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The role of working memory and verbal fluency in autobiographical memory in early Alzheimer's disease and matched controls

Maxwell J. Benjamin[1,6], Alberto Cifelli[2], Peter Garrard[3,4], Diana Caine[5] and Fergal W. Jones[1]+*

[1]Salomons Centre for Applied Psychology, Canterbury Christ Church University, UK
[2]Department of Neurology, Barking, Havering and Redbridge University Hospitals NHS Trust, UK
[3] Department of Neurology, St. George's Healthcare NHS Trust, UK
[4] Neuroscience Research Centre, St. George's, University of London, UK
[5] Department of Neuropsychology, National Hospital for Neurology and Neurosurgery, UCLH NHS Foundation Trust, UK
[6] Neuroepidemiology and Ageing Research Unit, School of Public Health, Imperial College London, UK

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[+]Corresponding author: Dr. Fergal Jones, Salomons Centre for Applied Psychology, Department of Psychology, Politics and Sociology, Canterbury Christ Church University, Runcie Court, Broomhill Road, Tunbridge Wells, Kent TN3 0TF, UK. Tel: (+44) 03330117110; Fax: 01892 520888 ; email: fergal.jones@canterbury.ac.uk

*Drs. Caine and Jones were joint senior authors

Abstract

Retrieval of autobiographical memories (AMs) is important for "sense of self".

Previous research and theoretical accounts suggest that working memory (WM) and semantic and phonemic fluency abilities facilitate the hierarchical search for, and reliving of past, personal events in the mind's eye. However, there remains a lack of consensus as to the nature of the relationships between these cognitive functions and the truly episodic aspects of AM. The present study therefore aimed to explore the associations between these variables in a sample with a wide range of cognitive abilities. The study incorporated a between-groups component, and a correlational component with multiple regression. Participants with Alzheimer's disease (n = 10) and matched healthy controls (n = 10) were assessed on measures of semantic and episodic AM search and retrieval, auditory and spatial WM, and semantic and phonemic fluency. The AD group produced less episodic AM content compared to controls. Semantic fluency predicted episodic AM retrieval independent of age effects but there were no significant relationships between measures of phonemic fluency, WM and episodic AM. The results suggest that the ability to maintain hierarchical search of the semantic knowledge-base is important for truly episodic reliving, and interventions for people with AM impairment might therefore benefit from incorporating structured, individualised external memory-aids to facilitate AM search and retrieval.

Keywords: autobiographical memory, Alzheimer's disease, working memory, executive function, verbal fluency

Autobiographical memory (AM) retrieval is thought to be a dynamic cognitive and affective process between episodic memory and self-relevant goals and beliefs (the "working self"; Conway, Singer, & Tagini, 2004). AMs are reconstructed, hierarchical representations of personal experiences incorporating, at the most specific level, sensory and perceptual details rather than factual accuracy (Conway, 1990). The Constructive Model of AM (Conway & Pleydell-Pearce, 2000) proposes two methods of retrieval: *generative retrieval*, involving the hierarchical search of personal semantic information (semantic AM) for information relevant to a query in order to facilitate access to event-specific knowledge in episodic memory (episodic AM); and *direct retrieval*, where the semantic search is bypassed due to a strong association between a cue and episodic AM. The model predicts that executive control components of working memory (WM) enable hierarchical search and subsequent "reliving" of AMs to take place with evidence implicating both the phonological loop (e.g. Matuszewski et al., 2006) and the visuospatial sketchpad (e.g. Piolino et al., 2010). When these are disrupted generative retrieval will be inefficient and may not allow for adequate specificity in accessing episodes, resulting in "over-general" AM (Sumner, Griffith, & Mineka, 2011), manifested in disproportionately semantic content of AM reproductions.

There is considerable support for the notion of a relationship between executive function and AM retrieval. For example, it has been shown that impairments to updating and inhibition in traumatic brain injury (TBI) and depression account for a significant proportion of the variance in participants' ability to continue hierarchical search of AM beyond the more general, semantic

levels (Coste et al., 2010; Dalgleish et al., 2007; Ros, Latorre, & Serrano, 2010). Furthermore, Unsworth, Spillers and Brewer (2012) showed that AM generation in healthy controls was associated with measures of executive function and WM, supporting the role of these cognitive processes in AM retrieval.

Insights from Research in Alzheimer's Disease

Perhaps the most prevalent cause of AM impairment is Alzheimer's disease (AD), a progressive neurodegenerative condition characterised by medial temporal lobe (MTL) atrophy in the early stages, and subsequent, more widespread pathology (Almkvist, 1996). The loss of AM in AD can have potentially devastating consequences for the individual and their family (Conway & Fthenaki, 2000; Howe, 2011). Despite the importance of AM and self-defining memories for sense of self (Conway et al., 2004) and mood in general (Holland & Kensinger, 2010), the evidence for reminiscence or AM interventions in AD is weak (Woods, Spector, Jones, Orrell, & Davies, 2005). Therapeutic interventions directed at facilitating the pleasurable retrieval of long-term memories in a care setting for people with AD will typically involve the use of verbal and visual cues for direct retrieval (e.g. photographs, or a particular piece of music); but if appropriate cues are not known or used then the use of guided, generative retrieval methods may be beneficial as an intervention as the person becomes more able to provide their own internal cues in response.

Whilst *direct* retrieval may be the most cognitively efficient method of eliciting AMs, very specific cue material is not always available, known by carers, or even consciously accessible to the individual with AD. Given that executive

functions have been considered as significant predictors of functional outcomes (such as activities of daily living) in AD (de Paula & Malloy-Diniz, 2013), it is important to examine the relationships between the proposed cognitive mechanisms enabling *generative* AM retrieval (i.e. executive functions and WM).

Several studies examining these relationships in AD have used phonemic and semantic fluency tasks, which require the participant to search their semantic knowledge-base for words, inhibit inappropriate, "rule-break" (or repetitive) responses, and retrieve an appropriate, relevant response. According to the Constructive Model, these are all abilities required in hierarchical search of AM, though there is no consensus as to their relative contributions. Moreover, the evidence base with regard to their contribution is inconsistent: semantic fluency has been shown to correlate with only semantic AM (Eustache et al., 2004; Moses, Culpin, Lowe, & McWilliam, 2004); with only episodic AM (Greene, Hodges, & Baddeley, 1995); with both semantic and episodic AM (Sartori, Snitz, Sorcinelli, & Daum, 2004); or not at all (Ivanoiu, Cooper, Shanks, & Venneri, 2006). Similarly diverse results have been reported with respect to phonemic fluency (Greene et al., 1995; Ivanoiu et al., 2006; Moses et al., 2004). Methodological differences are likely to explain such inconsistent results. For example, most studies of the relationship between executive function and WM and AM have used the Autobiographical Memory Test (AMT; Williams & Broadbent, 1986) which does not allow for the measurement of "mental time travel" that must occur for the truly episodic reliving of phenomenological details (Matuszewski et al., 2006). This is a key limitation because it is possible that previous associations thought to occur between executive function or WM and episodic reliving may actually be

relationships with semantic rather than episodic AM. This issue is further complicated by results suggesting a role for MTL-mediated episodic memory in semantic fluency tasks. For example, Sheldon and Moscovitch (2012) have demonstrated that inherently autobiographical semantic fluency tasks (e.g. "names of friends") recruit MTL structures compared to closed-ended semantic fluency tasks requiring little spatial or contextual information (e.g. "things that are red"), but that there was increased MTL activity as semantic fluency shifted from early-generated, closed-ended items to later generated items derived from personally relevant examples. They suggest that this shift occurs once the general, semantic knowledgebase is exhausted, prompting an individual to generate new items from their own experience. It is clear, therefore, that the specific nature of semantic fluency tasks will influence the extent of any associations with autobiographical retrieval.

The Present Study

Given potential methodological shortcomings of the assessment of AM in previous studies, the aim of this study was to examine the relationships between semantic and phonemic fluency, WM, and semantic and episodic AM in a sample of AD patients and matched controls using an AM task designed specifically to capture truly episodic reliving. Based on Conway and Pleydell-Pearce's (2000) Constructive Model of AM, it was predicted that verbal fluency and WM abilities would be associated with both the hierarchical search of semantic AM and episodic AM retrieval; and that verbal fluency and WM measures would predict episodic AM retrieval independent of age.

Method

Participants

Participants with a clinical diagnosis of AD (n = 10) and healthy controls matched for age and education (n = 10) were recruited from five National Health Service sites across the South East of England. Inclusion criteria for all participants included having capacity to give written, informed consent, being aged 18 years or older, fluent in English, and have no other neurological illness following their clinical investigations. The control group comprised partners or relatives of people presenting to neurology/memory clinics (though not necessarily of those patients who took part in this study). Exclusion criteria for both groups included significant psychiatric history. Inclusion of both clinical and control participants in the study was deemed necessary to ensure a wide distribution of scores on neuropsychological measures for the purposes of testing the specific hypotheses.

Design

The study included both a between-groups comparison and a cross-sectional, correlational component. Group served as the independent variable (IV) with AM, WM, and verbal fluency measures as the dependent variables (DVs) in the between-groups analysis. Verbal fluency, WM, semantic and episodic AM measures were selected *a priori* as variables in correlational analyses. Verbal fluency and WM measures were entered as predictors of episodic AM in a hierarchical regression analysis on the basis that these are theoretically proposed to contribute to AM reconstruction in the Constructive Model of AM.

Materials

  Working memory. Auditory and spatial WM were assessed with the digit-span and spatial-span subtests from the Wechsler Memory Scale – Third Edition (WMS-III; Wechsler, 1998), respectively.

  Verbal fluency. The verbal fluency subscale of the Addenbrooke's Cognitive Examination – Revised (ACE-R; Mioshi, Dawson, Mitchell, Arnold, & Hodges, 2006) was used as a measure of executive function required for generative retrieval. It requires participants to list as many words beginning with the letter "P" as possible, excluding proper nouns, (phonemic fluency) and as many animals as possible (semantic fluency), each in 60 seconds. Total scaled scores of 7 are possible for both phonemic and semantic fluency tasks, combining to produce a potential total scaled score of 14 verbal fluency subscale. Single-letter phonemic fluency tasks have been shown to give similar results to multiple letter tasks (Barr & Brandt, 1996), including similar test-retest reliability to the gold standard F, A, and S phonemic fluency task (e.g. $r = .73$; Harrison, Buxton, Husain, & Wise, 2000). Thus, to strike a balance between participant burden and reliable assessment, the ACE-R verbal fluency scale was used in place of a multi-letter fluency task.

  Autobiographical memory. A Verbal Autobiographical Fluency task (VAF; Piolino et al., 2010) was used to guide generative AM retrieval over four stages. In the first stage (VAF1), participants were asked to list as many general *life-periods*, lasting three years or more, as possible (e.g. "living with Peter", or "caring for my

mother"). Overlapping life-periods were permitted as per the original task

instructions. In the second stage (VAF2), participants were asked to choose one of

the general life-periods from VAF1 and list as many *general events* as possible

within that life-period, that lasted several days or weeks (e.g. "our holiday to

Italy", or "when I went to stay with my grandparents"). The third stage (VAF3)

required participants to list as many *specific events* as possible, lasting from

several minutes or hours up to a day, from within one VAF2 general event of

choice (e.g. "my 10th birthday party", or "Sunday lunch with my aunt"). In the

fourth and final stage (VAF4), participants were asked to provide as many *details*

as possible of a specific event or happening lasting no more than a few minutes,

from within a VAF3 specific event of their choice.

Piolino et al. (2010) provide scoring criteria for VAF responses however the

Autobiographical Interview (AI) scoring schedule (Levine, Svoboda, Hay, Winocur,

& Moscovitch, 2002) was used to score episodic and semantic aspects of AM in the

VAF4 condition as this has been more widely validated in AD samples, including

good inter-rater reliability, concurrent and convergent validity (Barnabe,

Whitehead, Pilon, Arsenault-Lapierre, & Chertkow, 2012; Levine et al., 2002). The

AI scores truly episodic details (specific descriptions of the event, time, place,

perceptions, thoughts or emotions) as "internal details". Details from other events,

general semantic information, repetitions, or editorialising are scored as "external

details". Episodic AM was calculated as the percentage of internal details in the

total response to the VAF4 condition to control for variation in total fluent responses on the VAF task. Thus, a lower percentage would be indicative of more generalised AM, predominantly semantic in nature, with higher percentages indicative of AM retrieval that is more episodic in nature. VAFs 1-3 were scored using the original Piolino et al. (2010) criteria, and response time for VAFs 1-4 was limited to two minutes as per original task instructions.

VAFs 1 and 2 have been shown to correlate significantly with semantic AM scores on the *Test Episodique de Mémoire du Passé autobiographique* (TEMPau) task (Piolino, Belliard, Desgranges, Perron, & Eustache, 2003), whilst scores on the VAF3 and to a greater extent, the VAF4, have been shown to correlate with episodic AM on the TEMPau, demonstrating concurrent, convergent and divergent validity in young and older-adult samples (Coste et al., 2010; Piolino et al., 2010). In addition to these properties, verbal autobiographical fluency tasks have been shown to avoid ceiling effects observed on some AM tasks in healthy controls (Greene & Hodges, 1996).

Procedure

All participants were administered a neuropsychological battery in order to establish premorbid intellectual functioning, current general cognitive functioning, semantic and episodic memory abilities and mood levels. The assessment battery was administered in its entirety unless participants became fatigued, in which case the battery was shortened for ethical reasons. The AD participants took between one and two hours to complete the battery depending on the number of tests administered. The control participants took between one and one and-a-half

hours, as they were generally quicker to complete the tasks. Responses to the

VAF4 condition were recorded using a digital voice recorder for transcription and

coding, which was carried out by the lead investigator.

Ethical approval for the study was obtained from a NHS Research Ethics

Committee. Written, informed consent was obtained from all participants and

British Psychological Society (2010) research ethics guidelines were followed.

Data Analysis

Data were analysed with IBM SPSS (version 22). Correlations were explored

with Pearson's product moment coefficients (r) for parametric data or Kendall's

tau coefficients (τ) for non-parametric data. Kendall's tau was used in preference

to Spearman's rho as it provides a more accurate estimation of the population

coefficient with smaller sample sizes (Howell, 2007), and it is more

straightforward to conduct partial correlations with Kendall's tau (Clark-Carter,

2010). Correlations were conducted two-tailed. Between-groups analyses were

conducted using two-tailed t-tests for parametric data or Mann-Whitney U tests for

non-parametric data, and Cohen's d effect sizes calculated. Cohen's (1988)

recommendations for classifying effect sizes of .2, .5, and .8 as small, medium and

large effects, respectively, were observed. Medians and ranges are presented in

place of means and SDs for non-parametric comparisons.

Predictive relationships were analysed using bootstrapped linear, multiple

regression modelling with bias-corrected and accelerated (BCa) 95% confidence

interval (CI) estimation. The bias-corrected bootstrap was selected as it is more powerful than other bootstrap methods (Fritz & Mackinnon, 2007).

Results

Demographics and Between-Groups Comparisons

Demographic analyses appear in Table 1. The groups were matched for age, education, premorbid intellectual function, and current mood self-report. The AD group performed at a consistently lower level on tests of cognitive ability, validating the distinction between the groups. The AD group generated significantly fewer episodic details compared to the control group. Mean group performance on each stage of the VAF task is shown in Table 2. The groups differed significantly on all measures of WM, and semantic fluency, total verbal fluency, but not phonemic fluency. With respect to AM tasks, the groups differed only on VAF3 and episodic details in VAF4.

[INSERT TABLE 1 ABOUT HERE]

[INSERT TABLE 2 ABOUT HERE]

Correlational Analyses

[INSERT TABLE 3 ABOUT HERE]

To reduce the likelihood of Type 1 errors, correlational analyses were limited to those required to test the *a priori* hypotheses and are presented in Tables 3 and 4.

Age was negatively correlated with episodic AM, indicating that with increasing age, the episodic detail of retrieved AMs decreased (Table 3). The only

significant relationship with a measure of mood was between anxiety and search for *general events* (VAF2), indicating that with increasing anxiety the ability to recall general events diminished (Table 3). With respect to the proposed components of the Constructive Model, there were significant, positive relationships between auditory WM and hierarchical search for life-periods, and between semantic fluency and episodic AM (Table 4). There were no significant relationships between measures of WM or phonemic fluency and episodic AM (Table 4).

[INSERT TABLE 4 ABOUT HERE]

Regression Analyses

To test the theory-based predictors of episodic AM, a hierarchical regression model was constructed with WM and verbal fluency scores entered first as theoretically-driven predictors of episodic AM (Table 5, Step 1). Age was subsequently introduced to the model as an additional predictor to assess any additional contribution to the variance as a potentially influential covariate (Table 5, Step 2). The first model accounted for approximately half of the variance in episodic AM (R_{adj}^2 = .52, $F[4, 12]$ = 5.09, p< .05), with the addition of age in the second model accounting for a further 13% (R_{adj}^2 = .13, $F[5, 11]$ = 7.08, $p < .01$). BCa 95% CIs for semantic fluency did not span zero in either model, and thus could be considered a predictor of episodic AM, with stronger semantic fluency predicting greater episodic AM, independent of age. Neither WM measures nor phonemic fluency could be considered independent predictors of episodic AM in this sample.

[INSERT TABLE 5 ABOUT HERE]

Discussion

This study sought to examine the relationship between verbal fluency and WM and the episodic content of retrieved AMs, as predicted by the Constructive Model (Conway & Pleydell-Pearce, 2000). Given the methodological shortcomings of previous studies investigating the relationship between executive functioning, WM and AM, the present study used an arguably more valid test of autobiographical memory (Piolino et al., 2010) than previously used with AD patients.

The significant, strong relationship between digit-span scores and search for general life-periods (VAF1) is consistent with previous, well-powered research (Coste et al., 2010; Piolino et al., 2010) that also demonstrated a relationship between a verbal WM measure and the VAF1 condition, but not other AM measures. However, the present study found no relationship between spatial WM and hierarchical search stages, which is in contrast to previous research in healthy ageing (Piolino et al., 2010) which found moderate to strong correlations with VAF2 and 3. Whilst this raises the possibility of a Type 2 error, it is also possible that hierarchical search for semantic content is primarily a verbal task, and so a relationship with spatial memory at this stage of the search process may not necessarily be expected.

There was only a trend for a moderate relationship between semantic fluency and the VAF1 condition. Previous research has found associations between auditory inhibition and hierarchical search (Piolino et al., 2010). This may reflect the fact that initiating the hierarchical search at the most general level requires

the most cognitive effort, after which access to relevant semantic knowledge becomes less demanding.

Multiple regression analysis supported the role of semantic fluency in retrieval of episodic AM, independent of age. It would be tempting to argue that the predictive value of semantic fluency for episodic AM was simply due to the nature of the AM task used here as a verbal fluency task itself. However, in an effort to control for total fluent response, episodic AM was calculated as a percentage of total episodic and semantic productions. Two further findings somewhat validate these efforts: firstly, phonemic fluency could not be considered a predictor of episodic AM independent of age; and secondly, the AD group generated significantly fewer episodic details compared to the control group and this effect was large.

One possible interpretation of this result is that it is necessary to continue to search the event-specific knowledge base and update the episodic buffer component of WM (Baddeley, 2000) during episodic re-construction (rather than all phenomenological details becoming available at once), and that weaker semantic fluency limits this process of hierarchical search. The results presented here are consistent with the staged search and retrieval approach advocated by the Constructive Model (Conway & Pleydell-Pearce, 2000), and other research demonstrating that semantic fluency is associated with MTL-facilitated episodic memory (e.g. Sheldon & Moscovitch, 2012), and over-general AM in the context of weaker executive function (Sumner et al., 2011). To further elucidate these links, future studies may benefit from examining the relationship between initiation of semantic search and episodic retrieval, as this could have important implications

for test selection in neuropsychological assessment and care approaches for those with episodic memory impairment.

Nevertheless, verbal fluency, WM, and age combined accounted for just under three quarters of the variance in episodic AM retrieval, suggesting that other processes may be important for episodic reliving. One potential candidate is medial-temporal lobe feature-binding which is impaired in AD (e.g. Parra, Abrahams, Logie, & Della Sala, 2010; Parra, Abrahams, Logie, Méndez, Lopera, & Della Sala, 2010). Furthermore, declining phonological and visuospatial WM associated with AD was not directly associated with the ability to retrieve episodic AMs in this sample, despite previous findings that WM capacity is related to strategic search of the event-specific knowledge-base (Unsworth et al., 2012). Indeed, the absence of significant relationships between spatial WM and episodic AM in this study was surprising given that mentally reliving events from the past appears to require holding spatial information in mind. This may support the notion that episodic AM is represented in the episodic buffer, as distinct from phonological or visuospatial stores per se, and therefore tasks measuring the latter stores will not be sensitive enough to detect such a relationship. The implication is therefore that the buffer itself, comprising parietal cortical networks (Vilberg & Rugg, 2008), is responsible for binding phenomenological details via search and retrieval (in contrast to recent evidence; Allen et al., 2012; Baddeley et al., 2011); or non-conscious MTL feature-binding (Pertzov et al., 2013) occurs prior to representation in the buffer. The use of more passive, short-term storage tasks to assess the relationship between WM and AM in this study may have meant it was not possible to capture the role of more active manipulation WM representations in

AM recollection. Future research might therefore include measures to determine whether spatial reliving is associated with more on-line, fluent retrieval and binding processes rather than short-term spatial storage.

Clinical Implications

The finding that episodic AM retrieval was predicted by semantic fluency rather than by phonemic fluency or WM suggests that memory training (e.g. internal strategies such as chunking, word-association, or spaced rehearsal for AMs) may not be particularly helpful in improving AM retrieval. This is consistent with the existing weak evidence for such interventions in dementia (Bahar-Fuchs, Clare, & Woods, 2013). It is possible that guided hierarchical search with external support could facilitate the generative retrieval process in those with weaker semantic fluency, thus scaffolding semantic search, and potentially increasing the episodic content of AM relative to what would occur otherwise. Such external support could include the use of structured life-story booklets (or electronic aids) that follow the hierarchical search strategy, collaboratively devised with people in the earlier stages of AD and their family members. It is possible that continued reference to a structured aid in this way over the course of neurodegenerative conditions might help maintain the efficiency of the working-self, and thus the person's sense of self and wellbeing for longer. Given the paucity of evidence for reminiscence therapy in dementia (Woods et al., 2005), a more structured format following the principles of generative retrieval and hierarchical search may help to increase the benefits received by those taking part, and lead to more consistent outcomes. This remains to be tested.

Methodological Considerations and Limitations

The relatively small sample presented here does necessitate that due caution is given to the interpretation of the results. To reduce the possibility of false positives and negatives, statistical tests were kept to the minimum required to test the specified hypotheses. In addition, the sample was controlled to the extent possible including age, education, premorbid intellectual ability, cultural background and other neurological and psychiatric history, which reduces the chance that the effects observed in this study were due to such confounding factors. The sample size precluded correlation analyses by group, which would be useful to look at in future research with a larger sample as different patterns of relationships have been found previously between AD and controls (e.g. Moses et al., 2004). It may be worth conducting a similar study to the present one with a larger sample to explore the more subtle relationships between WM and hierarchical search; however given that this study found several patterns of results consistent with previous, well-powered studies (e.g. Piolino et al., 2010), future studies will need to consider carefully how aspects of WM are assessed, as outlined above.

Coding of the VAF 4 task was carried out by the lead investigator, which meant it was not possible to blind to group status. Ideally, scoring of autobiographical responses should be blind to reduce bias; although there is a risk that the qualitative difference in response between AD and control groups (e.g. number of repetitions) can effectively unblind raters and thus blinding integrity can be difficult to maintain.

It is important to note the limitations of hierarchical regression approaches in an attempt to model cognitive theory. Whilst it attempts to statistically attribute predictive effects, it is not possible to infer causality from a correlational design.

Conclusion

To the best of the authors' knowledge, the present study is the first to examine the relative contributions of auditory and spatial WM, and phonemic and semantic fluency, to truly episodic AM retrieval in a sample of participants with AD and matched controls. Semantic fluency predicted truly episodic AM, independent of age effects. The results suggest that the ability to maintain a search of the semantic knowledge-base is necessary for episodic reliving, as opposed to phonemic fluency or WM span, and that therapeutic strategies could focus on providing external support for the fluent retrieval of semantic information to enable greater semantic and possibly episodic AM retrieval in those with AM impairments.

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Table 1.

Participant demographic and neuropsychological variables.

	AD	Controls	Test statistic	*p* value
n	10	10		
Age (years)	66.2 (11.1)	61.4 (11.8)	$t = .94$	.360
Education (years)	11 (10-16)	10.5 (7-21)	$U = 45.5$	.724
Neuropsychological tests				
WTAR FSIQ	97.7 (8.0)	100.4 (9.3)	$t = .70$	.496
MMSE /30	20.5 (13-26)	29.0 (25-30)	$U = 1.00$	.000
ACE-R /100	65 (48-77)	94.5 (69-99)	$U = 3.50$	.000
GNT Percentile*	32.4 (29.6)	69.0 (30.4)	$t = 2.65$	.017
LM1**	5.4 (3.3)	11.8 (3.1)	$t = 4.07$	.001
Mood scales (DASS 21)				
Depression	3 (0-20)	4 (0-30)	$U = 41.5$	.513
Anxiety	3 (0-10)	1 (0-18)	$U = 49.0$	.937

Stress	8.6 (7.6)	11.6 (12)	$t= .67$	.512

Notes.

Means (and standard deviations) are presented except where data did not meet

parametric assumptions, in which case medians (and ranges) are presented. Abbreviations:

AD = Alzheimer's disease; WTAR FSIQ = Wechsler Test of Adult Reading Full Scale

Intelligence Quotient); MMSE = Mini Mental State Examination; ACE-R = Addenbrooke's

Cognitive Examination – Revised; GNT = Graded Naming Test; LM1 = Logical Memory 1 first

recall scaled score; DASS = Depression Anxiety and Stress Scale.

*1 control missing data

**3 AD missing data

Table 2.

Performance on verbal fluency, WM, and verbal autobiographical fluency task by group.

	AD n = 10	Controls n = 10		
	Mean (*sd)*	Mean (*sd)*	Test statistic	Effect size (*d*)
Forwards Digit Span %ile[$]	19.00 (5-82)	57.20 (*25.73*)	*U* = 23.00*	1.16
Backwards Digit Span %ile	18.90 (*12.63*)	41.40 (*22.73*)	*t*(18) = 2.74*	1.22
Digit Span SS	7.10 (*1.29*)	10.50 (*2.68*)	*t*(12.95) = 3.62***+	1.62
Forwards Spatial Span SS	4.63 (*3.34*)	10.67 (*3.61*)	*t*(15) = 3.57**	1.74
Backwards Spatial Span SS	3.75 (*3.12*)	12.67 (*2.83*)	*t*(15) = 6.20***	3.00
Spatial Span SS[$]	3.00 (1-10)	11.56 (*3.47*)	*U* = 3.00**	2.57
Phonemic Fluency SS	4.60 (*1.17*)	5.40 (*1.35*)	*t*(18) = 1.41	0.63
Semantic Fluency SS	3.00 (*1.16*)	6.10 (*.99*)	*t*(18) = 6.43***	2.88
Verbal Fluency Total SS[$]	7.60 (*2.07*)	11.00 (7-14)	*U = 5.50**	2.23
VAF 1	6.60 (2.41)	8.80 (*2.62*)	*t*(18) = 1.96	0.87
VAF 2	4.20 (*2.30*)	6.10 (*2.23*)	*t*(18) = 1.87	0.84
VAF 3[$]	1.50 (1-9)	4.00 (3-8)	*U* = 23.50*	0.69
VAF 4 external (semantic) details	20.60 (*11.59*)	16.50 (*4.35*)	*t*(11.49)= 1.05+	0.47
VAF 4 internal (episodic) details	9.50 (*7.37*)	22.80 (*12.19*)	*t*(18) = 2.95**	1.32
VAF 4 Episodic AM	34.51 (*27.63*)	54.92 (*17.65*)	*t*(18) = 1.97	0.88

* p < 0.05, ** p < 0.01, *** p< .001; ⁺equal variances not assumed; [$] Median and range reported for Mann-Whitney U test; SS = scaled score

Table 3.

Pearson's and Kendall's correlation coefficients (two-tailed) between potentially confounding variables and autobiographical memory (AM) measures.

	VAF1	VAF2	VAF3	VAF4 Episodic AM
Age (years)	-.339	-.271	-.188 τ	-.653**
Education (years)	.031 τ	.162 τ	.126 τ	.130 τ
WTAR FSIQ	.408	.425	.193 τ	-.052
DASS-21 Depression	-.023 τ	.024 τ	.101 τ	-.124 τ
DASS-21 Anxiety	-.341 τ	-.366* τ	-.207 τ	-.161 τ
DASS-21 Stress	-.097 τ	-.237 τ	-.012 τ	.082 τ

Notes.

Abbreviations: VAF = Verbal Autobiographical Fluency; WTAR FSIQ = Wechsler Test of Adult Reading Full Scale Intelligence Quotient; DASS = Depression Anxiety and Stress Scale.

*p<.05; ** *p< .01; τ = Kendall's tau coefficient

Table 4.

Pearson's and Kendall's correlation coefficients between the autobiographical memory

task, verbal fluency and working memory measures

	Phonemic Fluency	Semantic Fluency	Digit-Span Total	Spatial-Span Total [+]
VAF1	.33	.41	**.45***	.20
VAF2	.12	.41	.40	.28
VAF3 [τ]	-.12	.27	.34	.08
VAF4 Episodic AM	.26	**.49***	.20	.19

Note. * $p < .05$; [+] AD group missing data n=3; Abbreviations: VAF = Verbal Autobiographical Fluency; AM = Autobiographical Memory; [τ] Kendall's tau coefficients presented in this row

Table 5.

Regression coefficients for predictors of VAF4 episodic AM with bias-corrected and accelerated 95% confidence intervals (BCa CIs).

						BCa 95% CI	
Step 1	R_{Adj}^2	ΔR^2	**b**	**S.E.[+]**	**β**	**Lower**	**Upper**
Phonemic Fluency			5.90	3.92	.36	.00	11.46
Semantic Fluency			11.02	3.76	.98*	2.23	21.31
	.51	-					
Spatial Span			-2.34	1.56	-.54	-5.40	-.14
Digit Span			-2.70	2.02	-.35	-7.63	3.45
Step 2							
Phonemic Fluency			4.56	5.92	.28	-3.33	14.51
Semantic Fluency			8.62	5.24	.77	1.79	23.98
Spatial Span	.76	.13	-2.01	1.61	-.47	-6.38	.49
Digit Span			-1.94	2.11	-.25	-6.23	2.41
Age			-.85	.80	-.41	-1.91	1.28

* $p < .05$; [+]Based on 1000 bootstrap samples