A short cut to the past: Cueing via concrete objects improves autobiographical memory retrieval in Alzheimer's disease patients

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Abstract

Older adults diagnosed with Alzheimer's disease (AD) have difficulties accessing autobiographical memories. However, this deficit tends to spare memories dated to earlier parts of their lives, and may partially reflect retrieval deficits rather than complete memory loss. Introducing a novel paradigm, the present study examines whether autobiographical memory recall can be improved in AD by manipulating the sensory richness, concreteness and cultural dating of the memory cues. Specifically, we examine whether concrete everyday objects historically dated to the participants' youth (e.g., a skipping rope), relative to verbal cues (i.e., the verbal signifiers for the objects) facilitate access to autobiographical memories. The study includes 49 AD patients, and 50 healthy, older matched control participants, all tested on word versus object-cued recall. Both groups recalled significantly more memories, when cued by objects relative to words, but the advantage was significantly larger in the AD group. In both groups, memory descriptions were longer and significantly more episodic in nature in response to object-cued recall. Together these findings suggest that the multimodal nature of the object cues (i.e. vision, olfaction, audition, somatic sensation) along with specific cue characteristics, such as time reference, texture, shape, may constrain the retrieval search, potentially minimizing executive function demands, and hence strategic processing requirements, thus easing access to autobiographical memories in AD.

Keywords: Autobiographical memory; episodic memory; Alzheimer's disease; object-cueing; multimodal cueing

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1. Introduction

Autobiographical memory--the ability to remember the personal past--is a multifaceted cognitive, social and motivational system crucial to many aspects of everyday functioning (e.g., Bluck, et al., 2005; Pillemer, 2003). Impairment to autobiographical memory is an early and central deficit in Alzheimer's disease (AD) that affects many areas of life. Besides guiding and directing behavior, autobiographical memory is the cornerstone of social interaction (e.g., Nelson & Fivush, 2004) and enables and helps to maintain relationships with significant others through sharing important and self-relevant information about oneself. Autobiographical memory is furthermore central to the subjective sense of identity, as it facilitates a sense personal continuity and familiarity with the past (Bluck & Alea, 2008; Conway, 2005; Klein, 2010; Prebble et al., 2013). Consistently, autobiographical memory impairment in AD has been associated with a weakened sense of self, as well as identity impairments (Addis & Tippett, 2004; Fargeau et al., 2010; Jetten et al., 2009).

Here we examine whether concrete everyday objects that are historically dated to the participants' youth (e.g., a skipping rope), relative to verbal cues (i.e., the verbal terms for the objects) allow easier access to autobiographical memories in older adults diagnosed with AD and thus may serve as a viable therapeutic technique for stimulating autobiographical memory retrieval in this population. In the following, we provide a theoretical motivation for this new method of facilitating autobiographical remembering in dementia.

1.1. Autobiographical memory impairment in dementia

AD is associated with progressive neurodegeneration in brain areas that overlap greatly with the extensive neural network involved in AM, such as the medial temporal lobes, and other regions associated with the default network, including the precuneus and posterior cingulate (e.g. Addis et

al., 2009a; Buckner et al., 2008; Budson & Price, 2005; Rugg & Vilberg, 2014; St. Jaques, 2012; Sperling et al., 2010; Svoboda et al., 2006; Vilberg & Rugg, 2012).

However, the memory impairments associated with this neurodegeneration tend to vary with the age of the memories. Several studies have shown that memories for remote events are more accessible than recent ones in in dementia, including AD (Barnabe et al., 2012; De Simone et al., 2015; Graham and Hodges, 1997; Greene et al., 1995; Kopelman, 1989, 1992; Leyhe et al.,2009; Piolino et al., 2003; Thomas-Antérion et al., 2000). Still, some have failed to replicate these findings (e.g. Addis et al., 2009b; Irish et al., in this issue) or find support limited to the semantic aspects of the memories (e.g., Addis & Tippett, 2004; Ivanoiu et al., 2004; Ivanoiu et al., 2006; see El Haj et al., 2015 and Kopelman & Bright, 2012, for reviews).

These mixed findings may reflect the use of different measurements. For example, some studies have used raw memory frequencies and some measures of content and memory details as their dependent variables. It is beyond the scope of the present article to provide a thorough review. However, overall, the findings support the position that memories for remote, relative to recent, events are relatively spared in AD, at least with regard to the semantic content (for a recent review, see El Haj et al., 2015). This position is also consistent with a different research literature, namely research on the reminiscence bump in autobiographical memory, which refers to a dominance of autobiographical memories from adolescence and young adulthood relative to surrounding periods (Koppel & Berntsen, 2016; Rubin et al., 1986), when middle-aged and older adults are cued by words or freely produce memories sampled from across the life span. Although its exact location varies with cueing methodology, the reminiscence bump is a robust finding in autobiographical memory research (Koppel & Rubin, 2016), and has been found also in individuals with dementia (Fromholt & Larsen, 1991; Fromholt et al., 2003). See also Bonnici and Maguire (this issue) for time related changes in the neural underpinnings of individual memories.

It is also well-established that autobiographical memories in AD, overall, are more general and semantic in nature, devoid of the specificity and episodic richness that usually characterizes autobiographical remembering (Barnabe et al., 2012; Irish et al., 2011; Ivanoiu et al., 2006; Piolino et al., 2003; Seidl et al., 2011). This shift from specific to more generalized memories is observed with healthy, older adults as well, although less markedly so (Piolino et al., 2010; Piolino et al., 2006), and is generally thought to reflect that memories become more semanticized due to factors such as the passage of time and the reoccurrence of similar events. In AD, other factors, such as neurodegeneration in the hippocampal formation and surrounding areas, likely add to the semanticization.

1.2. Verbal versus non-verbal cuing of autobiographical memories

Although often overlooked, autobiographical memory recall in everyday life is initiated not only in a top down fashion in response to verbal stimuli, but may also occur spontaneously in response to external cues in our environment, such as specific individuals, objects, locations and activities (Berntsen, 1996, 2009). Research has demonstrated that multisensory stimuli activate a larger neural network relative to unisensory stimuli (Shams & Seitz, 2008), which suggests that multisensory cueing, relative to verbal cueing, may contribute to additional spreading activation in underlying associative networks. As one of the hallmarks of AD is significantly impaired signal transmission due to the loss of connections between neurons (Budson & Solomon, 2016), the ability of sensory-perceptual cues to engage extended neural networks, as opposed to, for instance, verbal stimuli, may benefit this population.

Only relatively few studies have examined the effects of sensory-perceptual cuing on autobiographical recall. This research has mainly focused on healthy adults and the effects of olfactory cues. There is evidence that olfactory cues activate earlier memories (e.g., Chu & Downes, 2002; Willander & Larsson, 2006; see Koppel & Rubin, 2016, for a review). Studies have

also demonstrated that memories retrieved in response to olfactory cues are associated with more emotion and a greater feeling of being brought back in time, relative to visual and verbal cues (Cady et al., 2008; Herz & Schooler, 2002; Willander & Larsson, 2006; but see Goddard et al., 2005; Rubin et al., 1984). In spite of such advantages, olfactory cues may be less ideal in the AD population due to impaired odor identification (Velayudhan, 2015).

Within the dementia population, surprisingly few studies have examined the effects of nonverbal stimuli as a means of cueing autobiographical remembering. Together these studies demonstrate that AD patients, despite the widespread loss of cognitive abilities, appear to benefit from nonverbal cues. Work by El haj and colleagues (El Haj et al., 2012a, 2012b) demonstrated that cueing AD patients with music, preferably music of personal significance to the rememberer, improved recall of autobiographical events. Autobiographical memories elicited in response to such music were more specific, and more emotional, relative to memories evoked in silence. Interestingly, the music-cued memories were also retrieved faster, suggesting that specific musical cues may have engaged less effortful (more spontaneous) retrieval. Although it remains uncertain as to how music exerts influence on autobiographical recall, mood improvement and anxiety reduction have been suggested as viable mechanisms (El Haj et al., 2012b; Foster & Valentine, 1998, 2001; Irish et al., 2006).

Using a museum context, Miles et al. (2013) demonstrated that older adults with dementia showed improved autobiographical remembering when situated in a historically authentic environment that recreated the material and cultural context of the participants' youth as compared with being in a modern surrounding. In both conditions, the participants were presented with concrete objects matching the context (i.e., old-fashioned objects in the historical context and contemporary objects in the modern context, such as an old-fashioned versus a modern telephone). Results demonstrated that memories retrieved in response to objects matching the time period of the

participants' younger years were both quantitatively and qualitatively different, that is, more elaborated, spontaneous and episodic in nature, relative to condition matched cues of modern items from the recent past. Miles et al. proposed that the multi-sensory, environmental cues matching early memories provided additional retrieval support that may have reduced the demands of strategic retrieval, and hence reduced the need for top-down control. This may have allowed the participants to retrieve more specific autobiographical memories.

These findings are in line with theoretical models proposing two routes to autobiographical memory recollection, an involuntary (direct) route and a voluntary (intentional) route. The involuntary route is an automatic, bottom-up retrieval form, where a sufficiently distinctive cue triggers a memory through spreading activation in the associative autobiographical network. The voluntary route is a top-down strategic retrieval form that draws on higher-order cognitive functions and is less context sensitive (Berntsen, 1996; 1998; 2009; Conway & Pleydell-Pearce, 2000; Moscovitch, 1995).

Neuroimaging studies (Hall et al., 2014; Kompus et al., 2011) have demonstrated that voluntary autobiographical memory retrieval engages more prefrontal regions relative to involuntary retrieval, indicating that the two routes of autobiographical recall tax executive functioning differently (see Addis et al., 2012; Hall, Gjedde & Kupers, 2008, for similar findings). In a series of studies, Berntsen and colleagues (e.g., Berntsen, 1996, 1998; Berntsen & Hall, 2004) have demonstrated that salient everyday features, such as objects, other people, activities, and themes, can be highly potent triggers of autobiographical memories. This research has also demonstrated that, as a proximal cue increases in distinctiveness and specificity in relation to the stored event, (i.e. increase in cue-item-discriminability, Rubin, 1995), the more likely it is to facilitate involuntary memory retrieval (Berntsen et al., 2013). Because it is relatively effortless, involuntary recall may be less affected by executive deficits in AD (e.g., Bäckman et al., 2005;

Grober et al., 2008; Perry et al., 2000). In contrast, the voluntary route involves a cyclic search process (Conway & Pleydell-Pearce, 2000; Norman & Bobrow, 1979), critically dependent on executive control structures to constrain and restrict top-down processing, (e.g., Alvarez & Emory, 2006; Henry et al., 2004), for which reason executive deficits in the AD population may hamper autobiographical memory access.

1.3. The present study

The present study combines insights from autobiographical memory and dementia research. First, it builds upon research showing that remote memories tend to be better preserved than recent memories in individuals with dementia. Second, it incorporates the finding that non-verbal cues may be beneficial for facilitating memory retrieval in dementia, by activating larger neural networks. Third, it draws upon research with healthy adults showing that involuntary (unintentional) recall in response to distinctive cues takes place with little executive involvement. It combines these three elements into a unique research program, in which concrete objects with a clear reference to the earlier parts of the participants' lives are used as memory cues.

We use concrete objects as memory cues for the following reasons. First, they can be selected to have a clear and historically documented address to specific time periods, and thus can be chosen to match the earlier parts of the participants' lives from which the participants are expected to retain most memories. Second, handling objects may involve all senses, including vision, audition, olfaction and the tactile sense; thus, also senses whose mnemonic abilities have been left largely unstudied in dementia. Third, in nursing contexts for older adults with dementia, handling old objects are often used as part of reminiscence activities, but the effects on autobiographical memory retrieval have not been examined systematically, relative to verbal cueing.

We expect that the multimodal nature of the object cues (i.e. vision, olfaction, audition,

somatic sensation) along with specific cue characteristics, such as time reference, texture, color, shape, will all contribute to constraining the retrieval search, potentially minimizing executive functioning requirements, thus easing access to autobiographical memories in a sample of older adults diagnosed with AD. We therefore predict better performance in response to object cues than in response to verbal cues (nouns designating the same objects). An advantage of object cues is also expected in a control group of healthy older adults, but likely to a lesser extent.

2. Method

2.1. Participants

Figure 1 provides an overview of the recruitment and screening of the participants. The final sample consisted of forty-nine participants (35 women, 14 men) diagnosed with AD and 50 healthy, older control participants (HC) (27 women, 23 men)[1]. The two groups did not differ significantly with regard to age and years of formal education (Table 1). One AD participant was excluded from the final analyses, due to confabulation.

All AD patients had received a formal AD diagnosis prior to the study, entailing a thorough examination by a specialized dementia unit at a hospital clinic, based on the international guidelines by the National Institute on Aging and Alzheimer's Association clinical criteria (McKhann et al. 2011). Screening for participation in the present study included assessment on the Global Deterioration Scale (GDS; Reisberg et al., 1982) in order to establish level of global impairment, with 14.3 % of the AD patients demonstrating mild dementia, and 85.7 % moderate dementia, M = 3.98, SD = 0.52, range = 3 – 5. Exclusion criteria for both groups involved history of substance

[1] After completing the present study, all AD participants were furthermore included in a prospective study that included a more extensive test battery not limited to the measures included in the present study. The participants were screened to ensure that they could participate in both studies. This also affected the exclusion criteria. Participants were excluded if; 1) they were assessed too fragile to attend a 5-weeks programme, or 2) the AD patient or the carer simply declined participation due to the logistics of participating in the study. Other common reasons for exclusion included communication or comprehension difficulties, significantly impaired vison/ hearing, history of psychiatric/ neurological disorder, substance abuse, comorbidity of vascular dementia

abuse, severe head injury, any other major psychiatric disorders or substantial vision or hearing disability. Exclusion criteria for the HC participants also included signs of dementia as indexed by a score of 26 or below on the Mini Mental State Examination (MMSE; Folstein et al., 1975). Use of antidepressants and medication used to treat AD was not an exclusion criterion.

AD patients were recruited through the assistance of social workers in charge of coordinating regional activities in relation to dementia, who facilitated the initial contact to patients and their primary caretakers. HCs were recruited from Aarhus University's own participant database as well as through seniors' organizations. Ethical approval was obtained from The Central Denmark Region Committees on Health Research Ethics, and each participant, AD patients in the presence of their primary caretaker, gave informed consent to participate in the study. Participants received a 150 DKK gift voucher or an organized trip to a local museum upon completion of the study in return for their participation.

2.2. Materials

2.2.1. General neuropsychological assessment

A battery of neuropsychological measures was used to assess overall level of dementia, cognitive functioning, executive functioning and depressive symptoms (see Table 1). In order to assess overall cognitive ability, participants were administered the Addenbrooke's Cognitive Examination (ACE; Mathuranath et al., 2000), which includes the MMSE (Folstein et al., 1975). Both measures are effective and extensively used screening tools for dementia, where high scores indicate normal cognition. To assess level of dementia, participants were also assessed on the Global Deterioration Scale (GDS; Reisberg et al., 1982) that orders the progression of dementia into seven distinct prototypical categories with scores from 1 – 3 reflecting the pre-dementia stages, and scores from 4-7 indicating mild to severe dementia. Participants were screened for depressive symptoms with the Geriatric Depression Scale (GDS; Brink et al., 1982) consisting of 15 items on a

self-report scale that can be answered with a yes or no in reference to how the respondent felt over the past week. Scores below 5 are considered normal with higher scores being indicative of depression. To assess executive functioning, participants were tested on phonemic and semantic fluency, i.e. verbal letter (S) and category (animals) fluency, respectively (Lezak et al., 2012), as well as digit span forwards and backwards (Wechsler, 2009).

2.2.2. Word- and object-cued recall task.

The present study introduces a new autobiographical memory task, developed by the authors, that uses concrete objects to cue retrieval from autobiographical memory. This task is molded over the structure and procedure of the standard cue word task for autobiographical memory retrieval in which participants are presented with concrete nouns and asked to retrieve a memory in response to each one (Crovitz & Shiffman, 1974). Similarly, in the object-cueing task, participants were presented with concrete objects (e.g. a skipping rope, a bottle of perfume, a package of cigarettes) and required to respond with the first personal memory that came to mind. Participants' performance in this condition was compared with their performance in a word-cued recall condition where participants were presented with the verbal labels of concrete objects (e.g. the word "skipping rope").

All object cues had been carefully selected, in collaboration with two historians, who specialize in 20th century history, to match the time-period from which the participants' memories were assumed to be best preserved, that is, from when they were children or young adults. All object cues were evaluated through thorough pilot testing in order to ensure that the stimuli were sufficiently relevant and distinctive to a broad range of participants, varying in age, gender, geographical, and socio-economic backgrounds.

Each participant was presented with 10 cues in total, that is, five words and five objects presented in two blocks, respectively. As the design involved a within-subjects manipulation, the

order of presentation of the two recall conditions were counterbalanced. The cues for each participant was drawn from a pool of 20 objects and their verbal signifiers (see Appendix) that were counterbalanced and matched across participants and conditions to ensure that each participant was never presented with a word and object cue that matched, e.g. the word "skipping rope" and the object of a skipping rope.

2.2.2.1. Procedure for word- and object-cued recall

Standardized interview protocols ensured that the interviewers adhered to a strict script with a minimum of flexibility in the wording of questions or prompting during the recall tasks. In the object-cued condition, participants were presented with concrete objects (e.g. a skipping rope, perfume, cigarettes) that they were invited to explore with their hands and senses. In the word-cued recall condition, word cues were presented in black font, size 36, on a 210 x 297 mm (8.3 x 11.7 in) white card.

Participants were presented with one cue at a time. All cues, irrespective of modality of cueing, were overtly named by the interviewer, that is, verbal cues were read out and objects named, and remained visible to the participant throughout each trial. This was done in order to reduce attentional demands and to ensure that participant did not forget the cue during testing, and furthermore prevent potential reading impairments from affecting the task.

On each trial, participants were presented with an object or a word card, and were then instructed to recall an event from their life. Consistent with the cue word method, participants were explicitly told that their memory did not need to relate directly to the word or object, but they could report any memory that came to mind in response to the cue. They were also instructed that the cue might not necessarily elicit a memory or a response at all, which was completely acceptable. If no memory was recorded, the interviewer simply would proceed to the next cue. Interviewers were required to offer three prompts in relation to each cue in order to ensure that the participants stayed

on task. Prompts included asking participants if they could provide more details, elaborate on the recalled information, and recall a specific day, or time, of the event. The latter prompt was mandatory if the participant did not provide a specific event by themselves, and was always provided at the end of the memory report. There was no time limit on the recall task. All recall sessions were audio recorded in order to allow transcription and scoring.

2.2.2.2. Scoring of data

Based on the verbatim transcriptions created from the audio recordings, two raters, blind to condition and group, segmented and coded the content into a total of 1274 units. A unit was defined as a unique piece of narrative, with a clear beginning and end, and no thematic overlap between separate units.

2.2.2.2.1. Frequency of units retrieved in response to object- and word-cued recall

A maximum of one memory per cue was included for subsequent statistical analysis. Thus, the range in frequency varied from 0 to 5 units per cue modality (i.e., from no memory to five memories in response to the five word or object cues). In order for a unit to be counted as a memory, it had to refer to an event of personal relevance, that is, units that simply provided general information were assigned a 0 score. Within the AD patient group, 33.16% of all units (words: 41.28 %; objects: 25.17 %) were purely general in nature or indicated an absence of an answer (i.e. obtained a score of 0), relative to 8.91 % in the HC group (words: 10.28 %; objects: 7.56 %).

2.2.2.2.2. Episodic content of object- and word-cued memories

In order to examine the episodic content of the reported memories, all units were separately coded, and scored according to a rating scale developed by Piolino et al. (2002) that extends the episodic memory score from the Autobiographical Memory Interview (Kopelman et al., 1990) scoring the degree of detail and specificity of the recalled events. The scale consists of seven different scores that range from an absence of an answer to providing a specific event with a high

degree of detail; 0 = *Absence of an answer or general information*, 0.5 = *Vague personal impression*, 1 = *Vague event /repeated or continuous with little details of time and space*, 1.5 = *Generic event (repeated or continuous situated in time and space*, 2 = *Detailed generic event (repeated or continuous, situated in time and space)*, 2.5 = *Specific event (isolated, situated in time and space) without details, and* 3 = *Specific event (isolated in time and space) with details (thoughts, emotions, images etc.).* Thus, lower scores are indicative of semanticized and decontextualized information, whereas higher scores reflect more episodic and autobiographical recall with a high degree of episodic content, that is, specificity and a high degree of details, such as emotions, thoughts and images. If a participant reported more than one memory unit in response to a given cue, the memory with the highest episodic score (range; 0 to 3) was subsequently entered for statistical analysis. Data were scored by the first author and a research assistant who were blind to group and cueing condition. An interrater reliability analysis using the Kappa statistics was performed to determine consistency among raters, demonstrating high levels of agreement (r = .83, p < .001) (Landis & Koch, 1977).

2.2.2.2.3. Description length of object- and word-cued memories

Description length was indexed by the total word count calculated for the verbatim transcripts generated in response to each cue. Thus, description length was not calculated per unit, but rather for the total amount of words produced in response to each cue.

2.3. Procedure

Testing was carried out by trained psychologists or advanced research assistants. With the exception of a few HC participants who preferred the interview to be conducted at the research center, testing was conducted in the home of the participants.

Participants were assessed on overall cognitive ability (i.e., MMSE and ACE), executive functioning (fluency tasks, and digit span), level of dementia and depressive symptoms prior to the

word- and object-cued autobiographical memory task. Assessments were carried out in a set order with the more cognitively demanding tasks at the beginning, and the recall task at the end of the session in order to prevent exhaustion. Rest breaks were provided through the session when necessary.

2.4. Data Analysis

First, data from the word- and object-cued memory recall task were processed using a 2 × 2 (Group [AD, HC] × Cueing [words, objects]) mixed-design analysis of variance (ANOVA). These analyses were conducted on: 1) the frequency data, that is, the mean number of memories recalled in response to the five cues in each condition (range: 0 to 5 memories for each cue modality), 2) episodic content, that is, the mean episodic score of the five reported memories (7-point rating scale; minimum = 0 and maximum = 3), and, 3) description length (i.e. mean word count generated in response to each cue). Second, we conducted a series of follow-up analyses, including bivariate correlation analyses to assess associations between memory performance (i.e. frequency, episodic content, and description length) and executive functioning (word fluency, digit span), as well as analyses of co-variance (ANCOVAs) with the fluency meaures in order to examine whether controlling for executive functioning would eliminate cueing effects. Additional ANOVAs were conducted to examine whether disease severity impacted on overall performance on the three outcome measures.

3. Results

The results are presented in the following order. First, we examine groups differences on neuropsychological measures. Second, effects of group and cueing are examined for the three key memory performance measures. Third, follow-up analyses examine the influence of executive functioning and disease severity on word- and object-cued recall.

3.1. Background Neuropsychological Examination

The AD group performed at a significantly lower level on tests of cognitive ability as demonstrated by the MMSE and the ACE scores in Table 1, validating the distinction between the two groups. The AD patients were also significantly impaired on executive functioning (i.e. word fluency and digit span) as demonstrated by the low fluency and digit span scores relative to the HC group. Results indicated higher levels of depressive symptoms in the AD group, relative to the HC group. However, with a mean score of 2.94 (*SD* = 2.01), this is still considered within the normal range of the Geriatric Depression Scale, where only scores above 5 points are indicative of depression (Reisberg et al., 1982).

3.2. Object versus Word-Cued Autobiographical Memory Recall

We report findings on the effects of cueing on three dependent variables: frequency, episodic content and description length.

3.2.1. Frequency of units retrieved in response to object- and word-cued recall

In order to examine how word versus object cues might differ in terms of their ability to facilitate access to autobiographical memories, we examined whether the mean frequencies of cues leading to successful retrieval differed between the two conditions and in the two groups. As expected, the main effect of group was significant, $F(1, 97) = 42.82$, $p < .001$, $\eta\rho^2 = .31$, demonstrating that the HC group reported a significantly higher number of events compared with the AD patients, see also Figure 2A. The main effect for cueing was also significant, $F(1, 97) = 29.63$, $p < .001$, $\eta\rho^2 = .23$, indicating that participants overall, irrespective of AD diagnosis, recalled a significantly higher number of events, when they were cued by objects as opposed to words. The interaction between cueing and group furthermore reached significance, $F(1, 97) = 9.50$, $p = .003$, $\eta\rho^2 = .09$, suggesting that although cueing by objects, relative to words, led to increased recall of memories in both groups of participants, object-cueing benefitted recall in the AD group

more so. As illustrated in Figure 2A, the AD group on average retrieved 27.57 % more memories when cued by objects, as opposed to words, $t(48) = -5.66$, $p < .001$, d = .81, relative to a modest and non-significant increase of 5.88 % in the HC group, $t(49) = -1.79$, $p = .079$, d = .27, see Figure 2A.

Limiting the frequency count to a maximum of one memory per cue, potentially resulted in a ceiling effect for the control group, which could have driven the interaction effect. In order to control for this potential problem, an additional ANOVA was conducted with the total number of memories retrieved in response to the five cues as the dependent variable (see supplementary material for details on the frequency distribution).

We adjusted the frequency count with a square root transformation due to the open-ended nature of the response format, and hence large variation in scores (cf. Osborne, 2002; Tabachnick and Fidell, 2001). Results revealed main effects for cueing, $F(1, 97) = 31.49$, $p < .001$, $\eta\rho^2 = .25$, and group, $F(1, 97) = 32.83$, $p < .001$, $\eta\rho^2 = .25$. Importantly, the interaction effect remained significant $F(1, 97) = 4.54$, $p = .036$, $\eta\rho^2 = .05$, replicating the results of the original ANOVA, and establishing that the observed effect in the original analysis was not an artifact of a ceiling effect. Consistent with this interaction effect, the descriptive results[2] again showed a pronounced difference in the relative advantage of the object cues within the two groups, with the AD group reporting 29.86 % more memories in response to objects versus words (AD: $M_{words} = 2.96$, $SD = 2.05$, range = 0 – 10; $M_{objects} = 4.22$, $SD = 2.32$, range = 1 – 10) relative to 10.74 % more in the HC group ($M_{words} = 5.82$, $SD = 2.70$, range = 0 – 13; $M_{objects} = 6.52$, $SD = 2.75$, range = 2 – 17).

3.2.2. Episodic content of object- and word-cued memories

In order to examine whether object versus word-cueing yielded differences in the degree of episodic content, that is, specificity and details (e.g., thoughts, images, and emotions), we examined how the episodic content scores varied as a function of group and cueing. As expected, memories

[2] The descriptive statistics are presented as untransformed means and standard deviations

recalled by the HC participants in response to both types of recall overall scored significantly higher in terms of episodic content, $F(1, 97) = 47.40$, $p < .001$, $\eta\rho^2 = .33$ (Figure 2B). As also shown in Figure 2B, both groups of participants recalled memories with a significantly higher degree of episodic content when cued by objects as opposed to words, $F(1, 97) = 21.15$, $p < .001$, $\eta\rho^2 = .18$. Although Figure 2B illustrates a seemingly larger increase in episodic content between word- and object-cued recall for the AD group, the interaction between cueing and group did not reach significance, $F(1, 97) = 2.90$, $p = .092$, $\eta\rho^2 = .03$.

3.2.3. Description length of object- and word-cued memories

Word counts were calculated in order to examine the effects of object versus verbal cueing on the description length of the reported memories. As demonstrated in Figure 2C, the HC group on average produced significantly more words for both types of recall compared with the AD group, $F(1, 97) = 9.70$, $p = .002$, $\eta\rho^2 = .09$. There was a significant main effect for cueing, $F(1, 97) = 5.41$, $p = .022$, $\eta\rho^2 = .05$, showing that description length significantly increased in both groups when cued by objects rather than words. The interaction between cueing and group was nonsignificant, $F(1, 97) = 1.09$, $p = .298$, $\eta\rho^2 = .01$, suggesting that the two groups benefitted equally from object cueing in terms of increased description length.

3.4. Follow-up analyses examining the influence of executive functioning and disease severity on object- and word-cued recall

Follow-up analyses, including bivariate correlations and ANCOVAs, were conducted in order to examine the influence of executive functioning on object- and word-cued recall. Further ANOVAs were computed to assess if the main findings interacted with level of cognitive impairment within the AD group. (See Supplementary Materials for related analyses within the group of HC participants).

3.4.1. The influence of executive functioning on object- and word-cuing

Correlational analyses and ANCOVAs were conducted in order to explore whether the abilities in executive functioning were related to performance on memory recall in the AD group. Bivariate Pearson correlation coefficients were computed to assess the relationship between memory performance (i.e. frequency, episodic content, and description length) and executive functioning (word fluency and digit span). Measures of digit span forwards and backwards yielded no significant associations with any of the three outcome measures, all *p*s > .236. Semantic and phonemic fluency were analyzed for associations with frequency, episodic content, and description length. Only semantic fluency was significantly and positively associated with memory frequency for the AD patients in the object-cued recall condition, (r = .43, p = .002), all other associations were non-significant, all *ps* > .054.

The correlational analyses do not clarify whether the advantage of object cues relative to word cues was related to executive functioning. In order to examine whether executive functioning impacted on the observed advantage of object relative to verbal cues, phonemic and semantic fluency were entered as covariates in analyses of covariance. The two measures tap several of the same executive control processes (e.g. self-monitoring, suppression, self-initiation; e.g. Azuma, 2004; Henry et al., 2004). However, poor performance on semantic fluency has furthermore been associated with degradation of the semantic store (Henry et al., 2004; Henry & Crawford, 2004). We therefore conducted two separate series of ANCOVAs, one controlling for semantic and one controlling for phonetic fluency within each group.

As demonstrated in Table 2, ANCOVAs conducted for the AD group with semantic fluency as a covariate yielded non-significant main effects for cueing with respects to frequency, episodic content, and description length, suggesting that semantic search ability influenced the observed differences between modality of cueing. When examining the unique influence of semantic fluency, a significant effect was found for frequency and episodic content, but not description length.

Introducing phonemic fluency as a covariate in the ANCOVAs also eliminated the significant main effects of cueing for frequency, episodic content, and description length. However, phonemic fluency was not significantly related to any of the three outcome measures.

A similar pattern emerged in the HC group, where separate ANCOVAs performed on the three dependent outcome measures with semantic and phonemic fluency as covariates, also yielded non-significant main effects for cueing with respects to frequency, episodic content, and description length. When examining the influence of semantic and phonemic fluency on the three dependent variables, phonemic fluency was significantly related to description length (Table 2).

Overall, examining the influence of semantic and phonemic fluency on memory recall, demonstrated that the positive effect of object- relative to word cues on memory frequency, episodic content and description length was eliminated in both groups. This suggests that strategic search ability, and possibly access to semantic representations, explained a substantial part of the variance in the observed differences between the word- and object-cueing, consistent with our expectations that object-cueing is advantageous in part by reducing the demands for executive processes.

3.4.2. Alzheimer's disease severity and object- and word-cued recall

As demonstrated in Table 1, the average ACE score of 55.96 (SD = 13.91; range 20-87) in the AD group was relative low, indicating a moderately to severely impaired sample. In order to examine whether disease severity impacted on overall performance on word- and object-cued recall, the AD patients were divided into two separate groups based on a median split; AD low (ACE ≤56) versus AD high (ACE ≥57). Separate ANOVAs were then conducted on the three dependent measures (frequency, episodic content, word count) with object versus word cues as a repeated measures factor and group (AD low versus AD high) as a between-subjects factor. In line with the main analyses, the results demonstrated significant main effects for cueing with respect to

frequency, $F(1, 47) = 34.16$, $p < .001$, $\eta\rho^2 = .42$, episodic content, $F(1, 47) = 15.60$, $p < .001$, $\eta\rho^2 = .25$, and word count, $F(1, 47) = 5.01$, $p = .030$, $\eta\rho^2 = .10$. Importantly the main effects for group, and the interactions, were all non-significant, $ps > .066$. Thus, the results indicated that cueing by objects was advantageous to AD patients, both for individuals with higher and lower levels of cognitive impairment as measured by the ACE.

4. Discussion

The present study investigated whether concrete objects historically dated to the youth of older adults diagnosed with AD allowed easier access to their autobiographical memories, relative to verbal cues, designating the same objects. The results demonstrated that AD patients reliably benefitted from object-cued recall relative to word-cued recall. Both AD patients and age-matched HCs recalled significantly more memories that were more detailed and elaborative, when cued by objects than by words, but the advantage was relatively larger in the AD group.

Together, these findings suggest that object cues may constrain the retrieval process, likely minimizing top-down strategic processing demands, thus easing access to autobiographical memories in AD. In the following we discuss in greater detail the different, but most likely complementary, mechanisms that may drive the observed effect of object-cueing.

First, object-cueing may offer easier access to semantic knowledge through means of recognition upon seeing the object, which then, through spreading activation, may stimulate autobiographical knowledge. This can be seen as consistent with our finding that controlling for semantic fluency diminished the advantage of object-cueing in the AD group and significantly accounted for variance in the outcome measures. This may suggest that object-cueing compensates for some deficits in semantic fluency abilities by offering external support that scaffolds the search, and thereby facilitates access to memories in the AD group. This possibility is consistent with the idea that the semantic impairment in AD may not be due simply to degradation of information in

the semantic network, but may also reflect an access problem, that is, a retrieval deficit, in combination with a partially degraded semantic network (Corbett et al., 2012; McCabe et al., 2010). It also agrees with Benjamin et al. (2015), who examined the relationship between fluency and autobiographical memory recall in AD, and found that semantic fluency, but not phonemic fluency, significantly predicted autobiographical memory performance. Nonetheless, the present findings only lend suggestive evidence for such relationship and should be interpreted with caution.

Second, relative to their verbal labels, objects inherently offer a contextual, historical and cultural frame that potentially constrains the search to a specific life time period, thus, minimizing the demands for top-down search strategies. This may be beneficial especially to the AD patients due to executive deficits (Bäckman et al., 2005; Grober et al., 2008). For example, consider being presented with the verbal cue of a 'skipping rope' versus an actual old-fashioned cotton jump skipping rope with wooden handles. Both cues have the potential of mentally transporting one back in time, but cue-item discriminability (Rubin, 1995) is increased in the latter case, as sensory-perceptual details, such as look, texture, and weight of the skipping rope may automatically narrow the search to a specific time period in the person's own childhood as well as a particular domain of activities. There is evidence that providing contextual cues matching the participants' younger years supports memory retrieval in AD (Miles et al. 2013).

Third, it is well-established that multisensory stimuli engage a larger neural network, and increase spreading activation, relative to unisensory stimuli, during retrieval (Shams & Seitz, 2008). This may have benefitted especially the AD patients, who demonstrate reduced signal transmission due to the loss of connections between neurons (Budson & Solomon, 2016). The multimodal nature of the objects, and the interplay of vision, audition, olfaction, somatic sensation, allowed participants to process cue properties, such as, texture, color, motion, weight, depth, and form. Combined this may have generated increased spreading activation in, for example, the visual,

olfactory, auditory and motor cortices, thereby activating larger neural networks, and recruiting the brain regions that were involved in forming the memory (Danker & Anderson, 2010).

This is also consistent with observations that participants often automatically started handling the objects during testing, for example, rotating their hands to mimic skipping, or pouring milk from the milk bottle of glass. Thus, active exploration of the object cues may have stimulated more implicit and procedural types of memory processes, such as action memory, which are relatively spared in AD (Eslinger & Damasio, 1986; Kuzis et al., 1999; Postle et al., 1996; Rusted & Sheppard, 2002; Rusted et al., 1995; van Halteren-van Tilborg et al., 2007; Verfaellie et al., 2000).

Fourth, according to the visual dominance hypothesis that posits a modality hierarchy, where vision dominates the other senses (Witten and Knudsen, 2005), the object cues may simply have had an advantage over the verbal cues due to their visual properties. This would be in line with research that demonstrates that the imageability of a verbal cue influences the age, specificity and vividness of autobiographical memories (e.g., Greenberg & Knowlton, 2014; Rasmussen & Berntsen, 2014; Rubin, 1980; Rubin & Schulkind, 1997; Williams et al., 1999), and research showing a central role for visual imagery in autobiographical memory (Rubin & Greenberg, 1998). In individuals diagnosed with AD, Ally et al. (2009) and Embree et al. (2012) demonstrated a picture superiority effect, using a recognition paradigm where participants were tested on memory for words versus pictures. Compared to older, healthy adults, this picture superiority effect was markedly greater in the AD group (Embree et al., 2012), suggesting that visual stimuli may be advantageous to AD patients. Visual richness alone, however, is unlikely to fully account for the success of the object cues to facilitate autobiographical remembering. Research on sensory-perceptual cueing has demonstrated that visual stimuli do not necessarily elicit more specific or vivid autobiographical memories relative to verbal stimuli (e.g., Goddard et al., 2005; Miles &

Berntsen, 2011; Willlander and Larsson, 2006).

In short, different properties of the object cues may have facilitated the retrieval of autobiographical memories, by easing the initial and effortful stages of setting up a search strategy and monitoring the search.

The present study has a number of limitations. First, with regards to cue selection, the study had to rely on relatively non-personal cues in order to ensure that the stimuli were relevant and distinctive to a broad group of participants, varying in gender, age, geographical locations and socio-economic backgrounds. A future study may address whether more personalized object cues would allow for more specific and vivid autobiographical memory recall overall (e.g., Hebscher et al., this issue). Second, the present study also leaves unresolved whether pictures of objects, rather than concrete objects, would generate similar results. Some findings in healthy adults appear to speak against this possibility (e.g., Goddard et al., 2005), but a future study should address this question within dementia populations. Third, it remains speculative whether the events generated in response to objects were indeed retrieved more automatically, as we did not measure reaction times that would have provided an index of the effort required to generate a memory in response to the presented cues. It might also be seen as a limitation that the present study included no subjective ratings. For example, asking participants to provide remember versus know judgements, or rate the level of detail and emotional valence of the reported memories, might reveal whether AD patients experienced a higher degree of autonoetic reliving during object-cued recall, relative to cueing by words (Addis et al., 2009b).

In spite of these limitations, the present study opens important new avenues of research. A substantial part of the existing literature on autobiographical remembering in AD is concerned with understanding the nature of the autobiographical memory deficit, such as the temporal distribution and the phenomenological quality of the reported memories (El Haj et al., 2015). The present study

adds to this endeavor, but in addition it makes an important new contribution to the field by demonstrating that autobiographical memory recall in AD patients can successfully be enhanced by providing specific cueing, that is, multimodal cueing via concrete objects. We have also shown that the benefits of such cueing are not unique to the AD population. However, as demonstrated by the present study, the impact of concrete object-cueing is highly advantageous to this group of patients, and in some respects, more so, relative to a group of healthy, older adults.

5. Conclusion

The present study demonstrated that concrete objects with relevant cultural and historical references to the participants' youth improved autobiographical memory recall relative to verbal cueing in older adults diagnosed with AD. The findings suggest that cueing via historical objects is a viable way of stimulating autobiographical memory in AD, which may have important therapeutic implications. From a theoretical perspective, the findings suggest that parts of the autobiographical memory deficit observed in individuals with AD reflect a memory access problem (Tulving & Pearlstone, 1966), potentially resulting from malfunctional executive processes, rather than simply an availability problem in terms of degeneration of autobiographical information in long-term memory.

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Table 1

Age, education, depression, cognitive ability, executive functioning and working memory in AD and HC participants

	Alzheimer's	Controls		
	M (SD)	*M (SD)*	*t* (df)	*p*
Age (years)	80.47 (7.29)	81.20 (6.49)	*t*(97) = -0.53	.599
Education (years)	9.69 (3.02)	10.9 (3.56)	*t*(97) = -1.82	.072
Geriatric Depression Scale/ 15	2.94 (2.01)	1.50 (1.66)	*t*(97) = 3.89	<.001
MMSE/ 30	19.88 (4.07)	28.88 (0.96)	*t*(97) = -15.21	<.001
ACE/ 100	55.96 (13.91)	89.24 (6.90)	*t*(97) = -15.12	<.001
Category fluency (animals)	9.71 (4.90)	20.32 (6.38)	*t*(97) = -9.26	<.001
Letter fluency (S)	7.14 (4.32)	12.4 (4.65)	*t*(97) = -5.83	<.001
Digit span forwards	7.09 (1.36)	8.38 (1.92)	*t*(95) = -3.81	<.001
Digit span backwards	4.7 (1.68)	7.9 (2.14)	*t*(95) = -8.15	<.001

Note. MMSE = Mini Mental State Assessment (the MMSE is part of the ACE); ACE = Addenbrooke's Cognitive Examination.

Table 2.

Within group ANCOVAs with semantic and phonemic fluency as covariates

	Alzheimer			Control		
		Cueing	Covariate		Cueing	Covariate
	df	*F*	*F*	df	*F*	*F*
Semantic fluency						
Frequency	1, 47	1.15	6.44*	1, 48	.05	2.28
Episodic content	1, 47	2.12	4.37*	1, 48	1.29	3.12
Description length	1, 47	1.20	2.75	1, 48	2.64	3.32
Phonemic fluency						
Frequency	1, 47	3.76	1.00	1, 48	.25	1.64
Episodic content	1, 47	.62	2.19	1, 48	1.75	1.81
Description length	1, 47	1.37	3.51	1, 48	1.83	4.87*

*$p < .05$.

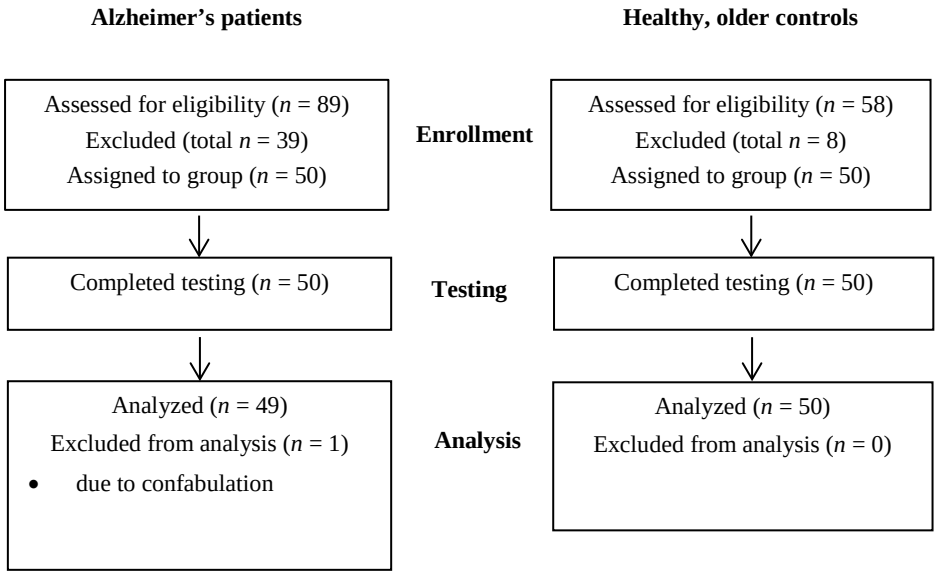

Fig. 1. Flowchart showing attrition of the two groups.
Note. MMSE = Mini Mental State Examination; AD = Alzheimer's disease

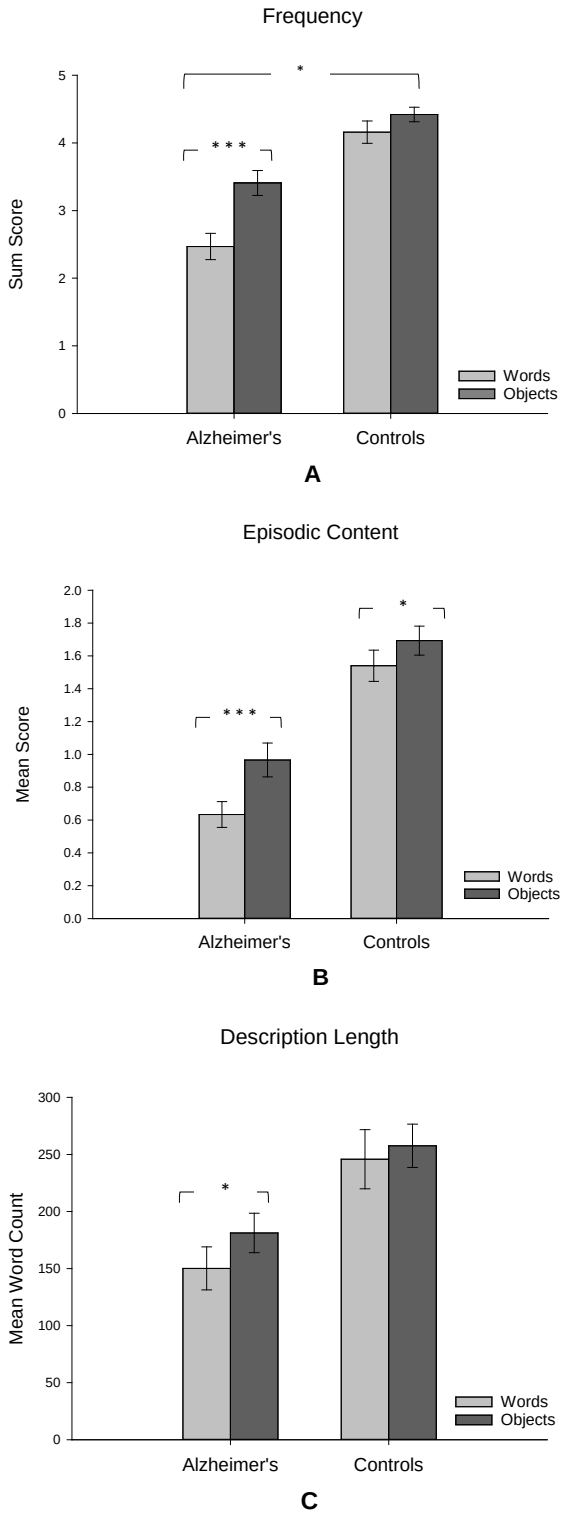

Fig. 2. Mean scores with standard errors for (A) frequency, (B) episodic content, and (C) description length in response to word- and object-cued recall.
*$p < .05$, *** $p < .001$

Appendix. List of stimulus materials used in the word and object-cued recall task

	Objects/ verbal referents	**Danish**	**Additional information**
1	Cigarettes	Cigaretter	
2	Skipping rope	Sjippetov	
3	Grade book	Karakterbog	
4	Milk bottle	Mælkeflaske	
5	Account book	Rengskabshæfte	
6	Food coupons	Rationeringsmærker	
7	Perfume	Parfume	
8	Paper scraps	Glansbilleder	
9	Hopscotch	Hinkesten	
10	Nickel	Enøre	
11	Marbles	Lerkugler	
12	Liquorice root	Lakridsrod	
13	Exercise book	Skolehæfte	
14	Coffee substitute	Kaffeerstatning	
15	Weekly magazine	Ugeblad	
16	Girdle	Rollon	
17	Children's book	Børnebog	
18	Marking ring	Hønseringe	Small plastic rings used as toys
19	Confirmation celebratory card	Konfirmationstelegram	Special greeting card for confirmation
20	Lotion	Fugtighedscreme	