Abstract

The aim of this study was to investigate inconsistent findings in the ageing autobiographical memory literature. Twenty older and 20 younger adults were compared across a battery of tasks which measured memory for everyday events, recent and remote time periods, word-cued autobiographical memory, and word-list recall. The results showed a variable effect of age on the retrieval of specific episodic information, with young adults outperforming older adults on word-list recall, word-cued AM, and memories from adolescence, but no evidence of a difference between groups on the other two tasks. In addition, older adults recalled more semantic information than younger adults, particularly during recall of everyday events. This pattern explains some of the discrepancies in the literature by suggesting that some aspects of episodic AM are more age-sensitive than others. Despite ostensibly measuring the same type of memory, different tasks used to measure episodic AM are differentially sensitive to age-related changes. Possible contributing factors are discussed, and we highlight the need for a more rigorous examination of the processes involved in different AM tasks.

Keywords: autobiographical memory; episodic memory; everyday memory; ageing;

Dissociable age effects across measures of autobiographical memory

The present study examines age-related differences across a range of measures that ostensibly measure the same thing, episodic autobiographical memory (AM), yet have produced inconsistent findings with respect to the relative performance of older and younger adults. The aim is to investigate whether these inconsistent age effects can be replicated within the same sample of participants, which would provide evidence for the multifaceted nature of episodic AM, some aspects of which may be more age-sensitive than others. Although this idea is relatively uncontroversial there has been little in the way of empirical demonstration, and ageing studies generally still treat episodic AM as a unitary construct.

Autobiographical memory is a broad term that incorporates both episodic and semantic information related to oneself[1] (Brewer, 1986; Conway & Pleydell-Pearce, 2000; Renoult, Davidson, Palombo, Moscovitch & Levine, 2012). In the ageing literature, most measures of AM involve retrospectively sampling events from within a given time period (e.g. Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002) or in response to a generic cue (e.g. Addis, Wong & Schacter, 2008; Beaman, Pushkar, Etezadi, Bye, & Conway, 2007; Madore, Gaesser, & Schacter, 2014). These time periods and other cues have varied from study to study, and there has been little empirical investigation of the effects of different cues on the number or type (i.e. episodic/semantic) of details subsequently recalled. That is, memories elicited by generic cue words are implicitly assumed to be equivalent to those elicited by time periods, music, or emotional valence. Part of this assumption may stem from the fact that much of the published work in this area converges on the finding that older adults do not perform as well

[1] In the present paper we adopt "episodic" and "semantic" as our preferred terms to describe subcategories of autobiographical memory detail, in order to maintain consistency with previous work in ageing. Using these definitions, episodic autobiographical details are those that describe a specific event lasting a day or less, and semantic autobiographical details are retrospective memory details that are abstracted from the context of a specific event. This definition of semantic details is a catch-all term that incorporates a broad range of non-episodic memory details, and we briefly discuss the need to subdivide the category in the discussion section.

as younger adults (Addis et al., 2008; Beaman et al., 2007; Gaesser, Sacchetti, Addis & Schacter, 2011; Ford, Rubin & Giovanello, 2014; Levine et al., 2002; Madore et al., 2014; Piolino, Coste, Martinelli, et al., 2010; Piolino, Desgranges, Benali & Eustache, 2002; Piolino, Desgranges, Clarys, et al., 2006; Ros, Latorre & Serrano, 2009). Typically, older adults' memories are found to contain less episodic detail (Addis et al., 2008; Levine et al., 2002; Piolino et al., 2010; St Jacques & Levine, 2007), or be less specific (Beaman et al., 2007; Ford et al., 2014; Ros et al., 2009), than younger adults' memories. The replication of this deficit across multiple cue types may have been taken as evidence that resulting memories are similar.

However, there have been a number of cases in which age-related deficits have not been observed (e.g. Aizpurua & Koutstaal, 2015; Mair, Poirier, & Conway, 2017; McDonough & Gallo, 2013; Schryer & Ross, 2014; Schulkind & Woldorf, 2005), and the reasons for these disparities are not clear. It may be that these cases represent statistical artifact or sampling bias, or the discrepancies may be the result of methodological differences between studies. One must also consider the well-established publishing bias which favours significant findings over null effects (Fanelli, 2010; Küberger, Fritz, & Scherndl, 2014); hence, there may be many more instances where age-related differences in autobiographical memory were not observed.

One of the most common measures of AM is based on the Autobiographical Memory Test (AMT; Williams & Broadbent, 1986), and requires participants to generate specific memories in response to generic cue words. Typically, responses are scored using a pre-defined scale, which ranges from a score of 0 indicating that no memory was recalled, through low scores for memories of repeated or general events, to a maximum score of 3 or 4 for the recall of a specific event with the addition of some contextual details. This task has been used extensively to measure age differences in AM (De Beni et al., 2013; Dijkstra & Kaup, 2005; Grady, St-Laurent & Burianovà, 2015; McDonough & Gallo, 2013; Beaman et al., 2007;

Holland, Redout, Walford & Geraghty, 2012; Hyland & Ackerman, 1988; Maylor, Carter & Hallett, 2002; Ros et al., 2009; Schlagman, Kliegel, Schulz & Kvavilashvili, 2009; St. Jacques, Rubin & Cabeza, 2012), and provides an index of AM retrieval that seems to be particularly linked to executive function (Dalgleish, Williams, Golden, et al., 2007; Holland et al., 2012). One limitation of this approach is that the amount of information recalled is of little consequence – a maximum score is awarded whether the participant recalls 4 event details or 40. The lack of sensitivity at the upper end of this scale makes it ideally suited to measuring the ability to retrieve the basic facts of past events (e.g. *I remember going to the park with my mum to feed the ducks*), rather than the ability to recall events in rich episodic detail.

Another commonly adopted method is to provide participants with a set of time periods (e.g. childhood, teenage years, the past year) from which to recall specific past events. Additional cues (e.g. a list of possible events, music, pictures) may also be provided to facilitate remembering (e.g. Aizpurua & Koutstaal, 2015; Gaesser et al., 2011; Levine et al., 2002; St. Jacques & Levine, 2007). Following a popular protocol developed by Levine et al. (2002), memories can be subsequently coded for the number of details that are internal (episodic) and external to the described event (general and personal semantic details, repetition, and episodic details pertaining to a different, non-target event). Proponents of this procedure argue for its increased sensitivity over previous clinical measures such as the Autobiographical Memory Interview (AMI; Kopelman, Wilson & Baddeley, 1989)[2], and this approach is ideally suited to measuring the quality of episodic recollection (Levine et al., 2002).

[2] As far as we are aware, there are no studies comparing the performance of healthy older and younger adults on the AMI. This may be because the test was developed for people with memory impairments, and is less sensitive than other measures for detecting age-related changes to AM. However, Levine et al. (2002) compared their scoring to the AMI rating scale and found that the two were significantly correlated.

As outlined above, these two approaches have produced largely consistent findings with regards to the effect of age, with older adults usually observed to perform more poorly (i.e. their memories are usually less episodic or less specific) than younger adults on both measures (e.g. Ford et al., 2014; Levine et al., 2002; Piolino et al., 2006). For this reason, it is easy to see why researchers might consider the findings from both types of study to be evidence of a general age-related decline in episodic AM. In support of this, Ford et al. (2014) assessed older and younger adults' memories, retrieved in response to musical clips, for both specificity and detail, allowing comparison of the two coding techniques. Age effects were similar for both the proportion of specific memories, and the proportion of episodic details within the memories.

However, the equivalence between memory specificity and detail was recently called into question by Kyung, Yanes-Lukin, and Roberts (2015), who dual-coded autobiographical narratives produced in response to generic cue words. In one round of coding, memories were classed as describing specific, temporally extended, or repeated events, and in the second round of coding specific memories were analysed for the number of non-redundant information units they included. They found that, in a sample of undergraduate students, the proportion of memories classed as specific did not correlate with the number of information units contained in those specific narratives.

A recent study measured memory for recently experienced everyday events in older and younger adults (Mair, Poirier & Conway, 2017). In that study, participants used a wearable camera, SenseCam, to record typical events of their own choosing, over the course of a week. Two weeks later, they returned to the laboratory to recall the events. In the recall session, they were presented with event titles they had generated themselves during the event sampling phase, and were asked to recall what had happened during the event. For some of the events retrieval support was provided in the form of sequences of images captured by their SenseCam. Both with and without SenseCam retrieval support, older and younger adults recalled a similar amount of episodic event information (measured as the number of standalone episodic "idea units", followed by ratings of the level of detail present within each episodic detail). This finding was inconsistent with the general consensus regarding age-related declines in memory, but by no means represents the only example of such inconsistency (Aizpurua & Koutstaal, 2015; Bluck, Levine & Laulhere, 1999; De Beni, Borella, Carretti, Zavagnin, Lazzarini & Milojevi, 2013; McDonough & Gallo, 2013; Schryer & Ross, 2014; Schulkind & Woldorf, 2005). Moreover, the methodology of the Mair et al. (2017) study was a considerable departure from that of previous studies, particularly as its aim was to measure recent, as opposed to remote, memory. In addition, the to-be-remembered event was specified, which may reduce the need for generative retrieval processing (Conway & Pleydell-Pearce, 2000). Given the apparent inconsistencies in the literature, it is plausible that age effects in AM can be dissociated across different tasks; perhaps some aspects of episodic AM are more age-sensitive than others, in which case age-related memory deficits should be greater in tasks that place more demand on these features.

However, there are other reasons why age differences may not be observed in a particular study. For example, the results may occur by chance, and therefore may not be replicable. Alternatively, the results may reflect a sampling bias; typically, young adult samples are drawn primarily from undergraduate cohorts, while older adults are recruited from the community. It is possible that samples differ in motivation to participate, as well as on other factors that may affect memory performance, such as education and IQ. To address these potential confounds, it is therefore of interest whether different measures of AM, administered to the same group of individuals, produce different results.

In the present study we investigated whether variable age effects across tasks were observable within the same sample of older and younger participants, and we also sought to conceptually replicate the Mair et al. (2017) finding that older and younger adults' episodic recall is comparable for everyday events (hereafter the *everyday memory* task). We therefore compared the same individuals across the everyday memory task and the two commonly employed approaches outlined above, namely AM cued by lifetime periods, and AM cued by generic words. Two lifetime periods were assessed as cues for AM: age 11-17, for which the age at memory encoding was matched for young and older adults (but the retention interval was much longer for older adults), and the past year, for which the retention interval was matched for both groups (but the age at encoding was different). Since AM tasks are relatively low in experimental control due to the idiosyncrasy of the recalled events, we also compared performance on AM tasks to a typical laboratory measure of episodic memory – word list recall – which was higher in experimental control.

If these episodic tasks measure the same underlying construct, namely the ability to recall specific, highly contextualised information, then age effects should be similar across all tasks. On the other hand, if episodic AM refers to a cluster of distinct processes, features or abilities, some of which are more sensitive to age than others, then we would expect age effects to vary by task (assuming the profile of features assessed by each task is sufficiently different). Comparison of age effects across these different tasks could therefore shed light on the processes involved in the AM tasks, and provide a more nuanced answer to the question of how older adults' AM differs from that of younger adults.

Method

Participants. Twenty young (age 20-31, M=25.05, SD=4.04; 18 female) and 20 older adults (age 66-82, M=70.60, SD=4.11; 17 female) participated for a payment of £20. Young adults were recruited via posters displayed around the university campus, while older adults were recruited from a panel of individuals over the age of 65, who had previously responded to an advertisement placed in a local newspaper. All participants had self-reported normal or corrected-to-normal vision and hearing. Older adults were screened for early indicators of dementia using a cut-off of 24 on the Mini Mental State Examination (MMSE; Folstein, Folstein & McHugh, 1975). Both older and younger adults completed the Geriatric Depression Scale (GDS; Yesavage, Brink, Rose, et al., 1983), which provided an indicator of emotional state that may be associated with memory specificity. To measure IQ in the two groups, all participants completed the two-subscale version of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) and the number of years of formal education was recorded for each participant. The results of the screening tests are presented in *Table 1*. Older adults were less educated than young adults but had significantly higher IQs. Both groups had similar scores on the GDS.

[Table 1 here]

Design. Episodic and semantic memory were measured separately because semantic details were not recorded in all tasks. For episodic memory, a 2 (age: young vs. older adults) x 5 (memory test: everyday memory vs. remote lifetime period (age 11-17) vs. recent lifetime (past year) vs. word-cued AM vs. episodic (word list) free recall) mixed design was employed with memory test as a repeated measures factor. Semantic memory was measured in the first three tasks only (everyday memory, remote lifetime period, recent lifetime period), therefore a 2 x 3 design was employed for the investigation of semantic AM. The dependent variable was different for each task; the scoring procedures are described in more detail below.

Materials and procedure.

Participants were interviewed individually, in person, by the first author, who administered the same five memory tests to all participants. Tests comprised four measures of “real world” episodic memory and one laboratory episodic memory task. The selection of tasks measured memory for different types of experience (i.e. more or less personally significant, mundane or distinctive), recalled in response to different cues (event title, time period, generic word) and at different retention intervals (seconds, days, months, years). Two of the tasks specified precisely what the participant was required to recall (everyday memory, immediate word list recall), while the others let participants choose their own events to describe.

Everyday memory. The everyday memory task was based on Mair et al. (2017), and involved the prospective sampling of everyday events over a one-week period, two weeks prior to the test date. An event was defined as anything lasting between 30 minutes and a few hours, and with a defined start and end, which could be given a title. In Mair et al. (2017) the events were sampled using a wearable camera (SenseCam), and an accompanying diary booklet in which participants titled the event and rated the frequency, familiarity, and distinctiveness of the activity. In the present study, participants were not provided with a wearable camera, and instead were asked to write basic event details (e.g. who, what, where, when) in a diary booklet, along with the event title and ratings of event frequency (*How often do you do what you did in this event?*) and distinctiveness (*How distinctive was this event/how much does it stand out from your usual activities?*). Frequency and distinctiveness ratings were made on a scale of 1-10, with 10 denoting the most frequent and most distinctive events. Twelve events were sampled in this way, sealed by the participant, and brought to the test session. During the test session, four of the 12 events were randomly selected by the experimenter for the participant to recall. The large number of sampled events was intended so that participants did not know in advance which events they would be asked to recall, and were therefore less able to practise. For the recall task, the experimenter read the title of the event to the participant, who then had unlimited time to describe what happened in as much detail as possible. Where participants only gave general information about routines or repeated events they were prompted with general cues to recall what had happened on that specific occasion (e.g. *Can you remember anything about the particular event for which you filled out the diary?*). No further cues were given. Responses were audio recorded, transcribed, and coded by the first author for the number of episodic and semantic details. Episodic details tended to be expressed as a sentence or a clause, and each detail constituted a piece of standalone information that directly described the experience of the event in question (e.g. *I saw a dog; I remember buying carrots*). In contrast, a semantic detail was a piece of standalone information that described something remembered, but not related to a specific event (e.g. *Jo is my sister; I always take the scenic route home*). A coded example is presented in *Appendix B*. Episodic details pertaining to different events, and other (non-memory) information reported by the participants (e.g. repetition, reflection, evaluation), were not coded.

AM cued by lifetime periods. Participants recalled one event from a temporally remote lifetime period and one event from a recent lifetime period; both events were required to be specific (i.e. not repeated), and to have lasted a day or less. For the remote period, participants described an event that happened when the participant was aged between 11 and 17, and for the recent period they described an event that had happened in the past year, but excluding the last month. For the remote period, age-at-encoding was matched in the two groups but retention interval was not, and for the recent period retention interval was matched but age-at-encoding was not. To assist with the selection of an event, participants were provided with a list of example events that could have happened within the given time period (e.g. first day at high school, a birthday party, trip to the seaside, a meal in a restaurant), however they were permitted to describe an event that was not on the list. Participants were given unlimited time to describe the events in as much detail as possible, and if they described an event that did not fit the required criteria they were prompted with a general cue (e.g. *Can you think of something that happened only once? Can you think of something that lasted a day or less?*). Responses were audio-recorded, transcribed, and coded by the first author. Following the coding scheme developed by Levine et al. (2002), each memory was divided into individual details which were classified as internal or external. Internal details were those that were specific to the event in question and included information about what happened, location, time, and thoughts and emotions. Internal details were therefore equivalent to the episodic memory details coded in the everyday memory task, and are therefore hereafter referred to as episodic details. External details included semantic details, unsolicited repetitions, reflections, and contemporaneous evaluation, as well as episodic details that referred to an event other than the one in question. For the purposes of the present study, only the semantic subcategory of external details was analysed. This resulted in two categories of detail – episodic and semantic – which were equivalent in the lifetime period-cued AM and everyday memory tasks.

Word-cued AM. For this task, participants were provided with six cue words (*happy, wildlife, excited, library, luck, occasion*) and were asked to describe, in as much detail as possible, a specific memory associated with and the word, which lasted a day or less. For each word two minutes were allowed for the production of a memory, after which if participants had not started speaking the response was recorded as zero and the next cue word was attempted. If participants began to speak within the two minutes, they were allowed to continue uninterrupted for as long as they required. Memories were rated on a scale of 0-4, following the protocol of episodicity ratings devised by Piolino et al. (2006). The maximum rating of 4 was given to memories that described a specific instance (i.e. not a repeated event), lasted less than a day and contained episodic detail. A score of 3 was given if the memory was as above, but lacking episodic detail. Memories of repeated or extended events situated in time and space received a rating of 2 if they contained some event detail, and 1 if they did not. A rating of 0 was applied in cases where there was an absence of memory, or only very general information was provided regarding the cue word.

Free recall. For this task participants were presented with a list of 25 unrelated common English nouns presented on a computer at a rate of 5s per word. The presentation was deliberately slow in order to minimise the influence of processing speed as a confounding variable, since older adults' processing speed is typically reduced (Salthouse, 1996), and because no time limit was set for the autobiographical tasks. Word characteristics were obtained from the MRC Psycholinguistic Database (Coltheart, 1981). The selected words all had 5 letters, two syllables, concreteness ratings of between 500 and 650 and familiarity ratings of between 450 and 550 (both concreteness and familiarity scales range from 100 to 700). From the original pool of 56 words, 10 were excluded because (a) they differed by only one letter from another word in the list (e.g. *daisy*/*dairy*; one of each pair was excluded at random), (b) the word was considerably less common in British English than American English (e.g. *burro*; confirmed using Google Ngram Viewer 2009 corpora), (c) had different meanings in British and American English (e.g. *jelly*), or (d) pronunciation was highly irregular (e.g. *choir*). Of the remaining 46 words, 25 were randomly selected for inclusion (see *Appendix A*). Immediately after presentation of the word list, participants were allowed 3 minutes to verbally recall as many words as possible, in any order. If participants indicated that they had finished the recall attempt within the 3 minutes but they had not recalled all 25 words, the timer was kept running and they could add to the recall at any point until the 3 minutes had elapsed. The score for this task was the number of words correctly recalled.

Reliability of AM coding. All transcripts were coded by the first author, and three additional independent raters coded subsets of transcripts (*n*=6) from each of the autobiographical tasks. For the lifetime period AMs and everyday memories, raters were asked to count the total number of episodic and semantic details in each transcript, and for the word-cued AMs coders rated the memories on the 5-point scale described above. Independent raters were blind to the study hypothesis and were not informed about the age groups to which the transcripts belonged. However, the content of the memories was not redacted and it is possible that group membership could have been inferred from the content (e.g. talking about grandchildren would have indicated the transcript belonged to an older participant). Two-way random intraclass correlations were calculated to determine the consistency between raters for each detail type in each AM task. Consistency was high for all measures, suggesting good agreement between raters (everyday memory: episodic α=.90, semantic α=.98; lifetime periods: episodic α=.95, semantic α=.90; word-cued AM: α=.98).

Results

Everyday memory event characteristics. First, we analysed the frequency and distinctiveness ratings for the events sampled in the everyday memory task, and the relationship between frequency and distinctiveness ratings and the number of episodic and semantic details recalled at test. Since participants recalled four separate memories in this task, there were four scores per participant for each variable and the data were hierarchical, which compromised statistical independence (Wright, 1998). To account for person-level variance within these data, we first calculated the within-subject correlations between each pair of variables, across the four ratings per participant. In three cases it was not possible to calculate a correlation coefficient because one of the variables was continuous (i.e. all ratings for a particular participant were the same). One older adult rated the distinctiveness of all events at “1”, and one older and one younger adult did not recall any semantic details for any of the events. This resulted in the exclusion of these three participants for the corresponding analyses only, therefore the sample *n* varied slightly across different pairs of variables (see *Table 2*). We then calculated the mean correlation for each pair of variables across the whole sample, and conducted one-sample t-tests, corrected for multiple comparisons (α =.008) to determine whether the correlation coefficients were statistically different from zero. The mean sample correlations are presented in *Table 2*. There were significant correlations between the number of episodic details and event frequency ratings ($t(39)=-6.10$, $p<.0005$), episodic details and event distinctiveness ($t(38)=5.45$, $p<.0005$), and event frequency and event distinctiveness ($t(38)=-10.80$, $p<.0005$), but correlations between semantic details and event frequency ($t(37)=1.51$, $p=.14$), semantic details and event distinctivenss ($t(36)=.83$, $p=.41$), and episodic and semantic details ($t(37)=-.82$, $p=.42$) were not significantly different from zero.

[Table 2 here]

We next checked whether there were between-group differences in event characteristics. Here we used the mean frequency and distinctiveness for each individual, across the four sampled memories, which is consistent with our later analyses. There were no between-group differences in either event frequency ($M_{older}=4.90$, $SD_{older}=1.69$; $M_{younger}=4.40$, $SD_{younger}=1.17$; $t(38)=-1.10$, $p=.28$) or distinctiveness ($M_{older}=5.42$, $SD_{older}=2.40$; $M_{younger}=6.16$, $SD_{younger}=1.21$; $t(38)=1.24$, $p=.22$), which suggests that despite the idiosyncratic nature of naturalistic memory sampling, the events sampled in this study were relatively well matched.

IQ and education. Correlations between age, IQ, and memory measures are presented in *Table 3*, below. In contrast to the correlations reported above, tasks for which multiple observations were made are here averaged across the number of observations per participant.

The critical alpha level was adjusted (α=.0009) for multiple comparisons. As reported above, IQ and education scores were significantly different between groups. However, there were no significant correlations between IQ and episodic memory measures, and IQ only correlated with semantic recall on the everyday memory task. In addition, there were no significant correlations between education and semantic memory measures, and education was only correlated with episodic memory on the word-cued AM task. Given the large number of calculations, some significant correlations would be expected to occur by chance. Since it is not possible to know which, correlations are provided only as a means of visualising the data and are not interpreted further.

[Table 3 here]

Analysis of memory measures. To examine the main hypothesis of interest, which is that the effect of age group varies across tasks, we converted episodic and semantic memory scores to *z* scores so that differences in scoring protocols did not skew the results. The *z* scores were calculated around the sample mean raw score for each individual test. Because semantic recall was not measured on two of the five tasks (word list free recall, word-cued AM), episodic and semantic scores were analysed separately, in a 2 (age group) x 5 (episodic score) and a 2 (age group) x 3 (semantic score) mixed ANOVA run in SPSS, with age group as the between-subjects factor and task as the within-subjects factor. Bayes factors were also calculated for these analyses in the JASP software package (JASP, 2018), using the default settings. Follow-up t-tests (in SPSS) and Bayesian t-tests (in JASP) were conducted to examine age effects on each task. Bayesian t-tests were run using the default Cauchy prior width of 0.707, but specifying the directional hypotheses, based on previous research, that younger adults would outperform older adults on episodic measures, and that older adults would outperform younger adults on semantic measures. The raw scores for each of the memory measures are presented in *Table 4,* and the *z*-scores are plotted in *Figures 1* and *2*.

[Table 4 here]

Episodic memory. As expected, given that the conversion of raw scores to z scores centred all scores around a mean of 0, there was no main effect of task ($F(4,152)<.01$, $p=1.00$, $\eta_p^2<.001$; $BF_{10}=.02$), but there was a main effect of age group ($F(1,31)=10.96$, $p=.002$, $\eta_p^2=.22$; $BF_{10}=14.97$). Overall, younger adults ($M_z=.31$, $SD_z= .72$) outperformed older adults ($M_z=-.32$, $SD_z= .45$) on episodic memory measures. However, this effect was qualified by a significant age group by task interaction ($F(4,152)=3.22$, $p=.01$, $\eta_p^2=.08$; $BF_{10}=.82$). This interaction was followed up with five independent t-tests, adjusted for multiple comparisons ($\alpha=.01$), which showed significant age effects on word-cued AM ($t(38)=4.68$, $p<.0005$, $BF_{10}=1052.92$) and word list free recall ($t(38)=3.31$, $p=.002$; $BF_{10}=34.79$), but not on the everyday memory task ($t(38)=.46$, p=.65; $BF_{10}=.44$) or the lifetime period-cued AM from the past year: $t(38)=.62$, p=.54, $BF_{10}=.51$). The small Bayes factors for these two tests indicate that the data for these tasks were insensitive, and do not constitute evidence for the null hypothesis (Dienes, 2014). However, it is the differential sensitivity of the tasks to age effects which is discussed below. The lifetime period-cued AM from age 11-17 did not meet the corrected threshold for statistical significance($t(38)=2.23$, p=.03), however the corresponding Bayes factor, given the hypothesis that younger adults would outperform older adults, indicated that the data provided moderate evidence for the superior performance of young adults ($BF_{10}=4.08$). This suggests that the observed data are four times more likely under this hypothesis, relative to the null hypothesis.

[Figure 1 here]

Semantic memory. As above, there was no main effect of task on semantic recall ($F(2,76)<.001$, $p=1.00$, $\eta_p^2<.001$, $BF_{10}=.08$), but there was a main effect of age group ($F(1,38)=9.25$, $p=.004$, $\eta_p^2=.20$; $BF_{10}=9.25$), which showed that older adults ($M_z=.34$, $SD_z= .84$)

recalled more semantic details than younger adults (M_z=-.34, SD_z= .53). The age by task interaction was not significant (F(2,76)=2.96, p=.06, η_p^2=.07; BF_{10}=.97). Frequentist follow-up t-tests were not conducted because the interaction effect was not significant. However, as above, Bayesian t-tests compared older and younger adults' semantic recall on each task. There was strong evidence for older adults' increased semantic recall in the everyday memory task (BF_{10}=462.64), but results for memories from the past year (BF_{10}=.88) and age 11-17 (BF_{10}=1.79) were inconclusive.

[Figure 2 here]

Memory age. One obvious way in which the AM tasks described above differ from one another is the length of retention interval between the original experience and the memory test. Visual inspection of the plotted *z*-scores in *Figure 1* suggests that age effects may generally increase with increasing retention interval. The interval is greater for older adults than younger adults when recalling memories from age 11-17, and previous studies have shown that where no time period is specified (as in the word-cued AM task) older adults tend to recall older memories than do younger adults (Hyland & Ackerman, 1988; Sperbeck, Whitbourne, & Hoyer, 1986). We next asked whether the older adults' deficit on the word-cued AM task might be attributable to a bias towards recalling older memories.

First, each memory from the word-cued AM task was rated by the experimenter according to its age (1 = 0-5 years; 2 = 6-10 years; 3 = 11-20 years; 4 = more than 20 years). Participants were not asked to date the memories, but very often they voluntarily reported information about the time period (e.g. *when I was 21*; *last year; in 2006*). However, a number of responses did not contain sufficient information to be assigned to a time period, and some responses could not be dated because they were repeated or extended over a period that spanned two or more age bins, they were too vague, or because the participant had failed to recall anything at all. Overall there were eight such responses across seven participants in the younger group and 22 such responses across 12 participants in the older group. These responses were excluded before calculating the binned mean retention interval for each participant across the remainder of the memories recalled on this task. The mean retention interval for younger adults (M=1.32, SD=.35) was significantly shorter than the retention interval for older adults (M=2.24, SD=1.01; $t(38)=3.85$, $p<.0005$). *Figure 3* shows the age of the memories recalled by both groups. The between-group difference in the number of memories recalled from the >20 years time bin is not surprising, given both the lower age of the younger adults and the well-established "reminiscence bump" for older adults (e.g. Jansari & Parkin, 1996; Koppel & Berntsen, 2015; Rubin & Schulkind, 1997), which refers to the tendency to recall more experiences from adolescence and early adulthood relative to other lifetime periods. The older adults' increased recall for the most remote period seems to correspond to a decrease in memories for the most recent period, and both groups recalled relatively few memories from the intervening 6-20 year period.

[Figure 3 here]

There were not enough data to compare memory specificity at each retention interval, therefore the specificity of younger and older adults' memories was compared for the most recent period only (0-5 years). Three older participants were excluded from this analysis because they did not recall any memories less than five years old. For the remaining sample, the mean specificity rating was calculated for all eligible memories to give a single score per participant. Even when retention intervals were similar for both groups, younger adults' memories (M=3.57, SD=.50) were more episodic than older adults' memories (M=3.03, SD=.47; $t(35)=3.36$, p=.002). Thus, although this does not rule out the possibility that retention interval negatively affects recall, the difference in older and younger adults' specificity ratings could not be attributed only to differences in retention interval.

Discussion

Episodic memory

The results presented above demonstrate that within the same sample of participants the magnitude of the age effect varies across tasks, with marked performance differences between older and younger adults on some tasks (word-cued AM, word list free recall), and little evidence for an age-related deficit on others (everyday memory, memory for events from the past year). This suggests that methodological differences between studies can produce inconsistent results due to tasks' differential sensitivity to age-related changes. In order to understand the effects of ageing on memory it is important to consider the memory mechanisms involved in different AM tasks, as well as the characteristics of the recalled memories. Using a prospective sampling method, we found little evidence of a difference in older and younger adults' episodic memory for recent everyday events, which conceptually replicated the finding from Mair et al. (2017). However, the same group of older participants were markedly impaired relative to younger participants on other more widely-used measures of memory. In particular, and consistent with previous findings, age-related deficits were observed for episodic free recall (e.g. Bouazzaoui, Fay, Taconnat, Angel, Vanneste & Isingrini, 2013; Craik, Byrd & Swanson, 1987) and word-cued autobiographical recall (Beaman et al., 2007; Holland et al., 2012; Ros et al., 2009). Moreover, scores on these two tasks were correlated, but were not related to performance on the other episodic tasks, which suggests that there are features common to episodic free recall and word-cued AM that are not shared, or are shared to a lesser extent, with the other measures.

Executive/retrieval processing. One potential explanation is that the two tasks with the greatest age effects – word-cued AM and episodic free recall – both rely heavily on executive processes (e.g. Clarys, Bugaiska, Tapia, & Baudouin, 2009; Dalgleish et al., 2007). It is welldocumented that older adults perform poorly on many executive function measures (Berna Schönknecht, Seidl, Toro & Schröder, 2012; Clarys et al., 2009; Fisk & Sharp, 2004; Lee, Crawford, Henry, et al., 2012), therefore poor performance in these tasks could reflect a mismatch between the task demands and executive processing capacity. A possible mechanism is the extent to which the task requires generative retrieval processing – an executive "working-with-memory" faculty (Moscovtich, 1992) that appears to be particularly difficult when executive capacity is compromised (Williams et al., 2006). For example, the word-cued AM task uses generic nouns that may be (a) only loosely associated with the retrieved memory, (b) only retrospectively associated with the retrieved memory, and (c) possible to associate with several memories other than the one that is selected during the test. This task is therefore likely to require more generative retrieval processing than the everyday memory task, which specifies precisely which event is to be recalled, and may therefore facilitate the direct retrieval of event information (see Conway & Pleydell-Pearce, 2000, for an account of direct vs. generative processing). It may be that reducing the demand on executive retrieval processes is particularly beneficial for older adults. On the other hand, even when some event information can be directly retrieved, generative retrieval is presumably still required to produce a detailed description of what happened, therefore even the everyday memory task is likely to involve considerable generative processing. In addition, the number of episodic details recalled in the everyday memory task was comparatively low for both groups, which suggests that recall was not so much facilitated, but rather hindered in this task.

Retention interval. It is also possible that older adults perform more poorly than younger adults because their memories tend to be older. The largest age effect was observed in the word-cued AM task, for which older adults recalled memories that were, on average, older than younger adults' memories, and there was more evidence of an age difference in memories from age 11-17 (~55- year retention for older adults vs. ~10-year retention for young adults) than memories from the past year. In addition, the smallest difference between the two groups was observed in the everyday memory task, for which the recalled memories were only two weeks old. However, although it is generally understood that memories become "semanticised" over time (e.g. Cabeza & St. Jacques, 2007; Conway, 2009; Moscovitch, Nadel, Winocur, Gilboa, & Rosenbaum, 2006; Nadel & Moscovitch, 1997; Smith & Graesser, 1981), this account fails to explain why (a) a large effect of age was observed on the episodic free recall test, which measured performance after an interval of only a few seconds, and (b) older adults' word-cued AMs from the past five years were still less episodic than younger adults' word-cued AMs from the same period. Moreover, and as argued above, episodic recall was relatively poor for both groups on the everyday memory task, and comparatively better on the lifetime period-cued AM task when retention intervals were longer.

Prospective sampling/elaborative encoding. A further argument is that, due to prospective event sampling in the everyday memory task, participants were aware that their memory would later be tested, and could engage in elaborative encoding (e.g. Bradshaw & Anderson, 1982), which would facilitate their later performance. A related possibility is that the act of completing the diary form for each sampled event was an act of elaborative encoding or event rehearsal, which led to better memory for the events two weeks later. However, Craik and Rose (2012) argued that meaningful stimuli such as pictures and scenes are automatically processed deeply by individuals of all ages, and it seems reasonable to suggest that this automatic elaborative encoding would be particularly true of autobiographical events which are by definition high in personal significance. In contrast, everyday events sampled prospectively across a typical week are likely to be less personally important, and less well-rehearsed than events sampled retrospectively from across the lifespan. Older adults' clearly poorer performance on some of these tasks, but not others, is therefore hard to reconcile with the hypothesis that differences in elaborative encoding or rehearsal are the causal factors.

Moreover, advance knowledge of the memory test cannot itself be a sufficient condition for older adults to perform well, or this performance enhancement would have been observed in the episodic free recall task. In addition, and as above, it is difficult to argue that the everyday memories were particularly well-remembered since the amount of information reported by both older and younger adults was comparatively low in this task.

Event salience. One factor that remains difficult to measure is the degree to which the characteristics of the recalled event affect what is remembered. In the everyday memory task, we found that participants' subjective ratings of event frequency and distinctiveness at the time of the experience were strongly correlated with subsequent memory for what happened, which indicates that some events are simply more memorable than others. In particular, events that were rated at the time as less frequent (i.e. the participant experienced similar events less often) were recalled in more episodic detail two weeks later. Similarly, events that were rated at the time as more distinctive (i.e. stood out more from the participant's usual activities) were also recalled in more episodic detail two weeks later. This is consistent with the layperson's view of memory, and suggests that accumulating interference from repeated, similar events makes retrieval of the specific instances more difficult (see Yassa & Reagh, 2013). Previous research investigating repeated events has shown that people who experience more health events within a given period tend to recall fewer of them, and individual instances of recurrent health events are recalled more poorly than non-recurrent health events (Cohen & Java, 1995; Means & Loftus, 1991). In addition, children exposed to multiple instances of a repeated event have been shown to have difficulty recalling information specific to one instance, yet they are able to recall details that reoccurred in every instance, or more general information about what usually happens (Farrar & Goodman, 1992; Hudson & Nelson, 1986).

Importantly, event frequency and distinctiveness may not be task-independent. In typical AM tasks such as the word-cued and lifetime period-cued tasks employed here, participants are afforded some freedom to choose which memories they will describe, and those that come readily to mind, or are selected over others as appropriate to the task, are likely to be those that are the most distinctive, and therefore stand out in some way. For example, when asked to recall a memory from the past year, it is far more likely that the participant will describe a wedding, party, or day trip than an average day at work, breakfast alone at home, or a visit to the supermarket. In contrast, when everyday events are sampled from the previous few days or weeks, the likelihood that something truly outstanding happens within the sampling period is fairly small. Thus, although there may be variation in the salience of recently experienced events, on average they are likely to be less distinctive than AMs that are sampled from a longer time period. In the present study, therefore, recall that appeared to be poorer in the everyday memory task than the similarly-scored lifetime period-cued AM task, despite the much shorter retention interval for the everyday memory task, may have been so because events sampled in the everyday memory task were more frequently experienced and less distinctive.

Although in the present study the coding system for the different tasks was not identical, the pattern of results is consistent with a recent study, which showed that, in both older and younger adults, memories from the past 10 years were better remembered than memories from the past year, which in turn were better remembered than memories from the past week (Aizpurua & Koutstaal, 2015). Interestingly, that study also found that younger adults recalled significantly more episodic details than older adults in memories from the past 10 years, but not from the past year or the past week, which is broadly consistent with the pattern of results reported here (i.e. greater between group differences observed at longer retention intervals), and raises the question of whether older adults may be less sensitive to memory enhancements associated with event distinctiveness.

If interference from previous similar experiences is acknowledged as a potential detractor from event memorability, this could have important implications for the study of memory in ageing. Across their longer lifespan, older adults have necessarily accumulated more experiences than younger adults, and thus interference must be greater in this group (Ramscar, Hendrix, Shaoul, Milin, & Baayen, 2014). One hypothesis, then, is that this large amount of accumulated experience reduces or eliminates the beneficial effect of event distinctiveness for older adults, because even distinctive events share many features with previous experiences. An alternative conceptualisation is that young adults' everyday memory performance is older adult-like, due to interference from a large number of similar experiences.

Semantic Memory. The results presented here did not find evidence of a dissociable age effect on semantic recall. However, the findings were broadly consistent with previous research (Aizpurua & Koutstaal, 2015; Levine et al., 2002; Mair et al., 2017) in that older adults generally recalled more semantic details than younger adults. The instructions for each task in the present study emphasised the recall of specific event details, therefore the production of semantic information might be considered tangential, and at present, there is little consensus regarding why these details are more common in older adults' memories. A recent multilevel analysis of autobiographical memories from eight previous studies suggested that, at the level of the individual memory, recall of external memory details (including semantic details) was negatively correlated with recall of internal (episodic) details (Devitt, Addis, & Schacter, 2017). In this study, however, older adults' semantic recall did not appear to compensate for a failure to retrieve episodic details. Firstly, older adults' semantic recall was increased on the everyday memory task despite no evidence of an episodic deficit.

Secondly, there was a strong positive correlation between episodic and semantic recall in memories from the past year, and no correlation between episodic and semantic recall in memories from age 11-17 A negative relationship between the two detail types was not observed in any task. The apparently variable relationship between episodic and semantic recall is not easy to explain; one issue which has complicated attempts to understand semantic AM is the heterogeneity of the category exemplars. Typical semantic details may be highly abstracted from episodic memory (e.g. *John is my brother*), or may be "experience-near", and overlap considerably with episodic memory (e.g. repeated events), yet do not meet the strict defining criteria for episodic memory (Grilli & Verfaellie, 2014, 2016; Renoult et al., 2012; Rubin & Umanath, 2015). There is growing recognition of the need to consider subdivisions in semantic memory separately (e.g. Strikwerda-Brown, Mothakunnel, Hodges, Piguet, & Irish, 2018), but it is not yet clear whether particular subtypes of semantic detail are more prevalent in older adults' memories.

Two alternative explanations for older adults' increased semantic recall suggest that older adults attempt to find meaning in their experiences by relating them to a wider context (Habermas et al., 2013), or that their semantic recall reflects a shift in communicative goals (James et al., 1998), but evaluation of these accounts is beyond the scope of the present findings.

Conclusion

The findings reported here show that different tasks measuring memory for personally experienced events are differentially sensitive to age-related changes. This raises important questions about the specific processes involved in retrieval of AM across different tasks and time periods, and the effect of the characteristics of the recalled events themselves. Further research should be aimed at better understanding the factors that contribute to this variance in performance for both older and younger adults.

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Appendix A: Word list used in immediate recall task

ANKLE
DAISY
ONION
MURAL
RIFLE
PEDAL
MAPLE
ROBIN
LIVER
MEDAL
CABLE
ALLEY
TOWER
MOTOR
CABIN
LEVER
HONEY
PUPPY
CANAL
GRAVY
CIDER
CIGAR
JEWEL
SATIN
LEMON

Appendix B: Coding instructions for the everyday memory task

Episodic details are those that are bound to the context of the event. They are things that are **specific to the event** and not associated with any other context – they deal with **what actually happened during the event**. An episodic detail might be something visual, an action, an interaction, a concept, a thought, a feeling… etc.

Semantic details are those that are not bound to the context of the event. They deal with more general information, including things like **knowledge about the self and others** (*John used to be a teacher; I like cats; Sarah lives in East London*), information about **routines** (*I usually visit my sister on Sundays*) or **repeated events** (*We used to play in the street on summer evenings; I spent my first year going to seminars*), and **temporally extended events** (*I grew up in London; I spent two weeks in France this summer*). Note that temporally extended events are defined here as anything longer than about 24 hours.

Example: Walk with T in parks

T is the boy, the disabled boy I work with **(S)** and on that day he fancied using the walking sticks. **(E)** He's got a pair of walking sticks to go out in the park **(S)** and he really enjoys using the walking sticks. **(S)** So he always works to get what he wants most, so he's got an hour to work for what he wants to do**.(S)** And we did that and he got all the rewards **(E)**. And I remember now, it was really raining on that day **(E)** and I got drenched **(E)** and then I felt, I can't do a four hour session inside the home so I need to get him out of the home, I'd rather be outside again than inside wet. **(E)** And so we got out and just walked through the park **(E)** which is next to where he lives, **(S)** and then all the way to Richmond Park. **(E)** With the walking sticks he was absolutely fine, really well behaved, **(E)** and we got to the café and it was closed **(E)** which was a shame. But we walked back **(E)** and I was quite surprised that he could walk that [far] **(E)** yeah, he normally moans when he has to walk along a stretch, **(S)** but I think he was so obsessed with these walking sticks he was fine. **(E)** So that was good.

Table 1

Group depression, IQ and education scores

	Young adults		Older adults		
Sample characteristics	*M*	*SD*	*M*	*SD*	*t*
IQ	111.50	9.06	119.45	14.47	2.08*
Education	16.85	2.54	14.11	4.38	2.41*
GDS	4.50	3.66	5.39	5.96	.56

*p<.05

Table 2

Mean within-subject correlations between event characteristics and episodic and semantic recall in the everyday memory task

	Distinctiveness	Episodic detail	Semantic detail
Frequency	-.66^	-.48 ^	.08+
Distinctiveness		.42	.14§
Episodic detail			-.08+

n=40, except where: ^ *n*=39; + *n*=38; §*n*=37

Table 3

Correlations between IQ, education, and memory measures

	2	3	4	5	6	7	8	9	10	11
1	.32	.37	.30	.17	-.13	.13	.22	.44	.26	.17
2		-.35	.13	.01	.10	.44	.30	-.05	.05	-.24
3			.04	-.04	-.41	-.59*	-.48	.64*	.27	.28
4				.33	.24	.23	.13	.17	.01	.11
5					.28	.32	.43	.14	.61*	.27
6						.48	.19	.05	.07	-.05
7							.52	-.23	.02	-.14
8								-.13	.11	-.05
9									.43	.33
10										.45

Note. 1= IQ, 2= education, 3=age group (Spearman's rho), 4=everyday memory episodic, 5=past year episodic, 6=age 11-17 episodic, 7=AMT, 8=word list immediate recall, 9=everyday memory semantic, 10=past year semantic, 11=age 11-17 semantic. All correlations are pearson's *r*, except age group for which spearman's rho was calculated because it is a categorical variable. Episodic memory measures are in grey cells. Coefficients marked with an asterisk (*) are significant at the adjusted level, α = .0009.

Table 4

Raw unstandardized scores on each of the memory measures

		Young adults		Older adults		Difference
Measure	Task	*M*	*SD*	*M*	*SD*	
Number of episodic details	Everyday memory	12.14	11.96	10.78	5.94	-1.36
	AI (past year)	34.10	29.03	29.45	16.49	-4.65
	AI (age 11-17)	26.20	18.17	16.20	8.45	-10.00
Number of semantic details	Everyday memory	2.54	1.69	8.09	5.42	5.55
	AI (past year)	4.75	7.03	7.15	6.11	2.40
	AI (age 11-17)	4.85	5.95	8.85	8.65	4.00
Word count	Everyday memory	224.05	190.42	259.06	112.99	35.01
	AI (past year)	364.70	416.19	333.25	165.51	-31.45
	AI (age 11-17)	307.05	215.60	254.15	126.59	-52.90
Episodic rating	AMT	3.43	.57	2.60	.56	-0.83
Number of words recalled	Immediate word list recall	15.75	4.25	11.68	3.73	-4.07

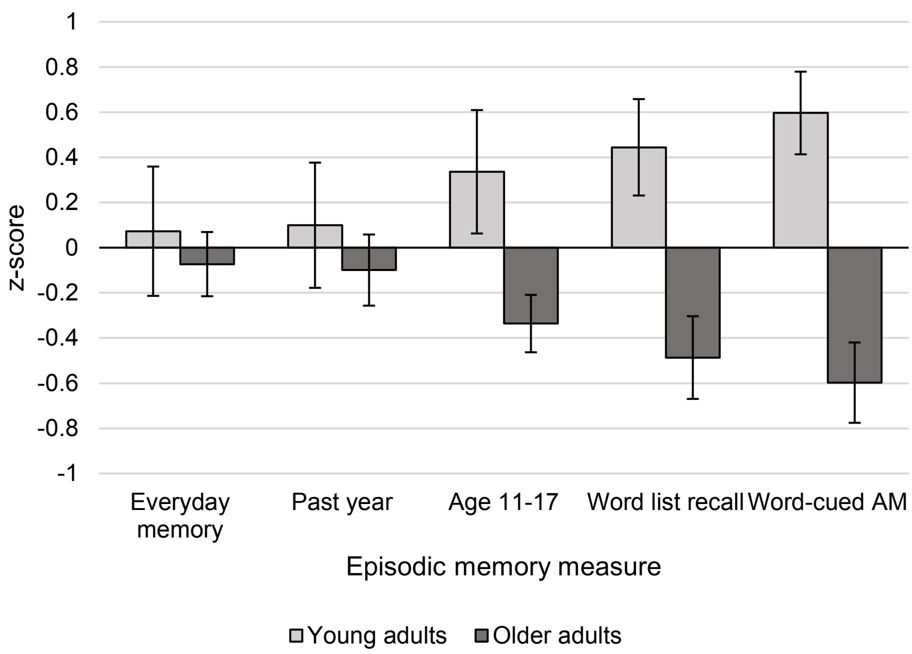

Fig. 1. Older and younger adults' episodic memory scores, plotted as *z*-scores and presented in order of increasing magnitude. Error bars represent standard error.

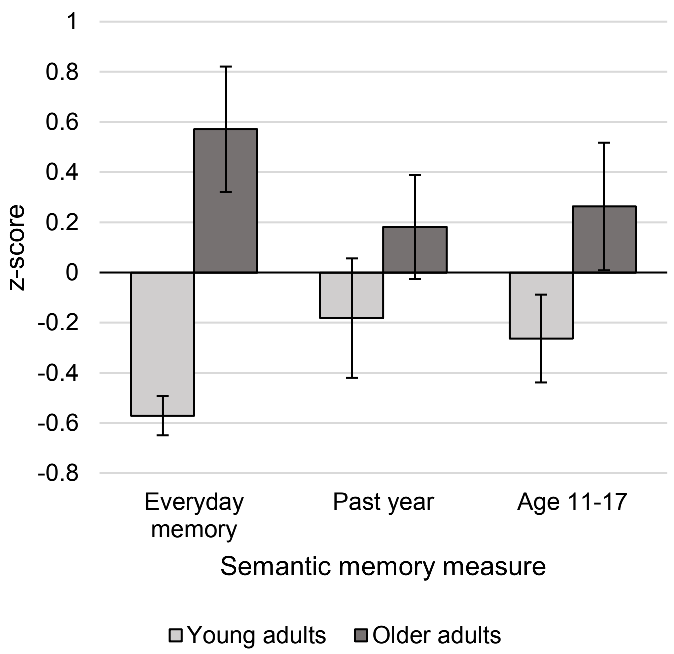

Fig. 2. Older and younger adults' semantic memory scores, plotted as *z*-scores. Error bars represent standard error.

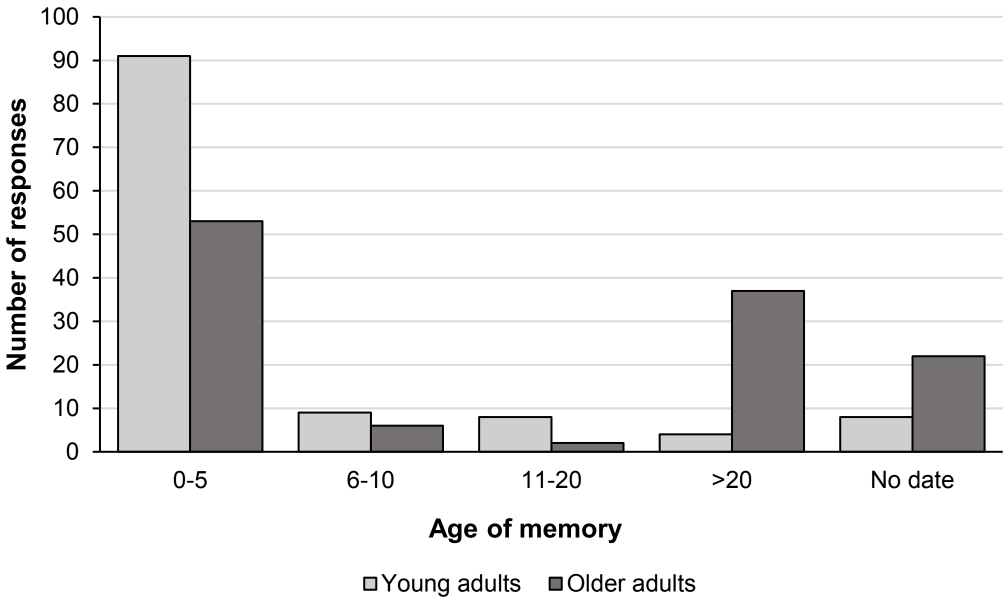

Fig. 3. Approximate age of memories (in years) recalled by older and younger adults on the word-cued AM task