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



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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.

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1. Introduction

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 et al., 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 and 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 et al., 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; Dagleish et al., 2007; Ros et al., 2010). Furthermore, Unsworth et al. (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.

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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 and 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 and Kensinger, 2010), the evidence for reminiscence or AM interventions in AD is weak (Woods et al., 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 and 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 et al., 2004); with only episodic AM (Greene et al., 1995); with both semantic and episodic AM (Sartori et al., 2004); or not at all (Ivanoiu et al., 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 and 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 knowledge base 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.

2. 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.

3. Method

3.1. 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.

3.2. 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.

3.3. Materials

3.3.1. 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.

3.3.2. Verbal fluency

The verbal fluency subscale of the Addenbrooke's Cognitive Examination-Revised (ACE-R; Mioshi et al., 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 s. 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 and Brandt, 1996), including similar test-retest reliability to

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