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The Life Span Distribution of Autobiographical Memory in Alzheimer's Disease

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Abstract

Objective*:** The literature on the temporal distribution of autobiographical memory in Alzheimer's disease (AD) is characterized by mixed findings concerning the presence of a temporal gradient in the loss of autobiographical memory. Some studies show a gradient, implying better access to more remote autobiographical memories, whereas others do not. These conflicting results likely reflect differences in the test methodologies, accentuating the need for replications and extensions. ***Method**:* Forty-five older adults diagnosed with AD (M_{MMSE} = 19.89, SD = 4.05) and a matched sample of forty-four healthy, older adults were assessed on two different autobiographical memory measures; the Autobiographical Memory Interview (AMI; Kopelman, Wilson & Baddeley, 1990), and the Galton-Crovitz task (word- and object cueing) in order to examine the temporal distribution of personal autobiographical memories across the life span. ***Results: The impairment of episodic and personal semantic remembering, as indexed by the AMI, was associated with a negative temporal gradient with better preservation of memories from the remote past, relative to the recent one. The results from the word- and object-cueing task replicated the finding that AD is associated with markedly impaired recall of recent events. In addition, both groups showed a peak in the recollection of events from middle childhood and adolescence, consistent with research on the reminiscence bump. ***Conclusions***: Older adults diagnosed with AD demonstrate increased recollection of personal semantic and episodic events from the remote past relative to the recent one. The findings are discussed in relation to prominent models of memory consolidation.

Keywords: Autobiographical memory; episodic memory; Alzheimer's disease; temporal gradient; reminiscence bump

Public health significance. The finding that Alzheimer's disease patients demonstrate better recall of personal significant events from their younger years, relative to the recent past, indicates that stimulating remote memories in psychosocial interventions may be beneficial to this population.

The life span distribution of autobiographical memory in Alzheimer's disease

One of the most prominent hallmarks of Alzheimer's disease (AD) is impairment of autobiographical memory, and hence the ability to recall memories of personal events. As autobiographical memory and our sense of self and identity are intrinsically related (Conway, 2005), impairment to this type of memory has been associated with a weakened sense of self in AD (Addis & Tippett, 2004; Klein, Cosmides & Costabile, 2003; El Haj & Antoine, 2017; Martinelle, Anssens, Sperduti & Piolino, 2013). Although there is evidence that individuals diagnosed with AD demonstrate impoverished autobiographical recall across the life span relative to healthy controls (El Haj, Antoine & Nandrino, 2015), the exact nature of the impairment has been a matter of debate.

Two theoretical frameworks suggest different involvement of the medial temporal lobes, including the hippocampus, in episodic remembering, and therefore predict different consequences of the medial temporal lobe atrophy observed in AD. According to the standard consolidation model (Alvarez and Squire, 1994; Squire and Alvarez, 1995), semantic and episodic memories are only temporarily dependent on the hippocampi and medial temporal lobes during consolidation, where upon completion they become represented in neocortex. According to this view, medial temporal lobe atrophy, as observed in AD, will impact negatively on recent episodic memories only, resulting in a temporally graded memory loss, consistent with Ribot (1881). In contrast, the multiple trace theory (Nadel & Moscovitch, 1997) states that episodic memories continue to be dependent on the medial temporal lobe structures and hippocampus. The hippocampus is what binds the different parts of an episode, such as sensory-perceptual features, contextual information and emotional content, into a coherent and detailed memory of an experience (Moscovitch, Cabeza, Winocur & Nadel, 2016). As a result, this model predicts a flat, or minimal, gradient in the temporal

distribution of both personal semantic and episodic memories, following medial temporal lobe damage, where memories across all life time periods are equally impaired.

In research with AD patients, these conflicting views have been examined using two different semi-structured interviews, the autobiographical memory interview (AMI; Kopelman, Wilson & Baddeley, 1990) and the autobiographical interview (AI; Levine, Svoboda, Hay, Winocur & Moscovitch, 2002). In both the AMI and the AI, participants are probed by specific life time periods when asked to recall autobiographical events. For example, in the AMI, participants are asked to recall an incident that occurred during secondary school (or high school) or from their wedding, whereas participants during the administration of the AI are provided with a list of life time periods, as well as a list of typically occurring events, and required to provide an event from each listed time period.

The two methods differ with respect to how many life time periods are included in the test. In the AMI, participants are examined on three life time periods (childhood, early adult life, recent adult life). In contrast, the AI involves five life time periods (early childhood, adolescent–teenage years, early adulthood, middle age, and the previous year), although some studies have used modified versions (see for example Addis, Sacchetti, Ally & Schacter, 2009; Irish, Hornberger et al., 2009). The two methods are similar in the way they both probe memories for typically occurring events.

Studies using the AMI (or modified versions of it) generally have demonstrated a negative temporal gradient for episodic memory, indicating that memory for remote events, compared with recent events, is better preserved in AD patients (Barnabe, Whitehead, Pilon, Arsenault-Lapierre & Chertkow, 2012; De Simone et al., 2016; Graham & Hodges, 1997; Greene, Hodges & Baddeley, 1995; Irish, Lawlor, O'Mara & Coen, 2011; Ivanoiu, Cooper, Shanks & Venneri, 2006; Kopelman,

1989; Leyhe, Müller, Milian, Eschweiler & Saur, 2009; Müller, Mychajliw, Reichert, Melcher & Leyhe, 2016). A few studies using the AMI have failed to find statistically significant effects, but report numerical differences in the same directions (Addis & Tippet, 2004; Gilboa et al., 2005; Meeter, Eijsackers & Mulder, 2006; Nestor, Graham, Bozeat, Simons & Hodges, 2002). The results for the personal semantic part of the AMI largely follow the same pattern with the majority of studies reporting a negative temporal gradient or finding non-significant differences in the same direction (e.g., Addis & Tippett, 2004; De Simone et al., 2016; Ivanoiu et al., 2006; Kopelman, 1989; Leyhe et al., 2009; Nestor et al., 2002, but see Meeter et al., 2006).

In contrast, some studies using the AI (Addis et al., 2009; Irish, Hornberger et al., 2011) have reported a flat temporal gradient for episodic memories in AD. These conflicting results likely reflect differences in the two test methodologies. In a recent study, Barnabe et al. (2012) showed that the pattern of a temporal gradient varies as a function of how many epochs (i.e., life time periods) were included in the analyses, as well as the number of memories included in each epoch (i.e., one or two memories). Barnabe et al. (2012) scored the memories using both the AI and the AMI procedure. Contrasting only two life periods--childhood versus recent adult life--yielded a temporal gradient for both the AMI and the AI, whereas fewer memories per epoch (i.e., one memory per epoch) diminished it. These findings may help to explain the absence of a gradient in some studies using the AI procedure. For example, Addis et al. (2009) reported a flat gradient for autobiographical memory in their study using an adapted version of the AI with five life time periods and one memory per epoch. Probing for just one memory per life time period may result in participants reporting a well-rehearsed, and thus, relatively better preserved and more accessible memory, potentially yielding a flat gradient with similar performance across the life span. Irish, Hornberger et al., (2011) used a shortened version of the AI in which they omitted the childhood

life time period (up to age 11). Even if participants may not recall many memories from early childhood due to infantile amnesia (Rubin, 2000; West & Bauer, 1999), work generally shows that AD patients report a high proportion of memories from middle childhood (e.g., Greene et al., 1995; Kopelman, 1989). Thus, omitting this life time period when examining the life span distribution of autobiographical memories will most likely influence the results.

A different line of research addressing the temporal distribution of autobiographical memories comes from studies examining the reminiscence bump, that is, the finding that healthy middle-aged and older adults recall a preponderance of memories, clustering around adolescence and early adult life, compared with the surrounding life time periods, when asked to freely generate memories from across the entire life span (Rubin, Wetzler & Nebes, 1986). The majority of studies examining the presence of a reminiscence bump for autobiographical memories have relied on the Galton-Crovitz method (Crovitz & Schiffman, 1974; Galton, 1879), where participants retrieve memories of personal events in association to single nouns. Other techniques involve asking the participants to report their most important memories or tell their life story (see Koppel & Berntsen, 2015, for a review). In contrast to the AMI and the AI, studies addressing the reminiscence bump typically do not use time-periods as constraints for memories; that is, participants are not asked to retrieve each memory from within specific life time periods. Instead, the memories are freely generated from across the entire life course.

Surprisingly, very few studies have examined the bump using such open-ended recall across the entire life span in dementia populations. Fromholt and Larsen (1991) asked 15 older adults with dementia and 15 healthy older adults to freely tell their life stories. Afterwards, events mentioned in the life stories were dated in the life course of the person. Both groups showed a reminiscence bump (see Fromholt, Mortensen, Torpdahl, Bender & Rubin, 2003, for similar results). Fromholt and

Larsen (1991) also found that the life stories told in the dementia group involved more repetitions and more normative events. The latter may suggest that the personal life stories in the dementia group to a larger extent drew upon the cultural life script, which is highly schematized and culturally shared knowledge about the expected order and timing of important transitional life events in a typical life, such as beginning school, getting married, having children, obtaining a major achievement (Berntsen & Rubin, 2002, 2004; Rubin & Berntsen, 2003).

Although the reminiscence bump is a robust finding, recent work (Koppel & Berntsen, 2015; Koppel & Rubin, 2016) shows that the bump is far from stable across different experimental designs, and that both the size and temporal location of the bump are sensitive to the cueing method employed. Recent reviews (Koppel & Berntsen, 2015; Koppel & Berntsen, 2015) have shown that the temporal location of the bump varies systematically according to how memories are probed, with the mean range of the bump located from 8.7 to 22.5 years of age for word-cued memories, compared to 15.1 to 27.9 for important memories. Thus, memories generated in response to word cues yield a bump located during the second decade of life compared with memories for important events showing a peak located in the third life.

In summary, the vast majority of studies examining the life span distribution of autobiographical memories in older adults with AD (and other types of dementia) has employed structured autobiographical memory interviews, probing memories by referring to specific life time periods. These studies typically find a temporal gradient, but several exceptions are identified, most likely reflecting methodological differences in the number of life time periods employed and the number of memories requested. Surprisingly, only few studies have attempted to integrate this research with research on the reminiscence bump in the broader autobiographical memory literature (Kopelman, 2008). In contrast to the structured autobiographical interviews, this research examines

the temporal distribution of memories by using open-ended memory retrieval from across the entire life span, that is, with no temporal constraints for each memory trial. Using this open-ended approach, a few studies involving dementia patients have examined the temporal distribution of events mentioned in life stories, but we were unable to identify any studies using the Galton-Crovitz word cue task, unconstrained by time period, in older adults with dementia.

The Present Study

In the present study, we examine the temporal distribution of autobiographical memories in a large sample of AD patients and matched healthy controls. We employ two different episodic autobiographical measures. First, we use the AMI (Kopelman et al., 1990) to examine whether episodic and personal semantic memories yield differences in the patterns of a temporal gradient. Second, we use the Galton-Crovitz task with two different conditions, a word- and object cueing condition, where participants are cued with concrete everyday objects historically dated to the participants' youth, or the verbal signifiers for the objects, respectively.

In line with the majority of previous studies using the AMI, we expected to find that AD patients overall demonstrate a temporal gradient with better memory for remote events, relative to recent ones, on both the personal semantic and episodic subscales of the test. We furthermore predicted that the healthy, older control participants would demonstrate similar performances across the three life time periods. For the Galton-Crovitz tasks, we expected patients to show increased recollection of events dated during middle childhood and early adult life compared to the surrounding life time periods, when cued by both words and objects (Koppel and Berntsen, 2015). In line with the vast amount of studies that have demonstrated a reminiscence bump for healthy, middle-aged and older adults, we also expected the control participants to demonstrate a bump in the recollection of memories, when cued by words and objects.

Thus, we expected AD patients to demonstrate increased recollection of memories from the earlier parts of life irrespective of method of testing, whereas for healthy older adults, we expected to find this only for the Galton-Crovitz tasks.

Method

Participants

Eighty-nine participants were included in the study. Forty-five (32 females) AD patients and 44 healthy controls (HC) (24 females). These participants were drawn from the samples used in Kirk & Berntsen (2018) to examine different aspects of autobiographical memory in AD[1][2]. The AD and HC groups were matched on age and years of education, see Table 1. All 45 AD patients had been formally diagnosed at a memory clinic according to the international guidelines by the National Institute on Aging and Alzheimer's Association clinical criteria (McKhann et al., 2011). AD patients were recruited with the assistance of regional dementia workers, who established the initial contact to the patients through their primary care takers. Trained psychologists then assessed and screened eligible patients according to the inclusion criteria. Inclusion criteria for both groups involved fluency in Danish, no history of severe head injury, substance abuse, or any other major psychiatric disorder. Participants were not eligible for participation if they demonstrated substantial vision or hearing disability. Use of antidepressants and medication used to treat AD was not an exclusion criterion.

Additional exclusion criteria for the HC participants included signs of dementia, as indexed by a score of 26 or below on the Mini Mental State Examination (MMSE; Folstein, Folstein &

[1] Of the 50 AD patients included in Kirk & Berntsen (2018), only 46 were included in the present study as four participants did not complete or perform the AMI and one participant was excluded from analysis due to confabulation. Of the original 50 HC participants, four participants were excluded from analysis as the scored <88 on the Addenbrooke's Cognitive Examination.

[2] The Kirk & Berntsen (2018) paper does not address the temporal distribution of autobiographical memories

McHugh, 1975. HC participants were recruited through senior's organizations, and from the research center's participant database. The study was approved by the Central Denmark Region Committees on Health Research Ethics, and all participants gave informed consent to participate in the study, the AD patients always in the presence of their primary caretaker.

Materials

Neuropsychological assessment. All participants were assessed on The Addenbrooke's Cognitive Examination (ACE; Mathuranath, Nestor, Berrios, Rakowicz & Hodges, 2000), which includes the MMSE (Folstein et al., 1975), in order to assess global cognitive ability[3]. Maximum scores on both measures index better cognitive ability. As part of the ACE, participants were furthermore assessed on verbal fluency, that is, phonemic (letter *S*) and semantic fluency (animal category) (Lezak, Howieson, Bigler & Tranel, 2012). Participants were also screened for depressive symptoms with the Geriatric Depression Scale (GDS; Brink et al., 1982). The self-report scale consists of 15 items that can be answered with a yes or no in reference to how the respondent felt over the past week. Higher scores are indicative of depression with scores below 5 considered to be within the normal range.

The Autobiographical Memory Interview. The autobiographical memory interview (AMI; Kopelman, Wilson & Baddeley, 1990) is a semi-structured interview that assesses autobiographical memory and personal semantic memory across three broad time bins that span from childhood, early adult life to recent life. More specifically, the interview consists of two schedules; a personal semantic schedule, which assesses recall of personal semantic information (e.g., name of the first school that one attended), and an autobiographical incident schedule, which

[3] All the AD participants were furthermore included in a prospective study (Kirk, Rasmussen, Overgaard & Berntsen, Manuscript submitted for publication) that included a more extensive test battery not limited to the measures included in the present study.

assesses recall of specific events (e.g., recall of an incident that occurred while one was at primary school). Both schedules generate a composite score (range 0 - 27 for the autobiographical incidents schedule; and 0 - 63 for personal semantic information), as well as subdomain scores for the three individual time bins (range 0 – 9 for each time bin on the autobiographical incident memory schedule: range 0 – 21 for each time bin on the personal semantic memory schedule). Participants are required to recall three autobiographical incidents from each of the three time bins, adding to a total of nine episodic incidents. Each reported incident is then scored according to the scoring criteria outlined in Kopelman et al. (1990). Scores range between 0 to 3, where the different scores range from an absence of an answer or purely semantic response to providing a specific event; 0 = *No response, or response based on semantic memory*, 1 = *Vague personal memory*, 2 = *personal but non-specific event, but time and place not recalled*, 3 = *episodic memory, specific in time and place*. Higher scores on both the autobiographical incident memory schedule and the personal semantic memory scale index better recall function.

The Galton-Crovitz Cueing technique. In order to examine autobiographical memory recall, we included the Galton-Crovitz task (Crovitz & Schiffman, 1974; Galton, 1879) with two different conditions; an object-cueing condition and a word-cueing condition[4].

In the object-cued recall condition, participants were presented with concrete objects with a clear reference to the participants' younger years, such as a skipping rope or a bottle of perfume (see Appendix A for list of stimuli). Two experts (a historian and a social anthropologist and museum curator) with extensive knowledge of 20th century history assisted in the selection of the object cues. All the object stimuli were piloted prior to the commencement of the study with nine AD patients in order to ensure that the stimuli were relevant to a broad group of participants. As an

[4] The task has been described in detail in Kirk and Berntsen (2018)

example, some object cues were omitted from the final study as it was found that specific brands of soaps and washing powder were only familiar to a few participants due to large variations in regional use of these goods during the 1950s. Similarly, a handheld chalkboard did not match the age group of the participants as the majority of these used paper and pencils during their time of education. In the object-cued condition, participants were handed a concrete object, which they were encouraged to explore with their hands.

In the word-cueing condition, participants were presented with the verbal signifiers of the objects, such as the word "skipping rope" or "perfume". Word cues were presented in black font, size 36, on a 210 x 297 mm (8.3 x 11.7 in) white card.

In both conditions, participants were presented with a cue and then requested to retrieve a memory in response to each word. Participants were presented with a total of five verbal cues and five object cues. Stimuli were presented in blocks of modalities (i.e., words versus objects) with the order of presentation counterbalanced across participants to prevent order effects. In both conditions, participants were presented with one cue at a time. Each cue was named out loud by the interviewer. Participants were then required to report the first memory of a personally experienced event that came to mind, if any, and were informed that the recalled memory did not need to be specifically related to the cue, the test instructions are provided in Appendix B. In order to minimize variation in prompting and wording of questions, all interviewers followed a standardized test protocol. The participants were not interrupted during recall, but were asked to provide more details, such as time and place of the event, if this was not naturally provided.

Procedure and Coding

All participants were tested at their home by trained psychological staff with the exception of three HC participants, who preferred to be tested at the university. Participants were initially

assessed on cognitive functioning before conducting the AMI, followed by the word- and object-cuing task. Tests were always administered in the same order.

Answers generated in response to the AMI and the word- and object-cuing task were audio recorded to allow for subsequent verbatim transcriptions and coding. Autobiographical content from the AMI was coded according to the AMI protocol by two raters blind to condition and group allocation. In cases of disagreement between the two raters, and in accordance with the AMI guidelines, the mean score was taken when they disagreed by more than one point. When they disagreed by more than one point, they would discuss the response together before coming to an agreement. Interrater reliability analyses using Kappa statistics demonstrated high consensus between raters, $r = .78$, $p < .001$.

In order to segment the answers generated in response to word- and object-cued recall, a unit was defined as a unique piece of narrative, with a clear beginning and end, and no thematic overlap between separate units. Only units with a discernible time period reference were included in the analyses, resulting in 740 of the total 1087 entries being categorized into five different time spans. All units were then categorized according to five broad time bins in order to examine the temporal distribution of the reported memories; 1 = *Preschool, 0-6 years of* age (pre-school; in Denmark, formal schooling does not commence before age 6 years of age), 2 = *Middle childhood and adolescence, 7-15 years of age*, 3 =*Young adulthood, 16-30 years of age*, 4 = *Adulthood, middle-age and older, 31+ years*, 5 = *Recent years* (last 5 years). These age bins were chosen based on previous work (e.g., Kopelman et al., 1990; Rubin et al., 1986) showing that people typically report memories that tend to naturally cluster around early and middle childhood and adulthood, as well as recent life. The age bin used here were roughly consistent with the ones used in similar analyses in previous work (e.g., Barnabe et al., 2012; Addis et al, 2009). All 740 datable units were entered for

statistical analyses on the temporal distribution.

In order to examine whether memories generated by the participants were associated with major transitional events, and thus, were more personal important or significant to the rememberer, all memories were categorised according to the 35 categories outlined by the life script schedule (Berntsen & Rubin, 2004; Table 3). Memories not associated with a life script event were coded as 'other'. Cases of disagreement were solved by discussion. Interrater reliability analyses using Kappa statistics demonstrated high consensus between raters, $r = .79$, $p < .001$.

Statistical Analyses

Independent t-tests were conducted in order to examine group differences between the AD and HC groups on measures of global cognitive ability (MMSE, ACE) including executive functioning (verbal fluency), and depressive symptoms. To examine patterns in the temporal distribution of memories retrieved in response to the AMI, two separate 2 × 3 (Group [AD, HC] × Life Time Period [childhood, early adult life, recent five years]) repeated measures analyses of variance (ANOVA) were conducted on the data from the personal semantic incidents schedule, and the autobiographical episodic memory schedule, respectively, with group as a between-subjects factor, and life time period as a within-subjects factor with three levels. To explore the temporal distribution of memories recalled in response to word- and object-cued recall, two separate 2 × 5 (Group [AD, HC] × Life Time Period [preschool, middle childhood and adolescence, young adulthood, adulthood, middle-age and older, recent five years]) repeated measures ANOVAs were processed with the frequency scores (i.e., total number of memories recalled) within each time bin in response to each of the two modalities of cueing. Post hoc t-tests were conducted when justified in order to examine differences between and within groups and/or life time periods. Descriptive statistics were furthermore conducted in order to provide the percentages of memories categorized

as being a life script event versus non-life script event.

Follow-up analyses were conducted on results from the AMI and word- and object-cued recall, in order to examine whether the temporal distributions differed as a function of disease severity, that is, level of cognitive ability.

Results

General Neuropsychological Assessment

The demographic background information and performance on neuropsychological performance is presented in Table 1. The AD group was significantly impaired in terms of global cognitive ability as indexed by lower scores on the MMSE and the ACE, relative to the HC group (Table 1). With respects to executive functioning, AD participants also scored significantly lower on phonemic and semantic fluency, when compared to the HC group. As demonstrated in Table 1, the AD participants scored significantly higher on the Geriatric Depression Scale than the HC group (Reisberg, Ferris, de Leon & Crook, 1982), indicating higher levels of depressive symptoms in the patient group. However, despite the significant difference between the two groups, a mean score of 2.96 is considered within the normal range, and thus not suggestive of clinical depression. Including the geriatric depression score as a covariate did not change the results from the analyses of variance to be reported in the following.

The Autobiographical Memory Interview

Autobiographical episodic memory. The results from the autobiographical incident memory schedule are presented in Table 2 and Figure 1A, and show that the AD group was significantly impaired on autobiographical recall from all three life time periods when compared to the HC group, F (1, 87) = 119.49, $p < .001$, $\eta\rho^2 = .58$. Overall, memories from earlier life periods were more common than recent memories, F (1, 87) = 10.59, $p < .001$, $\eta\rho^2 = .11$. However, this

pattern was more pronounced for the AD group, reflected in a significant interaction between group × life time period, F (1, 87) = 5.63, p = .004, $\eta\rho^2$ = .06. As illustrated in Figure 1A, the AD group showed a marked negative temporal gradient. Post-hoc t-tests demonstrated that the AD group showed significantly better recall for remote events. More specifically, they showed better recall from childhood than recent life, t(44)= 4.15, p < .001, 95% CI [0.92, 2.65] and early adult life than recent life, t(44)= 3.70, p = .001, 95% CI [0.60, 2.02] indicating better recall for remote autobiographical incidents relative to recent ones. There was no significant difference in performance on recall for autobiographical incidents from childhood versus early adult life, t(44)= 1.30, p = .226, 95% CI [-0.31, 1.26] suggesting that overall, memory for remote autobiographical incidents are best preserved in this group. In contrast, the HC group demonstrated similar performances in recall from across all three life time periods, with no significant differences between childhood and early adult life, t(43)= .92, p = .362, 95% CI [-0.30, 0.80] childhood and recent life, t(43)= .1.26, p = .215, 95% CI [-0.20, 0.86] and early adult life and recent life, t(43)= .37, p = .712, 95% CI [-0.35, 0.51] indicating an absence of a temporal gradient in memory for autobiographical incidents.

As noted in previous research, the episodic scale of the AMI may be subject to ceiling effects for healthy, older adults (e.g., Levine et al., 2002), giving rise to a flat gradient that may not be present if the scale included a more open-ended response format. As a result, we repeated the ANOVA after excluding control participants (n = 15) that scored at the maximum end of the scale. The results demonstrated significant main effects for group, F (1, 72) = 66.99, p < .001, $\eta\rho^2$ = .48, and life time period, F (1, 72) = 7.95, p =< .001, $\eta\rho^2$ = .10, as well, as a significant interaction between group × life time periods, F (1, 72) = 5.38, p = .006, $\eta\rho^2$ = .07, replicating the finding of a negative temporal gradient for episodic memory in AD, thus ruling out that a ceiling effect may

have caused a flat gradient in the HC group.

Personal semantic memory. The results from the personal semantic schedule are presented in Table 2 and Figure 1B. Similar to the results obtained from the autobiographical memory incident schedule, the AD group was significantly impaired on recall of personal semantic facts from all three life time periods compared with the HC group, F (1, 87) = 177.02, $p < .001$, $\eta\rho^2 = .67$. A main effect of life time periods was also found, F (1, 87) = 9.13, $p < .001$, $\eta\rho^2 = .10$, again qualified by a significant interaction between group × life time periods, F (1, 87) = 19.15, $p < .001$, $\eta\rho^2 = .18$, indicating a significant and negative temporal gradient in the AD group with better recall of remote personal semantic facts relative to recent ones, see also Figure 1B. Post-hoc tests confirmed that the AD group overall demonstrated better recall for remote semantic memory. More specifically, the AD patients showed significantly better recall for childhood than early adult life, t(44)= 2.86, p = .006, 95% CI [0.46, 2.65] , and childhood than the recent life, t(44)= 4.98, $p < .001$, 95% CI [2.26, 5.34] , and early adult life than recent life, t(44)= 3.48, p = .001, 95% CI [0.95, 3.54] (see Table 2 for means and standard deviations), indicating a steadily decreasing slope in the temporal gradient. In contrast, post-hoc tests conducted for the HC group, demonstrated similar performances for recall of personal semantic facts across childhood and early adult life, t(43)= .48, p = .632, 95% CI [-0.78, 0.48] and childhood and recent past, t(43)= 1.82, p = .075, 95% CI [-1.44, 0.75] but better recall for recent events than early adult life, t(43)= 2.43, p = .019, 95% CI [-0.98, -0.10].

The Galton-Crovitz Task (Word- and Object-Cued Recall)

As demonstrated by Table 3, memories were clearly not evenly distributed across the five time bins for any of the two groups in any of the two cue conditions. Two separate ANOVAs were conducted for frequencies of memories generated in response to word- and object-cueing,

respectively.

Word-cued recall. Results from the word-cuing condition yielded significant main effects for group, F (1, 87) = 154.90, $p < .001$, $\eta\rho^2 = .64$, and life time period, F (1, 87) = 43.14, $p < .001$, $\eta\rho^2 = .33$, as well a significant interaction between group × life time periods, F (1, 87) = 7.90, $p < .001$, $\eta\rho^2 = .08$, indicating different patterns in the temporal distribution of word-cued memories between the two groups. As illustrated in Figure 2A, the HC group did on average recall a higher frequency of memories relative to the AD group, but also demonstrated better recall for the two last bins (i.e., adulthood, middle age and recent years), which was confirmed by post-hoc tests, see Table 3. Both groups showed a peak around middle childhood and adolescence, but it was significantly greater in the HC group, consistent with the overall greater recall of events in the HC group.

Object-cued recall. A similar pattern emerged for memories recalled in response to object-cueing. Results yielded significant main effects for group, F (1, 87) = 20.10, $p < .001$, $\eta\rho^2 = .19$, and life time period, F (1, 87) = 66.21, $p < .001$, $\eta\rho^2 = .43$, and once again a significant interaction between group × life time periods, F (1, 87) = 8.86, $p < .001$, $\eta\rho^2 = .09$. As demonstrated in Table 3, post-hoc t-tests showed that the healthy control participants, relative to the AD group, demonstrated significantly better recall of events from the two most recent time bins, and a significantly larger bump clustering around the time of middle childhood and adolescence, mimicking the results from the word-cueing task. See also Figure 2B.

Significance of events. In order to examine whether the bump observed for both groups around middle childhood and adolescence was a function of event significance according to cultural norms, percentages of memories associated with events from the life script coding scheme were calculated. The two conditions of the Galton-Crovitz task (word- and object cueing) were collapsed

across participants as they had yielded similar patterns in the temporal distribution (cf. Figures 2a-2b). Overall, only 10.2 % of the memories were categorised as being a life script event. As the descriptive data show in Table 4, the majority of memories from across the five life time periods were not associated with a life script event, indicating that the Galton-Crovitz task did not per se elicit memories of events that were related to a major transitional life time event, and thus more personally significant. This is consistent with previous studies using the Galton-Crovitz task in healthy adults (e.g., Berntsen & Bohn, 2010; Berntsen & Jacobsen, 2008; Rubin & Schulkind, 1997).

Test of the nature of the word cues in a younger sample. One might suggest that the presence of a reminiscence bump in both groups of participants may have been a result of the present cues being inherently more prone to elicit remote memories from middle childhood and adolescence, irrespective of the study population. In order to test this possibility, we conducted a follow-up study on line to examine the range of memories reported by 101 younger participants (51 female, 50 male, *M*age = 33.71, SD = 9.90), when they were asked to retrieve autobiographical memories in response to the same word cues as used in the present study. In contrast to the findings from the older participants, we found that 21.2 % of all the memories retrieved by the younger sample were of recent events (i.e., events dated to the most recent year). This suggests that the word cues used in the present study did not inherently favour memories from middle childhood and adolescence. In contrast, when used in a younger population, the word cues generated a clear dominance of recent memories, consistent with normal forgetting.

The Effects of Disease Severity on the Temporal Distribution

Additional follow-up analyses were conducted in order to examine whether disease severity, (i.e., global cognitive functioning, as indexed by performance on the MMSE) affected the temporal

distributions of personal semantic and autobiographical memories generated in response to the AMI, and word- and object-cued recall. AD patients were divided into two separate groups based on a median split; moderate AD (n = 21; MMSE ≤19; range 13 – 19, M = 16.14, SD = 1.85) versus mild AD (n = 24; MMSE ≥20; range 20 – 26, M = 23.17, SD = 2.08). The categorization of patients into groups of mild and moderate AD corresponds well to the categorization criteria used by others based on large sample sizes (Perneczky et al., 2006).

Two separate 2 × 3 (Group [Moderate AD, Mild AD] × Life Time Period [childhood, early adult life, recent five years]) ANOVAs were conducted for autobiographical and personal semantic memory, and two separate 2 × 5 (Group [Moderate AD, Mild AD] × Life Time Period [preschool, middle childhood and adolescence, young adulthood, adulthood, middle-age and older, recent five years]) were computed for the results generated in response to word- and object-cued recall. Post hoc tests were conducted in order to examine significant interactions.

Autobiographical incident memory. Results from the ANOVA yielded significant main effects for group, F (1, 43) = 5.06, p = .030, $\eta\rho^2$ = .11, and life time period, F (1, 43) = 11.17, p < .001, $\eta\rho^2$ = .21. The ANOVA yielded a non-significant interaction between group × life time period, F (1, 43) = .51, p = .600, $\eta\rho^2$ = .01, suggesting that both groups, despite significant between group differences in recent recall, demonstrated a similar pattern in the temporal gradient, see also Figure 3A.

Personal semantic memory. Results from the ANOVA yielded significant main effects for group, F (1, 43) = 15.08, p < .001, $\eta\rho^2$ = .26, and life time period, F (1, 43) = 18.99, p < .001, $\eta\rho^2$ = .31, as well as a significant interaction between group × life time period, F (1, 43) = 3.91, p = .024, $\eta\rho^2$ = .08, suggesting different temporal profiles for the two groups on personal semantic memory recall, see Figure 3B. Paired post-hoc t-tests showed that participants in the moderate AD group

demonstrated better recall of personal semantic facts from the two earlier life time periods, more specifically, childhood than recent life, $t(20) = 4.56$, $p < .001$, 95% CI [2.93, 7.88] and early adult life than recent life, $t(20) = 4.59$, $p < .001$, 95% CI [2.14, 5.71] whereas there was no significant difference between recall of personal semantic facts from childhood versus early adult life, $t(20) = 1.61$, $p = .123$, 95% CI [-0.44, 3.38]. Thus, the results indicated better memory for remote personal semantic facts, leading to a negative temporal gradient with a steep drop in recall of memories from early adult life to recent life in this group, see also Figure 3B. In contrast, this steep drop was not observed in the mild AD group, where patients recalled significantly more personal semantic facts from childhood relative to early adult life, $t(23) = 2.50$, $p = .020$, 95% CI [0.28, 2.97], and childhood than recent life, $t(23) = 2.63$, $p = .015$, 95% CI [0.51, 4.28]. There was no significant difference between performances of recall of personal semantic memory between early adult life and recent life, $t(23) = .90$, $p = .377$, 95% CI [1.00, 2.54], yielding a more flat temporal gradient. However, these results should be interpreted with caution as a follow-up three-way analysis, 2 × 5 × 2 (Group [AD, HC] × Life Time Period [preschool, middle childhood and adolescence, young adulthood, adulthood, middle-age and older, recent five years] × [personal semantic memory, episodic memory]) showed no significant interaction, F (2, 86) = 2.15, $p = .123$, $\eta\rho^2 = .05$.

Word-cued recall. Results from the word-cueing condition, revealed a significant main effect for life time period, F (1, 43) = 16.02, $p < .001$, $\eta\rho^2 = .27$, suggesting an uneven distribution of memories across the five life time periods. The main effect for group, F (1, 43) = .27, $p = .603$, $\eta\rho^2 = .01$, and the interaction between group × life time period, F (1, 43) = .18, $p = .950$, $\eta\rho^2 = .00$, were both non-significant, indicating similar patterns in the temporal distribution of memories for both groups, see Figure 3C.

Object-cued recall. The results from the object-cueing condition yielded similar results,

with a significant main effect for life time period, F (1, 43) = 27.66, p < .001, $\eta\rho^2$ = .39, and a non-significant main effect for group, F (1, 43) = 1.31, p = .259, $\eta\rho^2$ = .03, and non-significant interaction between group × life time period, F (1, 43) = .45, p = 772, $\eta\rho^2$ = .01, again, indicating similar distribution of memories across the five life time periods between the two groups, see Figure 3D.

Discussion

We examined the temporal distribution of autobiographical memories in a large sample of older adults diagnosed with AD and matched healthy controls using a semi-structured autobiographical memory interview (Kopelman et al., 1990) and the Galton-Crovitz task with two conditions (word- and object-cueing).

Consistent with most previous findings (e.g., De Simone et al., 2016; Ivanuoi et al., 2006; Kopelman, 1989; Leyhe et al., 2009), the impairment of episodic and personal semantic remembering on the AMI in AD was associated with a negative temporal gradient with better recall of remote events relative to more recent events. Similarly, results from the Galton-Crovitz task replicated the robust finding that AD is associated with impaired recall of recent events, as evinced by the AD groups reporting almost no memories from middle to later adulthood and the recent past, in contrast to the HC group who reported some memories from this period. Both groups showed increased recollection of events from middle childhood and adolescence, consistent with a reminiscence bump (Rubin et al., 1986), replicating and extending findings from other studies on the reminiscence bump in dementia (e.g., Barnabe et al., 2012; Fromholt & Larsen, 1991; Fromholt et al., 2003) and healthy older adults (e.g., Rubin, Rahhal & Poon, 1998; Rubin, Wetzler & Rubin, 1986, see Koppel & Berntsen, 2015, for a recent review). The relatively early temporal location of

the reminiscence bump in the present study is consistent with other studies using word cues (or similar associative) cueing procedure (Koppel & Berntsen, 2016).

Although the results from examining the effect of disease severity on memory recall should be interpreted with caution due to the reduction in sample sizes, we found that the mild AD group performed better than the moderate AD group on the AMI, with respect to both personal semantic and episodic memory recall. In both severity groups, we found a negative temporal gradient for personal semantic and episodic memories on the AMI as well as a reminiscence bump for memories generated in response to the Galton-Crovitz task.

The finding that healthy, older control participants demonstrated similar recall from across the life span, when they were probed by specific life time periods on the AMI, is in line with previous work (e.g., Barnabe et al., 2012; Kopelman, 1989; Leyhe et al., 2009). Likewise, it is well-established that healthy, middle-aged and older adults demonstrate an uneven temporal distribution of autobiographical memories across the life span with a peak of memories being located during the earlier parts of life when they are asked to perform the Galton-Crovitz task (Rubin, Wetzler & Nebes, 1986, see Koppel & Berntsen, 2015, for a review). Although, a flat gradient on the AMI versus a reminiscence bump on the Galton-Crovitz task may seem contradictive, differences between the methods used to assess autobiographical memory most likely account for this. First, the number and temporal boundaries of epochs on the AMI do not allow for examination of a reminiscence bump, as the childhood epoch spans from the pre-school years to the late teens. Second, previous work has shown that a bump is typically not found, when retrieval is limited to specific time periods, such as participants retrieving memories from three successive periods of life, instead of freely across the entire life span (e.g., Rabbit & Winthorpe, 1988; see Rubin et al., 1998, for a review). Third, given that the majority of questions from the AMI taps into life scripts events

(e.g., Berntsen & Rubin, 2004), which must be considered less vulnerable to forgetting as they are central to one's life story and thus likely to be well-rehearsed, one might predict healthy participants to perform similarly across the life span. In other words, the highly structured format of the AMI with memory retrieval from clearly defined life periods is likely to work against observing a reminiscence bump, whereas an adapted, more open-ended format of the AMI might replicate a bump. This is a question for future research.

Taken together, the present findings lend some support to the standard model of consolidation (Alvarez and Squire, 1994; Squire and Alvarez, 1995), which predicts a temporally graded memory loss in AD for both personal semantic and episodic memory. This theory asserts that both types of memory are only initially dependent on the hippocampal formation before becoming represented in neocortex, for which reason medial temporal lobe atrophy will only negatively affect memory for recent events, due to insufficient encoding. In contrast, the multiple trace theory (Nadel & Moscovitch, 1997) posits that episodic memory, but not semantic memory, continues to be dependent on the hippocampus, for which reason this model only predicts a dissociation between the two types of memory with a temporally graded loss for semantic memory, and a flat gradient for episodic memory (Nadel & Moscovitch, 1997; Nadel, Winocur, Ryan & Moscovitch, 2007).

Different accounts have been put forward to explain the presence of a reminiscence bump in studies using the Galton-Crovitz paradigm. For example, some work (Berntsen & Rubin, 2002; Rubin & Berntsen, 2003; Thomsen & Berntsen, 2008) suggests that the cultural life script may serve as a schema that structures recall, when middle-aged and older adults are requested to produce personal memories they view as important. As the majority of transitional life script events occur during adolescence and early adult life, people will more be inclined to recall more memories from

this period, when they use the life script to guide retrieval. However, the life script account does not provide a satisfactory account for the bump, when memories are prompted by word cues or similar associative cueing strategies. There is no evidence of a dominance of life script events among the memories forming the bump in such studies (e.g., Koppel & Berntsen, 2015, for a review). Consistent with this finding, the majority of memories in the present study (i.e., 90 %) generated in response to the Galton-Crovitz task were categorised as non-life script events and there was no difference in the relative frequencies of life script events across the different life periods.

According to another account, adolescence (and early adult life) is a life time period rich on novel first-time-experiences, which thus are more distinctive and hence more memorable (Pillemer, 2001; Rubin et al., 1998). As a result, these memories undergo more elaborate cognitive processing and hence become less susceptible to forgetting. Another, and related, explanation emphasizes that adolescence and early adult life is a critical period of identity formation, for which reason retention of memories from this period receives preferential encoding due to high self-relevance of these memories (Conway, 2005; Conway & Pleydell-Pearce, 2000). This account is also related to the concept of self-defining memories (Singer & Salovey, 1993) with work demonstrating a dominance of this type of memories during the bump years in response to highly self-related cued (Rathbone, Moulin & Conway, 2008).

Overall, these arguments are compatible with both the standard consolidation model (Alvarez and Squire, 1994; Squire and Alvarez, 1995) and multiple trace theory (Nadel & Moscovitch, 1997) and the notion that repeated activation, and hence re-consolidation, strengthens cortical memory traces and leaves memories less vulnerable to forgetting. However, because these explanations focus on processes during encoding and consolidation, they have difficulties accounting for the fact that the temporal location of the bump interacts with the nature of retrieval

cues (e.g., Koppel & Berntsen, 2015; Koppel & Rubin, 2016). In short, it is not clear exactly which factors are responsible for the reminiscence bump and whether these factors are related to mechanisms underlying the temporal gradient in dementia, when autobiographical memory is measured by the AMI. This is an important question to pursue in future research (Kopelman, 2008).

The present study has a number of limitations. First, statistical analyses examining the distribution of scores generated in response to the AMI indicated that a substantial part of the control participants scored at the maximum end of the episodic memory scale, suggesting that the significant interaction between life time period and group may have been an artefact of a ceiling effect. However, we addressed this issue by a follow-up analysis in which we excluded control participants, who scored at the maximum end of the scale. The analysis replicated the significant interaction, supporting the validity of the temporal gradient for episodic autobiographical memory. This unfortunately, was not possible to do for the personal semantic results, as 84 % of the healthy, older control participants scored at celling level on one or more life time periods on the personal semantic schedule. Yet, this is a general limitation of the AMI, which is not specific to the present study. A particular strength of the present study is the inclusion of a second autobiographical memory task, the Galton-Crovitz task, with a more open-ended format, which minimizes the likelihood of a ceiling effect.

Second, memory reports were not systematically verified by family members or significant others. However, the majority of patients had a caretaker, typically their spouse, present or nearby during testing, and only on one occasion was confabulation observed, for which reason this participant was excluded from the study (as mentioned in the Method section). Moreover, there is evidence to suggest that confabulation in AD does not occur until the later stages of the disease (Gilboa & Moscovitch, 2002). As the AD patients included in the present study all presented with

mild to moderate signs of dementia, we consider confabulation less likely. Importantly, other studies report low rates of confabulations in studies using tests similar to the ones employed in the present study (e.g., Addis et al., 2009). Notably, Kopelman (1989; Kopelman et al., 1990) reported an accuracy rate of 94 % in his AD sample, suggesting that confabulation may not be a major concern in the earlier stages of the disease. Importantly, there was no pressure for participants to report a memory in the present study, meaning that they were explicitly told during the administration of the task that it was perfectly fine if they could not think of a memory, in which case, the interviewer would simply proceed to the next cue. Nonetheless, a future study should control for this potential problem by seeking more systematic memory corroboration from caregivers.

Third, relatively few observations were available for some of the epochs on the Galton-Crovitz task for both patients and control participants (see Figure 3). A future study should aim to include more participants or ask for more memories in order to increase the amount of observations in the individual time bins across the life span.

from middle childhood and adolescence than from the surrounding time periods, c

Fourth, the temporal boundaries of the epochs in the AMI did not allow for an examination of the reminiscence bump, as the first epoch begins before the the typical beginning of the bump and ends during, or slightly before, its typical peak. In contrast, data from the Galton-Crovitz task were analysed in terms of five periods, whose boundaries were defined specifically to allow observation of a possible bump. Adjusting the time periods in the AMI to allow similar analyses could help to clarify whether the temporal gradient (often observed in the AMI) and the reminiscence bump are independent phenomena.

Finally, as emotion may modulate memory in AD (e.g., El Haj, Gandolphe & Wawrziczny, 2016; Kalenzaga, Bugaiski & Clarys, 2013), future research should evaluate the emotional valence of the word- and object-cues in order to see if this influences recall. It may be that object cues by nature are more personal relevant to the participants, and thus carry higher positive valence, which may lead to better recall.

Conclusion

The present study found that older adults diagnosed with AD showed better retention of personal semantic and episodic memories from the remote relative to the recent past, when tested on the Autobiographical Memory Interview. This finding was replicated in the Galton-Crovitz task, where individuals with AD reported almost no memories from middle to later adulthood and the recent past, in contrast to healthy controls reporting some memories from this period. Both AD patients and control participants recalled more memories from middle childhood and adolescence than from the surrounding time periods, consistent with a reminiscence bump.

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Table 1

Descriptive Statistics and Independent t-test Results for Age, Education, Cognitive Ability and Executive Functioning

	Alzheimer		Control			
	M	*SD*	*M*	*SD*	*t*(87)	CI
Age (years)	80.67	7.52	80.18	6.02	0.34	[-2.39, 3.36]
Education (years)	9.96	3.05	11.09	3.58	-1.99	[-2.80, 0.00]
Geriatric Depression Scale/ 15	2.96	2.06	1.36	1.30	-4.36***	[0.87, 2.32]
MMSE/ 30	19.89	4.05	28.98	0.95	-14.51***	[-10.33, -7.84]
ACE/ 100	58.31	11.41	91.10	4.74	-17.63***	[-36.48, -29.08]
Semantic Fluency	9.82	4.96	21.10	6.35	-9.34***	[-7.33, -3.55]
Phonemic Fluency	7.38	4.22	12.82	4.72	-5.74***	[-13.66, -8.87]

Note. MMSE = Mini Mental State Assessment; ACE = Addenbrooke's Cognitive Examination; FAB = Frontal Assessment Battery; CI = Confidence Intervals. The MMSE is included in the ACE. Fluency scores are presented as total number of items recalled.
***$p < .001$

Table 2

Descriptive Statistics and Independent t-test Results for the Autobiographical Memory Interview

	Alzheimer		Control			
	M	*SD*	*M*	*SD*	*t*(87)	CI
AMI Episodic Part						
Total Score/ 27	10.10	5.50	21.27	4.01	-10.93***	[-13.20, -9.14]
Childhood/ 9	4.12	2.52	7.28	1.74	-6.87***	[-4.08, -2.25]
Adulthood/ 9	3.64	2.39	7.03	1.70	-7.70***	[-4.26, -2.51]
Recent past/ 9	2.33	2.23	6.96	1.49	-11.49***	[-5.42, -3.82]
	Child = Adult, n.s. Child > Recent*** Adult > Recent**		Child = Adult n.s. Child = Recent n.s. Adult = Recent n.s.			
AMI Semantic Part						
Total Score/ 63	36.24	10.18	58.97	3.08	-12.94***	[-23.92, -17.55]
Childhood/ 21	14.24	4.27	19.69	2.31	-7.46***	[-6.89, -3.99]
Adulthood/ 21	12.69	3.92	19.84	1.19	-11.57***	[-8.38, -5.92]
Recent past/ 21	10.44	4.98	20.37	0.72	-13.09***	[-11.44, -8.42]
	Child > Adult** Child > Recent*** Adult > Recent**		Child = Adult n.s. Child = Recent n.s. Recent > Adult*			

Note. AMI = The Autobiographical Memory Interview; CI = Confidence Intervals; N.s. = non-significant

*$p < .05$. **$p < .01$. ***$p < .001$.

Table 3

Descriptive Statistics and Independent t-test Results for Word- and Object-Cued Recall

	Alzheimer		Control			
	M	SD	*M*	SD	*t*(87)	CI
Word-Cued Recall						
1. Preschool	0.33	0.67	0.36	0.78	-0.20	[-0.33, 0.28]
2. Child/ adolescence	1.38	1.43	3.09	2.66	-3.80***	[-2.61, -0.82]
3. Young adulthood	0.40	0.91	0.41	0.87	-0.05	[-0.39, 0.37]
4. Adulthood	0.18	0.53	0.95	1.31	-3.68***	[-1.20, -0.36]
5. Recent years	0.11	0.32	0.50	0.90	-2.72**	[-0.67, -0.11]
Object-Cued Recall						
1. Preschool	0.51	0.79	0.25	0.53	1.83	[-0.02, 0.55]
2. Child/ adolescence	1.98	1.83	3.84	2.92	-3.61**	[-2.89, -0.84]
3. Young adulthood	0.51	0.87	0.52	0.79	-0.07	[-0.36, 0.34]
4. Adulthood	0.13	0.34	0.82	1.32	-3.37**	[-1.09, -0.28]
5. Recent years	0.04	0.21	0.36	0.89	-2.34*	[-0.59, -0.05]

Note. 1 = Preschool, 0-6 years of age, 2 = Middle childhood and adolescence, 7-15 years of age, 3 =Young adulthood, 16-30 years of age, 4 = Adulthood, middle-age and older, 31+ years, 5 = Recent years (last 5 years). CI = Confidence Intervals.
*$p < .05$. **$p < .01$. ***$p < .001$.

Table 4

Percentages of memories associated with events from the life script coding scheme

	Life Script Event		
	Alzheimer	Control	All
Preschool	9.52 %	0.00 %	5.79 %
Childhood	16.31 %	11.25 %	12.83 %
Early adult life	10.26 %	7.50 %	8.86 %
Adult 30+	0.00 %	2.53 %	2.17 %
Recent	0.00 %	11.76 %	9.75 %

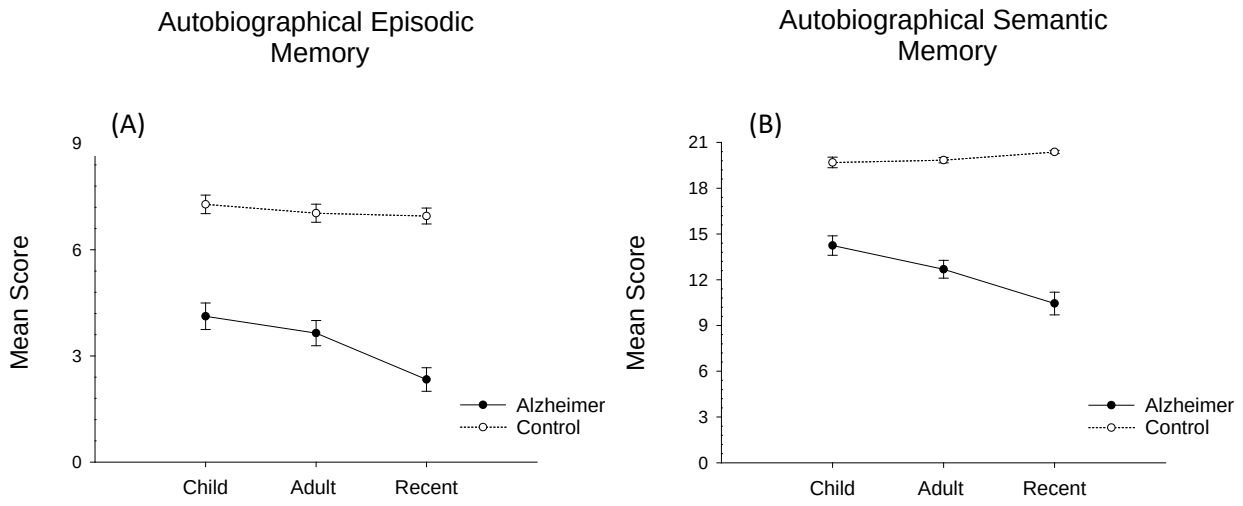

Figure 1. Performances of the Alzheimer and control group across the three life time periods on (A) the autobiographical incidents schedule, and the (B) personal semantic schedule of the Autobiographical Memory Interview. Error bars indicate standard error of the means.

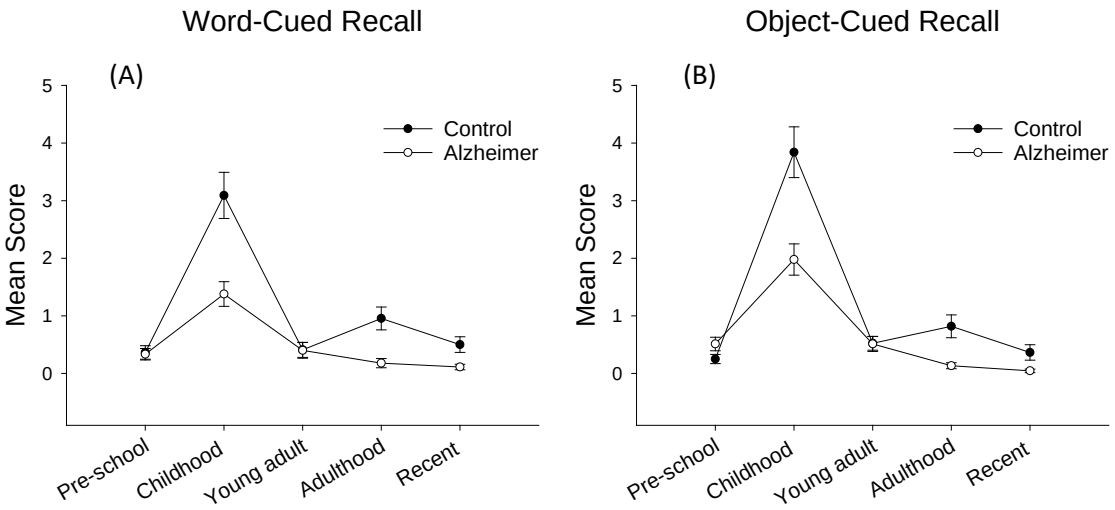

Figure 2. The average frequency across the five time periods of memories generated in response to (A) word-cued recall, and (B) object-cued recall for Alzheimer patients and controls. Error bars indicate standard error of the means.

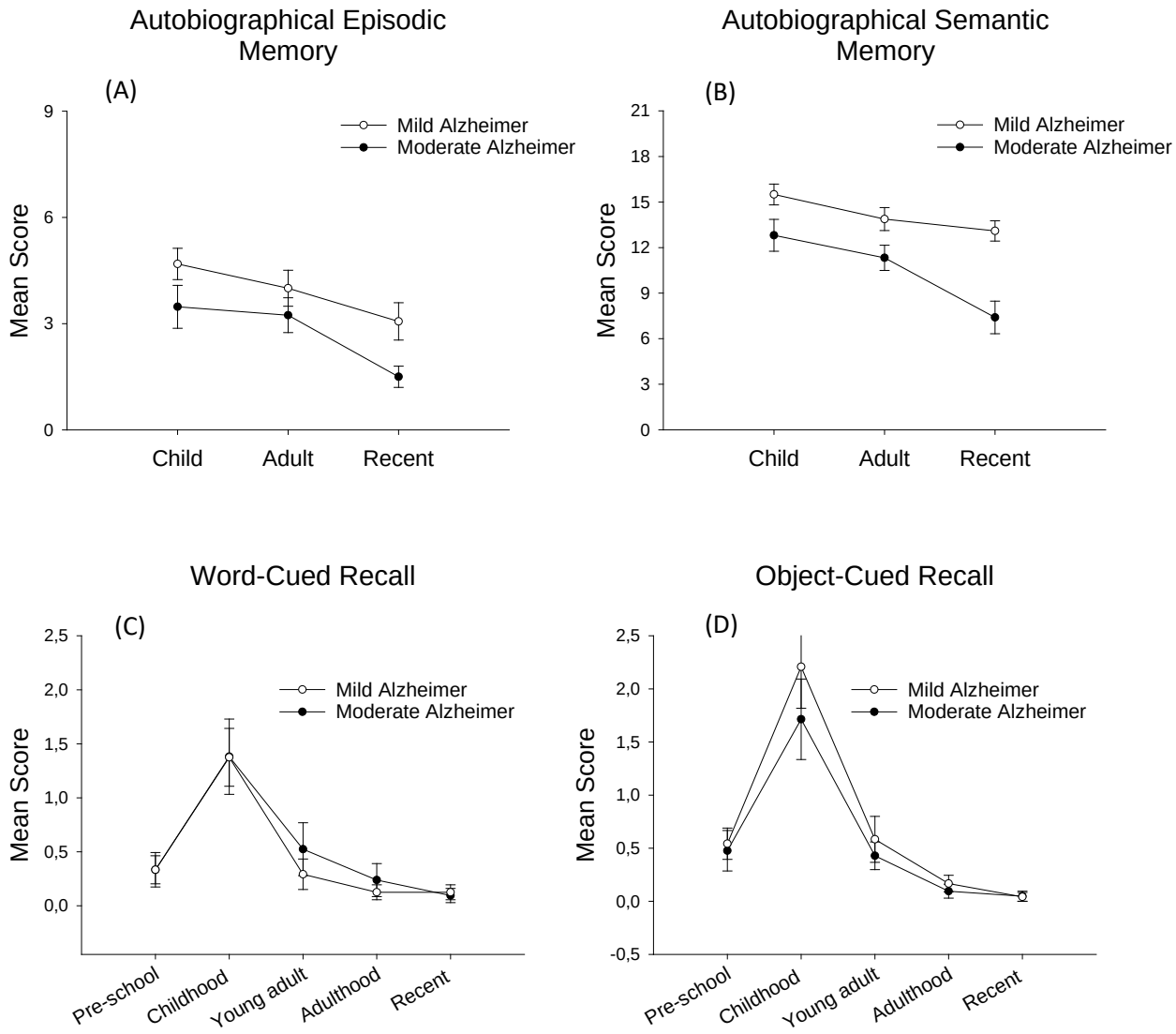

Figure 3. Performances of the mild and moderate Alzheimer groups across the different life time periods on (A) the autobiographical incidents schedule, (B) personal semantic schedule, (C) word-cued recall, and (D) object-cued recall. Error bars indicate standard error of the means.

Appendix A. 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	Regnskabshæfte	
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	

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Appendix B. Test Instructions for The Galton-Crovitz Cueing Task

Instructions:

I will now read a word/ show you an object, and then I would like you to try to remember a story or an event from your life and tell me about it. What you tell me does not have to be specifically related to the word/ object.

It is perfectly fine if you cannot think of something, then we will just proceed to the next word/ object.

In case, the participant does not try:

Try to see if you can think of something (this prompt can only be used a few times)

The interviewer is allowed to offer three prompts in total to the participant. For example:

- *Can you think of more details?*
- *Can you try to tell me a bit more?*
- *Can you think of a specific day/ event* (only use this prompt if the participant does not provide a specific event automatically)

Important: Besides the 3 prompts, the interviewer is only allowed to encourage participants by 'yes' and 'hmm'