including event-specific sensory perceptual details, commonly in the form of visual mental images (Conway, 2001). Importantly, ABMs are often imbued with emotional significance (Piefke et al., 2003) leaving long-lasting and evocative memory traces (Bernsten and Rubin, 2002; Conway et al., 2003). The capacity to consciously reflect on one's past and navigate through subjective time is critical for a sense of self-contiguity and identity (Conway and Pleydell-Pearce, 2000; Conway et al., 2004), and this underscores the importance of incorporating assessments of auto-noetic consciousness during investigation of ABM retrieval. Here we wished to investigate the prevalence and constituent elements of auto-noetic consciousness during ABM retrieval in healthy control participants and patients with mild Alzheimer's disease.

Studies of remote memory in healthy and pathological ageing have tended to focus on the fractionation of ABM into personal semantics and autobiographical incidents (Kopelman, 1989), representing the dissociable constructs of semantic and episodic memory, respectively (Levine et al., 2002). One of the earliest presenting features characteristic of Alzheimer's disease (AD) is that of memory impairment (Butters et al., 1987; Welsh et al., 1991) with medial temporal lobe (MTL) volume reduction in AD consistently shown to be associated with deficits on both verbal and visual anterograde memory tasks (Toledo-Morrell et al., 2000). There have been many

studies investigating ABM impairment in AD often producing mixed results depending on the method of assessment used (Kapur, 1999). The profile of retrograde amnesia in AD tends to present as a negative temporal gradient in accordance with Ribot's Law (Ribot, 1881) and this is most commonly observed on episodic subscales of ABM assessments (Eustache et al., 2004; Graham and Hodges, 1997; Greene et al., 1995; Kopelman et al., 1989; Piolino et al., 2003b; Sagar et al., 1988) with impaired recent recall of events in comparison with the more remote epochs.

In healthy ageing, the retrieval of episodic details has been shown to be compromised, with participants favouring the recall of semantic details not connected to time or place (Levine et al., 2002). Piolino et al. (2002) reported similar findings with episodic recall deteriorating more with age and retention interval than semantic recall. Piolino et al. (2002) proposed that "*in ageing, a part that makes memory 'truly' episodic, namely myriad details, is effectively lost*" (p.252). However, the retrieval of episodic ABMs involves much more than the recollection of personally relevant details, and as recent studies have shown, a complex interplay of phenomenological factors facilitates the rich subjective re-experiencing of the original event (Addis et al., 2004) via auto-noetic consciousness (Tulving, 2002; Wheeler et al., 1997).

Piolino et al. (2006) demonstrated that with increasing age, the ability to consciously recollect many specific events and relive the context in which they occurred deteriorates, with evidence for a process of semanticisation with time interval (Cermak, 1984; Conway et al., 1997). Auto-noetic re-experiencing, as indexed by Remember judgments on the Remember/Know paradigm, is also compromised in AD and the frontal variant of frontotemporal dementia but not in semantic dementia

(Piolino et al., 2003b) taken as supporting evidence for Multiple Trace Theory (MTT; Nadel and Moscovitch, 1997). Piolino and colleagues used the “field/observer” visual imagery paradigm (Nigro and Neisser, 1983) to distinguish between episodic and semantic aspects of ABM and found that in healthy ageing (Piolino et al., 2006), Alzheimer’s disease (Piolino et al., 2004) and TBI (Piolino et al., 2007) the “observer” perspective is often adopted, suggesting that the memory has been transformed out of the first person perspective and reconstructed rather than re-experienced. To date, mounting evidence points towards several critical features of episodic memory including the recency of memories (Piefke et al., 2003; Piolino et al., 2003b), the level of contextual detail (Levine et al., 2002; Moscovitch et al., 1999), emotional re-experiencing (Piefke et al., 2003; Sharot et al., 2004), the role of visual imagery (D’Argembeau and Van der Linden, 2006; Irish et al., 2008), and the personal significance of the retrieved event (Addis et al., 2004; Wheeler et al., 1997). However, little is known regarding the degree to which such markers contribute to the mental reliving of past ABMs, or the extent to which they are disrupted by the pathological disease process in AD.

The objectives of the present study were threefold. Firstly we wished to compare the profile of autobiographical event recall in non-pathological ageing and mild Alzheimer’s disease using the fine-grained scoring protocol of the Episodic Autobiographical Memory Interview (EAMI; Irish et al., 2008). We hypothesised that AD patients would exhibit considerable difficulties in the recall of contextual details, most likely culminating in the negative temporal gradient traditionally seen on ABM measures. Secondly, we wished to investigate in detail the phenomenon of auto-noetic consciousness across the lifespan in healthy ageing and mild AD, paying

particular attention to those phenomenological and experiential aspects of reliving such as vividness, visual imagery and emotional re-experiencing, which are posited as key factors in mediating subjective mental time travel. It was hypothesised that AD patients would display an impoverished capacity to mentally relive past memories via auto-noetic consciousness with impairments evident in their generation of egocentric visual imagery and a disconnection from the emotional re-experiencing of the event. Finally, we wished to investigate which behavioural markers were the strongest predictors of an auto-noetic reliving experience. The charting of such auto-noetic markers across the lifespan represents a fine-grained approach aimed at probing the complex construct of auto-noesis and the uncovering of impairments from non-pathological ageing into Alzheimer's disease.

## 2. Methods

### 2.1. Participants

30 middle-aged controls (age: mean  $\pm$  SD = 40.6  $\pm$  10.3), 30 healthy elderly controls (age: 73.2  $\pm$  5.2), and 20 patients diagnosed with mild probable Alzheimer's disease (AD; age: 73.0  $\pm$  7.4) according to NINCDS-ADRDA criteria (McKhann et al., 1984) took part in this study. Alzheimer patients were recruited through the Mercer's Institute for Research on Ageing (MIRA) by a multidisciplinary team, with those cases whose CT or MRI scans contained evidence of a significant degree of cerebrovascular pathology excluded. Middle-aged controls were recruited from within the staff and postgraduate community of Trinity College Dublin and represented a convenience sample. Healthy elderly controls were recruited from

Active Retirement organisations in the local community. Ethical approval was obtained from the St. James's Hospital and Adelaide and Meath Research Ethics Committee and all participants gave informed consent prior to testing. All experimental work was carried out in accordance with the Declaration of Helsinki (1991). Gender was evenly distributed amongst the middle-aged (16 F: 14 M) and AD groups (9 F: 11M), however there were considerably more females compared to males in the elderly control group (23F: 7M). There was a significant difference between the groups in terms of years spent in formal education ( $F(2,77) = 126.3$ ,  $p < .0001$ ) driven by the middle-aged control group (education:  $19.6 \pm 3.2$ ) in comparison with the healthy elderly (education:  $13.8 \pm 2.6$ ) and AD patients (education:  $12.6 \pm 3.6$ ).

## 2.2. Cognitive Screening

Participants were screened using the Mini-Mental State Examination (MMSE; Folstein et al., 1975) and the Clock Drawing Test (CDT; Manos and Wu, 1994; ten point scoring system) to assess overall level of cognitive functioning (see Table 1). The Geriatric Depression Scale 15-item version (GDS-15; Sheikh and Yesavage, 1986) was used to determine incidences of pervasive depression with a cut-off score of  $>7$  chosen to maximise specificity (see Herrmann et al., 1996). The Instrumental Activities of Daily Living scale (IADL; Lawton and Brody, 1969) was used to exclude control participants with a compromise in functional abilities (score  $<8$  on IADL). Further exclusion criteria included scores  $<27$  for controls and  $<20$  for AD patients on the MMSE,  $<8$  for controls on the CDT, and cases with history of



psychiatric illness, alcoholism, or significant head injury were excluded from the study.

### 2.3. Assessment of Autobiographical Event Memory

The Episodic Autobiographical Memory Interview (EAMI; Irish et al., 2008) is a semi-structured interview incorporating non-restrictive categories across the lifespan from Childhood (0-15 years), to Early Adulthood (16-30 years), to Middle Adulthood (31-45 years), to Later Adulthood (46 up to 5 years ago) to Recent memory (in the last 5 years). Participants are required to recall personal semantic information and autobiographical episodes for each life period, in keeping with previous measures of ABM (Kopelman et al., 1989; Piolino et al., 2002; 2003b). Here we are concerned with the assessment of event recall using the EAMI. Participants were instructed to recall in detail three events that occurred during each life epoch according to the following instructions, *“I would like you to describe out loud and with as much detail as possible, an event that occurred during this time period that stands out for you.”* If participants could not spontaneously bring an event to mind, cues specific to the epoch under investigation were provided (e.g. “your wedding day, a trip you took, a family event”). Participants were encouraged to firstly engage in a free recall of the event, after which the experimenter probed for further details using seven phenomenological categories, modified from Moscovitch et al.’s (1999) Event Details Checklist. The seven details categories assessed Event detail, Temporal Specificity, Sensory/Perceptual Details, Spatial Specificity, Emotion, Implication of Event, and Thoughts.

To score each event recalled, a detailed scoring system was applied to each of the seven categories of detail, with specificity central to the awarding of one full point for each type of detail. Partial marks (0.5 points) were awarded for details that were non-specific or repeated elements, and 0 marks were given for speculative details or guesses (see Appendix A for the EAMI event scoring protocol). A maximum of seven points could be awarded for each memory recalled. This detailed scoring system was developed to avoid the ceiling effects commonly seen on other measures of ABM. Participants were required to recall 3 events per life period, leading to a maximum details score of 21 per epoch (i.e. 7x3). The total pool of memories analysed on the event details subscale amounted to 303 in the middle-aged control group (n=11 were old enough to recall memories from the Middle Adulthood period), 450 in the elderly control group, and 258 in the AD group due to failure of patients to recall events from all epochs.

#### 2.4. Assessment of Autonoetic Consciousness

Following the recall of each memory, a detailed investigation of the subjective recollective experience was conducted using the autonoetic subscale of the EAMI. Participants were questioned along a number of key behavioural domains posited to be inextricably bound up with the phenomenon of auto-noesis (see Irish et al., 2008). Participants were asked to rate their subjective experience along the following dimensions; Vividness of Imagery Evoked, Viewer Perspective, Continuity of Accompanying Imagery, Frequency of Covert Rehearsal, Frequency of Overt Rehearsal, Emotional Re-experiencing, Overall Rating of Re-experiencing. The emotional valence of each memory was also noted. Participants were also asked to

confer a global judgment on the memory and to state if they were “reliving” the event or “looking back” on it. This judgment was used as the key criterion to denote whether an event was recalled with auto-noetic consciousness (“relived”) or whether the event was mediated by noetic consciousness (“looking back”). The auto-noetic subscale of the EAMI is provided in full in Appendix B.

The EAMI test session lasted approximately 60 minutes for middle-aged controls, 90-120 minutes for elderly controls and between 60-90 minutes for AD patients depending on the degree of memory impairment.

### 2.5 Reliability of the EAMI

The inter-rater reliability of the EAMI event subscale was established by comparing the experimenter’s scoring of all memories with that of two independent raters. Rater 1 scored all memory transcripts in reverse order (i.e. Recent period back to Childhood) whilst Rater 2 scored all transcripts in chronological order but in reverse participant order (i.e. Participant 30 back to Participant 1). The degree of concordance between the three raters was calculated using the R intraclass correlation coefficient for consistency. The concordance for the event details subscale of the EAMI was  $\alpha=.942$ , classified by Slick (2006) as “Very High”.

### 2.6. Statistical Analyses

To investigate whether there were differences between the healthy elderly controls and AD patients across the cognitive screening measures, we ran a multivariate analysis of variance (MANOVA). We used repeated measures ANOVAs to determine whether there were significant group differences between the healthy

elderly controls in comparison with the AD patients for the recall of contextual details across life epochs on the EAMI. The mean differences in contextual detail scores between groups were calculated with 95% Confidence Intervals. Middle-aged controls were not included in these between-group comparisons, given their truncated life span and significantly greater level of education. The repeated measures ANOVAs also permitted us to establish if there were overall effects of epoch on the EAMI for the recall of details. To establish where such epoch effects lay, we split the data file by group (Elderly, AD) and used paired t-tests with Bonferroni corrections ( $\alpha$ /number of comparisons) to compare the level of contextual detail recall across the EAMI time periods (Childhood, Early Adulthood, Middle Adulthood, Later Adulthood, Recent period). We used a similar procedure to investigate potential group differences and epoch effects for each of the seven types of contextual detail on the EAMI (Event, Temporal Specificity, Sensory/Perceptual, Spatial Specificity, Emotion, Implication of Event, Thoughts). We began by running repeated measures ANOVAs to investigate effects of group and epoch, using the Greenhouse Geisser correction where appropriate. We then ran paired t-tests within each participant group with Bonferroni corrections to determine where such epoch effects lay.

To establish if there were differences between participant groups in the overall prevalence of reliving and markers of auto-noetic consciousness on the EAMI, Chi-Squared statistics based on the frequency patterns in the variables were run, as these variables were categorical. We were interested in determining which of the auto-noetic markers exerted the greatest predictive value for reliving judgments, and entered all participants' memories across all life epochs ( $n=1011$ ) into a regression analysis. Backwards Wald stepwise binary logistic regression models were run, with

“looking back” set as the reference category for the dependent variable. The resulting significant Exponential Beta values were then converted to odds ratios for reliving judgments by inversion i.e. Odds Ratio =  $1/\text{Exp}(B)$ . In this manner, we could determine which markers exhibited the highest odds ratios and therefore were the best predictors of an auto-noetic reliving experience. Given the significant difference between the middle-aged and elderly control groups in years in education, we also ran binary and multinomial logistic regressions for reliving judgments and the auto-noetic markers respectively, using education level (Secondary < 15 years, Tertiary > 15 years) as a predictive variable.

### 3. Results

#### 3.1. Between-group differences for recall of autobiographical contextual details.

Repeated measures ANOVAs consistently revealed significant main effects for group, with AD patients showing impaired event recall on the EAMI (see Figure 1). This difference between groups was pronounced ( $F(1, 48)=103.502, p<.0001$ ) with elderly controls scoring on average 31.9 points higher than AD patients [95% C.I. for difference: 25.58, 38.18]. The analysis also revealed a main effect for epoch ( $F(4, 192)=2.466, p=.046$ ) and an epoch\*group interaction ( $F(4, 192)=21.685, p<.0001$ ). Independent t-tests revealed that AD patients recalled significantly less details across all life epochs ( $p<.0001$ ; Mean Differences: Childhood, 3.3; Early Adulthood, 3.8; Middle Adulthood, 6.3; Later Adulthood, 8.3, Recent, 10.2). These differences remained statistically significant following Bonferroni corrections.

### 3.2. Effect of epoch on recall of autobiographical contextual details.

Healthy elderly controls exhibited a recency effect for recall of contextual details on the EAMI, with a significant increase in the level of detail recalled as one approached the Recent period (Childhood < Recent,  $p < .0001$ ; Early Adulthood < Recent,  $p < .0001$ ; Middle Adulthood < Recent,  $p < .01$ ). In contrast, AD patients demonstrated a negative temporal gradient on the EAMI, with recall of contextual details significantly lower for more recent epochs in comparison with Childhood and Early Adulthood. A series of paired t-tests revealed significant declines between Early Adulthood and all subsequent time periods (Middle Adulthood:  $p < .001$ , Later Adulthood:  $p < .0001$ , Recent period:  $p < .0001$ ). These differences remained significant following a Bonferroni correction.

### 3.3. Breakdown of autobiographical event recall by contextual details across life epochs.

A repeated measures ANOVA revealed a significant main effect for the type of detail recalled ( $F(6, 4188) = 321.569$ ,  $p < .0001$ ) and a significant main group effect ( $F(1, 698) = 345.83$ ,  $p < .0001$ ) with elderly controls scoring at higher levels of detail than AD patients (see Figure 2). A significant interaction was found for Details\*Epoch ( $F(24, 4188) = 5.871$ ,  $p < .0001$ ) and for Details\*Group ( $F(6, 4188) = 26.634$ ,  $p < .0001$ ) with a three-way interaction emerging for Details\*Group\*Epoch ( $F(24, 4188) = 1.708$ ,  $p < .05$ ).

A multivariate analysis of variance revealed significant group differences across the following categories of detail ( $p < .0001$ ): Event,  $F(1, 698) = 286.677$ ; Temporal Specificity  $F(1, 698) = 116.040$ ; Sensory/Perceptual  $F(1, 698) = 186.781$ ; Spatial Specificity  $F(1, 698) = 397.151$ ; Implication of Event  $F(1, 698) = 28.811$ ; Thoughts  $F(1, 698) = 69.032$ . AD patients consistently showed impairments in recalling information from each details subcategory on the EAMI, except that of Emotion ( $F(1, 698) = .212, p = .645$ ). Paired  $t$ -tests with Bonferroni corrections ( $p < .005$ ) revealed that for each level of detail, except that of Thoughts, there was evidence for a negative temporal gradient in the AD group, with more recent recall compromised when compared with earlier epochs (see Figure 2B). AD patients' Event details showed significant decline from Middle Adulthood ( $t = 3.579, p < .001$ ) persisting in a negative gradient through to the Recent period. Temporal specificity for AD patients was most accurate in Early Adulthood, with significant decline in subsequent epochs (e.g. Middle Adulthood  $t = 6.082, p < .0001$ ; Later Adulthood  $t = 5.705, p < .0001$ ; Recent period  $t = 6.082, p < .0001$ ). Likewise, AD patients' Sensory/Perceptual details began to diminish towards more recent epochs (Later Adulthood  $t = 2.883, p < .005$ ; Recent period  $t = 2.231, p < .05$ ), as did Spatial Specificity, with the poorest recall of spatial details occurring in the Recent period ( $t = 6.987, p < .0001$ ). Recall of Emotion showed some decline in the Recent period when compared with more remote epochs (Middle Adulthood  $t = 3.049, p < .005$ ), as did the Implication of events, which declined significantly from Early Adulthood (Later Adulthood  $t = 4.886, p < .0001$ ; Recent period  $t = 4.985, p < .0001$ ) for AD patients. Finally, there were no significant differences in recall of Thoughts across life epochs in the AD group.

#### 3.4. Incidence of Autonoetic Consciousness during Autobiographical event recall.

Figure 3 shows the incidence of autooiesis across the life epochs on the EAMI for all participants, as indexed by the percentage of total memories recalled that were conferred with “reliving” judgments. This recollective judgment dissociated significantly between participant groups ( $\chi^2(2)=18.835$ ,  $p<.0001$ ). Middle-aged controls endorsed reliving for 32.7% of memories, in comparison with 26.7% for elderly controls, and 16.7% for Alzheimer patients. A binary logistic regression was run for all middle-aged and elderly control memories ( $n=753$ ), with “looking back” set as the default variable, and education level (Secondary, Tertiary) set as a predictor variable. This revealed that education level did not exert a significant predictive effect on autooietic judgments ( $p=.649$ ).

There was no significant difference in reliving judgments across life epochs for middle-aged controls ( $\chi^2(3)= 2.263$ ,  $p=.520$ ). A recency effect was observed for elderly controls with 14.4% of Childhood memories relived, in comparison with 35.6% in the Recent period ( $\chi^2(4)= 17.614$ ,  $p=.001$ ). There was no epoch effect in the AD group with memories consistently labelled as “looking back” irrespective of life period ( $\chi^2(4)= 7.048$ ,  $p=.133$ ).

### 3.5. Between-group differences in markers of autooietic consciousness

Table 2 shows the between-group differences for autooietic markers as revealed by the Chi-squared statistic. Those sub-categories of each marker which showed the greatest degree of discrimination between groups have been presented. As can be seen from Table 2, there were significant differences between the participant groups



across all auto-noetic markers, with the exception of emotional re-experiencing for which similar frequencies were reported by all participant groups. To investigate the possible effect of education level on auto-noetic markers, we ran a multinomial logistic regression for all middle-aged and healthy elderly control memories ( $n=753$ ) with education level (Secondary, Tertiary) set as a predictor variable. Tertiary education was not found to exhibit a significant predictive effect for any of the auto-noetic markers ( $p>.05$ ).

### 3.6. Effect of epoch on auto-noetic markers

For middle-aged controls, recency effects were evident on many of the auto-noetic markers. Recent memories were rated as “very vivid” or “vivid” significantly more often than Childhood memories ( $\chi^2(18)=31.305$ ,  $p=.027$ ). Similarly, a larger proportion of memories were viewed from an “own eyes” first person perspective in the Recent period in comparison with Childhood ( $\chi^2(6)=18.940$ ,  $p=.004$ ). There was no epoch effect for continuity of visual imagery ( $\chi^2(18)=18.444$ ,  $p=.427$ ), emotional re-experiencing ( $\chi^2(3)=2.425$ ,  $p=.489$ ) or emotional valence ( $\chi^2(6)=11.566$ ,  $p=.072$ ). However, middle-aged controls reported thinking about ( $\chi^2(9)=30.659$ ,  $p<.0001$ ) and talking about ( $\chi^2(9)=36.997$ ,  $p<.0001$ ) Recent memories more frequently than remote memories. Finally, there was no epoch effect for re-experiencing ratings in middle-aged controls ( $\chi^2(12)=12.489$ ,  $p=.407$ ).

For healthy elderly controls, recency effects were observed across many of the auto-noetic markers. Recent memories were more often rated as being “very vivid” or “vivid” ( $\chi^2(24)=56.169$ ,  $p<.0001$ ), exhibiting a “video” quality of imagery

( $\chi^2(24)=47.831$ ,  $p=.003$ ), and as being emotionally re-experienced ( $\chi^2(4)=16.136$ ,  $p=.003$ ) than Childhood memories. Positively valenced memories tended also to be recalled by elderly controls more often in the Recent period ( $\chi^2(8)=32.848$ ,  $p<.0001$ ). There was no epoch effect for viewer perspective ( $\chi^2(12)=7.128$ ,  $p=.849$ ) with similar ratings conferred across epochs. Recent memories were “Frequently” thought about ( $\chi^2(12)=93.585$ ,  $p<.0001$ ) and spoken about ( $\chi^2(12)=81.863$ ,  $p<.0001$ ) as well as being more likely to be re-experienced “A Lot” in comparison with Childhood memories ( $\chi^2(16)=36.009$ ,  $p=.003$ ).

Conversely, for AD patients, epoch effects were not found across the majority of markers of auto-noetic consciousness. Ratings of vividness remained similar across all epochs ( $\chi^2(24)=22.412$ ,  $p=.555$ ) as did viewer perspective ratings ( $\chi^2(16)=17.500$ ,  $p=.354$ ), continuity of imagery ratings ( $\chi^2(24)=19.098$ ,  $p=.747$ ), and emotional valence ( $\chi^2(8)=6.810$ ,  $p=.557$ ). Interestingly, AD patients reported a higher incidence of emotional re-experiencing in the Recent period in comparison with Childhood ( $\chi^2(4)=10.310$ ,  $p=.036$ ). There was no epoch effect for either covert ( $\chi^2(12)=16.091$ ,  $p=.187$ ) or overt rehearsal in the AD group ( $\chi^2(12)=17.394$ ,  $p=.135$ ), nor for overall re-experiencing ratings ( $\chi^2(16)=16.949$ ,  $p=.389$ ).

### 3.7. Predictive value of markers of auto-noetic consciousness

Figure 4 shows the results from the binary logistic regression analyses, whereby the auto-noetic markers exerting a significant predictive effect on reliving judgments are presented in ascending order according to the magnitude of their odds ratios. The three markers to exert the greatest predictive effect for reliving are those pertaining to

the “real-life” playing out of the memory akin to a video, followed by re-experiencing the emotion felt at the time of the original event, and the frequent covert rehearsal of the memory.

#### **4. Discussion**

The aim of this study was to investigate the profile of episodic ABM recall in healthy ageing and mild Alzheimer’s disease across the lifespan, paying particular attention to the detailed assessment of auto-noetic consciousness. AD patients demonstrated a compromised capacity to retrieve contextual details manifesting in a negative temporal gradient from Early Adulthood onwards. Overall there was a low incidence of mental reliving of ABMs for all participant groups, however, AD patients were significantly impaired where the instantiation of auto-noetic consciousness was concerned. Recency effects were found for reliving judgments in the healthy elderly group, however such epoch effects were absent in the AD group. AD patients demonstrated impairments across a host of behavioural markers inextricably bound up with the recollective experience, such as the generation of self-referential imagery, and the continuity of the imagery evoked, irrespective of time period being considered. Here we will discuss such auto-noetic markers in terms of their predictive efficacy for reliving judgments, with auto-noetic reliving conceptualised as a confluence of many important factors such as visual and emotional re-experiencing.

##### **4.1. Retrieval of Autobiographical Event Memories**

Deficits in ABM recall in Alzheimer's disease are well documented in the literature across a host of different test instruments (e.g. Greene et al., 1995; Ivanoiu et al., 2006; Kopelman et al., 1989; Piolino et al., 2003b) with the most striking impairments tending to emerge on the event subscales of these measures. Here we have shown robust dissociations between healthy elderly and AD participants in the provision of supportive contextual details for autobiographical events using the EAMI measure. Within-group comparisons across life epochs revealed a recency effect for healthy elderly controls on the EAMI, with memories becoming progressively more contextually rich in more recent epochs. This recency effect mirrors previous findings of Piolino et al. (2002) and Levine et al. (2002). In contrast to Levine (2004), however, we did not find decrements in healthy ageing for the recall of event, emotion, spatial, and sensory details, all of which were recalled at high levels. Elderly controls proved highly capable of recalling specific contextual details in contrast to Piolino et al.'s (2006) findings of age-related decreases in memory specificity, particularly on the two most recent epochs of the TEMPau measure. This difference may reflect methodological variations in the probing for information, as the extensive probing of the EAMI may have facilitated the recall of episodic details in elderly controls (Holland and Rabbitt, 1990; Levine et al., 2002).

In the AD group, a negative temporal gradient emerged from the Early Adulthood period on the EAMI, beyond which there was a marked deficit in the provision of contextual details for events. The emergence of temporal gradients on ABM measures is well documented in the literature (e.g. Graham and Hodges, 1997; Kopelman et al., 1989; Piolino et al., 2003b; Thomas-Antérion et al., 2000), however it is possible that given the length of the test session in this study, AD patients may

have experienced fatigue during the probing of Recent memories, producing this decline in contextual details. Key elements purported to signify the engagement of the episodic memory system such as rich sensory-perceptual details, temporal and spatial specificity (Levine et al., 2002) were largely compromised in the AD sample, reflecting their difficulty in retrieving once-off episodic memories in comparison with more generic autobiographical accounts (Nestor et al., 2002; Piolino et al., 2003b). This supports previous findings of Moses et al. (2004) who invoked a theory of mnemonic interlock to account for overgeneral memory in AD, whereby the retrieval search process for a specific memory terminates at the categoric level and is likely attributable to frontal pathology. The overgeneral accounts produced by our AD patients comprised mostly semanticised elements consistent with previous studies of ABM (Butters and Cermak, 1986; Cermak, 1984; Piolino et al., 2003b; Warrington and McCarthy, 1988) and studies of gist memory in which impairments have been documented in AD (Budson et al., 2006).

#### 4.2. Prevalence of Auto-noesis during ABM recall

The frequency of auto-noetic consciousness was a relatively rare occurrence across all participant groups. A significant group difference emerged whereby middle-aged controls had the highest incidence of auto-noesis (32.7%) followed by healthy elderly controls (26.7%) and AD patients (16.7%). The reduced efficacy to engage in the auto-noetic reliving of past events may arise in healthy ageing due to age-related changes in prefrontal cortical function (Moscovitch and Winocur, 1992; West, 1996) or a loss of resolving power resulting in the termination of retrieval search processes at the level of non-specific semantic representations ( Craik and Grady, 2002). Source

memory deficits due to frontal dysfunction characteristic of the AD pathological process likely disrupt auto-noetic event recall further in the AD group (Greene et al., 1995; Piolino et al., 2003b). The importance of the frontal lobes in the retrieval process has been emphasised in constructive models of ABM by facilitating access to sensory/perceptual details in posterior regions through the personal knowledge base (Conway, 2001; Conway and Pleydell-Pearce, 2002; Hodges and McCarthy, 1995). Our findings of an impaired capacity to mentally relive past memories via auto-noetic consciousness in AD are in line with those previously demonstrated using the Remember/Know paradigm (R/K; Piolino et al., 2003b). However, the low levels of auto-noesis for healthy controls found in the present study are at odds with previous reports in the literature. Piolino et al. (2006) reported high levels of auto-noesis using “R” judgments in all participants (middle-aged: 87%; old: 82%; very old: 75%) and speculated that R/K judgments may reflect participants’ confidence levels rather than the subjective recollective experience. We suggest that episodic memory infused with auto-noetic consciousness represents a unique type of memory unlikely to be the default retrieval mode of ABM, enabling humans to avoid the retrieval effort and emotional cost that reliving each ABM would entail. Whilst many of our personal past memories may be recalled with some degree of auto-noetic consciousness, for which the term “remembering” is appropriate, reliving may signify the top-end of this continuum, with participants conferring this judgment if and only if a memory is fully infused with a feeling of mentally travelling back in time to the original event.

#### 4.3. Profile of Auto-noesis across the Lifespan

Within-group analyses of reliving judgments across life epochs revealed that the auto-noetic flavour of ABMs is affected with the passage of time from encoding to retrieval. Elderly controls exhibited a recency effect, reliving significantly more memories from the Recent period than more remote epochs, similar to previous findings (Piolino et al., 2004). This epoch effect was absent in the AD group, with the lowest incidence of reliving judgments occurring in the Childhood period. Piolino et al. (2003b), by contrast, found that AD patients gave the most number of “R” judgments in Childhood and showed a steady decline throughout remaining life periods. This discrepancy in results may reflect fundamental differences in the conceptualisation and operational definition of auto-noesis between “Remembering” by Piolino and colleagues, and in our case, “Reliving” judgments. It would be worth investigating whether “remember” judgments and “reliving” judgments represent equivalent constructs, and are therefore comparable. As Piolino et al. (2006) suggested, participants may equate “remember” judgments with confidence levels, and in this sense, higher incidences of such judgments in Childhood is not surprising given the well-documented memory deficits AD patients exhibit in more recent epochs. We suggest that “remember” and “reliving” judgments most likely correspond to different degrees or intensity of auto-noetic re-experiencing, however whether such subtleties can be readily understood by patient groups without further elaboration remains to be seen, given the impaired capacity for abstract thought in AD (Waltz et al., 2004). Whilst there was no effect of epoch in the AD group, the greatest percentage of patients’ relived memories occurred in the Early and Middle Adulthood periods, coinciding with Robinson’s view (1992) that seminal and life-changing events are more likely to occur during this time. Such important self-referential events likely receive privileged encoding rendering them highly accessible and

evocative (Conway, 1995; 2001). The finding that episodic reliving can occur for events that stretch past 60 years, and is not confined to the moment just gone as a summary representation of previous states of the working memory system (Conway, 2001), adds support to the view that auto-noetic reliving is not contingent on recency of the event alone, but depends on the presence of other features to mediate the recollective experience (see Addis et al., 2004).

#### 4.4. Important markers of Auto-noesis

A number of key behavioural markers emerged as significant predictors of auto-noesis in keeping with previous findings (Irish et al., 2008). The most striking of these markers was related to viewing the memory as a continuous “video”, with recent memories more likely to be viewed as such. The ability to visualise the retrieved event in this lifelike manner was impoverished in the AD group, with their accompanying imagery resembling static snapshots akin to photographs or hazy imagery and lacking a real-life three-dimensional quality. Hassabis et al. (2007) reported that patients with hippocampal amnesia generated imagined experiences strikingly deficient in spatial coherence, resulting in fragmented constructions lacking in richness. The authors argued the hippocampus may make a critical contribution to the creation of new experiences by providing a spatial context or environmental setting into which details are bound (Eichenbaum, 2004; Moscovitch et al., 2005). Generation of integrated three-dimensional iconic representations of scenes, such as the viewing of ABMs as real-life videos, is posited to require parahippocampal and hippocampal cortical areas (Burgess et al., 2002) and is likely to be adversely affected by the pathology characteristic of AD.



A second branch of the visual recollective experience concerns the perspective one adopts in the mental “viewing” of a memory. Here we found the default viewpoint for middle-aged controls was that of an “own eyes” perspective (62.4%), which is closely aligned with the auto-noetic recollective experience (Crawley and French, 2005). However, elderly controls and AD patients tended to view their ABMs from a “third person” perspective as a removed observer (61.3% and 34.1% of memories, respectively), suggestive of noetic consciousness (Nigro and Neisser, 1983). Piolino et al. (2006) found that 52% of memories overall for healthy middle-aged and elderly controls were viewed via a “field” (“own eyes”) frame of reference. However, the present study did not constrain participants to make a dichotomous viewer perspective judgment and the inclusion of “general” imagery and “no imagery” categories on the EAMI may account for such discrepant findings. We found that 31.4% of AD patients’ memories were visualised via “general” off-tangent imagery that was not self-referential or related to the event being recalled, whilst a further 16.3% of memories were divested of any visual imagery whatsoever. This would suggest that all that is recalled by the patient group is an overgeneral account of the event divested of rich sensory-perceptual details (Brewer, 1996; Moses et al., 2004). Of note was the fact that the viewer perspective categories of “own eyes”, “third person” and “mixture of the two” were found to exert roughly equal predictive effects on reliving judgments in the regression analysis. This suggests that it is not the viewer perspective adopted during recall that conclusively indicates the accompanying conscious state per se, but rather the proclivity for the visual imagery generated during recall to be viewed in some self-referential manner. The compromised capacity of AD patients to deploy self-referential visual imagery during ABM recall may reflect pathology in medial

prefrontal cortical areas thought to mediate self-referential mental activity (Gusnard et al., 2001), or in posterior parietal cortices known to mediate egocentric processing (Andersen et al., 1985).

Where vividness ratings were concerned, those memories reported as “very vivid” by participants were more likely to be relived by participants. This corroborates Rubin et al.’s (2003) assertions that stronger visual imagery, and therefore more vivid memories, leads to higher levels of recollection for events. AD patients consistently conferred judgments of “vague” or “very vague” on their memories irrespective of epoch. Such semanticised accounts of past events were stripped of the visual details necessary to act as cues to activate information from other sensory modalities and produce a rich evocative experience during successful retrieval (Greenberg and Rubin, 2003). Our results reaffirm the importance of vision as the primary modality for recollection (Rubin and Greenberg, 1998). These deficits in evoking specific self-referential imagery during ABM retrieval for AD patients likely disrupts the reactivation of sensory-specific processing regions that can recreate a pattern of firing similar to that present during the original experience (Buckner and Wheeler, 2001; Rubin and Greenberg, 1998; Tranel and Damasio, 1995). In turn, this may obstruct activation of the autonomic nervous system and the triggering of an emotional response (Kosslyn et al., 2001) precluding the instantiation of autooetic re-experiencing of the event being recalled.

#### 4.4.1. Emotional re-experiencing during Autooetosis

There is a rich literature pointing to the enhancing effects of recall of emotional material on the experiential feeling of remembering, with emotional experiences often leaving remarkably durable ABMs (Buchanan et al., 2006). Our findings point to the importance of re-visiting the original emotional state for auto-noetic reliving of ABMs to occur. Piefke et al. (2003) note that the early stages of AD are associated with impairments of emotion processing (Hargrave et al., 2002) linked to pathology in the entorhinal cortex and adjacent limbic areas. Whilst we did not find that AD patients reported less instances of emotional re-experiencing as a proportion of their total memories recalled, we did not investigate the intensity or magnitude of such re-experiencing. It is likely that phrasing the emotional re-experiencing question as a dichotomous “yes/no” judgment may have masked underlying differences in emotional arousal between participant groups, which is posited as a critical factor accompanying retrieval of events that are relived (Talarico et al., 2004). Buchanan et al. (2006) assert that whilst both highly pleasant and highly unpleasant experiences are better remembered than neutral events, emotional arousal or intensity provides a more parsimonious account of the influence of emotion on memory, with the amygdala proposed to exert a preferential role in the processing of intensity rather than valence (Hamann et al., 2002). The AD patients in our study exhibited deficits in the recollection of more recent memories, consistent with pathology around the hippocampus and surrounding cortex, yet they reported emotional re-experiencing, which suggests some preservation of the amygdala, facilitating the recall of declarative memory for emotional events (Mori et al., 1999). However, we acknowledge that investigating the intensity of emotional re-experiencing would provide valuable information in further unravelling the importance of emotion as a marker for auto-noesis. This is of particular significance where the retrieval of

negatively valenced events is concerned, as we found such events were strong predictors of the reliving experience. We propose that it is the arousing properties of those negative memories which culminated in a reliving experience, as visceral emotional re-experiencing has been shown to be an integral feature of involuntary reliving of ABMs in post-traumatic stress disorder (Rubin et al., 2004).

#### 4.4.2. Degree of rehearsal of ABMs

Contrary to the idea that repeated rehearsal of an event might result in the loss of the auto-noetic flavour leaving a semanticised account, regularly thinking of and speaking about the past event appears to preserve or reinforce the evocative recollective experience. Judgments of “frequently” and “occasionally” for both covert and overt rehearsal emerged as significant predictors of reliving. However, the majority of such memories emanated from the Recent period, in which a clear recency effect for auto-noesis was documented and as such, rehearsal may represent an artefact of the Recent epoch rather than a marker of auto-noesis. A recency effect was observed with both control groups engaging in rehearsal of events, mediated by thinking or by overt discussion, in close temporal proximity to the present day, to the neglect of more remote epochs. This recency effect was not found for AD patients who reported similar levels of rehearsal across the lifespan, however the veracity of the patients’ judgments is questionable as the pathology observed in AD may result in their failure to recall past retrieval attempts. Piefke et al. (2003) assert that by necessity, retrieval of past memories is accompanied by simultaneous re-encoding processes. For those memories rehearsed either covertly or overtly, a new memory trace may be established leading to a stronger representation of that memory. However, the

repeated rehearsal of past events brings with it the potential for the manipulation and re-encoding of such events, with the later belief that the representation is unchanged (Conway, 2001). The general pattern to emerge suggests that more recent memories (<30 years) are more likely to be re-experienced in terms of the mental time-travel described by Tulving (2002).

In summary, our results offer further insights into the retrieval of ABMs and the accompanying recollective experience in healthy ageing and mild AD. Patients with AD exhibited deficits in the recall of phenomenological details of ABMs, and showed an impoverished capacity to mentally relive the original event via auto-noetic consciousness. The most striking impairments emerged where generation of lifelike self-referential imagery was concerned, with AD patients unable to visualise the event in a detailed manner or to integrate themselves in the visualised scene via egocentric frames of reference. AD patients demonstrate a compromised capacity to visualise or conceive of themselves as a traveller in subjective time, a pre-requisite for auto-noetic consciousness (Tulving, 2002). Without such self-referential imagery, the time-line within which these patients are attempting to navigate lacks vividness and cohesion and resulting memories are recalled as overgeneral, depersonalised accounts. To understand the phenomenon of auto-noesis requires further investigation into the interplay between generation of self-referential autobiographical images and instantiation of emotional re-experiencing, with a view to appreciating the insight patients have into their deficits and its impact on their sense of self.

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Fig. 1 – Recall of contextual details for healthy elderly controls and AD patients across the five life periods of the EAMI.

Fig. 2 - Average recall of contextual detail by category across life epochs on the EAMI for (A) healthy elderly controls and (B) AD patients. (Maximum score for each detail is 1.0).

Fig. 3 – Percentage of memories recalled with auto-noetic consciousness, as indexed by reliving judgments on the EAMI.

Fig. 4 – Auto-noetic markers ranked in cascading order of predictive efficacy for reliving.

**Table 1 – Cognitive Screening data (mean± SD) and Autobiographical Memory Performance for Healthy Elderly Controls and Patients with Mild AD<sup>a</sup>**

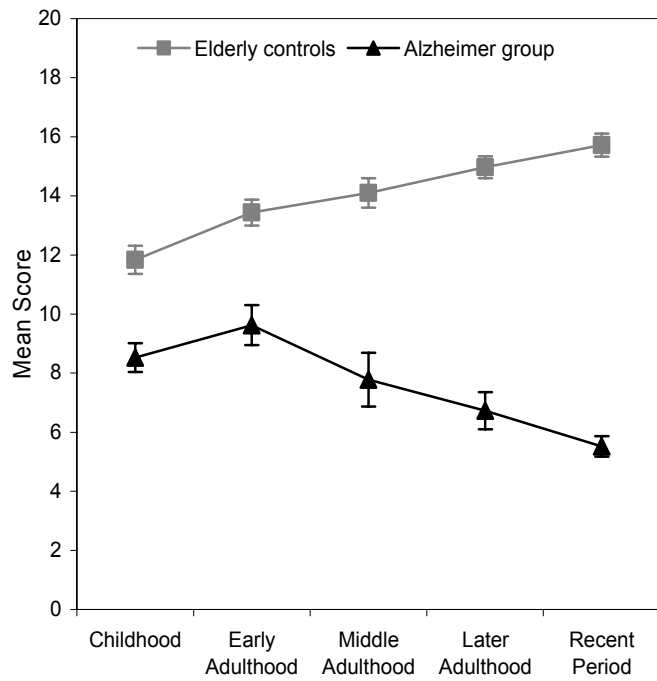
		<b>Elderly Controls</b>	<b>Alzheimer's Disease</b>	<b>Group Effect</b>
Cognitive Screening	MMSE “7s”	29.0 (1.1)	24.0 (2.4)	**
	MMSE “dlrow”	29.4 (1.0)	24.4 (2.4)	**
	CDT	9.2 (.9)	6.4 (2.7)	**
	GDS	1.5 (1.9)	1.1 (1.3)	n/s
ABM Assessment	EAMI Total PS	63.4 (4.4)	50.0 (8.5)	**
	EAMI Total Events	70.1 (7.6)	38.2 (14.5)	**

<sup>a</sup>PS, Personal Semantics; Group effect determined by multivariate analysis of variance (MANOVA) \*\*  $p < .001$ ; \* $p < .05$ ; n/s, non-significant.

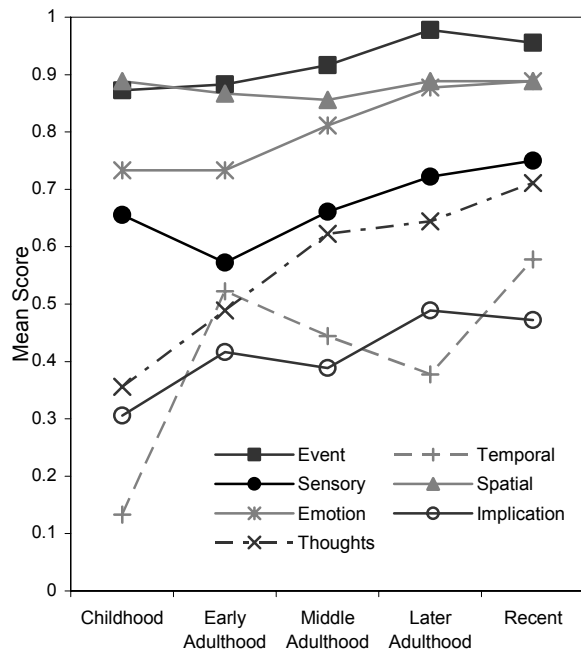
**Table 2 - Group Differences in the Recollective Experience**

Marker <sup>a</sup>	Rating	Middle-aged	Elderly	Alzheimer	Group
		Controls	Controls	Patients	
Reliving		32.7%	26.7%	16.7%	***
Vividness	“Very Vivid/Vivid”	55.7%	62.7%	46.5%	***
	“Vague/Very Vague”	5.9%	8.9%	24%	
Viewer Perspective	“Own eyes”	62.4%	36.7%	17.8%	***
Continuity of Imagery	“Video”/“Video clips”	60.7%	66.2%	9.7%	***
Emotional Re-experiencing	“Yes”	47.5%	48.7%	45.3%	n/s
Emotional Valence	Positive	53.1%	51.6%	72.1%	***
Covert Rehearsal	“Never”	2.6%	4.0%	14.0%	***
Overt Rehearsal	“Never”	11.2%	9.8%	25.6%	***
Overall Re-experiencing	“Fully”	7.3%	2.9%	2.3%	***
	“Not at all”	27.7%	45.1%	55.4%	

<sup>a</sup>The full range of subcategories for each auto-noetic marker on the EAMI are shown in detail in Appendix II; \*\*\*,  $p < .0001$ ; n/s, non-significant.



A



B

