Effects of Age on Autobiographical Memory

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Declaration

I grant powers of discretion to the University Librarian to copy this thesis in part or in whole without further reference to me. This covers only single copies for study purposes. The contents of this thesis are subject to normal conditions of acknowledgement. The content of this thesis is my own work.

The following three sections of this thesis have been submitted for publication.

Experiment 1:

Mair, A., Poirier, M., & Conway, M. A. (2017). Supporting older and younger adults' memory for recent everyday events: A prospective sampling study using SenseCam. *Consciousness and Cognition, 49,* 190-202.

Experiment 2:

Mair, A., Poirier, M., & Conway, M. A. (under revision). Dissociable age effects on different measures of autobiographical memory.

Experiments 4 and 5:

Mair, A., Poirier, M., & Conway, M. A. (under revision). Autobiographical memory for staged events: supporting older and younger adults' memory with SenseCam

Abstract

Six experiments investigate the effects of healthy ageing on autobiographical memory (AM). Previous work in this area has shown that older adults exhibit a deficit in recall of specific episodes from their personal past, yet there is evidence in the literature of exceptions to this rule. As yet, there have been few replications and little systematic exploration of the factors and processes that contribute to age effects in AM. *Chapter 1* begins with an examination of age differences in memory for prospectively sampled recent everyday events – an area which, despite the growing interest in AM research, has remained largely unstudied. The results showed similar event memory for younger and older adults, and demonstrated both replicability and dissociation from more typical measures of AM (Experiment 2). Subsequent investigations focused on ways of cueing AM by manipulating the need for generative retrieval processing (*Chapter 3*), and the effect of increasing experimental control and measuring memory for the same staged event (*Chapter 4*). On all other tasks older adults performed more poorly than younger adults. However, a reanalysis of the data suggested that younger adults exhibit an elderly-like deficit on measures of memory for mundane, everyday events. Moreover, analysis of semantic memory within autobiographical narratives suggested that older adults recall more temporally abstracted information than younger adults (*Chapter 5*). The findings are interpreted within a framework which suggests that accumulating experience drives a shift from specific episodic memory representation towards a more abstracted schematic form. A parallel line of research investigated the effect of a wearable camera, SenseCam (SC), on memory for recently experienced events (Experiments 1, 4 and 5). SC use provided a general retrieval benefit, but the effect was the same for both younger and older adults, which supports the notion that poor memory performance in older adults is related to altered memory representation rather than deficient retrieval processes.

Chapter 1: Introduction

This thesis is concerned with the effects of healthy ageing on autobiographical memory (AM), which is memory for information related to the self (Brewer, 1986). Thirty years ago, Brewer noted that in the field of AM "there is considerable divergence both in what is being investigated and in the terminology used to describe what is being investigated" (p.25). While the intervening period has seen a steep rise in the number of studies investigating AM, Brewer's comment remains pertinent. This is particularly evident in studies of AM in healthy older adults, an area in which methodological replications are rare: past studies have varied considerably in terms of the use of retrieval cues (e.g. words, time periods), retention intervals, characteristics of target memories (e.g. emotional vs. neutral), and dependent variables. These findings are reviewed in *Section 1.2*. One aspect of AM research that links most studies, however, is the focus on the ability to recall specific past episodes in detail. This is based on a dichotomy imported from laboratory-based memory research, namely the distinction between episodic and semantic memory, which is outlined in the following section.

Section 1.1

Background

Episodic versus semantic memory. The distinction between episodic and semantic memory was first proposed by Tulving (1972), and since then it has been widely employed in laboratory studies (e.g. Balota, 1983; Brandt, Gardiner, Vargha-Khadem, Baddeley & Mishkin, 2006; Graham, Simons, Pratt, Patterson & J. R. Hodges, 2000; Klimesch, Schimke & Schwaiger, 1994; Saive, Royet, Garcia, Thévenet & Plailly, 2015). According to Tulving's original work, episodic memory concerns information about temporally dated episodes and the way these episodes are related in space and time, whereas semantic memory is a "mental thesaurus" (p.386) and concerns a person's knowledge about the world, including knowledge of language (i.e. vocabulary and grammar). Thus, by this system, knowing that the word "cat" refers to a small, four-legged pet with fur, whiskers and a tail, would constitute semantic memory, while remembering that the word “cat” was present on a recently-seen list of words would constitute episodic memory.

Clinical groups whose memory impairments dissociate episodic and semantic memory are often cited as evidence that these two forms of memory are separate (but see *Retention interval as a confounding factor* section, below). For example, patients with hippocampal amnesia (both developmental and adult-onset) are typically observed to have episodic memory deficits, while their semantic memory is relatively spared (Brandt et al., 2006; Manns, Hopkins & Squire, 2003; Vargha-Khadem, Gadian, Watkins, Connelly, Van Paesschen & Mishkin, 1997; Warrington & McCarthy, 1988). A similar pattern is sometimes observed in patients with Alzheimer’s disease (Greene, J. R. Hodges & Baddeley, 1995; Nebes, Martin & Horn, 1984), although many Alzheimer’s patients also exhibit a semantic memory deficit (J. R. Hodges & Patterson, 1995; J. R. Hodges, Salmon & Butters, 1992; Vogel, Gade, Stokholm & Waldemar, 2005). In contrast, patients with semantic dementia have specific difficulty recalling semantic information but their episodic memory appears to be relatively unaffected (J. R. Hodges, Patterson, Oxbury & Funnell, 1992; J. R. Hodges, Patterson & Tyler, 1994; Maguire, Kumaran, Hassabis & Kopelman, 2010; Warrington, 1975). This kind of double dissociation has been taken as evidence of two separate declarative memory systems (e.g. Tulving, 2002).

Studies of memory in healthy older adults have found a similar dissociation between episodic and semantic memory. Typically, older adults are reported to have difficulty remembering episodic information, but their semantic memory is relatively spared (Balota, Dolan & Duchek, 2000; Bouazzaoui, Fay, Taconnat, Angel, Vanneste & Isingrini, 2013; Kausler, 1994; Mitchell, 1989; Souchay, Moulin, Clarys, Taconnat & Isingrini, 2007; Spaniol, Madden & Voss, 2006). This latter finding may even be underestimated in some studies because specific retrieval problems (e.g. word-finding, tip-of-the-tongue states) become more prevalent with increasing age (Burke, MacKay, Worthley & Wade, 1991; Heine, Ober & Shenaut, 1999).

Despite a large body of published work demonstrating an age-related decrease in episodic memory, the mechanisms behind it are still not clear. Certain characteristics of study tasks and/or materials make it more or less likely that older adults will exhibit a deficit. For example, in tasks involving memory for word lists, the deficit is reduced for recognition compared to free recall (Craik & McDowd, 1987; Perlmutter, 1979), and older adults tend to perform reasonably well on cued recall tasks (Perlmutter, 1979). Older adults also seem to perform well on tasks involving pictorial stimuli as opposed to word lists (Craik & Schloerscheidt, 2011; Park, Puglisi & A. D. Smith, 1986; Park, Puglisi, A. D. Smith & Dudley, 1987), but the age-related deficit is particularly pronounced for associative stimuli – that is, recalling that two or more items were associated with one another in a study list (Old & Naveh-Benjamin, 2008). However, if the two items have a pre-existing association (e.g. salt—pepper), then the associative memory deficit is reduced (Badham, Estes & Maylor, 2012; Naveh-Benjamin, 2000). Far from a general impairment in episodic memory, therefore, the pattern of age-related decline is complex, and appears to be moderated by semantic knowledge or experience (Badham et al., 2012; Badham & Maylor, 2015; Castel, 2005; Castel, 2007).

Associative deficit hypothesis. Despite these mixed findings, the literature generally suggests that older adults exhibit a deficit in forming episodic memories (i.e. binding information within a particular context). One of the most widely supported hypotheses to explain this age-related memory impairment is the associative deficit (or binding) hypothesis (e.g. Chalfonte & Johnson, 1996; Old & Naveh-Benjamin, 2008). The associative deficit hypothesis suggests that older adults perform poorly on tasks of episodic memory because of difficulty binding the representation of unrelated units of information into a cohesive episode (Naveh-Benjamin, 2000). The primary assertion of this hypothesis is that while memory for individual information units may be relatively good, memory for new relationships between these units is reduced in older adults. Thus, in laboratory tests older adults might have difficulty recalling that a particular word was presented in a study list because of difficulty recalling the association between the word (information unit) and the study context. There is ample evidence for an age-related deficit in memory for item-item pairings (e.g. Chen & Naveh-Benjamin, 2012; Naveh-Benjamin, 2000; Naveh-Benjamin, Brav & Levy, 2007; Ratcliff, Thapar & McKoon, 2011), item-location pairings (Chalfonte & Johnson, 1996; Kessels, Hobbel & Postma, 2007; May, Rahhal, Berry & Leighton, 2005; Mitchell, Johnson, Raye, Mather & D'Esposito, 2000), and memory for the source of previously presented information (Erngrund, Mäntylä & Nilsson, 1996; Schacter, Kaszniak, Kihlstrom & Valdiserri, 1991; Schacter, Osowiecki, Kaszniak, Kihlstrom & Vadiserri, 1994).

Comparing laboratory memory and AM. The studies described above are concerned with measures of memory obtained in the laboratory, which are low in ecological validity. According to Koriat and Goldsmith (1994), laboratory tasks tend to view memory as a storehouse into which items can be deposited, and from which they are retrieved (see also Roediger, 1980). The 'items' are discrete units of information, and are thus inherently countable. Good performance on laboratory tasks is normally measured in terms of the quantity of information that is recalled, while the content of information is typically not important (i.e. what matters is the number of words that are recalled from a study list, not which words they were). On the other hand, tasks that measure everyday memory emphasise correspondence – that is, how well a memory represents what actually happened during a previous event. Memory performance is judged by the accuracy of the reported information, and therefore the content of the report is important (Koriat & Goldsmith, 1994). Drawing on a distinction originally described by Baltes (1997), Ross and Schryer (2014) made a related point: laboratory measures of memory are concerned mostly with the mechanics of memory (e.g. structure, capacity) for a pre-defined set of stimuli, while memory outside the laboratory allows for the application of "learned expertise" and the ability to choose what to remember.

In addition to differences in conceptualisation, there are a number of other fundamental differences between laboratory and naturalistic memory, which can complicate attempts to compare them. Firstly, autobiographical memories are encoded within rich multisensory environments, whereas the laboratory encoding environment is relatively impoverished. Moreover, encoding contexts in naturalistic studies are highly variable, whereas in the laboratory, a large number of stimuli are encountered within the same encoding context. The to-be-remembered material is also more complex in naturalistic AM studies, while in laboratory studies stimuli are usually words or pictures presented sequentially on a computer screen. AMs are self-relevant, often emotionally valenced, and temporally and conceptually linked to other related memories, whereas laboratory memories are usually not. In addition, AMs are more likely to be personally important, and may have undergone considerable rehearsal. Finally, AM is goal-directed and intrinsically motivated, whereas laboratory memory is not. Laboratory measures are therefore concerned with only a fraction of overall experience compared to AM.

These differences are of potential consequence in the study of memory and ageing, for a number of reasons. Firstly, the ability to apply “learned expertise” (Ross & Schryer, 2014) in the context of everyday memory may be of particular benefit to older adults, whose long-term semantic knowledge is not usually impaired (e.g. Mitchell, 1989). Secondly, interference between memories in laboratory tasks caused by factors such as shared encoding contexts may be more difficult for older adults to resolve (e.g. Ebert & N. D. Anderson, 2009). Thirdly, older adults’ memory may be better for information that is more personally relevant, or for which there is more motivation to remember, compared to less relevant or less motivated remembering (Cassidy & Gutchess, 2012; Hess, Rosenberg & Waters, 2001). Older adults may therefore benefit particularly from the ability to choose what to recall, in order to take advantage of these features typical of AM, rather than being required to recall a set of pre-defined items.

There is some evidence that older adults’ prospective memory (i.e. remembering to do something in the future) is better than expected when the task is naturalistic. For example, Rendell and Thomson (1999) found that older adults’ prospective memory was deficient in an artificial laboratory setting, but when the task was naturalistic (participants were asked to log the time at set times during the week), older adults performed consistently better than younger adults. Similar results were obtained by Rendell and Craik (2000) and Kvavilashvili, Cockburn and Kornbrot (2013). Schnitzspahn, Ihle, Henry, Rendell and Kliegel (2011) suggested that older adults’ good performance on naturalistic prospective tasks is associated with high motivation and metacognitive awareness, while Altgassen, Kliegel, Brandimonte and Filippello (2010) found that increasing the social importance of a prospective task significantly improved older, and not younger, adults’ performance. Older adults have also been found to perform better on a working memory task that simulates a naturalistic context compared to standard laboratory tasks (Kemper, Kalicinski & Memmert, 2015), as well as in episodic tasks employing naturalistic stimuli (e.g. Castel, 2005).

Section 1.2

Age effects in AM

Episodic versus semantic AM. Autobiographical memory involves memory for both episodic and semantic information, although these concepts are defined slightly differently in AM studies. A typical classification system is presented in *Table 1.2.1*, which shows that episodic AM must adhere to relatively strict inclusion criteria. In contrast, semantic AM is generally understood to be any memory details that are *not* episodic, and therefore represents a broader category of experiences.

Studies that contrast episodic and semantic AM usually measure the number of each type of detail produced within freely recalled narratives (e.g. Levine, Svoboda, Hay, Winocur & Moscovitch, 2002). Memory for autobiographical events (episodic AM) is highly contextualised, and while the associative deficit hypothesis (Chalfonte & Johnson, 1996) would predict that this should pose a problem for older adults, certain characteristics of AM and the way in which it is studied could protect against an age-related deficit, as described in the previous section.

Most of the published research in this area suggests, however, that older adults recall fewer episodic details than younger adults (see *Table 1.2.2*). For example, Levine et al. (2002) asked participants to recall specific events from five different time periods across the life span. They developed a coding scheme in which the number of internal (equivalent to event-specific

Table 1.2.1

Typical criteria for classifying episodic and semantic details within AM narratives

Characteristic	Episodic	Semantic
Frequency of occurrence	Unique occurrence	Repeated events
Duration	< 1 day duration	Temporally extended events
Contextual detail	Taking place in a particular location at a particular time	Decontextualised

Note: Episodic details must fulfil all of the criteria in the episodic column, whereas semantic details are equivalent to those that do not meet the criteria for 'episodicity', thus must only meet one criterion (but may also meet more).

episodic details) and external details (including semantic details, details of different events, and repetitions) were measured. They found that older adults recalled fewer internal details than

Table 1.2.2

Summary of key findings from previous studies investigating episodic and semantic AM in older and younger adults

Paper	Retrieval cue	Main findings
Addis et al. (2008)	Generic words	OAs more external, fewer internal
Ford et al. (2014)	Popular music cues	OAs lower proportion episodic details*
Gaesser et al. (2011)	Generic colour photos	OAs more external, fewer internal
Levine et al. (2002)	Time periods (life span)	OAs more external, fewer internal
Madore et al. (2014)	Generic colour photos	OAs more external, fewer internal
Piolino et al. (2010)	Single event (past 10 years)	OAs fewer episodic details
St. Jacques et al. (2012)	Emotionally arousing words	OAs lower proportion episodic details
St. Jacques & Levine (2007)	Emotional valence (past 5 years)	OAs more external, fewer internal; greater effect for emotional memories

Note. Internal details are those that relate directly to the event in question, are specific to time and place, and reflect episodic re-experiencing. External details include semantic details, details not pertaining to a specific time and place, repetitions, and details about events other than the one in question. See Levine et al. (2002) for full specification.

*Ford et al. (2014) did not report the number of episodic details, therefore it is not clear whether their results are due to older adults recalling fewer episodic details, more semantic details, or both.

younger adults, but more external details. A number of studies replicated these findings using different retrieval cues, including generic colour photographs (Gaesser, Sacchetti, Addis & Schacter, 2011; Madore, Gaesser & Schacter, 2014), generic words (Addis, Wong & Schacter, 2008; St. Jacques, Rubin & Cabeza, 2012), popular music cues (Ford, Rubin & Giovanello, 2014) and emotions (St. Jacques & Levine, 2007).

While these studies generally support the idea of a deficit in episodic AM among older adults, closer inspection reveals some instances in which older adults performed as well as younger adults. For example, in St. Jacques and Levine's (2007) study, the age effect on episodic details for neutral memories was only significant when participants were probed with a general question, and not when participants freely recalled the events with no probe. In contrast, in Levine et al.'s (2002) study, younger adults recalled more episodic details from the previous year without probes, but when a general probe was used there was no significant difference between age groups.

Each of the studies described above varied in their administration of the tasks, including the use of different cues, different target time periods (and thus varying retention intervals), and whether or not the to-be-recalled events were emotional. Furthermore, a handful of studies have reported an absence of age-related decrement among their primary results. Aizpurua and Koutstaal (2015) found that older adults describing memories from the past ten years, the past year and the past week only recalled fewer episodic details about the oldest memories. Both groups recalled similar numbers of external details in each condition. Bluck, L. J. Levine and Laulhere (1999) studied memory for the announcement of the verdict in the O. J. Simpson murder trial and found that older and younger adults recalled a similar number of correct details and made a similar number of errors. In addition, in a study in which a large number of participants (*n* = 1733) were cued with everyday words, Gardner, Mainetti and Ascoli (2015) found that older adults' AMs contained slightly *more* episodic detail than younger adults AMs, although these results should be interpreted with caution since each participant tallied the number of details present within their own memories.

Specific versus general memory. As an alternative conceptualisation of AM, the distinction between specific and general memories is, in theory, similar to the episodic/semantic distinction. Specific AMs are defined in much the same way as episodic AMs: the typical qualifying criteria are that the memory is unique (i.e. not a repeated event), situated in time and space, and describes an occasion that lasted less than a day (e.g. Holland, Ridout, Walford & Geraghty, 2012; Piolino, Desgranges, Benali & Eustache, 2002; Viard, Piolino, Desgranges, et al., 2007). General memories are memories that do not qualify on the basis of one or more of these criteria. Memory specificity is usually rated on a scale, however, (e.g. see *Table 1.2.*3) and although quick and easy to score, this approach measures the ability to retrieve a memory rather than the amount of detail that an individual can recall (see Kyung, Yanes-Lukin & Roberts, 2015 for an investigation of specificity and detail as separate constructs). Perhaps for this reason the specific/general distinction has been widely used in conjunction with difficult tasks, such as cueing AM with generic cue words or broad time periods (e.g. Piolino et al., 2002; Piolino, Desgranges, Clarys, et al., 2006). If the task is such that search for, and retrieval of, an AM is highly likely to be successful (e.g. if the to-be-recalled event is precisely specified, for example, *Going out for lunch last Tuesday*), then ratings such as those presented in *Table 1.2.3* are unlikely to be sufficiently sensitive, because the cue itself satisfies most of the specificity criteria.

As with the episodic/semantic distinction, several studies have dissociated older and younger adults' memory performance along this specificity axis. Thus, older adults' memories are usually reported to be less specific and more general than younger adults' memories (i.e. lower average score when using ratings such as those in *Table 1.2.3*).

Table 1.2.3

Typical scale rating AMs along a continuum of specificity (from Piolino et al., 2006)

Rating	Description
0	Absence of memory, or general information about a theme
1	Repeated/extended event not situated in time or space
2	Repeated/extended event situated in time and space
3	Specific event situated in time and space, but without details
4	Specific event situated in time and space, with details

For example, in the study by Piolino et al. (2006), participants were given both a general cue (e.g. "an event linked to a person") and a lifetime period (e.g. age 18-30) and asked to recall specific memories that satisfied both cues. Younger adults recalled a greater proportion of specific events, defined as only those that scored 4 on the scale in *Table 1.2.3*. Similar results were obtained in a number of other studies, using slight variations in cueing and coding procedures (Beaman, Pushkar, Etezadi, Bye & M. Conway, 2007; Ford et al., 2014; Holland et al., 2012; Piolino et al., 2002; Ros, Latorre & Serrano, 2010; Schlagman, Kliegel, Schulz & Kvavilashvili, 2009; see *Table 1.2.4*). One study interviewed participants prior to testing in order to create personalised memory cues. In contrast to the studies cited above, they found no difference in the number of specific memories recalled by older and younger adults, but the experimenters rated older adults' memories as less episodically rich (Martinelli, Sperduti, Devauchelle, et al., 2013).

Table 1.2.4
Summary of key findings from previous studies investigating AM specificity in older and younger adults

Paper	Retrieval cue	Coding scheme	Main findings
Piolino et al. (2006)	General cue + lifetime period	1-4	Proportion of specific memories smaller for OAs
Piolino et al. (2002)	General cue + lifetime period	0-3	Specificity of AMs declined from age 60
Beaman et al. (2007)	Generic words (emotionally valenced)	1-3	Memory specificity negatively correlated with age
Schlagman et al. (2009)	Generic cue words	Specific vs. general	Proportion of specific memories smaller for OAs
Ros et al. (2010)	Generic cue words	Specific vs. extended vs. categorical	OAs recalled more general events and fewer specific events
Holland et al. (2012)	Generic cue words	Specific vs. extended vs. categorical	Proportion of specific memories smaller for OAs – but only for neutral cue words
Martinelli et al. (2013)	Personalised cues	- Single event vs. repeated/routine/ extended - Episodic richness (1-4)*	No effect of age on number of specific memories; episodic richness lower in older adults
Habermas et al. (2013)	Emotional valence/life story narrative	Specific vs. general vs. extended	Emotional valence: % of specific memories declines from age 16-65; Life story: Reduction in specificity only up to age 40
Ford et al. (2014)	Popular music	1-5	OA memories less specific than YAs

*Episodic richness ratings coded for the presence of spatial, temporal, contextual and phenomenological details, up to a maximum of 4

Note. Unless otherwise indicated, the low end of specificity rating scales denotes no memory, the middle values represent temporally abstracted memories (e.g. repeated/extended events), and the top end of the scales represents specific memories with/without additional detail.

As with experiments measuring the number of episodic versus semantic details, the reduction in memory specificity in older age comes with some caveats. For example, Habermas, Diel and Welzer (2013) found that, when asked to recall important positive and negative memories from across the life span, the percentage of specific memories declined monotonically from age 16 to 65. However, a second sample of participants completed a narrative task that placed emphasis on the importance of certain memories for the life story. In this second sample, a reduction in memory specificity was observed only from adolescence to middle age, and memories were similarly specific from age 40 onwards, suggesting that the way the memory task is framed can affect the relative group performance. In addition, the study by Schlagman et al. (2009) found a reduction in specificity only for memories retrieved in response to cue words in the laboratory; those that came to mind involuntarily during everyday life were recorded in a daily diary task, and were found to be no less specific for older adults. This raises the possibility that difficulty with effortful retrieval processing could account for specificity reductions in older adults. Finally, Holland et al. (2012) found that older adults' memories were less specific for neutral cue words only, while for both positive and negative cues older and younger adults' memories were equally specific.

Section 1.3

Autobiographical memory models

For the most part, models of AM do not rely on a dissociation between episodic and semantic memory, although the literature review above demonstrates that these concepts still dominate empirical work. However, the notion of specific and general forms of memory representation corresponds reasonably well to some of the ideas outlined by the models. One major difference is that empirical investigations contrasting specific with general memories take the view that memories are *either* specific *or* general, whereas theories of AM allow for a much more dynamic system comprising information represented at multiple different levels of specificity within an individual memory. An important point made by models of AM is that memory is a transient mental state. This stance emphasises the reconstructive nature of memory (Bartlett, 1932), and suggests that different "types" of memory draw on the same underlying knowledge base. The phenomenological experience of these different "types" therefore is thought to arise from the particular reconstructive processes that occur.

The most influential model of autobiographical memory in recent years was developed by M. A. Conway and Pleydell-Pearce (2000). They proposed a "self-memory system", driven by an interaction between current goals and long-term knowledge about the self. This self-memory system constructs transitory representations of events which, when they enter consciousness (which is not always), are experienced as autobiographical memories. Within this system autobiographical information is represented hierarchically, on three broad levels: lifetime periods, general events, and event-specific knowledge. Items represented as event-specific knowledge (e.g. sensory-perceptual information) are roughly equivalent to episodic memory details, and clusters of these form more general events (e.g. holiday in Spain, Wednesday afternoon seminars at work). General events, in turn, are nested within overarching lifetime periods, such as *when I lived in London*, or *when I was at school*. An important feature of specific event memory as conceived in this model is that it is transient, and reconstructed only at the time of remembering. Precisely what form the reconstructed memory takes is based on current goals and the information available in long-term knowledge.

A recent theory by Rubin and Umanath (2015) takes a similar stance, in that a single system is assumed to support all types of declarative memory, with specific event memories and semantic memory both reconstructed mostly from general knowledge. Rubin and Umanath propose *event memory* as an alternative term to *episodic memory* because it provides a better account of findings from a wide range of studies, and event memory better encapsulates the way information is represented at the time of remembering. As the authors point out, an event memory that is experienced as episodic (i.e. as a single occurrence, with visual imagery) may combine elements from several similar events, such as consecutive Thanksgiving dinners, and thus may not represent a unique time and place (as is required by definitions of episodic memory). In addition, semantic knowledge may be available on the basis of a single encoding episode. That is, general or abstract knowledge, for example that *John is an accountant*, may be available after only having met John once, and may be recalled later in the absence of any episodic recollection of the conversation in which John disclosed the information (i.e. in the absence of memory for the event). Event memory is therefore defined as "the mental construction of a scene, real or imagined, for the past or the future" (Rubin & Umanath, 2015, p.2), which can be about the person recalling the event or about someone else, experienced from a first- or a third-person perspective (as long as the self occupies a location relative to the scene), and can contain any type of content. Event memories can describe unique or repeated occurrences, can be positive or negative, and can be voluntary or involuntary. Event memories can also be accompanied by a sense of "reliving", whereas semantic memories cannot. The only property that defines an event memory is that it describes an event. According to Rubin and Umanath, episodic memory is a type of event memory, which has the additional properties of being about the self, describing a unique occurrence, being voluntarily recalled and accompanied by feelings of reliving.

The neuropsychology of AM.

Several studies have documented cases of patients with lesions resulting in selective deficits of specific event memory, most commonly as a result of medial temporal lobe damage. For example, Warrington and McCarthy (1988; 1992) described the case of amnesic patient RFR, who was unable to recall any specific memories in response to cue words, but could still recall more general information about extended periods in his life, such as jobs that he had held. Similarly, patient MH suffered occipital damage in a motorcycle accident, which left him unable to recall specific events from before the accident, although his memory for songs released before the accident, as well as more general life knowledge, was relatively spared (Ogden, 1993). In addition, two studies described two different patients with temporofrontal damage resulting in a similar retrograde deficit in specific event memory, but leaving more general conceptual life knowledge relatively spared (Calabrese, Markowitsch, Durwen, et al., 1996; Markowitsch, Calabrese, Liess, Haupts, Durwen, & Gehlen, 1993).

The opposite pattern of impairment has also been observed in some patients. For example, De Renzi, Liotti, and Nichelli (1987) described a patient with a profound semantic autobiographical memory deficit due to anterior temporal lobe damage, whose memory for specific events was not impaired. Another study compared AM in a patient with hippocampal amnesia and a patient with semantic dementia, and found that the amnesic patient was unable to recall specific episodes but his memory for autobiographical facts was spared. In contrast, the semantic dementia patient demonstrated preserved memory for specific past episodes but impaired memory for personally-relevant names (Westmacott, Leach, Freedman, & Moscovitch, 2001). During recall of specific past events, patients with semantic dementia have been shown to recall a similar number of internal details as controls, but fewer external details (Irish, Addis, Hodges, & Piguet, 2012). This double dissociation of specific event memory and more general knowledge of facts relating to one's life suggests that the two types of memory are separate. However, one study examining two patients with semantic dementia using the Levine et al. (2002)

Autobiographical Interview showed little evidence of episodic impairment, and *increased* recall of external memory details across five lifetime periods, compared to controls (McKinnon, Black, Miller, Moscovitch, & Levine, 2006).

Subjective experience at the retrieval stage

Inconsistent experimental findings may in part reflect differences in the way events are subjectively experienced at the time of retrieval. For example, Cermak and O'Connor (1983) showed that an amnesic patient, SS, was able to remember certain specific autobiographical events despite performing poorly on a word-cued AM task. The authors suggested that what seemed like episodic memories for some events were actually remembered as facts about had happened. Aside from their emphasis on transient reconstruction processes, what the two AM models outlined above have in common is the assumption that a single knowledge base supports all kinds of AM, although memories can be experienced differently at the time of retrieval. While the episodic/semantic and specific/general distinctions delineate memory types on the basis of the properties of the events they describe (e.g. a unique occurrence), they say little of the way in which the memories are subjectively experienced. As Ross and Schryer (2014) note, everyday experience is characterised by both constancy (e.g. spatial locations remain the same over time) and repetition (e.g. routines). Yet an implicit assumption made by both the episodic/semantic and specific/general distinctions is that a single exposure to an event or stimulus will result in an episodic memory, while multiple exposures will result in a semantic (or general) memory. Such an assumption seems to suggest that almost all of our everyday experience is represented semantically; for example, if we enjoy a movie so much that we go to see it a second time, the implication is that our memory for that film is semantic. If this is not the case, then we might question how many exposures are required before a memory *becomes semantic*, which is, of course, difficult to answer. Indeed, Rubin and Umanath (2015) note that semantic knowledge can be acquired from a single exposure to the relevant information, while memories of unique events may be reconstructed from multiple similar experiences. Thus, the properties of the event may be the basis of a somewhat arbitrary distinction in AM. Two further distinctions – remembering versus knowing, and field versus observer perspective – have attempted to separate older and younger adults' AM on the basis of the subjective experience of remembering.

Remembering versus knowing

According to Tulving (1983), one of the axes along which episodic and semantic memory can be separated is the subjective experience that accompanies each. Episodic memory is accompanied by *autonoetic consciousness* (knowing something about the self), while semantic memory is accompanied by *noetic consciousness* (simply "knowing"). Autonoetic consciousness, according to Tulving, is what allows an individual to experience "mental time travel" when remembering – the individual mentally travels back in time to place themselves at the scene of a previous experience. In contrast, the self is not present in the representation of semantic memory. In empirical work, Tulving (1985) found that participants were able to report on their subjective experience of remembering by selecting one of two responses, "remember" or "know", when indicating recognition of previously encountered items on a recognition test. As might be expected if the remember/know distinction maps onto the episodic/semantic distinction, older adults have been found to report fewer "remember" responses than younger adults in tests of recognition memory for word lists (Bugaiska, Clarys, Jarry, et al., 2007; Parkin & Walter, 1992; Souchay et al., 2007) and unfamiliar faces (Bastin & Van der Linden, 2003), and fewer "remember" and more "know" responses when recalling AMs from across the life span (Piolino et al., 2006). Indeed, Piolino et al. (2006) found the greatest difference between groups in justified remember responses – a condition in which participants had to provide episodic detail to justify their subjective feelings of remembering. However, a recent study by Rathbone, Holmes, Murphy and Ellis (2015) asked participants to generate statements about self-image ("I am…" statements) which were used as cues for probing event memory. They found that there were no differences between groups in the proportion of justified "remember" responses, despite younger adults' memories demonstrating more episodic specificity, as rated on a scale similar to that presented in *Table 1.2.3*. It is interesting to note that, while "remembering" is, in theory, equivalent to episodic memory, and "knowing" equivalent to semantic memory (Tulving, 1983), both types of response can be elicited in a simple laboratory test involving a single presentation of a sequence of items and subsequent test after a short delay; usually, such tests are considered to be firmly in the domain of episodic memory.

Field versus observer memories

The perspective from which memories are experienced can also vary. Memories that are re-experienced from the individual's own point of view are said to have a *field* perspective, while memories in which an individual can see themselves as part of the scene, from the outside, are said to have an *observer* perspective (Nigro & Neisser, 1983). Memories that are emotional or involve a high degree of self-awareness may be more likely to be experienced from an observer perspective, whereas focusing on internal processes such as feelings at the time of recall is associated with a field view (Nigro & Neisser, 1983). Crawley and French (2005) and Harris, O'Connor and Sutton (2015) found that memories that were "remembered" were most likely to be recalled from a field perspective, while those that were "known" were more likely to be experienced from an observer perspective. In addition, more recent events tend to be recalled from a field perspective, while more remote events are likely to be remembered from an observer perspective[1] (Nigro & Neisser, 1983; Robinson & Swanson, 1993). In relation to the episodic/semantic distinction, one possibility is that memories that have undergone more reconstruction at the time of retrieval, and incorporate more semantic knowledge, may be experienced from an observer perspective (M. A. Conway, 2009). Consistent with this idea, Harris et al. (2015) found that directly, as opposed to generatively[2], retrieved memories (see *Chapter 3*) were more likely to be experienced from a field perspective. Piolino et al. (2006) showed that older adults reported fewer AMs with a field perspective, and more with an observer perspective, compared to young adults. Together these findings suggest a correlation between field perspective, recollective experience and episodic memory.

[1] However, Robinson and Swanson (1993) also reported that individuals were able to switch the perspective from which they remembered an event, and Rice and Rubin (2009) found that participants were able to remember events from more than one perspective at once.

[2] Directly retrieved memories are those that can be recalled without the need for cue elaboration (i.e. if cue is sufficiently specific). Generative retrieval, on the other hand, involves elaboration of the retrieval cue, followed by an iterative process of memory search and evaluation operations, which should eventually lead to retrieval of a memory that satisfies the evaluation criteria (Conway & Pleydell-Pearce, 2000).

Retention interval as a confounding factor

Since AMs may be recalled from any point in the life span, the retention interval – that is, the amount of time that has elapsed since the original experience – can vary greatly. Although there is no theoretical reason to consider that recent memory and remote memory are different "types", there is some evidence that there are qualitative, as well as quantitative, differences between them. For example, it is often noted that autobiographical memories become "semanticised" over time – that is, the information appears to shift from episodic towards semantic representation (e.g. Cabeza & St. Jacques, 2007). Likewise, the prevalence of memories with a field perspective decreases with memory age, while the prevalence of observer-perspective memories increases (Piolino et al., 2006). The number of "remember" responses also decreases for older memories, while the number of "know" responses increases (Piolino et al., 2006), and as these findings might suggest, the proportion of specific (as opposed to generic) memories also decreases with increasing retention interval (Piolino et al., 2002).

It is important to consider retention interval because there is evidence that patients with hippocampal amnesia are impaired on tests of recent but not remote memory (e.g. Scoville & Milner, 1957), and that this "temporal gradient" is reversed in patients with semantic dementia (Graham & Hodges, 1997). As with older adults, it is often noted that semantic memory is relatively spared in amnesic patients (e.g. Schmolck, Kensinger, Corkin & Squire, 2002; Tulving & Markowitsch, 1998), however the semantic tests often examine material that was acquired prior to the amnesic event (e.g. vocabulary). In contrast, people with amnesia do seem to be impaired on tests of semantic memory for material encountered since the amnesic event (Gabrieli, N. Cohen & Corkin, 1988), while their remote episodic memory can be as good as that of controls (MacKinnon & Squire, 1989; Squire, Haist & Shimamura, 1989; Zola-Morgan, N. Cohen & Squire, 1983). These findings highlight the fact that retention interval often confounds comparison of episodic and semantic memory in laboratory tests. Differences between recent and remote memories are also potentially important in the context of ageing research because older adults' oldest memories will usually be much more remote than younger adults' oldest memories, and experimental findings show that the effects of memory age are similar to the effects of participant age. The inter-correlation of each of the factors outlined in this introduction – episodic memory, specific memory, recollective experience, field perspective, and recent memory – presents an interesting challenge in AM ageing research, in terms of experimental design and measurement, as well as the integration and interpretation of findings from experiments with different methodologies. This highlights the need for a more systematic investigation of age differences in AM, in which confounding variables are addressed.

Section 1.4

Aims and scope of this thesis

The experiments presented within this thesis investigate AM in ageing using a range of techniques. The aim is to draw together a diverse literature on the topic and systematically examine how different approaches to cueing and measuring AM affect the relative performance of older and younger adults. Based on the experimental findings presented in the following chapters, we will also begin to develop a hypothesis of how ageing affects AM. Since AM involves both memory for details of specific events and decontextualised information related to the individual and their environment, the focus of the studies throughout the thesis is broad, and encompasses information represented in different ways. The predominant approach we take to quantifying these memories is to measure the number of episodic and semantic details that participants recall. This distinction is employed in order to maintain consistency with previous work in the area, rather than on the basis of any assumption that episodic and semantic memory represent truly independent memory types. Indeed, in agreement with the two theories of AM outlined above (M. A. Conway & Pleydell-Pearce, 2000; Rubin & Umanath, 2015), our preferred theoretical stance is that AM primarily involves reconstruction based on long-term knowledge, and is therefore based on a unitary system. Nevertheless, the episodic/semantic distinction provides a useful heuristic for delineating very specific event information from knowledge that is less contextualised, and therefore also provides a good starting point from which to explore AM.

The primary means of assessing whether reported information should be classified as episodic or semantic is based on the way in which it is described by the participant, rather than based on the properties of the events they describe. Thus, except for instances in which we perform replications of previous studies (e.g. Experiment 2), we assume that verbal descriptions of events correspond, at least roughly, to the way the event is represented in memory. For example, memory for current routines or scripts is reported in the present tense, while the past tense is used for memory for past experiences (Hudson & Nelson, 1986). The assumption of correspondence between memory and language is based on the broader understanding of language as an effective tool for communicating internal thoughts and emotions (Tausczik & Pennebaker, 2010), and findings suggesting that particular features of natural language usage are linked to a wide range of behavioural characteristics, to the extent that language analysis might be used diagnostically (Pennebaker & Graybeal, 2001; Pennebaker, Mehl & Niederhoffer, 2003).

The experiments presented in the following chapters begin with an investigation of memory for typical everyday events (*Chapter 2*), followed by an exploration of the effects of different methods of cueing and sampling AMs (*Chapter 3*). In *Chapter 4,* we study AM under increased experimental control by introducing a novel staged event procedure. We also examine the effect of a wearable camera technology (SenseCam) to support memory for both everyday and staged events (Experiments 1 & 4). Finally, in *Chapter 5* we turn to a specific investigation of semantic (or decontextualised) information within AM narratives.

Chapter 2: Everyday Memory

Abstract

Two experiments tested older and younger adults' autobiographical memory for personally experienced everyday events. In Experiment 1, participants reviewed pictures of the events taken on a wearable camera, SenseCam, for some of the events. In an unsupported recall condition, in which no photographs were reviewed, both groups' memories were found to be comparably episodic, although older adults recalled more semantic details. SenseCam review was found to be associated with increased episodic and semantic recall in both groups. Experiment 2 replicated the pattern of unsupported recall observed in Experiment 1, but demonstrated that the same older participants do exhibit a deficit in standard laboratory episodic tasks. The results show that within a single sample the magnitude of the age effect in memory varies by task. These findings are discussed in terms of possible contributing factors, including retention interval and rehearsal.

Section 2.1

Introduction

The aim of the present research was to examine AM for *everyday events* in older and younger adults, logged using a wearable camera. While age-related memory changes have been observed across a number of memory tasks, in AM studies events are usually self-selected by participants and are therefore probably well-rehearsed, personally important, and emotionally salient. However, older adults often mention day-to-day difficulties in remembering everyday events (e.g. Jungwirth, Fischer, Weissgram et al., 2004; Mol, van Boxtel, Willems & Jolles, 2006), and since older adults' community independence and quality of life may depend in part on the ability to remember typical everyday activities, this is an important form of memory that, unusually, remains largely unstudied. The present research, then, systematically examines age-related changes in memory for everyday events and compares performance in this area with other types of AM and episodic memory recall. We also examined the effect of retrieval support, in the form of photographs captured during the everyday events.

Autobiographical memory in ageing

Autobiographical memory is a rich and complex form of memory for events from one's own life, that incorporates both context-bound episodic event details and decontextualised[3] personal semantic details, the latter of which comprises factual knowledge about the self and others and information about routines and repeated events (M. A. Conway & Pleydell-Pearce, 2000; Renoult, Davidson, Palombo, Moscovitch & B. Levine, 2012). Several studies of AM in ageing have reported a deficit in older adults' ability to remember episodic event information (Ford et al., 2014; Habermas et al., 2013; B. Levine et al., 2002; Piolino et al., 2002; Piolino et al., 2006; Piolino, Coste, Martinelli et al., 2010; Ros et al., 2010; St. Jacques et al., 2012) which mirrors the age-related deficit in laboratory tests of episodic memory (Nyberg, Bäckman, Erngrund, Olofsson & Nilsson, 1996). However, a growing body of evidence demonstrates that

[3] *Decontextualised* is used here, and throughout this thesis, in the sense that information is removed from the specific context of a single episode, rather than completely without context.

this is not always the case (Aizpurua & Koutstaal, 2015; Bluck et al., 1999; De Beni, Borella, Caretti, et al., 2013; McDonough & Gallo, 2013; Schryer & Ross, 2014; Schulkind & Woldorf, 2005).

Most studies of AM in ageing have employed a retrospective sampling technique, wherein participants self-select which events to describe, either in response to a cue word (Beaman et al., 2007; De Beni et al., 2013; Maylor, Carter & Hallett., 2002; Ros et al., 2010; St. Jacques et al., 2012), a specified time period (Aizpurua & Koutstaal, 2015; B. Levine et al., 2002; Piolino et al., 2002, 2006, 2010), a particular emotion (Fernandes, Ross, Wiegrand & Schryer, 2008; Habermas et al., 2013; St. Jacques & Levine, 2007), or some other cue. During the process of searching for an appropriate event to describe, participants are likely to draw on memories that are well rehearsed and therefore more accessible (Galton, 1879; Harris et al., 2015). Since test sessions necessarily only measure a small number of memories, and without a more specific retrieval cue, typical retrieval sessions are unlikely to probe memory for material that is less readily available. Previous research therefore demonstrates a deficit in older adults' memory for important or significant events.

Nevertheless, everyday interaction and competent goal-directed behaviour requires memory for a host of more mundane, everyday events. We need to remember things such as the last conversation or news from neighbours and friends, the fact that we did buy that needed spice two weeks ago, that our partner told us they will be out on Wednesday evening, and so on. Yet, we know very little about any age-related changes for this type of everyday AM. In fact, to our knowledge, there has been no research investigating ageing in everyday AM so far. In this paper we explore whether ageing affects the retrieval of typical everyday events in the same way as older, well-rehearsed AMs.

Section 2.2

Experiment 1

Supporting AM with SenseCam

Experiment 1 investigated the effect of SenseCam (SC) on everyday event memory. SC is a small camera that is worn around the neck, which automatically captures still images of the wearer's environment from his or her own perspective. Photographs are recorded whenever the device registers a change in external light, motion, acceleration, temperature or magnetic flux; in a stimulating environment SC will take a photograph approximately once every 9-10 seconds. Images can later be uploaded to a computer and presented to the participant as a retrieval cue (S. Hodges, Berry & Wood, 2011).

While SC has been shown to successfully support AM in amnesic patients (Berry, Kapur, L. Williams, et al., 2007; Loveday & Conway, 2011) there is little data on whether this effect can be extended to healthy older groups. However, recent research has shown that the use of SC can improve healthy young adults' memory relative to baseline performance. For example, in one study investigating memory consolidation support using an end-of-day review procedure, participants wore SC for a period of 5 days during their normal day-to-day activities. At the end of two of the days, they reviewed a random subset of images collected by their SC. After delays of 1, 3 and 8 weeks, participants were better at recognising their SC pictures, and their picture-cued recall reports contained more words, for those days on which they had reviewed SC images (Finley, Brewer & Benjamin, 2011). Another study used SC as a retrieval support, asking participants to recall event details (*who, what, where, when*) before and after viewing images captured 3 days, 10 days or 4 months earlier. At all retention intervals, participants were able to add more details to their memories after viewing SC images, and rated more of their memories as being "remembered" rather than "known" (Sellen, Fogg, Aitken, et al., 2007). In a study investigating reconsolidation, St. Jacques and Schacter (2013) found that reviewing SC images 48 hours after a museum tour led to an increase in both hits and false alarms on a subsequent recognition test. These findings were extended to older adults in a separate study, although the effect was reduced in the older group (St. Jacques, Montgomery & Schacter, 2015)[4].

As the studies presented above demonstrate, there are numerous ways SC can be used as a tool to support AM. One of the main challenges in selecting the most appropriate approach is that there is, as yet, no strong consensus on the theoretical basis from which to evaluate SC's effectiveness. That is, it is not empirically clear exactly *why* SC works as a memory aid. S. Hodges, Berry and Wood (2011) suggest two possibilities: the first is that the sheer number of images captured by SC makes it likely that at least one of the images reflects the moment that a memory was encoded. The second possibility is that the sequential nature of SC images resembles the way AMs are normally experienced (i.e. time-compressed, temporally ordered, visual, passively captured, field perspective, etc.) A small number of previous studies have found support for the latter hypothesis, including the finding that passively captured images lead to better memory than actively captured images (Sellen et al., 2007), and that recognition memory is better after reviewing images from one's own SC, compared to images taken from an altered perspective (St. Jacques & Schacter, 2013).

A recent review by Silva, Pinho, Macedo and Moulin (2016) highlighted the unorthodox methods employed by many of the previous SC studies and emphasised the need for research evaluating SC's potential to cue *recollection* (i.e. "something more" than what can be seen in the images). In keeping with this, in the present study we examine the number and type of memory details produced in an ecologically valid cued recall procedure. If older adults show evidence of a decline in everyday AM performance, SC may be a useful tool to compensate for the deficit. This is especially of interest as life-logging devices are becoming commonplace and are typically easy to use.

[4] In fact the older adult study (St. Jacques, Montgomery & Schacter, 2015) was not a SC study. Participants did not wear SC for the museum tour and subsequently did not view SC images in the reviewing phase. Instead, images of the museum similar to those that would have been captured by SC were presented to participants for reviewing. Every participant therefore saw exactly the same images. The findings are included here with the SC research because they build directly on the same authors' previous findings using SC in younger adults (St. Jacques & Schacter, 2013).

We also included a temporal order manipulation of the SC images, to examine the hypothesis that SC is an effective memory aid because it mirrors normal AM (S. Hodges et al., 2011). If this is the case, viewing SC image sequences in random temporal order should lead to poorer memory performance compared to viewing the images in forward order. In contrast, if the effectiveness of SC as a memory support is due to the large number of images it captures for each event (S. Hodges et al., 2011), then the temporal order of the sequence should have no effect. One previous study (St. Jacques & Schacter, 2013) found that reactivating memory with a temporally distorted sequence of SC images led to worse subsequent recognition of related images. However, in that study only a small number of images were presented (6 per sequence). In the present experiment, we examined whether narrative recall is also hurt by randomising the image sequence. In addition, all images captured by SC were presented to participants, thereby allowing us to compare the two hypotheses put forward by S. Hodges et al. (2011).

In Experiment 1, therefore, we measured older and younger adults' memory for everyday events. Participants used SC to record typical events from everyday experience, which were recalled after an interval of two weeks. The aim was to establish whether the age-related memory deficit for significant events across the lifespan was also evident in memory for more recent everyday events, and whether reviewing SC images affected the information recalled. We measured recall of episodic and semantic information for two reasons: first, to maintain consistency with the previous research in the field of AM in ageing, so that our findings would be directly comparable to the findings concerning age differences in memory for significant events. Second, measuring episodic recall allows us to evaluate the effectiveness of SC for cueing recollective experience (Silva et al., 2016).

Method

Participants. Twenty-one young (age 18-32, *M*=24.62, *SD*=4.04; 18 females) and 21 older adults[5] (age 65-78, *M*=69.10, *SD*=3.53; 11 females) participated for a payment of £8 per hour. Young adults were recruited through advertisements displayed around the university, while older adults were recruited from the University of the Third Age (*n*=8), a local newspaper advertisement (*n*=7) and through word of mouth (*n*=6). All participants had self-reported normal or corrected-to-normal vision. Older adults were screened for cognitive impairment using a cut-off of 27 on the Mini Mental State Examination (MMSE; Folstein, Folstein & McHugh, 1975). Older adults were also screened for depression using the Geriatric Depression Scale, with a cut-off of 9 points (GDS; Yesavage, Brink, Rose, et al., 1983). No individuals were excluded on the basis of these screening measures. The full 4-subscale form of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) was administered to all participants, and total years of education was recorded for both groups. *Table 2.2.1* shows the mean full-scale IQ and years of education for younger and older adults; differences were not significant (*p*>.05).

Table 2.2.1

Group IQ and education scores

	Young adults		Older adults	
Measure	*M*	*SD*	*M*	*SD*
IQ	115.52	11.90	118.67	17.61
Education	17.29	1.95	15.78	5.12

Design. A 2 (age group: young vs. older) x 3 (review condition: baseline vs. random temporal order (hereafter "random") vs. forward temporal order (hereafter "forward") x 2 (segment type: episodic vs. semantic)) mixed factorial design was employed, with review condition and detail type as repeated measures factors. The baseline condition measured participants' recall in the absence of any support from SC, while in the random and forward conditions participants were shown every image captured by SC during a given event in random

[5] The older adult sample described here were predominantly a group of young-old participants (i.e. those aged 65-74). However, the participants were not intentionally recruited as a young-old sample, and consequently one participant falls into the old-old category (age 78). We therefore refer to the sample simply as *older adults*, to avoid misrepresentation.

order and forward order, respectively. The dependent variable was the average number of episodic and semantic segments recalled in each recall condition. Coding of the segments is described in detail below.

Materials & procedure. Participants visited the laboratory on three separate occasions. During the first session screening tests were administered and each participant was given a SC to take home. Training on the operation of the device was provided, and participants received a comprehensive written guide to assist with operating the camera and troubleshooting technical problems. In addition, participants were provided with short diary forms which they were asked to fill in for each recorded event. The information provided by the participants in the diary forms included an event title, date, start time and duration, and three subjective ratings of event characteristics (event frequency, familiarity of location, event distinctiveness). Event characteristic ratings were made on a scale of 1-10, with a score of 1 representing the lowest possible value (i.e. least frequent/familiar/distinctive).

Event-sampling phase. The day after the first session participants began the event-sampling week in which they selected and recorded a minimum of 15 typical events distributed as evenly as possible over a period of five days. Participants were free to choose which events to record, although some basic criteria were specified in order to ensure that the resultant images would be of sufficient quality, and to encourage participants to record a range of different events. Specifically, an event was defined as anything lasting between 30 minutes and one hour in duration that could be easily titled and had a definite (though subjective) start and end point. Participants were given suggestions for “good” events (lunch with a friend, trip to the supermarket, visit to a museum, etc.), which typically involved some change of scenery or action so that the SC photographs did not all depict the same scene. They were specifically discouraged from recording events in which there was little movement, such as watching the television or working at a computer. This constraint was included to promote the difference between image sequences in the forward and random conditions, which in more visually static events may not be readily detectable. Finally participants were asked to record events during the day time or in a brightly lit indoor space wherever possible since SC is not equipped with a flash, and to be aware that photograph quality would be diminished in low lighting conditions. At the end of the event sampling week, participants returned their SCs and their individualised stimuli were produced for the second phase.

Preparation of stimuli. Twelve of the 15 events for each participant were randomly selected for the recall sessions after excluding any events for which the photographs did not come out well (for example they were underexposed, or the participant had clothing covering the lens). In a number of cases, camera malfunctions meant that some of the photographs were not stored, resulting in the loss of one or more of the participant's events. In such cases, participants proceeded to the recall phase with the maximum number of available events that was divisible by the three recall conditions (baseline, random, forward), such that the number of events recalled in each condition was equated. In total, 36 events were missing or excluded from each age group, therefore 432 events were tested in the recall phase (216 for each group). Selected events were allocated to a retrieval condition on the basis of the event characteristic data (*frequency, familiarity* and *distinctiveness*) provided by the participants during the event sampling phase, such that the distribution of salient events in each retrieval condition was controlled as far as possible. The allocation of events was also constrained by the requirement that retrieval conditions were split evenly over the two recall sessions (i.e. each recall session involved the recall of six events – two in each of the three conditions), and the oldest six events were recalled in the first session in order to equate retention interval.

Event recall. Two weeks (14 ±2 days) after the event sampling phase, participants returned to the lab on two separate dates to complete the event recall in two sessions, each lasting approximately 2 hours. In each recall session, participants recalled six events. The order of presentation of events was randomised within each recall session, so that although the oldest six events were recalled during the first session, they could be recalled in any order within that session. This in turn meant that the order of conditions was also randomised within each recall session. The following instructions were presented on the computer screen before each of the events.

Think back to the event in question and say aloud all the details that you can remember for that event – what you did, where you went, who you were with and so on, as well as anything you can remember about what things looked like, any conversations you had, any thoughts you had at the time and anything else at all that you can remember from that specific event.

The first time these instructions were presented they were also repeated verbally, and emphasis was added to recall all possible details, even if they seemed insignificant. In the baseline condition, participants were given the title that they generated for the event in the sampling phase, as well as the date of the event, but did not see any SC photographs. Unlimited time was permitted in order for participants to talk about the event in as much detail as possible. In the random and forward conditions, additional instructions relating to the viewing of the photographs were presented alongside the above instructions before each event. Participants were instructed that they would see a sequence of images of the event captured by their SC, which may or may not be in the correct order. Participants were asked to verbally recall the details of the event while looking at the SC images.

During the recall session all stimuli were presented by a bespoke computer programme that set the maximum viewing time per SC image at 7s, which was determined in a pilot study to give older adults enough time to view the image carefully. Because the image sequence for each event sometimes contained a large number of similar SC images (e.g. sitting on the bus, talking to a friend in the street, standing in a queue, etc.) participants could press a key to move to the next image more quickly, and no minimum image presentation time was set. In addition, the sequence could be paused if more time was required to inspect a particular image. In practice, therefore, participants largely controlled the timing of their own image sequences, however the 7s automatic presentation time was kept in place to drive progression through the sequence of images.

Participants recalled the event while viewing the photographs, therefore were encouraged to recall information that was "something more" than what was depicted in the images (see Silva et al., 2016). The reasons for concurrent viewing and recall were two-fold. Firstly, if participants first reviewed the images and subsequently recalled the event, it was possible that some of the effect of SC would be missed if, in the intervening period, the reminder provided by SC was forgotten. Moreover, older adults may be more likely to forget the SC cues during such a delay, and thus recalling after review may have favoured the younger adults. Secondly, if participants recall events while looking at the images, it is subsequently easier to code the resultant memories. The reason for this is that the language used to describe what is in the pictures is easily distinguishable from the language used to describe the details of the memory that are not depicted. For example, information recognised within the pictures tends to be reported as a present tense commentary of the event (e.g. *That's me looking to see what we had in the cupboards*), particularly if both the experimenter and the participant view the images together. In contrast, remembered details tend to be reported in the past tense (e.g. *I looked in the cupboards to see if we had any spaghetti*). If the recall attempt took place *after* reviewing the pictures, the information that was seen in the images would be integrated into the recall narrative, and it would be very difficult to determine the source of the information without seeking explicit clarification from the participant on each point. Memories were reported orally, and responses were recorded using a digital hand-held voice recorder. During the recall sessions participants were able to take breaks at any time between recalling events.

Prompts & clarification. Where participants' recollections were overly general (e.g. *It was just my weekly trip to the supermarket*), the experimenter repeated the recall instructions in question form (e.g. "Try to be as specific as you can. Can you remember anyone you saw, any conversations you had, or anything you were thinking?"). In some instances participants were asked for clarification of information they provided, for example if it was not clear whether a location they were describing had been visited many times previously or just once. Participants who focused on describing what was shown in the photographs (e.g. *That's my husband, that's our kitchen…* etc.) were reminded that they should focus on the event instead and try to remember the details that were not necessarily depicted. If participants recalled something that appeared to be depicted in the images (e.g. *The man that served me had dark hair*) the experimenter asked the participant to clarify whether the image did indeed include the information.

Data processing. Audio files for each participant were transcribed and coded using a novel system. First, information in the transcripts was divided into coarse-grain segments that described a single concept or episode, similar to an idea unit in content/narrative analysis[6] (C. P. Smith, 2000). These were sometimes expressed as a simple sentence or a clause but often were longer if the concept or episode was described in more detail. For example, a participant who reported seeing a dog on their walk might additionally describe several of the dog's features, but the recollected information would be classified as one segment because it related to a single concept or idea. Examples of single segments at this coarse-grain level of coding are presented in *Appendix 2A.*

Importantly, any details that were deemed to be simply recognised from the images themselves were excluded from the analysis. Recognised details were usually easily identifiable by the language used to describe them (e.g. *that's my local park*, or *I remember that man)*. Because the experimenter viewed the images at the same time as the participant, clarification was sought at the time for any ambiguous instances in which a participant appeared to simply describe what was visible in the picture. However, items that were recognised on the photographs and then elaborated were included in the analysis. To clarify, information was included in the analysis if it *explained* what was in the images, but not if it simply *described* the images.

[6] We did not follow previous coding schemes here, such as that of Levine et al. (2002), because attempts to do so highlighted some unique challenges presented by the data we collected. Firstly, because participants recalled events while viewing SC images, recall narratives were of a considerable length (number of words per participant: *M*=9181.02, *SD*=5228.17; range= 2482—21058), and tended to contain a lot of information, therefore coding entire narratives at a fine grain could take upwards of 10 hours for one participant. Secondly, the detailed nature of recall attempts in the present experiment meant that much of the information could reasonably be construed in various ways, which meant inter-coder reliability was difficult to achieve. For example, if a participant recalled going for a walk around their local neighbourhood, they might mention a number of places they walked to, through, or past. Reiteration of the act of walking could be seen as either repetition (i.e. they have already said they were on a walk) or separate episodic detail (i.e. they recall this particular location from the perspective of walking as opposed to some other form of transport). Such ambiguity is difficult to resolve without knowledge of the participant's recollective experience of each detail at the time of the test. Moreover, participants tended to recall the contents of each event in chronological order, which often involved recall advancing in time beyond the part of the event currently depicted in the SC image sequence. Subsequently, viewing images for a part of the event that had already been described frequently led to the addition of further recalled details which were somewhere between repetitions of what had already been recalled and new details. (e.g. changing *I saw a black dog* to *I saw a brown dog*). That is, SC seemed to increase the lability of the event memory. Fine-grained coding required that these ambiguities be resolved within each sentence, whereas the segmentation method allowed for minor amendments to be incorporated into the narrative. In short, the system of Levine et al. is ideally suited to measure episodic detail in memories that are slightly less detailed, and less labile, than those measured in this study.

Individual segments were then coded as either episodic or semantic. In keeping with previous studies, in order to be classed as episodic, a segment had to be specific (i.e. describing a one-off, rather than a general or repeated event; Levine et al., 2002; Piolino et al., 2006), context-bound (i.e. inextricably tied to the context of that event, which includes thoughts that the participant remembered having at the time, but excludes reflections on the event that were generated later) and recollective (i.e. something that the participant "remembers" rather than "knows"; Tulving 1983, 1985). Episodic segments that were external to the event in question (those that described a separate event) were not included in the analysis. All other segments were classed as semantic, in the sense that the information they contained was decontextualised. The semantic category therefore comprised a small, heterogeneous selection of personal and social knowledge, and information about routines (see *Appendix 2A*). All coding was initially completed by the first author, but five additional raters coded a random subset of the transcripts (n=10; same transcripts for all coders) to give a measure of the reliability of the system. Fleiss's κ indicated an inter-coder reliability score of .99, however the large number of comparisons (> 800) may have inflated this value, therefore Cohen's κ was additionally calculated for each combination of the six raters and averaged at .85. This suggests that there was good agreement between the independent coders.

A second stage of coding measured the level of detail reported for each episodic segment, which was rated on a scale of 1-5. This provided a more fine-grain measure of what was recalled, and here a distinction was made between short, simple details (e.g. *I took the train*) and more complex ideas, concepts or episodes (see *Appendix 2B*). It is important to note that this second round of coding comprised a scale rating, rather than a count of the total number of details. The reason for avoiding a detail tally is explained in Footnote 5, above, and to avoid confusion this rating will hereafter be referred to as the *specificity score*. Two additional independent coders rated the specificity of a subset participants' transcripts, and their ratings correlated with those of the first author (r=.91 and r=.75).

Results

Preliminary analysis. We first checked whether the sampled events were allocated evenly across the three conditions. Our rationale was that events that are naturally more salient may be remembered in greater detail regardless of the retrieval condition, therefore biased allocation (e.g. more non-salient events in the baseline condition) may confound our experimental manipulation. To check for bias, we examined the three event characteristic ratings (*frequency, familiarity, distinctiveness*) recorded for each event during the sampling phase. The ratings were significantly correlated (see *Table 2.2.2*), such that less frequent and less familiar events tended to be more distinctive and, as expected, distinctive events were associated with greater episodic recall scores overall (i.e. collapsed across retrieval conditions).

To facilitate the analysis of event distribution, a composite salience score (out of 10) was calculated for each event by summing distinctiveness ratings with inverted frequency and familiarity scores, and averaging the total. This compound salience score (*Table 2.2.2*) was correlated more strongly with episodic recall than any of the individual ratings. The mean score for each group in each condition is presented in *Table 2.2.3*. Event salience was not significantly different across conditions ($F(2,80)=.76$, $p=.47$, $\eta_p^2= .02$) or age groups ($F(1,40)=.66$, $p=.42$, $\eta_p^2= .02$), and there was no interaction ($F(2,80)=.62$, $p=.54$, $\eta_p^2=.02$), suggesting that salient events were evenly distributed.

Table 2.2.2

Correlations between event characteristics and number of episodic segments recalled

	Frequency	Familiarity	Distinctiveness	Salience
Episodic	$-.34^{**}$	$-.31^{**}$	$.21^{**}$	$.38^{**}$
Frequency		$.53^{**}$	$-.35^{**}$	$-.83^{**}$
Familiarity			$-.20^{**}$	$-.78^{**}$
Distinctiveness				$.66^{**}$

$^{**}p<.001$

Table 2.2.3

Salience score (out of 10) across groups and conditions

	Baseline		Random		Forward	
Age Group	*M*	*SD*	*M*	*SD*	*M*	*SD*
Young adult	4.15	2.24	4.00	2.19	3.96	1.95
Older adult	4.44	2.08	4.43	2.05	4.15	1.99

Autobiographical recall. The following analyses were carried out on the average number of segments recorded for each participant in each condition, which are presented in *Figure 2A*. While some previous studies have investigated the ratio of episodic-to-total details within AM narratives (e.g. Ford et al., 2014; Levine et al., 2002), our primary interest is in whether older adults can remember the details of recent events as well as younger adults, therefore our dependent variables are the *number* of episodic and semantic segments recalled. This distinction is important, since a greater proportion of episodic information within a narrative does not necessarily mean that an event is better-remembered. For example, using the proportion of episodic details, a memory containing two episodic segments and no semantic segments would be scored as more episodic than a memory containing 20 episodic segments and 10 semantic segments, despite the latter example clearly containing more specific information about the event. Nevertheless, to facilitate comparison across studies, we calculated the proportion of episodic details in addition to our main analyses, and these are presented in *Table 2.2.4*.

Autobiographical recall was analysed in a 2 (age) x 3 (retrieval condition) x 2 (segment type: episodic vs. semantic) ANOVA. There was a main effect of condition ($F(2,80)=29.96$, $p<.0005$, $\eta_p^2=.43$): more segments were recalled in the random ($M=10.35$, $SD=5.36$, $p<.0005$) and forward ($M=11.88$, $SD=6.36$, $p<.0005$) conditions compared to baseline ($M=7.49$, $SD=4.88$), and more segments were recalled in the forward condition compared to the random condition ($p=.03$). There was also a main effect of segment type ($F(1,40)=39.14$, $p<.0005$, $\eta_p^2=.50$), with more episodic ($M=13.36$, $SD=7.75$) than semantic ($M=6.46$, $SD=4.56$) segments recalled overall. There was no main effect of age ($F(1,40)=.03$, $p=.87$, $\eta_p^2<.01$), and no interaction between age and condition ($F(2,80)=1.68$, $p=.19$, $\eta_p^2=.04$), but age did interact with segment type ($F(1,40)=9.22$,

p=.004, η_p^2 = .19). The interaction between age and segment type was due to increased semantic recall in the older group (M_{older}=7.98, SD=4.21; $M_{younger}$=4.93, SD=4.49), but no significant group difference in episodic recall (M_{older}=11.56 vs. $M_{younger}$=15.15). There was no interaction between condition and segment type (F(2,80)=.22, p=.80, η_p^2=.01), thus the pattern of episodic and semantic recall was similar both with and without SC. There was no significant 3-way interaction (F(2,80)=.41, p=.67, η_p^2=.01).

Table 2.2.4

Mean episodic-to-total ratios across conditions

	Baseline		Random		Forward	
Age Group	*M*	*SD*	*M*	*SD*	*M*	*SD*
Young adult	.79	.11	.75	.13	.74	.14
Older adult	.57	.20	.57	.20	.55	.18

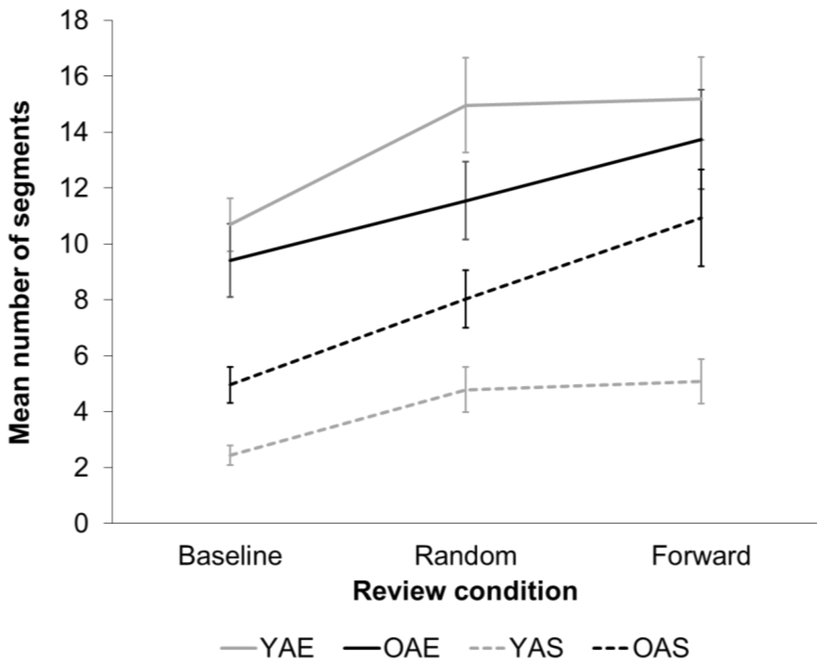

Figure 2A. Number of episodic and semantic segments recalled by younger and older adults, as a function of review condition. Episodic recall was similar in both groups, while older adults recalled more semantic segments than younger adults. Error bars represent standard error of the mean. YAE = young adult episodic; OAE = older adult episodic; YAS = young adult semantic; OAS = older adult semantic.

Specificity analysis. As noted above, specificity is used here to refer to the *average level of detail* within episodic segments. We use the term specificity to avoid confusion with the practice of tallying individual details, although the two approaches should be correlated. One possibility for the lack of age effect reported in the previous section may be that although the number of segments produced by each group was similar, the older adults' segments may be less detailed than the younger adults' segments. *Figure 2B* shows the mean specificity ratings across groups and conditions. The mean specificity rating of episodic segments was 1.74 (*SD*=.27). Specificity did not differ significantly between age groups ($F(1,40)=.70$, $p=.41$, $\eta_p^2=.02$; $M_{young}=1.78$, $SD=.23$; $M_{older}=1.71$, $SD=.31$) or across conditions ($F(2,80)=1.40$, $p=.25$, $\eta_p^2=.03$; $M_{baseline}=1.75$, $SD=.36$; $M_{random}=1.78$, $SD=.34$; $M_{forward}=1.70$, $SD=.27$), and there was no interaction ($F(2,80)=.56$, $p=.57$, $\eta_p^2=.01$). As such, no impairment was observed in older adults' recall, in either the number of episodic segments or the level of detail present in the segments, and the lack of age effect could not be attributed to coarse-grain coding.

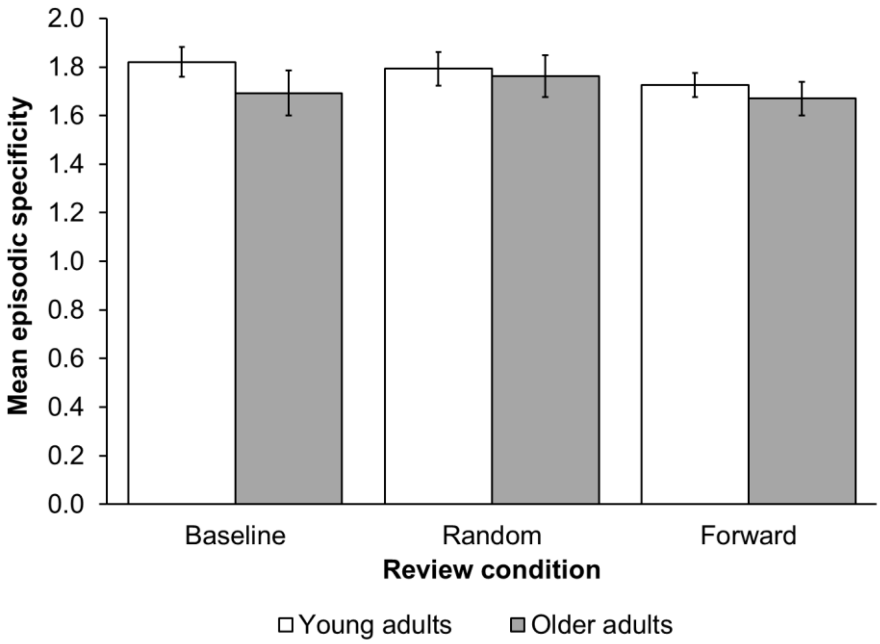

Figure 2B. Mean specificity (i.e. level of detail, rated on a scale of 1-5) of episodic segments recalled by younger and older adults in each condition. Note. Control = event title cue only; Random = all SC images for the event in random temporal order; Forward = all SC images for the event in forward temporal order.

Power analysis. In order to investigate further the null effects of age group, we conducted a power analysis using the downloadable *G*power* software from the University of Dusseldorf[7] (Faul, Erdfelder, Lang, & Buchner, 2007). We did not compute the observed power based on the obtained effect size because observed power calculations are derived directly from p values, and therefore do not provide any additional interpretative value (Hoenig & Heisey, 2001). Instead, we calculated the power to detect effects of different sizes, given the parameters of the present experiment (sample size, experimental design, and the degree of correlation between the repeated measures). The results suggested that with the obtained sample size there was 95% power to detect a large effect (Cohen's f=.4), 61% power to detect a medium effect (f=.25) and only 15% power to detect a small effect (f=.1). It is therefore possible that the failure to demonstrate an effect of age group on memory performance was due to low experimental power. An additional analysis revealed that in order to detect a small effect with 80% power, a sample size of 396 would be required.

Discussion

The "SC effect". Consistent with previous research (Berry et al., 2007; Finley et al., 2011; Loveday & M. A. Conway, 2011; Sellen et al., 2007; St. Jacques & Schacter, 2013), it was found that reviewing SC images was associated with better recall of episodic event information, and this SC effect was evident for both older and younger adults. Two previous studies have also examined SC effects in older adults: St. Jacques et al. (2015) found that reactivating memory with SC photos improved recognition performance, while Silva, Pinho, Macedo and Moulin (2013) found that reviewing images of day-to-day activities improved performance on standardised memory measures. The present study extends these findings to include improvement in memory for everyday events as a result of viewing SC images.

Despite general acceptance of the notion that SC is a powerful memory aid (Silva et al., 2016), there has been little agreement in the literature about how to use SC to maximum effect.

[7] G*Power software available from http://www.gpower.hhu.de/en.html

This is in part because there is as yet no theoretical consensus on why SC should be particularly effective (Silva et al., 2016). S. Hodges et al. (2011) noted that SC users often report that something trivial or mundane in the images is enough to trigger a “Proustian moment” (Loveday & M. A. Conway, 2011) of recollection, causing past images to flood into consciousness. This is consistent with our experiences of pilot testing the devices, and for that reason we chose not to eliminate any images from the sequences presented to participants in this study. However, even under the present experimental conditions in which participants sampled and recalled a relatively small number of daily events, using SC in this way is time-consuming. It is of practical as well as of theoretical interest, then, to understand what it is about SC images that proves to be effective in triggering AM.

In the present study we included a temporal order manipulation in order to test two competing hypotheses proposed by S. Hodges et al. (2011). The first hypothesis, was that SC’s effectiveness can be attributed to the sheer amount of information provided by the retrieval cue, such that in a sequence of hundreds of images, at least one or two are likely to depict moments that memories were encoded. The second hypothesis was that SC works because its mode of operation shares properties with AM, for example SC images are taken passively and from the wearer’s own perspective, and cue sequences are temporally compressed and temporally ordered. In the present experiment we addressed this *compatibility hypothesis* via the temporal ordering mechanism, which allowed a direct comparison with the first hypothesis, that the amount of information in the cue accounts for SC’s effect. The compatibility hypothesis predicts that randomising the order of images within the cue sequence should have a detrimental effect on SC’s benefit, because the cue sequence is less similar to the way in which AM is encoded. In contrast, if the amount of information in the cue is the important factor, then temporal order should have no effect on SC’s benefit because forward order and random order cues sequences contain equal amounts of information. The results of the present study were broadly consistent with the compatibility hypothesis, demonstrating that more segments were recalled when cue sequences were presented in forward order compared to random order. However, the effect of the temporal order manipulation was small in comparison to the general benefit of SC on memory performance, which suggests that the amount of information available in the cue was a more important factor. St. Jacques and Schacter (2013) showed that randomising the order of only a small number of SC images during a memory reactivation task hurt later recognition performance, therefore it may be that compatibility between SC cues and memory is important when cues contain less information overall. Interestingly, in the present study the temporal order effect was observed for both episodic and semantic segments, suggesting that SC cues more than just recall of event-specific information.

Episodic AM. In the present experiment we failed to demonstrate an age-related deficit in episodic AM even at baseline, when memory was not supported by the use of SC. While this is consistent with the findings from a handful of other studies (Aizpurua & Koutstaal, 2015; Bluck et al., 1999; De Beni et al., 2013; McDonough & Gallo, 2013; Schryer & Ross, 2014; Schulkind & Woldorf, 2005), it is inconsistent with the popular conception of memory in old age, as well as with a larger number of studies that have found an impairment in older adults' episodic AM (Ford et al., 2014; Habermas et al., 2013, B. Levine et al., 2002; Piolino et al., 2002, 2006 & 2010; Ros et al., 2010; St. Jacques et al., 2012). A post-hoc power analysis suggested that our sample size was likely to be sufficient to detect a large effect, but not a small effect, therefore it is not clear whether there was no difference between older and younger adults, or whether there was a small effect of age that was not detected. To our knowledge this was the first study to examine older adults' AM for typical everyday events; most previous studies have employed a retrospective sampling approach whereby participants are provided with a generic cue and asked to select any related event from their past experience. Under such conditions, memories that are available for retrieval are likely to be those that are personally significant and/or well-rehearsed (e.g. Galton, 1879; Harris et al., 2015). It is possible that older adults performed as well as younger adults in the present study because their memory for everyday events is not impaired, however there are a number of other important differences between this and previous studies that could explain the lack of age-related deficit observed here, and which cannot be ruled out on the basis of the present findings.

One possibility is that the group of older adults tested in the present study were particularly high-functioning. It is well-understood that the process of cognitive ageing is heterogeneous (Baltes & Carstensen, 1996; Rowe & Kahn, 1997), and that typical samples of older adults can vary widely in terms of cognitive abilities. It is possible, however, that either by chance or due to an unintentional sampling bias, the group of older adults participating in the present study were, on average, high performers. If this were the case, we might reasonably expect that the same individuals would also perform as well as younger adults on other types of memory task. Although the participants in the present experiment did not complete any other tasks, it seems unlikely that cognitive superiority can account for the present findings, since older and younger groups were matched on both full-scale IQ and years of education. Nevertheless, the present findings do not preclude this possibility.

A second possibility is that the comparable performance observed here may have reflected some sort of general benefit of wearing SC during the event sampling phase. That is, the fact of wearing SC during event encoding could have boosted performance even for those events for which SC images were not reviewed. For example, thinking back to the times when SC was worn may have provided a specific retrieval cue that was able to counter any age-related deficit. Indeed, Sellen et al. (2007) found that young participants were better able to recall events for which they had worn SC compared to events for which they had not, even before reviewing the SC images. A related possibility is that the benefit of reviewing SC images at the retrieval stage could have extended to non-reviewed events that took place on the same day, or were same type of event as the reviewed events, by way of increased activation of associated temporal or semantic information. For example, viewing SC images for an event that took place in the morning could increase the availability of information about an event that took place that afternoon. It is possible that a generalised benefit of this sort could have supported older adults' performance enough to eliminate any episodic deficit that might be observed without SC. Experiment 2 sought to address these potential confounds.

Semantic AM. In the present study we also measured recall of semantic AM in older and younger adults. Following the work of a number of previous studies (e.g. B. Levine et al., 2002) we approached semantic information as a broad category of heterogeneous detail types, including repeated and temporally extended events, as well as autobiographical facts and general knowledge. Consistent with previous work (Addis et al., 2008; B. Levine et al., 2002; Gaesser et al., 2011; Madore et al., 2014), the results of the present study showed that older adults recalled more semantic information than younger adults, thereby extending the previous findings to include recently acquired memories for everyday events.

In the literature to date, relatively little attention has been paid to this seemingly highly reproducible finding. One possible explanation, according to Levine et al. (2002), is that the semantic increase is directly related to the difficulty of retrieving episodic details. That is, within the hierarchical structure of AM, specific episodic AMs are considered to be accessed via more general autobiographical information such as lifetime periods (M. A. Conway & Bekerian, 1987; M. A. Conway & Pleydell-Pearce, 2000). Levine et al. suggested that if episodic AMs cannot be retrieved, the retrieval attempt stops at the level of general information instead, thereby giving rise to an increase in semantic recall. The results of the present study are inconsistent with this view, since here the increase in semantic recall in older adults was observed in the absence of any episodic deficit.

B. Levine et al. (2002) proposed two more possible explanations for the increase in semantic recall in older adults. Firstly, they suggested that older adults may be better at applying knowledge and wisdom than younger adults, as proposed in the psychological growth model of cognitive ageing (LaBouvie-Vief & Blanchard-Fields, 1982). A similar conceptualisation was investigated by Habermas et al. (2013), who found an increase in searching for meaning in AM narratives between adolescence and middle age. Secondly, B. Levine et al. (2002) suggested that the increase in semantic recall reflected the need for older adults to contextualise their memories for a young adult experimenter (see James, Burke, Austin & Hulme, 1998). While evaluation of these explanations is beyond the scope of the present study, we return to a more detailed investigation of semantic memory in *Chapter 5*.

Section 2.3

Experiment 2

The aim of Experiment 2 was to test the competing hypotheses outlined above, and determine whether the absence of age effect found in Experiment 1 was replicable. Firstly, we wanted to test whether the absence of age-related episodic deficit in Experiment 1 was attributable to a sampling effect (i.e. a particularly high-functioning group of older adults). If this were the case, then we would expect to find that older adults' performance was also comparable to younger adults' performance on a number of other memory tasks which have reliably produced an age-related deficit in other studies. Thus, in Experiment 2, participants completed an everyday memory task as well as a battery of autobiographical and episodic tasks on which older adults have previously been found to exhibit poorer performance.

Much of the previous work in this area has adapted one of two general procedures. Perhaps the most common technique is based on the Autobiographical Memory Test (AMT; J. M. G. Williams & Broadbent, 1986). This method involves presenting participants with a list of generic cue words and asking them to recall a specific memory related to each word. 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 (e.g. Beaman et al., 2007; Ford et al., 2014; Holland et al., 2012; Piolino et al., 2006). 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 400. 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.

The other most commonly adopted procedure is the B. Levine et al. (2002) Autobiographical Interview (AI), which involves the presentation of a set of cues such as broad time periods or generic images, from which participants must recall specific past events (e.g.

Aizpurua & Koutstaal, 2015; Gaesser et al., 2011; St. Jacques & B. Levine, 2007). Participants' memories are 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 technique argue for its increased sensitivity over previous clinical measures such as the Autobiographical Memory Interview (Kopelman, Wilson & Baddeley, 1989), and this approach is ideally suited to measuring the quality of episodic recollection (B. Levine et al., 2002).

These two approaches have produced largely consistent findings with regards to the effect of age, with older adults usually observed to perform more poorly than younger adults on both measures (e.g. Ford et al., 2014; B. Levine et al., 2002; Piolino et al., 2006). If the absence of age effect observed in Experiment 1, above, is attributable to a high-functioning group of older adults, then it might be reasonably assumed that the same individuals who perform well on the everyday memory task will also perform well on the AMT and the AI. Importantly, we chose to measure performance on both the AMT and the AI, because although results obtained via both methods are broadly consistent, as outlined above it is not clear that these two tasks measure the same construct (i.e. retrieval of event facts vs. quality of episodic recollection). A high-functioning sample of participants could therefore perform well on one task but not the other. Testing the same group of participants on all three AM tasks should enable us to gain a better understanding of whether sampling bias can account for any absence of episodic deficit on a replication of our task from Experiment 1. Moreover, we also included a typical laboratory measure of episodic memory, which was high in experimental control. AM tasks are necessarily less controlled because the events described by each participant are idiosyncratic. The laboratory measure was included as a more "pure" measure of memory ability, uncontaminated by individual differences in event characteristics. On each of these measures, older adults are typically observed to exhibit a deficit. If the same participants are impaired on these more traditional measures, but still unimpaired on our replication of Experiment 1, we argue that this may constitute preliminary evidence for the presence of different constructs within the study of AM. Secondly, we wanted to test whether the comparable performance in Experiment 1 was related to the use of SC, either at encoding or retrieval. In Experiment 2, therefore, participants did not wear SC for any of the events, and instead sampled events by filling out a short diary form.

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. Five younger and six older adults had also participated in Experiment 1. All participants had self-reported normal or corrected-to-normal vision. Older adults were screened for early indicators of dementia using the Mini Mental State Examination (MMSE; Folstein et al., 1975). Both older and younger adults completed the Geriatric Depression Scale (GDS; Yesavage 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-scale 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 2.3.1*. Older adults were less educated than young adults but had significantly higher IQs. Both groups had similar scores on the GDS.

Table 2.3.1

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

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: Recent AM vs. age 11-17 vs. past year vs. word-cued AM vs. word list recall) mixed design was employed with repeated measures on the second factor. Semantic memory was measured in the first three tasks only (Recent AM, age 11-17, past year), 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. Older and younger adults were compared on a battery of episodic and autobiographical memory tests. For clarity, the prospective sampling task based on the task from Experiment 1 will henceforth be referred to as the *Recent AM* task. In addition, two other AM tasks were employed in Experiment 2. The first of these was based on B. Levine et al.'s (2002) Autobiographical Interview, in which participants were asked to recall events from different lifetime periods. Two of Levine et al.'s five lifetime periods were selected for this study: *Age 11-17*, for which retention interval varied systematically for the two age groups, but age at encoding was matched, and *Past Year*, in which retention interval was matched for each group but age at encoding was not. The remaining AM task was word-cued memory for personal events, which has been used extensively (De Beni et al., 2013; Dijkstra & Kaup, 2005; Grady, St-Laurent & Burianovà, 2015; McDonough & Gallo, 2013; Beaman et al., 2007; Holland et al., 2012; Hyland & Ackerman, 1988; Maylor, Carter & Hallett, 2002; Ros et al., 2010; Schlagman et al., 2009; St. Jacques et al., 2012). Participants also completed a word-list recall task as a measure of episodic memory. In each of the tasks, participants recalled their memories orally, and their responses were recorded using a hand-held digital voice recorder.

Recent evidence suggests that success on a prior task can improve memory performance on subsequent tasks, particularly in older adults (Geraci & T. M. Miller, 2013). Since we wanted to compare older and younger adults' relative performance across all tasks, it was decided that the best way to achieve this while minimising noise in the data was to administer the tasks in the same order for all participants. The task order was therefore as follows: 1. *Episodic word list*; 2. *Age 11-17 lifetime period*; 3. *Past Year lifetime period*; 4. *Word-cued AM*; 5. *Recent AM*. We included the Recent AM task last because, based on previous research, we were not expecting older adults to perform as well as younger adults on any of the preceding tasks. Failure to find an age-related deficit on the recent AM task would therefore be unlikely to result from higher performance on earlier tasks.

Word list. The word list consisted of 25 common English nouns presented 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 (e.g. Salthouse, 1996), and because no time limit was set for the autobiographical tasks. Word characteristics were obtained from the MRC Psycholinguistic Database (Coltheart, 1981). Words were selected that had 5 letters, two syllables, concreteness ratings of between 500 and 650 and familiarity ratings of between 450 and 550. 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 finished the recall within the 3 minutes but had not recalled all 25 words then the timer was kept running, and participants could add to the recall at any point until the 3 minutes were over.

Autobiographical Interview (AI). This test was based on the procedure developed by B. Levine et al. (2002) in which participants are asked to self-select events for recall from different lifetime periods. In the study by Levine et al., participants were asked to recall events from five periods. In the present adaptation the task was shortened, and participants were asked to recall one event from each of two lifetime periods: the period when the participant was aged between 11 and 17 years (matched age of encoding), and the period of the previous one year, excluding the most recent month (matched retention interval). Participants were asked to describe events that were specific, one-off and lasted less than a day. As in Levine et al.'s study, to assist with choosing an event participants were shown a list of commonly experienced events from each period. The lists illustrated a number of events that fit the desired criteria, and participants had the choice of whether to describe an event that was listed or to choose their own. Participants were asked to recall as many details as possible about the event, and were not prompted once they had started speaking. Memories were coded based on the protocol set out by B. Levine et al. (2002). Each memory was divided into individual details which were classified as either internal or external. Internal details were those that were specific to the event in question and included event details, location, time and thoughts and emotions. External details included those that were the same type as internal but for an event different to the target event, as well as semantic details, unsolicited repetitions of information and other details such as reflections and evaluations of the recalled information. For the purposes of the present study, only episodic and semantic details were examined.

Word-cued AM. The word-cued task was based on the Autobiographical Memory Test (J. M. G. Williams & Broadbent, 1986). Participants were given six cue words (*HAPPY*, *WILDLIFE*, *EXCITED*, *LIBRARY*, *LUCK*, *OCCASION*) and were asked to describe a memory associated with each cue word that was specific, one-off and lasted a day or less. They were asked to describe their memories in as much detail as they could remember and no prompts were given. 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. When participants did produce a memory within the two minutes then they were allowed to talk uninterrupted about the memory 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 were a specific instance (i.e. one-off as opposed to 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 and repeated or extended events that were not situated in time or space received a score of 1. A rating of 0 was applied in cases where there was an absence of memory, or only general information was provided regarding the cue word.

Recent AM. For this task, participants used a written diary booklet to record details of 12 self-chosen events two weeks before arriving at the lab for the test session. As in Experiment 1, an event could be anything that was specific, lasted between about 30 minutes and a few hours, and could be given a title. The maximum event duration was extended in this experiment compared to Experiment 1 because there were no SC photographs to review, and the longer permitted time window increased the number of eligible events available for sampling. The diary booklet asked for details of the event date, start and end times, and *who, what*, *when*, *why* and *where* details. Participants also used the diary booklets to rate the events on a scale of 1-10 for frequency (*How often do you do what you did in this event?)* and distinctiveness (*How distinctive is this event/how much does it stand out from your usual activities?*) For both ratings, a score of 1 indicated the low end of the scale (i.e. events that were very infrequent/not at all distinctive). During the test session, four events were chosen at random; participants were verbally cued with event titles and asked to orally describe the events in as much detail as they could remember. 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?*). Memories were coded following the protocol set out in Experiment 1, which differentiated between episodic and semantic details.

Inter-rater correlations. Two additional independent raters coded subsets of transcripts from each of the autobiographical tasks. For the Autobiographical Interview, raters were asked to count the total number of episodic and semantic details in each transcript. Inter-rater correlations were high for both episodic (r=.99 and r=.96) and semantic details (r=.96 and r=.89). There were similar correlations between the original rater and each of the additional raters for the recent AM task (episodic: r=.94 and r=.93; semantic: r=.96 and r=.94). For the word-cued AM task, coders rated a subset of the memories on the 5-point scale described above. Independent coders' ratings were again correlated with the original ratings (r=.97 and r=.85).

Results

Preliminary analysis. First, we checked whether there were between-group differences in the characteristics of the events sampled, since in Experiment 1 event salience was significantly correlated with episodic recall. Consistent with Experiment 1, we found that episodic recall

Table 2.3.2

Younger and older adults' self-rated event characteristics in Recent AM task

	Young adults		Older adults		
Characteristic	*M*	*SD*	*M*	*SD*	*t*
Frequency	4.40	1.17	4.90	1.69	1.10 (ns)
Distinctiveness	6.16	1.21	5.42	2.40	1.24 (ns)
Salience	6.38	.99	5.74	1.87	1.35 (ns)

correlated with both frequency (*r*=-.28, *p*<.0005) and distinctiveness (*r*=.28, *p*<.0005), but older and younger adults' ratings were similar (see *Table 2.3.2*). As in Experiment 1, a compound salience score was calculated by averaging the distinctiveness and inverted frequency scores to give a single measure of event memorability for each participant. The strength of the correlation between episodic recall and compound salience was stronger than with the frequency or distinctiveness ratings (*r*=.30, *p*<.0005), but again there was no between-group difference in event salience.

IQ-matched sample. As noted above, there were significant differences in IQ and education between the two age groups in our sample. In addition, both measures were significantly correlated with dependent variables (see *General Appendices, G1*). Since we wanted to rule out the possibility that the older adults were simply a particularly high-functioning group, for the following analyses we excluded young adults with below group average IQ score but above group average education, and older adults with above group average IQ and below group average education. We chose this approach, rather than entering IQ into the analyses as a covariate, because IQ was statistically different between groups. Since participants were not randomly allocated to groups, this difference cannot be thought of as random, and an analysis of covariance under such circumstances would be invalid (G. A. Miller & Chapman, 2001). Using covariates in this way is liable to distort the effect that is being measured, since there is an overlap in the variance explained by the group and the covariate (Cochrane, 1957).

The sample-matching adjustment resulted in the exclusion of three young adults and four older adults, thus the remaining sample consisted of 17 younger and 16 older participants. T tests showed that in the new sample IQ (*t*(31)=.94, *p*=.35) and education (*t*(31)=1.63, *p*=.11) did not differ significantly between groups. The results are therefore presented for the matched sample, although equivalent analyses for the full sample can be found in the footnotes.

Replication of Experiment 1. To check whether the results of the recent AM task replicated the baseline condition of Experiment 1, the data were entered into a 2 (age: younger vs. older) x 2 (detail type: episodic vs. semantic) ANOVA with detail type as a repeated measures factor. There was no main effect of age ($F(1,31)=.27$, $p=.61$, $\eta_p^2<.01$), with similar numbers of details recalled by both younger (*M*=8.01, *SD*=6.91) and older (*M*=9.01, *SD*=3.56) adults. There was a main effect of detail type ($F(1,31)=12.28$, $p=.001$, $\eta_p^2=.28$), with more episodic (*M*=11.47) than semantic (*M*=5.54) details recalled overall. There was also a significant age x detail type interaction ($F(1,31)=6.80$, $p=.01$, $\eta_p^2=.18$). Follow-up t-tests with Bonferroni corrections (α = .025) indicated no significant group differences in episodic recall ($t(31)=1.02$, $p=.32$; $M_{older}=9.77$, *SD*=4.21; $M_{younger}=13.18$, *SD*=12.72), but older adults recalled more semantic details than younger adults ($t(31)=3.82$, $p=.002$; $M_{older}=8.25$, *SD*=5.59; $M_{younger}=2.84$, *SD*=1.64). The recent AM task therefore successfully replicated the baseline condition of Experiment 1.[8]

Episodic-to-total ratio. As in Experiment 1, we also calculated the ratio of episodic-to-total details recalled by older and younger adults. Although our primary concern was the amount of event-specific information recalled by each group (and thus the raw number of details recalled), comparing the episodic-to-total ratio provides a further measure of the extent to which the recent AM task replicated the baseline condition of Experiment 1, and also presents an interesting insight into the relationship between episodic and semantic recall across tasks. As can be seen in *Table 2.3.3*, the ratio of episodic-to-total details recalled in the recent AM task was almost identical to the ratio observed in the baseline condition of Experiment 1. These data were also entered into a 2 (age group) x 3 (task: recent AM vs. past year vs. age 11-17) ANOVA, which showed a main effect of task ($F(2,62)=14.71$, $p<.0005$, $\eta_p^2=.32$), in which the proportion of episodic details was higher in memories from the past year (*M*=.85, *SD*=.12) compared to both memories of age 11-17 (*M*=.76, *SD*=.20, *p*=.03) and recent AM (*M*=.68, *SD*=.19 *p*<.0005). The difference between recent AM and memories from age 11-17 did not reach significance (*p*=.09). There was also a main effect of age group ($F(1,31)=15.04$, $p=.001$, $\eta_p^2=.33$), in which younger adults' memories (*M*=.84, *SD*=.08) had a higher proportion of episodic details than older adults' memories (*M*=.69,

[8] The baseline condition of Experiment 1 was also replicated in the full sample. There was no main effect of age ($F(1,38)=1.40$, $p=.24$, $\eta_p^2=.04$), but there was a main effect of detail type ($F(1,38)=17.59$, $p<.0005$, $\eta_p^2=.32$) and an age x detail type interaction ($F(1,38)=5.57$, $p=.02$, $\eta_p^2=.13$).

SD=.14). The age by task interaction only approached significance (F(2,62)=2.48, p=.09, η_p^2=.07).[9]

Table 2.3.3

Mean episodic-to-total ratios in the three measures for which both episodic and semantic details were recorded

	Recent AM		Past year		Age 11-17	
Age Group	*M*	*SD*	*M*	*SD*	*M*	*SD*
Young adult	.79	.13	.89	.09	.85	.15
Older adult	.57	.19	.81	.14	.67	.22

Episodic memory. Results are plotted in *Figures 2C, 2D and 2E*. In order to compare performance across all tasks simultaneously, episodic scores from the autobiographical tasks were entered with word list scores into a 2 (age group) x 5 (task) MANOVA. Overall there was a main effect of age (*F*(5,27)=5.89, *p*=.001; *Wilk's Λ* = 0.48, η_p^2=.52), which was driven by a deficit in the older group on measures of word-cued AM (*F*(1,31)=22.16, *p*<.0005, η_p^2=.42), word list recall (*F*(1,31)=16.23, *p*<.0005, η_p^2=.34), and memory for an event from age 11-17 (*F*(1,31)=5.77, *p*=.02, η_p^2=.16). There was no significant difference in the number of episodic details recalled by each group in the Recent AM task (*F*(1,31)=1.04, *p*=.32, η_p^2=.03) or in memories from the past year (*F*(1,31)=1.68, *p*=.20, η_p^2=.05).[10] The findings plotted in *Figure 2D* suggest that the absence of age effect in memories from the past year may have been attributable to a large amount of variance in scores. We therefore checked whether there were any outliers in the data, which we defined as scores falling more than 3 standard deviations from the group mean (in the younger group: 37.94+/- 89.79, and in the older group: 27.06+/- 46.92). One such outlier (143 details recalled) was identified in the young adult group, and no outliers were identified in the older

[9] The results of the episodic-to-total analysis were similar in the full sample. Again, there was a main effect of task (*F*(2,76)=13.87, *p*<.0005, η_p^2=.27) and age (*F*(1,38)=18.75, *p*<.0005, η_p^2=.33). In the full sample, however, the age x task interaction was significant (*F*(2,76)=3.41, *p*=.04, η_p^2=.08). Post hoc t-tests with Bonferroni corrections (α = .016) indicated that the proportion of episodic detail was higher in younger adults' memories for both the recent AM task (*t*(38)=4.48, p<.0005) and age 11-17 (*t*(38)=2.87, *p*=.007) but there was no difference between groups in memories from the past year (*t*(38)=1.73, *p*=.09).

[10] Similar results were obtained when the same analysis was carried out on the full sample of participants: a main effect of age (*F*(5,34)=5.47, *p*=.001; *Wilk's Λ* = 0.446, η_p^2=.45) was driven by older adults' decreased performance on word-cued AM (*F*(1,38)=21.92, *p*<.0005, η_p^2=.37), word list recall (*F*(1,38)=10.97, *p*=.002, η_p^2=.22) and events from age 11-17 (*F*(1,38)=4.98, *p*=.03, η_p^2=.11).

group. Removal of the young adult outlier resulted in even more comparable performance between groups ($F(1,30)=.71$, $p=.41$, $\eta_p^2=.02$).

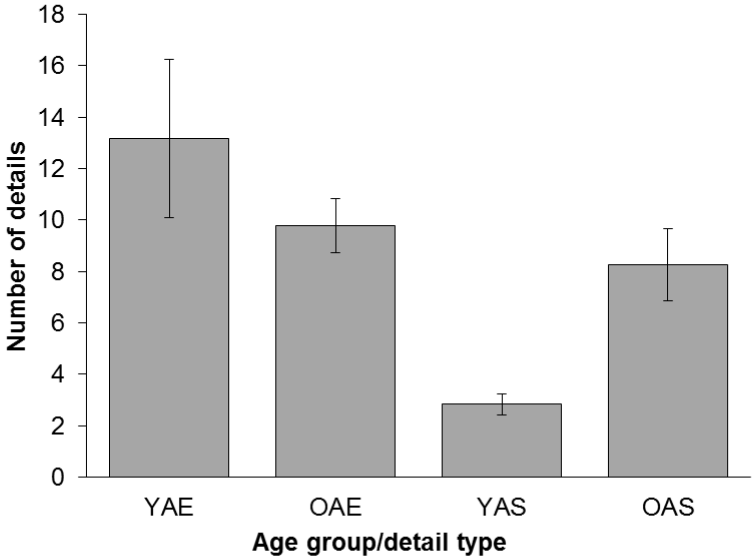

Figure 2C. Mean number of episodic and semantic details recalled by younger and older adults in the Recent AM task. Episodic recall was similar in both groups, but older adults recalled more semantic details than younger adults. Error bars represent standard error of the mean. YAE = young adult episodic; OAE = older adult episodic; YAS = young adult semantic; OAS = older adult semantic.

Power analysis. As in Experiment 1, we calculated the power to detect effects of different sizes, given the sample size, number of measurements, and average correlation between measures. The results revealed 91% power to detect a large effect (Cohen's *f*=.4), 54% power to detect a medium effect (*f*=.25), and only 13% power to detect a small effect (*f*=.1). This suggests that age differences in word-cued AM, word list recall, and remote episodic AM (age 11-17) were relatively large, while any age differences in the other two tasks were too small to detect in this experiment. The exclusion of the seven participants as described above, in order to match the samples, resulted in a 2% reduction in the power to detect a small effect and an 8% reduction in the power to detect a medium effect. In order to detect a small effect with 80% power, a sample size of 360 would have been required.

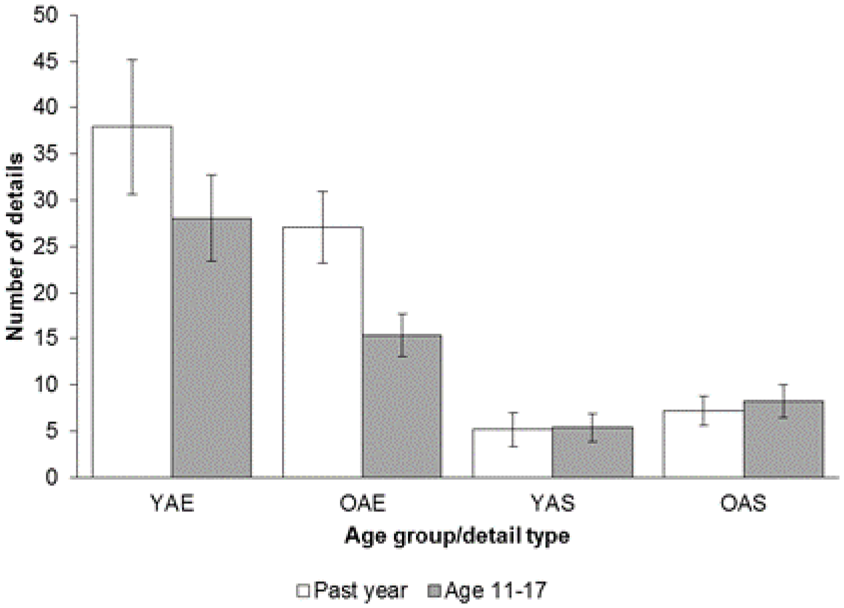

Figure 2D. Mean number of episodic and semantic details recalled by younger and older adults in the lifetime periods task. Episodic recall was similar in both groups in memories from the past year, but younger adults recalled more episodic details than older adults in memories from age 11-17. Semantic recall was similar in both groups for memories from both age 11-17 and the past year. Error bars represent standard error of the mean. YAE = young adult episodic; OAE = older adults episodic; YAS = young adult semantic; OAS = older adult semantic.

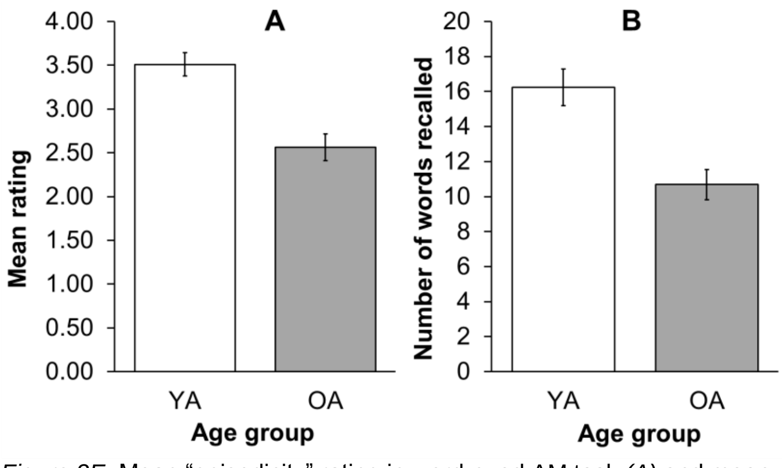

Figure 2E. Mean "episodicity" rating in word-cued AM task *(A)* and mean number of words recalled in word list task *(B).* Younger adults' word-cued memories were more episodic than older adults' memories, and younger adults recalled more words on the word list task. Error bars represent standard error of the mean. YA = young adults; OA = older adults.

Semantic memory. A second MANOVA analysed the effect of age on the number of semantic details recalled across AM tasks. There was a significant effect of age on semantic memory (F(3,29)=4.88, p=.007; *Wilk's* Λ = 0.664, η_p^2=.37). Between groups comparisons revealed that older adults recalled more semantic details in the recent AM task ($F(1,31)=14.61$, $p=.001$, $\eta_p^2=.32$), but both groups produced a comparable number of semantic details in memories from age 11-17 ($F(1,31)=1.51$, $p=.23$, $\eta_p^2=.05$) and memories from the past year ($F(1,31)=.68$, $p=.41$, $\eta_p^2=.02$)[11]. These results suggest an inconsistent pattern of semantic recall across tasks, which could shed light on the function of semantic details within AM narratives. The power to detect a significant effect was lower for semantic details than for episodic details, due to the combination of a smaller number of measures and increased intercorrelation. The power to detect a large effect was 82%, to detect a medium effect was 44%, and to detect a small effect was 11%. In order to detect a small effect with 80% power, 474 participants would have been required.

Memory age. The analysis above highlights a deficit in older adults' AM performance on the AI when the retention interval was longer for older adults (i.e. memory from age 11-17), but where the retention interval was similar for both groups (i.e. memories from the past year) the older adults' performance did not appear to suffer significantly. In the word-cued memory task there was no control on retention interval yet older adults did not perform as well as younger adults. We next asked whether older adults were biased towards recalling older memories, and whether this might explain some of the deficit in their performance.

First, each memory from the word-cued task was rated according to its age (1 = 0 -5 years; 2 = 6-10 years; 3 = 11-20 years; 4 = more than 20 years). The precise age of the memories were not recorded since participants could not always recall the exact date the event took place, particularly for older events. A number of responses could not be dated because they were repeated events, they lasted longer than a day, or because the participant had failed to recall anything at all. Overall there were 5 of such responses in the younger group and 19 of such responses in the older group. These responses were excluded before calculating the mean retention interval for each participant across the remainder of the memories recalled on this task. The mean retention interval for younger adults ($M=1.38$, $SD=.34$) was significantly shorter than

[11] For semantic memory details the results were also similar in the full sample. There was a main effect of age ($F(3,36)=6.55$, *Wilk's Λ* = .65, $\eta_p^2=.35$), driven by higher semantic recall in the recent AM task ($F(1,38)=19.12$, $p<.0005$, $\eta_p^2=.34$). There were no group differences in semantic recall in memories of age 11-17 ($F(1,38)=2.91$, $p=.10$, $\eta_p^2=.07$) or the past year ($F(1,38)=1.33$, $p=.26$, $\eta_p^2=.03$).

the retention interval for older adults (*M*=2.19, *SD*=.99; *t*(31)=3.21, *p*=.003). *Figure 2F* shows the percentage of memories recalled at each retention interval for both groups. The longer retention interval for the older group was driven by increased recall of memories more than 20 years old (*t*(31)=3.98, *p*<.0005) and decreased recall of memories from the last 5 years (*t*(31)=2.48, *p*=.02). There was no difference between groups in the percentage of memories recalled from between 6 and 20 years ago.

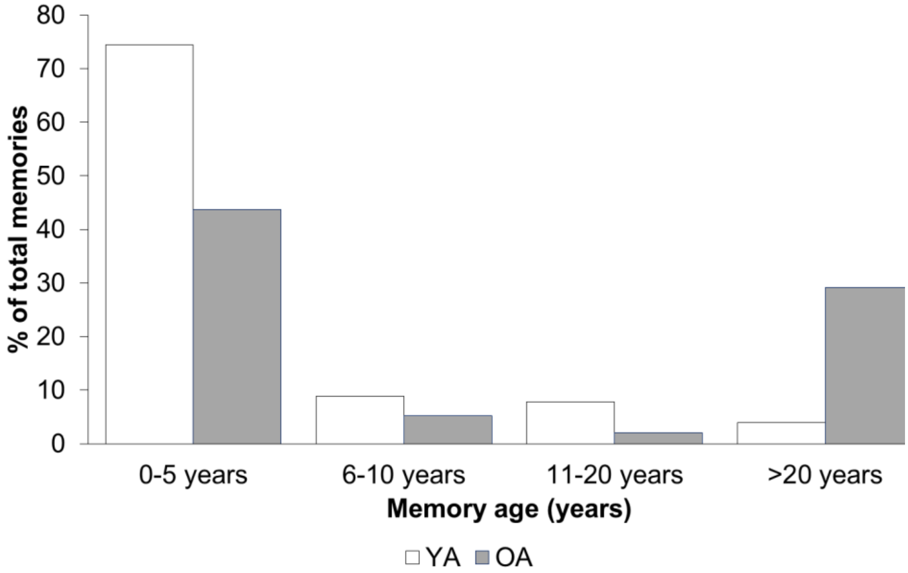

Figure 2F. Age of memories recalled by young and older adults during word-cued AM task, as a percentage of total memories recalled. Younger adults recalled more memories from the past five years, while older adults recalled more memories from more than 20 years ago. YA = young adults; OA = older adults

Next, we looked at the relationship between the age of the memory and its rated episodicity. There was a small but significant negative correlation (*r*=-.13, *p*<.05 (1-tailed)), such that older memories tended to be rated as less episodic. There were not enough data to look at all time bins individually, therefore the episodicity of younger and older adults' memories were compared in bin 1 (0-5 years) only. Two older participants were excluded from this analysis because they did not recall any memories from the previous 5 years. For the remaining sample, the mean episodicity rating was calculated for all memories recalled in bin 1 to give a single score per participant. Even under this retention interval control, younger adults' memories (*M*=3.62, *SD*=.51) were more episodic than older adults' memories (*M*=3.07, *SD*=.48; *t*(29)=3.05, *p*=.005), thus the difference in episodicity ratings in this task could not be attributed to differences in retention interval.

Discussion

Episodic memory. The results presented above demonstrate that within the same sample of participants, age effects vary in magnitude across different AM tasks. Using a prospective sampling method, Experiment 2 did not find a difference in older and younger adults' episodic memory for everyday autobiographical events, thereby replicating the findings of Experiment 1. These results rule out the possibility that the absence of age effect observed in this task was a product of the use of SC, either as a result of wearing the camera during encoding or reviewing images of related events during retrieval. We also wanted to rule out the possibility that the results obtained could be explained by a sampling effect, for example a particularly high functioning group of older adults. In both experiments, we ensured that IQ and education were matched; however, in Experiment 2 we were able to contrast the relative performance of the same older and younger adults on a number of different memory tasks in which older adults have previously been found to exhibit a deficit. We demonstrated here that the same older adults did have a deficit when episodic memory was measured in a word list task, and when autobiographical memory was cued using words. We also found a deficit in older adults' performance when recalling very old memories from adolescence, but no corresponding deficit for memories from the past year. Since older adults did not perform as well as younger adults on most of these tasks, this suggests that the sample was not particularly high-functioning, and therefore this explanation can be rejected. However, there was low power to detect small effect sizes in both Experiment 1 and Experiment 2, which prevents strong conclusions about the presence or absence of age-related deficit in measures of more recent AM. The remaining hypothesis, then, is that on some AM tasks the effect of age is smaller than on others. In the general discussion we return to this point to consider possible contributing factors.

Semantic Memory. The results of Experiment 2 also demonstrated that older adults recalled more semantic details than younger adults when describing everyday events, which was consistent with older adults' superior semantic recall in Experiment 1. In the present experiment, however, there was no significant difference in the number of semantic details recalled by older and younger adults in the AI task (memories from the past year and memories from age 11-17). This is inconsistent with the findings of B. Levine et al. (2002), on which the AI task was based. While it is possible that age effects were under-reported here due to low power to detect a small effect, the sample size of Levine et al. was similar. One possible reason for the inconsistency is that in the present experiment we chose not to count repetitions and episodic details of non-target events in this category. Levine et al. used the term *external* details to categorise all recall that did not directly describe the event in question, whereas in the present study we chose to focus on the contrast between episodic (i.e. event-specific) and semantic (i.e. decontextualized) recall. It is possible that the greater number of external details produced by older adults in the Levine et al. study were repetitions and/or episodic details pertaining to non-target events. In any case, this inconsistency highlights the difficulty inherent in drawing conclusions about a heterogeneous category of details.

Section 2.4

Chapter 2 Discussion

The two experiments presented here suggest that the magnitude of the age-related deficit in AM varies by the task used to measure it. In particular, when everyday events are prospectively sampled for a later memory test, age effects appear to be either absent or small. In Experiment 2, we showed that this was not due to a particularly high-functioning sample of older adults, since the same individuals (matched across groups on IQ and education) did exhibit a deficit on other episodic and autobiographical memory tasks.

Although a number of previous studies have shown that older adults do not perform as well as young adults on AM tasks (Ford et al., 2014; Habermas et al., 2013, B. Levine et al., 2002; Piolino et al., 2002, 2006, 2010; Ros et al., 2010; St. Jacques et al., 2012), these findings are not unequivocal, and several other studies have found little or no evidence for an age-related deficit (Aizpurua & Koutstaal, 2015; Bluck et al., 1999; De Beni et al., 2013; McDonough & Gallo, 2013; Schryer & Ross, 2014; Schulkind & Woldorf, 2005). An important question, then, is why older adults' performance is considerably worse on some tasks but not others, and what factors contribute to an age-related decline in performance. There are a number of differences between the Recent AM task, the AI and word-cued AM measures. For example, the Recent AM task measures memory at the same retention interval for both younger and older adults, and the retention interval (two weeks) is relatively short compared to more traditional measures of AM. In addition, in the Recent AM task the participant is cued by the specific title of the to-be-recalled event, whereas in other AM measures, which usually sample memories retrospectively, cues tend to be more general and thus require that the participant searches their memory for a related event to describe. Finally, the prospective sampling method employed in the Recent AM task requires that participants take note of the events that they will be asked to recall later, and thus allows for the intentional encoding of event-relevant information, whereas retrospectively sampled memories may be less likely to be encoded intentionally.

Retention interval

It is generally accepted that over time, memories lose episodic detail and their representation becomes more schematic (Cabeza & St. Jacques, 2007; M. A. Conway, 2009; Nadel & Moscovitch, 1997; A. C. Smith & Graesser, 1981). As such, measuring memories after long retention intervals is likely to produce accounts that are more semantic than they might be after shorter intervals. In Experiment 2 we showed that, under the same retrieval instructions, memories from adolescence were less episodic than memories from the past year. This supports the view that episodic detail is lost over time, possibly as a by-product of accumulating interference (e.g. Yassa & Reagh, 2013).

We also found that older adults' memories of adolescence were less episodic than younger adults' adolescent memories, which should not be surprising given that the retention interval was much longer for older (~55 years) compared to younger adults (~10 years). In comparison, older and younger adults' memories for the past year were comparably episodic, as were the two-week old memories sampled in the recent AM condition. One possibility is that older adults are more sensitive to long-term forgetting than younger adults, and that age-related memory deficits are larger at longer retention intervals. However this explanation fails to account for older adults' poorer performance in laboratory studies, such as the word list task in the current study, in which retention intervals are typically on the order of minutes (e.g. Nyberg et al., 1996).

Another possibility is that biases in retention interval in some AM tasks, which favour younger adults, lead to overestimation of age differences. That is, if retention intervals are systematically longer for older adults, it is difficult to determine whether any reduction in episodic content of the memories is due to the age of the participant or the age of the memory. One factor that is often not considered when measuring personal memories across different age groups is the tendency for older adults to recall more temporally remote events than younger adults (Hyland & Ackerman, 1988; Sperbeck, Whitbourne & Hoyer, 1986), which we replicated in the word-cued AM task in Experiment 2. Given the findings above, it might be suggested that older adults' poorer performance on this task can be explained by their tendency to select older memories to recall. However, comparing only those narratives that were less than five years old, we found that younger adults' word-cued memories were still more episodic than older adults' memories. Retention interval alone therefore cannot explain older adults' poorer performance on certain tasks, although it is difficult to discount entirely since, as described above, there still seems to be a measurable effect of retention interval on memory within the same task.

Executive function

Older adults' poorer performance on the word-cued task may instead reflect the extent to which the task recruits executive control processes (Dalgleish, J. M. G. Williams, Golden, et al., 2007; Holland et al., 2012), since executive function ability generally declines with age (Fisk & Sharp, 2004), and mediates age effects on some laboratory episodic memory tasks (Clarys, Bugaiska, Tapia & Baudouin, 2009; Lee, Crawford, Henry, et al., 2012). In particular, retrieving a specific memory in response to a generic word cue involves effortful generative retrieval processing, in which the participant must select a single memory from a large number of competing traces (see M. A. Conway & Pleydell-Pearce, 2000). Presumably, the larger the number of traces in competition with one another, the more difficult it is to recall a specific memory (e.g. Yassa & Reagh, 2013). Thus, older adults' performance may be poorer on the word-cued task both because of impaired executive function ability, and because the amount of experience accrued across the life span means there are more traces in competition for recall. In contrast, in the Recent AM task, the participants are provided with the title of the event to recall, which provides more direct access to the relevant memory, and consequently might be argued to place less demand on executive function.

Rehearsal

Another factor that may affect the content of reported memories is how often the memory has been rehearsed. In typical AM tasks, including the AI and word-cued tasks employed here, participants self-select the events that they will describe. This retrospective self-selection likely leads to the retrieval of events that are well-rehearsed, and therefore more readily available in memory (Galton, 1879; Harris, O'Connor & Sutton, 2015). The degree to which a memory has been previously rehearsed is an important consideration, since there is some evidence that reactivating memories can alter their representation (Foos & Fisher, 1988; Hupbach, Hardt, Gomez & Nadel, 2008; St. Jacques & Schacter, 2013). According to multiple trace theory (MTT; Nadel & Moscovitch, 1997), each time a memory is retrieved, a new memory trace is formed. Because each iteration of the retrieval occurs within a slightly different context, these memory traces are not identical, and certain commonalities are distilled from across the multiple representations. In this way the memory trace comes to be represented more schematically. Thus, MTT suggests that memories undergo a process of "semanticisation" with repeated retrieval (Moscovitch, Rosenbaum, Gilboa, et al., 2005, p. 42), and this is consistent with an empirically documented shift from episodic to schematic knowledge representation over the course of repeated tests (M. A. Conway, Gardiner, Perfect, S. J. Anderson & G. Cohen, 1997; Dewhurst, M. A. Conway & Brandt, 2009).

This rehearsal effect may be particularly evident for older adults, who appear to draw to a greater extent on a small pool of frequently repeated memories (G. Cohen & Faulkner, 1988). If indeed older adults draw more on these rehearsed memories than younger adults, we might reasonably expect that their memories would show more evidence of having been semanticised (i.e. a reduction in episodic detail and/or increased recall of decontextualised information). In any case, it is possible that for both older and younger adults the differences in recall between the recent AM task on one hand, and the word-cued task and AI on the other, could be affected by the degree to which the memories have been rehearsed. In the present study we did not collect ratings of the frequency of rehearsal, but the retrieval of well-rehearsed events seems particularly likely given the small number of memories sampled in the two retrospective conditions (two in the AI, and six in the word-cued AM task).

Semantic memory

An increase in older adults' semantic recall was observed the recent AM tasks of Experiments 1 and 2. This is broadly consistent with previous research (Aizpurua & Koutstaal, 2015; Habermas et al., 2013; B. Levine et al., 2002), but in the present study the semantic increase was not associated with any concurrent decline in episodic recall. This suggests that semantic recall did not reflect an over-reliance on general decontextualised information as a result of difficulty retrieving event-specific episodic information (e.g. B. Levine et al., 2002). One possibility is that older adults simply have difficulty inhibiting irrelevant information during recall (e.g. Hasher & Zacks, 1988), which might explain the increase in semantic details without reference to the number of episodic details recalled. However, the same pattern was not observed across all tasks, which suggests that production of this type of detail may be related either to task demands or the characteristics of certain memories, rather than to age group per se.

Conclusion

There is no doubt that older adults exhibit a decline in performance on some measures of memory, but the findings reported here suggest that AM for recently experienced everyday events is relatively spared. Indeed, the pattern of age-related memory performance appears to be dissociable across tasks that purport to measure the same phenomenon, which raises important questions about how autobiographical memory is operationally defined. In particular, there is a need to specify which processes (e.g. executive function) and features (e.g. length of retention interval, amount of rehearsal) are involved in the types of memory retrieved under different task instructions. The results presented here do not suggest a single explanation to account for age differences in AM, yet there is some indication that factors such as retention interval and executive processes nevertheless can affect the pattern of episodic and semantic recall, which highlights the need to control confounding variables. Further research should be aimed at better understanding the underlying factors that contribute to declining performance on certain tasks, which may help to resolve some of the apparent inconsistencies between previous findings.

Section 2.5

Chapter 2 appendices

Appendix 2A

Examples of episodic and semantic segments

Episodic	Semantic
I remember she ordered something in black squid ink	The restaurant of the Royal Free Hospital is in the basement
We talked about the kind of difficulties within families and relationships and mothers and children, and how it's difficult to let go of your children	I usually arrive at 10:45 and my class is at half past
I gave him a tenner and he only gave me £3 back and I thought, 'That's a lot for a little bit', so I looked at my receipt and gave it back to him and said, 'Look you've charged me twice', and I asked for the money back and he gave it to me	I'm her only relative in London except for her brother with whom she has an on and off flawed relationship

Appendix 2B

Criteria for specificity coding

Criteria	Specificity score	Example
Single detail with no elaboration	1	I paid by card
Single detail with a little elaboration, possibly involving two modalities	2	The woman from the counter came over and said that whatever my wife had ordered they didn't have any more and what would she like instead?
More complex detail, may be temporally extended and/or involving two or more modalities	3	I remember triple checking whether I still had the lid because I put it in the right pocket of my blue coat but I thought I'd put it in the other one, so I thought I'd lost it but I hadn't.
Richly detailed recollection describing a distinct episode within the event	4	There was a gentleman down there calling out "Anyone paying by card?", and I asked the chap in front of me if he was paying by card and he said no, so I started to go down to that one but somebody else had already jumped the queue and got there but that was okay, because I arrived at someone who was just leaving and the cashier became free.
As above, but with more detail, giving the impression of exceptionally clear or vivid recollection	5	He was looking at this thing and I asked if he was alright. I think he was looking for an exam room and he said "Where is the Social Sciences room?" So I said, "Do you mean the Social Sciences building?" So I tried to explain that it was the massive glass tower across the road and you can't really miss it. I'd never seen him before but he looked completely lost and that's really clear in my memory. He seemed quite grateful.

Chapter 3: Effects of specific task demands

In this chapter, we begin to investigate how differences in experimental task might affect memory performance in older and younger adults. One difficulty in interpreting previous findings relates to the heterogeneity of methods employed to study AM performance. In *Chapter 2* we showed that different measures of AM produce variations in the relative performance of older and younger adults. The tasks selected for inclusion in Experiment 2 were those that are employed frequently in the literature, often without reference to the specific demands placed on participants and how these might affect performance. Autobiographical memory retrieval consists of a number of different processes that converge on the experience of remembering a past event, and different tasks place varying emphasis on some of these retrieval processes. Regarding age-related deficits in memory, inconsistent findings from previous studies may arise because ageing affects some of these processes to a greater extent than others. Accordingly, tasks that emphasise the processes that decline with age should produce the greatest deficits in older adults. In the discussion of *Chapter 2*, we suggested two factors that might account for at least some of the variance in age effects between tasks: executive function/retrieval processes and retention interval. In this chapter, we investigate these variables directly.

Section 3.1

Introduction

Direct versus generative retrieval. Information stored in memory is not always accessible (Tulving & Pearlstone, 1966), since the successful retrieval of a memory depends on the availability of an appropriate cue. Several researchers have argued for a distinction between direct, automatic retrieval and effortful retrieval. If a cue is specific, that is, if it shares sufficient features with a target memory (and does not share those features with competitors), it can lead directly to that memory trace with relatively little additional processing (M. A. Conway & Pleydell-Pearce, 2000). Alternatively, a more general cue requires a process of generative, or strategic, retrieval in which an effortful sequence of search and evaluation operations is undertaken (M. A. Conway & Pleydell-Pearce, 2000; Moscovitch, 1992; D. A. Norman & Bobrow, 1979; J. M. G. Williams, Chan, Crane, et al., 2006). According to this view, during generative or strategic retrieval the particular demands of the retrieval task (e.g. experimental instructions to recall a specific memory) are first interpreted in a cue-elaboration stage, and a mental model is formed against which retrieved information is subsequently evaluated. This mental model in effect constitutes a description of what is to be remembered (D. A. Norman & Bobrow, 1979). If the description is not satisfied then the retrieved information serves as input for the next stage of processing in a negative feedback loop that iteratively reduces the number of candidate memory traces (M. A. Conway & Pleydell-Pearce, 2000). A memory is constructed when the retrieved information satisfies the evaluation criteria, and the generative retrieval process can be aborted. It is important to note that, if successful, the process of generative retrieval always ends in an act of direct retrieval (M. A. Conway & Loveday, 2010). Generative retrieval might thus be understood as a process of translating a generic cue into a specific cue, which can then access long-term memory directly.

J. M. G. Williams et al. (2006) argued that word cues that are higher in imagery are able to cue memory more directly, possibly by way of activating sensory representations. Importantly, the effect of cue specificity is treated here as a continuous rather than categorical variable, implying that there is variation in the extent to which generative retrieval is invoked by different cues. Rubin and Schulkind (1997a) showed that words that were higher in imagery, concreteness and meaningfulness cued autobiographical memories with shorter response latencies, which suggests that more direct retrieval (i.e. more imageable cues) is easier than more generative retrieval. These memories also tended to be more temporally remote than memories that were recalled in response to low-imageable cue words. Generative retrieval appears to be particularly difficult when executive capacity is compromised, as demonstrated in a study by J. M. G. Williams et al. (2006), who found that low-imageable word cues presented under cognitive load were associated with recall of over-general memories (i.e. memories of repeated or general life events rather than specific occasions). There is evidence that the content of memories retrieved in response to imageable and non-imageable cues also varies. For example, K. W. Rasmussen and Berntsen (2014) found that young adults' memories retrieved to imageable cues contained more episodic detail than memories recalled in response to non-imageable cues, and were more positively valenced and associated with greater subjective ratings of mental time travel. These findings support the distinction between direct and generative retrieval, suggesting that specific cues can activate direct retrieval, enabling fast recall of episodic event information. Moreover, the findings from Rasmussen and Berntsen suggest that memories retrieved directly may be qualitatively different from those retrieved generatively.

When a retrieval cue is generic, a strategy is required to enable a specific memory to be recalled. Within Conway's conception of the self-memory system (M. A. Conway & Pleydell-Pearce, 2000) memories are organised hierarchically, with specific event information connected to one or more general events (e.g. *Trips to the cinema* or *Holiday in Spain*), which are in turn embedded within lifetime periods (e.g. *Working at X* or *Relationship with Y*). According to Conway and Pleydell-Pearce (2000), conceptual knowledge is used to probe long-term memory during generative retrieval, and the usual way of accessing event-specific information is through general events. This model was supported by a study by Haque and M. A. Conway (2001) in which participants generatively retrieved events and were stopped at various points during the retrieval and asked to report what they were thinking of. Although some specific memories were reported as early as two seconds into the retrieval process (suggesting direct retrieval), almost half of the specific memories were only reported after 30s of retrieval. In contrast, lifetime periods and general events were most likely to be reported within the first 2-5s of the retrieval window. Further support comes from the study by J. M. G. Williams et al. (2006), who found that failure to successfully execute generative processing at retrieval results in a truncated search at the level of lifetime periods or general events.

Generative processing is considered as an executive, “working-with-memory” faculty (Moscovitch, 1992), and is thought to be modulated by frontal lobe activity (M. A. Conway & Pleydell-Pearce, 2000; Burgess & Shallice, 1996; J. M. G. Williams et al., 2006). This is supported by studies showing frontal activation during generative retrieval (M. A. Conway, Turk, S. L. Miller, et al., 1999; Daselaar, Rice, Greenberg, et al., 2008; St. Jacques et al., 2012), as well as the finding that generative compared to direct retrieval activates lateral prefrontal brain regions (Addis, Knapp, Roberts & Schacter, 2012). The role of the frontal lobes is relevant to memory retrieval in older adults, since ageing is associated with a decline in frontal lobe executive processing (Berna Schönknecht, Seidl, Toro & Schröder, 2012; Clarys et al., 2009; Fisk & Sharp, 2004; Lee et al., 2012). It follows, then, that older adults should find retrieving memories via a generative process more difficult. Several studies employing word cues have shown that older adults’ recall of specific events is impaired (Beaman et al., 2007; St. Jacques et al., 2012), with older adults more likely than younger adults to retrieve general (i.e. repeated or temporally extended) events. Indeed, over-general memory in older adults, as measured on a word-cued task, has been shown to correlate with reductions in working memory capacity (Ros et al., 2010). In contrast, reduced executive capacity does not appear to affect direct retrieval (J. M. G. Williams et al., 2006).

Generative retrieval outside the laboratory. General cues such as words, emotions and time periods are widely used in AM research because they can be easily controlled and the same cues can be used for all participants. However, the demand to recall highly specific memories in response to general cues is a difficult task that does not always result in the successful retrieval of a specific memory, despite the probability that a large number of candidate traces exist. Moreover, the extent to which performance on such generative retrieval tasks is reflective of real-life memory ability has not been empirically tested. Several researchers have argued for three distinct functions of autobiographical memory outside the laboratory, commonly referred to as self, social and directive (Bluck & Alea, 2002; Bluck, Alea, Habermas & Rubin, 2005; G. Cohen, 1998; Pillemer, 1992). The self function emphasises the importance of memory in maintaining the continuity of a self-concept (Brewer, 1986; M. A. Conway, 2005; Neisser, 1988) and regulating mood (G. Cohen, 1998), while the social function of memory is to facilitate social interaction and enable empathy and self-disclosure (G. Cohen, 1998; Neisser, 1988). The directive function involves using memory for problem-solving, predicting future events and guiding behaviour (Baddeley, 1987; G. Cohen, 1998; Robinson & Swanson, 1990). Within this framework, it is difficult to account for generic cues of the type often used in the laboratory. Each of the three proposed functions of memory involves motivated, goal-relevant retrieval, with the goals themselves providing specificity to the retrieval cue. For example, in order to solve a current problem we might remember what happened the last time we were faced with a similar problem, and in order to express empathy towards someone we might recall a time when we were in a similar situation. In both of these scenarios the current environment specifies a conceptually related retrieval goal. In addition, recent diary studies have found that memories are often experienced involuntarily in daily life (Berntsen, 1998; Schlagman, Schulz & Kvavilashvili, 2006). Furthermore, these involuntarily generated AMs are experienced as much as three times as frequently as voluntarily generated AMs (A. S. Rasmussen & Berntsen, 2011). These memories are usually cued by an individual's current goals or sensory context (Ball & Little, 2006) and involve no conscious retrieval effort. Consequently, it seems likely that the majority of our retrieval attempts in everyday life are prompted by cues that are more specific than those often used in the laboratory.

In the Recent AM task in Experiments 1 and 2, participants were presented with specific retrieval cues in the form of the name of the to-be-recalled event. In theory, this approach bypasses the need for effortful generative retrieval processing, because it allows for direct retrieval of the target memory (i.e. the event name is not associated with any other event). It might be expected, then, that older adults would perform better on this type of task than when presented with more generic retrieval cues. In Experiment 2 these two test types were compared directly and the results showed that, within the same sample, there was an age-related deficit on a generic word-cued task, but no such deficit when the cue was the specific event title. While this comparison succeeded in demonstrating that performance is not necessarily correlated across different AM tasks, there are a number of confounds that prevent the interpretation of these results as clear evidence of a cue-specificity effect. One issue is the retention interval difference between the two tasks – two weeks in the case of the title-cued memories, and between one month and several decades in the case of the generic word-cued memories. It is possible that the rate of forgetting is increased in older adults (Davis, Small, Stern, et al., 2003; Huppert & Kopelman, 1989), in which case testing memory after longer intervals would produce more pronounced deficits (but see Piolino et al., 2002). It is also possible that differences in retention interval for older and younger adults confound results, since older adults tend to recall more remote memories than younger adults when no target time period is specified (Hyland & Ackerman, 1988; Sperbeck et al., 1986), thus in the Recent AM task retention interval was equated across groups, while in the generic word-cued task it was not. However, when generic word-cued memories were compared for only the previous five years, younger adults still outperformed older adults, suggesting that retention interval differences could not account for the deficit in performance exhibited by older adults on this task. In Experiment 3, we manipulated retention interval and cue specificity within the same retrospective sampling task, in order to explore these issues.

Section 3.2

Experiment 3

The effect of cue specificity and retention interval on older and younger adults' autobiographical recall.

The present experiment sought to understand the effect of cue specificity on the autobiographical memories (AMs) reported by older and younger adults. The aim was to investigate why, in Experiment 2, older adults performed poorly on the word-cued and time period-cued tasks compared to younger adults, yet on the recent AM task older adults did not exhibit a significant deficit. As discussed at the beginning of this chapter, specific retrieval cues should allow for direct retrieval of episodic memories without the need for effortful generative processing, which may be more difficult for older adults because of reductions in executive function ability (Berna et al., 2012; Clarys et al., 2009; Fisk & Sharp, 2004; Lee et al., 2012). We hypothesised that this might be one reason for comparable performance on the recent AM task.

Cue specificity. Some of the most widely-used tasks in the autobiographical memory literature require substantial generative processing at retrieval, and on these tasks older adults often perform poorly (Beaman et al., 2007; Ford et al., 2014; Habermas et al., 2013; Holland et al., 2012; B. Levine et al., 2002; Mevel, Landeau, Fouquet, et al., 2013; Piolino et al., 2006; Piolino et al., 2010; Ros et al., 2010; St. Jacques & B. Levine, 2007; St. Jacques et al., 2012). These findings are generally consistent with age-related deficits on laboratory episodic memory tasks, in which considerable executive control is required for both encoding and retrieval (Baddeley, 1996; Bouazzaoui et al., 2013; Clarys et al., 2009; Dobbins, Foley, Schacter & Wagner, 2002; Lee et al., 2012; Tomita, Ohbayashi, Nakahara, Hasegawa, & Miyashita, 1999). There is evidence that poor performance on the word-cued AM task is related to impairments in working memory and/or executive function ability (Birch & Davidson, 2007; Dalgleish et al., 2007; Ros et al., 2010), and some evidence that the difficulty of this task relates to the amount of generative retrieval required (Uzer, 2016). Although each of these observations has been broadly supported, there is as yet no direct evidence of generative retrieval problems in older adults (but see J. M. G. Williams et al., 2006, for evidence of generative retrieval difficulties leading to a similar pattern of results among depressed patients) and no previous studies have directly examined the effect of cue specificity on older adults' AM. Accordingly, the present study set out to compare performance on an AM task when retrieval was prompted by either a specific or a general cue. Specific retrieval cues are difficult to use in AM research since the experimenter knows little about the participant's past experience, however, when to-be-remembered events were prospectively sampled and cued with specific event titles in Experiments 1 and 2, older adults appeared to perform as well as young adults in terms of the amount of episodic detail they recalled. In this experiment we examined the effect of cue specificity independently of how the memories were sampled, by retrospectively sampling the memories at each level of specificity.

Retention interval. We also looked at the effect of age group-bias in retention interval in this study. In Experiment 2, there was some evidence that the age-related memory deficit may be in part due to longer retention intervals for older adults on the word-cued and lifetime period-cued AM tasks. However, when we compared word-cued memories for only the past five years, older adults still did not perform as well as younger adults. Although this suggests that retention interval bias may not be the primary cause of age-related AM deficits, we wanted to manipulate this directly in the present experiment for two reasons. Firstly, in the word-cued AM task in Experiment 2, older adults' recalled events were, on average, more remote than younger adults' events. Consequently, in order to compare memories from only the past five years, a large amount of data had to be discarded; this analysis involved three quarters (75%) of the young adults' data, but less than half (44%) of the older adults' data. Secondly, following the procedure of B. Levine et al. (2002), the lifetime period cues in Experiment 2 were accompanied by a list of possible events that the participant may have experienced in that period. As we did not have access to the event list that Levine and colleagues used, we created a new list that was considerably shorter than that used by Levine et al. (16 items versus 100). Paradoxically, this may have made the task easier by reducing the number of candidate memory traces and thus reducing the processing effort required to retrieve a single memory. In other words, the retrieval cues that we provided in Experiment 2 may have been more specific than intended. We therefore did not have a clear measure of how bias in retention interval might affect what older and younger adults remembered. In the present experiment we examined the effect of retention interval without supporting retrieval with a list of possible events.

The present study. Given the mixed findings relating to AM in ageing, the effect of different types of retrieval cues needs to be systematically tested in order to better characterise the nature of age-related impairment. In this study, a generic time period cue was used as a baseline against which to measure the effects of cue specificity and retention interval. In this baseline condition, retention interval was the same for both groups. We expected that increasing the specificity of the retrieval cue would lead to better memory performance, while increasing the retention interval would lead to worse performance. In addition, we wanted to see whether these factors interacted with age. If older adults' generative retrieval processing is impaired, then specific cueing should particularly benefit older adults' performance (i.e. the difference in performance between specific and generic cues should be greater for older adults than younger adults). In addition, if memory performance is directly related to retention interval then older adults should exhibit a greater memory deficit when the retention interval is biased towards younger adults (i.e. the difference in performance between matched and mismatched retention interval conditions should be greater for older adults).

Method

Design. A 2 (age: younger vs. older) x 3 (retrieval cue: baseline (recent time period) vs. specific incident vs. remote time period) x 2 (detail type: episodic vs. semantic) mixed factorial design was employed, with repeated measures on the second and third factors. Participants recalled two memories for each of the three retrieval cue conditions. For the recent time period cue, participants were provided with a time window ("past month" and "past year") and asked to recall any event from within that period. For the specific incident cue, participants were asked to recall the last time they ate out and their last birthday or Christmas. In the remote time period condition, participants were asked to recall their first day of, or another specific day from, both school and their first job. The particular cues used in each condition were selected as examples that all participants would have experience of. In the specific cue condition it was necessary to specify the last incidence of each event in order to make the cue as direct as possible. The dependent variables were the number of episodic and semantic details recalled in each condition.

Participants. Seventeen young adults (age 18-32; *M*=24.29, *SD*=4.70; 14 female) and 19 older adults (age 66-85; *M*=71.00, *SD*=4.18; 15 female) participated in return for a payment of £10. The younger participants were recruited via a university-run participant sign-up scheme and older participants were recruited from a panel of individuals who had previously responded to a local newspaper advertisement expressing an interest in participating in memory research. All participants in this study also took part in Experiment 5 (*Chapter 4*), the recall session of which took place immediately prior to the present study. The 2-subscale short form of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) was administered to all participants to provide an estimate of IQ, and the number of years of formal education received was recorded. The Geriatric Depression Scale (GDS; Yesavage et al., 1983) provided an estimate of depressive symptoms in both groups, which may correlate with over-general memory. In addition, older adults were screened with the Mini Mental State Evaluation (Folstein et al., 1975).

Materials and procedure. Participants recalled their memories verbally in a one-to-one session with the experimenter. All participants retrieved the events in the following order: school, past year, last time you ate out, work, past month, last Christmas/birthday. The order was kept constant for all participants because of the potential for some cues to prime retrieval of related events (M. A. Conway & Bekerian, 1987; Mace & Clevinger, 2013; Mace, Clevinger & Bernas, 2013; Mace, Clevinger & Martin, 2010), and we checked for order effects by comparing recall of both events within each condition (e.g. school vs. work), the results of which are presented in the results section below. For each of the six recalled memories, participants were asked to retrieve a single, specific event, situated in time and space and lasting a day or less. Participants were explicitly asked not to report memories of repeated or extended events, and examples were provided to illustrate the point. The experimenter read aloud the retrieval instructions and checked that the participant understood, and before each recall attempt the experimenter read aloud the retrieval cue (e.g. "Now I'd like you to tell me about the last time you ate out"). Participants were allowed unlimited time to retrieve and describe each of the memories, and the experimenter did not intervene except where the participant retrieved only a repeated or extended event. In such cases, the experimenter prompted with “perhaps you could talk about one of those occasions/a single day or less within that event”, as appropriate. This prompt was used only once per memory, and no further cues or prompts were given. Participants’ responses were recorded on a hand-held digital voice recorder and later transcribed and coded for episodic and semantic details, following the same procedure as for the Recent AM task in Experiment 2 (which is similar to that of B. Levine et al., 2002). Participants were also asked to rate the distinctiveness of each event on a scale of 1-10, and these ratings were collected verbally.

Memory coding. As in our previous experiments, in order to be classed as episodic a detail had to be specific to the event in question, context-bound (i.e. recalled from the original experience, as opposed to a subsequent reflection on the event) and recollective (i.e. the participant should appear to remember the detail embedded in the context, rather than simply knowing that something happened; see Gardiner, 2001). Episodic details comprised information about objects, locations, actions, people, conversations, thoughts and feelings, and temporal signals. Semantic details were memory details that did not fit into the episodic category, and were either context-free or associated with temporally extended (e.g. when I was at school) or multiple (e.g. Christmases when I was younger) contexts. In order to assess the reliability of this strategy, a random subset (n=12) of the memories were selected and rated by an additional team of three coders, who were provided with instructions as above. Correlational analyses showed that there was a strong relationship between the scores allocated by the original and additional coders for both episodic (r=1.00, r=.99) and semantic (r=.95, r=.97) details, indicating good agreement about the relative number details reported by each participant in each memory.

Results

Preliminary analysis

Sample matching. Years of education did not differ significantly between younger (M=16.88, SD=3.10) and older adults (M=15.74, SD=3.35; $t(34)$=1.06, p=.29), but older adults (M=125.00, SD=8.89) had significantly higher IQs than younger adults (M=109.24, SD=13.74;

t(34)=4.13, *p*<.0005). Young adults (*M*=8.76, *SD*=6.58) also showed significantly more indicators of depressive symptoms than older adults (*M*=4.37, *SD*=3.82; *t*(34)=2.41, *p*=.02). There were significant correlations between IQ and the number of details recalled in each of the three retrieval conditions (see *General Appendix G1*). This suggested that it was necessary to adjust the sample to avoid IQ confounding the results. Following the procedure we used for Experiment 2, to control for group differences in IQ we balanced the sample by excluding the five young adults with the lowest IQ scores and the eight older adults with the highest IQ scores. This adjustment (*n*=24; 12 younger) left no significant group differences in IQ (*t*(22)=1.15, *p*=.26), education (*t*(22)=1.83, *p*=.08) or GDS (*t*(22)=.22, *p*=.83).

Order effects. Because the order of retrieval cues was the same for all participants, we checked for order effects by comparing recall of the first cue in each condition with the second cue in the same condition. The retrieval attempts that were compared were each separated by the recall of two intervening events (see *Materials & Procedure* for cue order). Specifically, we wanted to rule out two possibilities: that events recalled later in the test were remembered better because the participants had "warmed up" (i.e. become more relaxed over the course of the recall session), and that events recalled later in the test were remembered more poorly because of fatigue. There were no significant differences in the number of details (episodic + semantic) recalled about each event in the baseline (past year: *M*=43.00, *SD*=32.88; past month: *M*=38.96, *SD*=33.79; *t*(23)=.94, *p*=.36), remote (school: *M*=25.00, *SD*=15.45; work: *M*=28.04, *SD*=18.10; *t*(23)=.77, *p*=.45), and specific cue (eating out: *M*=30.33, *SD*=22.84; birthday/Christmas: *M*=31.33, *SD*=20.58; *t*(23)=.28, *p*=.78) conditions, suggesting that the order of recall did not affect performance.

Event salience. We next investigated whether different types of cue were associated with recall of events that were more or less distinctive. We entered participants' event distinctiveness ratings into 3-way repeated measures ANOVA, with cue types as the within subjects factor. One older participant was excluded from this analysis because she was unable to remember events from school or work, and was therefore unable to give a novelty rating for that cue. The results showed a main effect of cue type (*F*(2,42)=5.64, *p*=.007, η_p^2=.21) but no main effect of age

($F(1,21)=2.34$, $p=.141$, $\eta_p^2=.10$) and no interaction ($F(2,42)=.24$, $p=.79$, $\eta_p^2=.01$). Bonferroni-corrected pairwise comparisons found that events recalled in response to specific cues were rated as less novel/distinctive than events recalled in response to remote period cues ($p=.02$) and recent period cues ($p=.04$), but there was no difference between recent period and remote period memories ($p=1.00$).

We next looked at whether event novelty/distinctiveness ratings were related to episodic recall in each of the three cue conditions, since in Experiments 1 and 2 there was a strong positive relationship between the two. In contrast to our previous findings, partial correlations controlling for age group found no significant relationship between novelty and recall in any condition (recent period: *Pearson's* $r=.28$, $p=.22$; remote period: $r=.25$, $p=.27$; recent specific: $r=.13$, $p=.56$).

Age of memory. To check whether there were differences between recent time period cues and specific cues in terms of the memory age (measured in days), a 3 (cue type: recent period vs. remote period vs. recent specific) x 2 (age group: young vs. older) ANOVA was performed. There were missing data for two older adults in the remote period condition and one older adult in the recent period condition, because one or both of their memories in that condition could not be dated. Mauchly's test of sphericity was violated, therefore the results presented below are Greenhouse-Geisser corrections, with degrees of freedom rounded to the nearest integer. There was a main effect of cue type on memory age ($F(1,38)=697.82$, $p<.0005$, $\eta_p^2=.97$). As expected, memories from the remote time period were significantly older (M=11,433.430, SD=1,970.81) than memories from the recent time period ($M=102.66$, $SD=58.00$, $p<.0005$) and recent memories recalled to a specific cue ($M=70.97$, $SD=40.39$; $p<.0005$). The difference in age between recent time period and recent specific memories was not significant ($p=.22$). There was also a main effect of age ($F(1,19)=381.55$, $p<.0005$, $\eta_p^2=.95$), but this was qualified by a significant age by cue interaction ($F(1,38)=388.76$, $p<.0005$, $\eta_p^2=.95$). Post hoc t-tests with Bonferroni corrections (α = .016) showed that the interaction was driven by significantly older memories produced by older adults compared to younger adults in the remote period ($t(20)=20.03$, $p<.0005$), but no differences between groups for the recent time period ($t(21)=.46$, $p=.65$) or recent specific condition ($t(22)=1.35$, $p=.19$). The mean age of memories, in days, is presented in *Table 3.1.1*.

Table 3.1.1

Mean memory age in each condition, measured in days

Cue type	Young adults		Older adults	
	Mean	*SD*	*Mean*	*SD*
Remote period	2975.42	1255.40	19691.75	2551.30
Recent period	109.04	56.72	98.00	58.26
Recent specific	86.33	39.82	63.21	44.20

Memory performance. Episodic recall is presented in *Figure 3A*, and semantic recall is plotted in *Figure 3B*. To examine the effect of different cue types on memory performance, a 2 (age: younger vs. older) x 3 (cue type: recent period vs. remote period vs. recent specific) x 2 (detail type: episodic vs. semantic) mixed factorial ANOVA was carried out. We found main effects of cue type ($F(2,44)=6.28$, $p=.004$, $\eta_p^2=.22$), age ($F(1,22)=4.58$, $p=.044$, $\eta_p^2=.17$). and detail type ($F(1,22)=25.09$, $p<.0005$, $\eta_p^2=.53$), and interactions between age group and detail type ($F(1,22)=18.14$, $p<.0005$, $\eta_p^2=.45$), and between cue type and detail type ($F(5,110)=11.19$, $p<.0005$, $\eta_p^2=.34$). There was no interaction between age and cue type ($F(5,110)=.64$, $p=.53$, $\eta_p^2=.03$), and no three-way interaction ($F(5,110)=1.20$, $p=.31$, $\eta_p^2=.05$). The main effect of age was driven by increased recall among young adults ($M=20.41$, $SD=12.10$) compared to older adults ($M=12.37$, $SD=4.81$), and the main effect of detail type was due to increased recall of episodic ($M=23.76$, $SD=18.39$) relative to semantic details ($M=9.02$, $SD=6.22$). Bonferroni-corrected pairwise comparisons showed the main effect of cue type was driven by increased recall in response to the recent time period cue ($M=20.49$; $SD=15.82$) compared to the remote time period cue ($M=13.26$, $SD=6.90$; $p=.04$). There was no significant difference between remote period and recent specific cues ($M=15.42$, $SD=9.98$; $p=.35$) and between recent specific cues and recent time period cues ($p=.06$), although there was a trend towards higher recall in the latter.[12]

[12] In the full sample, there was a main effect of cue type ($F(2, 68)=6.29$, $p=.003$, $\eta_p^2=.16$), and a main effect of detail type ($F(1,34)=23.10$, $p<.0005$, $\eta_p^2=.41$), but there was no main effect of age ($F(1,34)=.02$, $p=.88$, $\eta_p^2<.01$). As in the matched sample, there were also interactions between cue type and detail type ($F(2,68)=16.33$, $p<.0005$, $\eta_p^2=.32$) and detail type and age group ($F(1,34)=14.29$, $p=.001$, $\eta_p^2=.30$), but no age by cue type interaction ($F(2,68)=.28$, $p=.76$, $\eta_p^2=.01$) and no 3-way interaction ($F(2,68)=.83$, $p=.44$, $\eta_p^2=.02$. The only qualitative difference between the full and IQ-matched samples was therefore the effect

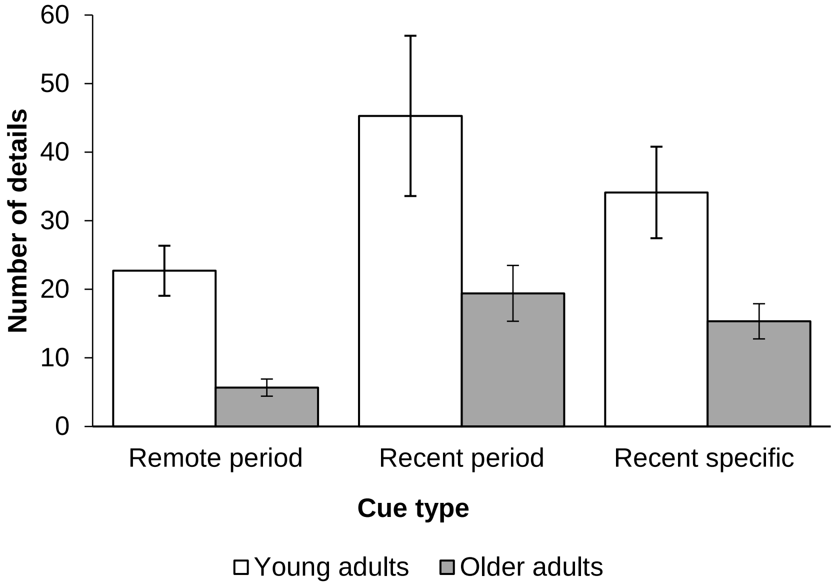

Figure 3A. Mean number of episodic details recalled by younger and older adults in response to remote time period cues, recent time period cues, and recent specific cues. Error bars represent standard error of the mean.

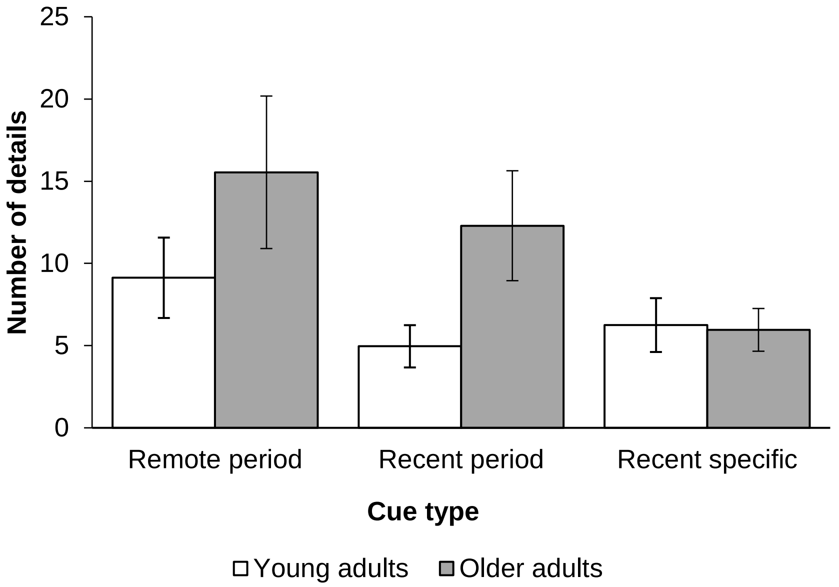

Figure 3B. Mean number of semantic details recalled by younger and older adults in response to remote time period cues, recent time period cues, and recent specific cues. Error bars represent standard error of the mean

Post-hoc comparisons (α = .0125) revealed that the interaction between age and detail type was driven by increased episodic recall in the younger group ($M_{younger}$=34.04, *SD*=21.20;

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of age observed when IQ was matched. The age effect may have been obscured in the full sample by the significantly higher IQ in the older group.

M_{older}=13.47, *SD*=7.03; *t*(22)=3.26, *p*=.004), while there was a trend towards higher semantic recall in the older group, but this did not reach significance ($M_{younger}$=6.78, *SD*=4.54; M_{older}=11.26, *SD*=7.03; *t*(22)=1.86, *p*=.08). The number of episodic and semantic details recalled by the older group was similar (*t*(11)=.92, *p*=.38), while the younger group recalled more episodic than semantic details (*t*(11)=5.08, *p*<.0005).

We next looked at the interaction between cue type and detail type using paired samples t-tests corrected for multiple comparisons (α = .008). The interaction was driven by differences in episodic recall, with recent time period (*M*=32.35, *SD*=31.10) and specific cues (*M*=24.73, *SD*=18.14) associated with better episodic recall than the remote memory condition (*M*=14.19, *SD*=11.84; *t*(23)=3.28, *p*=.003, and *t*(23)=3.92, *p*=.001, respectively). There was no significant difference in episodic recall between recent time period cues and specific cues (*t*(23)=1.98, *p*=.06). Semantic recall was significantly higher for remote time period cues (*M*=12.33, *SD*=10.16) than for specific cues (*M*=6.10, *SD*=4.04; *t*(23)=3.28, *p*=.003) but there was no difference between remote time period cues and recent time period cues (*M*=8.63, *SD*=8.09; *t*(23)=2.21, *p*=.04), and no difference between recent time period cues and specific cues (*t*(23)=1.71, *p*=.10).

Power analysis. These results should be interpreted with caution, since a post hoc power analysis indicated that the power to detect small and medium effects was only 11% and 40%, respectively. In order to detect a small effect with 80% power, 370 participants would have been required. In the full sample of 36 participants the experimental power was greater, with a 57% chance of correctly detecting a medium effect. Nevertheless, in the full sample (see footnote 12) the pattern of results was the same as in the matched sample, with the exception that a main effect of age was not detected in the full sample, possibly because it was masked by the older adults' increased competency, as evidenced by their higher IQ scores.

Discussion

This study examined the effect of different cues on AM retrieval. In particular, we tested whether increasing cue specificity increased the amount of event information that could be recalled, and whether increasing the retention interval reduced the amount of information that was recalled. In general, participants tended to recall memories that contained more episodic than semantic detail, but this was not the case for the most remote memories. For the most remote memories, the number of episodic and semantic details recalled was comparable. It is possible that this reflects a shift over time from episodic towards semantic memory representation, which is consistent with theories that describe a process of semanticisation in memory (e.g. multiple trace theory; Nadel & Moscovitch, 1997).

Comparison of specific and general cues for more recent events showed that episodic recall was similar in both conditions, although memories retrieved in response to specific cues were rated as less novel/distinctive than memories retrieved in response to time period cues. This novelty effect likely reflects that, similar to the remote memory condition, memories of salient events that have been well-rehearsed are more accessible when general retrieval cues are presented. In contrast, where the cue type restricts the selection of memories, participants are able to access less novel/distinctive events, but these events are remembered just as well as the more novel events. Another issue that may add to this observation is that recalling past events out loud is usually a social activity (Alea & Bluck, 2003; Nelson, 1993), and, given the choice, participants appear to talk about events that they deem to be interesting. Consequently, when retrieval cues are general, it is possible that participants will report more distinctive events such as weddings, parties, and holidays, and events are perhaps more likely to be emotionally significant. In comparison, in order to ensure the specific event cues in this study would be relevant to all participants, the selected events (birthday/Christmas and eating out) were those that were likely to have been experienced fairly frequently over the participant's life (i.e. at least once a year), and consequently may have been less significant and/or subject to more interference from similar experiences. This issue was probably compounded by the fact that older adults have many more years of life experience than younger adults (Ramscar, Hendrix, Shaoul, Milin & Baayen, 2014), and thus, probably, many more instances of each of the specified events.

On the other hand, the failure to find any significant relationship between novelty/distinctiveness ratings and episodic memory suggests that the practice of collecting such ratings at the time of retrieval may not provide the most accurate results. In Experiments 1 and 2 we found strong positive relationships between perceived novelty and episodic recall when the novelty ratings were recorded at the time of the original experience. This indicated that participants were reasonably good at knowing which events would be memorable and which would not. It is possible that the weaker correlations observed in this study are due to less variance in ratings overall, that is, the events that are memorable enough to retrieve within the test session without a highly specific cue are probably those that score relatively highly on novelty/distinctiveness ratings, otherwise they would not be retrievable under the task instructions. It also might have been problematic that the novelty/distinctiveness ratings were collected in this experiment immediately after describing the memory, because the ratings may have been affected by the perceived success the participant had at recalling the memory (e.g. *I remembered that quite well, so it must have been quite distinctive*).

The results also showed that the number of episodic details was lower overall in the remote memory condition compared to the other two conditions, indicating that testing memory at longer retention intervals produces worse performance. We looked at whether this interacted with age given that the remote memory condition was temporally biased towards younger adults, however we did not find any indication that older adults performed comparatively poorly in this condition. Instead, older adults exhibited impaired episodic recall across all tasks, and in fact the smallest difference in episodic recall was observed in the remote memory condition. This finding was somewhat unexpected, given that the older adults recalled events an average of 46 years older than the young adults' events. Previous research has shown remarkable stability of semantic memory for names and faces of classmates over a period of 50 years (Bahrick & Bahrick, 1975), and forgetting of semantic information has been shown to occur most rapidly soon after learning and levels off over time (Bahrick, 1984; Meeter, Murre & Janssen, 2005; Squire, 1989), but data on the rate of forgetting from very long term episodic memory are harder to locate. The current findings show that episodic memories can be persistent, and that factors in addition to retention interval are likely to be involved in forgetting.

The likelihood is that the remote memories that participants retrieved in the present experiment were of events that were particularly well-rehearsed and salient. If this was not the case, then it would be unlikely that these particular memories would have been recalled under such general cueing conditions. Theories that describe a shift over time from episodic to semantic memory suggest that the mechanism by which this shift is achieved is not time itself, but rather repetition, in the sense of repeated activation of the memory trace (e.g. Nadel & Moscovitch, 1997). It follows, then, that memories that are particularly well-rehearsed are more likely to have been "semanticised". This may be reflected, in part, by the increase in semantic details in more remote memories, but it is possible that the details of these very remote events which appear to be episodic are represented as something more similar to autobiographical fact (Ritchie, Skowronski, Walker & Wood, 2006), which may help to explain their durability, particularly among older adults. Cermak and O'Connor (1983) described something similar to this in an amnesic patient, S.S., who performed well on a test of remote AM, but seemed to be remembering "the general idea of a past event or the fact that an event had happened rather than the event itself… because it had become family folklore [more so] than because it was truly remembered" (p.230).

Interestingly, this study did not demonstrate the typical older adult increase in semantic recall that is sometimes observed in AM studies (Aizpurua & Koutstaal, 2015; B. Levine et al., 2002), which may be due to low power to detect small and medium effects. However, there appeared to be a general trend towards higher semantic recall in the older group that may have been weakened by similar levels of semantic recall in the specific cue condition. Semantic recall was generally lower for specific cues than for remote events, which could be due to the shorter retention interval in the specific cues condition, but in that case the recent time period cue should also be associated with fewer semantic details than the remote events. Since this was not the case, the findings suggest that retention interval/rehearsal is not the only factor contributing to the semanticisation of memories.

Judgement of whether a memory detail is "episodic" or "semantic" is subjective and depends at least in part on the language the participant uses to describe the event. The assumption is that the participant's choice of words at least roughly reflects the way the information is represented within the participant's knowledge base, but to our knowledge this has not been examined directly in the context of different types of memory. However, an interesting review by Tausczik and Pennebaker (2010) highlights relationships between a number of other psychological constructs and natural language usage, as measured by the Linguistic Inquiry and Word Count computer programme (LIWC; Pennebaker, Booth & Francis, 2007). The issue of language-dependence in memory coding is discussed in more detail in *Chapter 6*. Whether the tendency to recall information semantically is the result of attempts to resolve interference from several competing episodic traces, an attempt by the speaker to ground the episodic recall in a context that differs considerably from the present one, or something else entirely, remains an interesting avenue for further study, and something that is explored in more detail in *Chapter 5*.

Conclusions

Overall, older adults' episodic recall was poorer than younger adults' episodic recall, which is consistent with previous research that has employed similar retrospective sampling methodology (e.g. B. Levine et al., 2002; Piolino et al., 2006). The age-related deficit was observed in each cue condition, and the magnitude of the deficit was similar for each cue. These results suggest that, while retention interval and cue specificity may affect the amount that is recalled about an event, neither cue type appears to confer a bias towards or against either age group. We suggested that either or both of these factors may have contributed to performance differences observed across tasks in Experiment 2, as well as inconsistencies in previous studies that have used different tasks. However, the results of this study suggest that it is unlikely that retention interval biases and generic cues have a substantial effect on age differences in AM recall.

Section 3.3

Reanalysis

Comparison of prospective and retrospective sampling approaches

Experiment 3 showed that older adults' autobiographical memory was impaired regardless of differences in retention interval or the specificity of the cue. One aspect of Experiment 3 that differed from Experiment 1 and the recent AM task of Experiment 2 was the way in which memories were sampled for retrieval. In the experiments reported so far, older adults have performed relatively well on tasks in which the memories were prospectively sampled.

There are two major differences between prospectively sampled and retrospectively sampled memories: the first is a difference in encoding, since participants are aware that there will be a memory test at a later point in time. Consequently, they may be more vigilant in paying attention to what happens during the event. They may also think in advance about which events they will include in their sample (e.g. choosing more interesting events over more mundane activities), and they may consciously try to remember the event in order to perform well on the test. It is possible, then, that older adults do not exhibit a deficit on such tasks because they are able to compensate for poorer memory performance by trying harder to remember the events during the intervening period between encoding and retrieval.

The other major difference between prospectively and retrospectively sampled memories is the event type. As discussed in relation to Experiment 3, it is difficult to provide a specific retrieval cue that is applicable to all participants, and equally as distinctive as events that participants have self-selected. Perhaps older adults exhibit a deficit when memories are retrospectively sampled to specific cues because under these restricted conditions they are unable to select an event that will be particularly memorable; if the experimenter designates the to-be-remembered event, then participants must describe that event whether they can remember it well or not. It may be, then, that older adults perform better when they are able to play to their own strengths (Ross & Schryer, 2014).

Both of these explanations suggest that older adults' performance should be improved in prospective sampling tasks compared to retrospective sampling tasks, yet in the studies presented so far this was not the case: the average number of episodic details when memories were retrospectively, compared to prospectively, sampled was slightly higher for older adults and almost three times as high for younger adults (see *Table 3.2.1*).

Table 3.2.1

Mean number of episodic details recalled in response to specific cues, either prospectively or retrospectively sampled, in three previous experiments (SD in parenthesis)

Age group	Experiment 1 (baseline condition)		Experiment 2 (recent AM task)		Experiment 3 (specific cue condition)	
Younger adults	12.59	(10.35)	13.18	(12.72)	34.13	(21.12)
Older adults	9.38	(6.47)	9.77	(4.21)	15.33	(7.01)

Note. In Experiment 1 baseline condition and Experiment 2 recent AM task participants were presented with the titles of events that had been prospectively sampled two weeks earlier. In specific cue condition of Experiment 3, participants were presented with a cue designating the to-be-recalled event (e.g. *Last time you ate out*), but this was retrospectively assigned during the recall session and thus cues were the same for all participants.

To gain a better understanding of the relative performance of younger and older groups under prospective and retrospective sampling conditions, we re-analysed data from Experiments 2 and 3 in order to compare memory performance directly in an independent groups design.

The present analysis

To investigate the effect of specific cueing within retrospective sampling and prospective sampling tasks, prospectively sampled memories from the recent AM task in Experiment 2 were compared with retrospectively sampled memories from the specific cue condition in Experiment 3. In both conditions, memories were cued with a specific event title, but in the prospectively sampled condition the participants chose their own event titles and in the retrospectively sampled condition the event title was provided by the experimenter.

Method

Design. A 2 (age group: older vs. younger adults) x 2 (sampling method: prospective vs. retrospective) independent groups design was used. The dependent variables were the number of episodic and semantic details in the memory reports. A univariate design was employed with separate analyses carried out for each dependent variable because these factors were not correlated.

Participants. The participant groups were as described in Experiments 2 and 3, after matching the groups on IQ based on their scores on the 2-subtest version of the WASI (Wechsler, 1999). In the prospective sampling condition there were 17 younger adults and 16 older adults, while in the retrospective sampling condition there were 12 younger adults and 12 older adults. However, five of the younger adults and three of the older adults participated in both experiments, meaning the samples did not have full statistical independence. The participants who were represented in both samples were therefore excluded from the larger sample (prospective condition). The samples used for the present analysis therefore consisted of 12 younger and 13 older adults in the prospective condition, and 12 younger and 12 older adults in the retrospective condition. Group IQ data are presented in *Table 3.2.2*. Younger and older adults' IQ scores were not significantly different in either the prospective ($t(23)=1.15$, $p=.26$) or retrospective ($t(22)=1.15$, $p=.26$) conditions. There were also no significant IQ differences between the two younger ($t(22)=1.29$, $p=.21$) and the two older ($t(23)=.58$, $p=.57$) samples.

Table 3.2.2

Mean IQ score for each experimental group

Sampling method	Young adults		Older adults	
	M	*SD*	*M*	*SD*
Prospective	110.50	7.94	116.62	16.83
Retrospective	115.50	10.79	119.58	5.96

Materials & procedure. The prospective and retrospective sampling tasks were described in detail in Experiments 2 and 3. For the present analysis, the number of episodic and semantic details were recorded, along with the retention interval (measured in days) and event distinctiveness ratings. For the prospectively sampled memories, event distinctiveness ratings were collected at the same time as the memories were sampled. For the retrospectively sampled memories, distinctiveness ratings were collected after the event recall was completed.

Results

The mean number of episodic and semantic details is presented in *Table 3.2.3*. Episodic memory scores were entered into a univariate analysis of variance with age group and sampling method as between subjects fixed factors and IQ score as a covariate. There were main effects of sampling method (F(1,45)=19.23, p<.0005, η_p^2=.30) and age group (F(1,45)=8.92, p=.005, η_p^2=.17), and a sampling by age group interaction (F(1,44)=7.01, p=.01, η_p^2=.14). Overall, participants recalled a greater number of episodic details when memories were retrospectively sampled (M=24.73, SD=18.14) compared to when prospectively sampled (M=10.08, SD=5.35), and younger adults (M=22.40, SD=19.45) recalled more episodic details than older adults (M=12.32, SD=6.25). Post-hoc t-tests were adjusted for multiple comparisons (α = .0125), and showed no difference between age groups in the prospectively sampled memories (t(23)=.52, p=.61), but a significant group difference for the retrospectively sampled memories (t(22)=2.93, p=.008), with more episodic details recalled by the younger adults. Younger adults recalled more episodic details in the retrospective condition compared to the prospective condition (t(22)=3.67, p=.001) and a similar trend was observed in the older adult group, but this did not reach significance (t(23)=2.57, p=.02).

A similar analysis was carried out with semantic memory score as the dependent variable. There were no significant main effects (all Fs<4), but a significant interaction was observed between sampling method and age group (F(1,44)=5.02, p=.03, η_p^2=.10). Younger and older adults recalled a similar number of semantic details when their memories were retrospectively sampled (t(22)=.17, p=.86), but older adults recalled more semantic details when their memories were prospectively sampled (t(23)=2.97, p=.007). Young (t(22)=2.49, p=.02) and older adults (t(23)=1.04, p=.31) recalled similar numbers of semantic details across prospective and retrospective conditions.

These findings indicate that older adults' performance on retrospectively sampled autobiographical tasks is impaired but their memory for prospectively sampled events is relatively good, although the prospectively sampled memory test seems to be associated with poorer performance overall. However, the comparison of these two methods of sampling is confounded by differences in retention interval – two weeks for the prospectively sampled events and between 22 and 156 days for the retrospectively sampled memories (*M*=74.77, *SD*=42.80). In addition, there was a significant correlation between episodic memory score and retention interval (*r*=.40, *df*=49, *p*=.005), although the positive relationship was in the opposite direction from the negative relationship that would intuitively be expected to occur (i.e. forgetting increasing with the passage of time). In order to account for retention interval as a possible contributing factor, a linear multiple regression was carried out with age group, sampling method and retention interval entered as predictors in a backwards elimination procedure. The model was significant ($F(2,46)=12.35$, $p<.0005$, $R=.59$, $R^2=.35$), with sampling method ($\beta=.49$, $t=4.08$, $p<.0005$) and age group ($\beta=.33$, $t=2.76$, $p=.008$) emerging as significant predictors of the number of episodic memory details recalled. Retention interval did not significantly predict episodic memory scores ($\beta=.002$, $t=.01$, $p=.99$), suggesting that the observed correlation was instead explained by the prospective/retrospective sampling manipulation. However, we also considered the possibility that a retention interval effect might be difficult to detect because the retention period was the same for all prospectively sampled memories. To rule this out, we checked for a correlation between episodic memory score and retention interval within the retrospectively sampled memories alone. If retention interval had an effect on episodic recall then it should be observable within as well as between tasks. However, there was no evidence of a relationship (*r*=.07, *df*=24, *p*=.73), even when controlling for age group (*r*=-.09, *df*=21, *p*=.69).

Table 3.2.3

Mean characteristics of younger and older adults' memories sampled prospectively and retrospectively (SD in parenthesis)

Sampling method	Episodic		Semantic		Distinctiveness	
	Younger	Older	Younger	Older	Younger	Older
Prospective	10.67 (6.68)	9.54 (3.96)	2.92 (1.39)	8.02 (5.79)	5.94 (.89)	6.20 (1.71)
Retrospective	34.13 (21.12)	15.33 (7.01)	6.25 (4.42)	5.96 (3.82)	6.50 (1.64)	7.46 (1.98)
Prospective (social only)	11.92 (6.78)	11.65 (7.53)	2.56 (1.63)	9.64 (6.91)	5.86 (1.93)	7.50 (3.24)

We also checked for differences between conditions in ratings of event salience (means presented in *Table 3.2.3*). Distinctiveness ratings were entered into a univariate ANOVA with age group and sampling condition as independent variables. There was a main effect of sampling condition ($F(1,45)=5.06$, $p=.03$, $\eta_p^2=.10$), in which retrospectively sampled memories were rated as more distinctive ($M=6.98$, $SD=1.84$) than prospectively sampled memories ($M=5.80$, $SD=1.85$), but there was no main effect of age ($F(1,45)=1.58$, $p=.22$, $\eta_p^2=.03$) and no interaction between age and sampling method ($F(1,45)=.31$, $p=.58$, $\eta_p^2=.01$). It is possible that the difference in event distinctiveness could explain younger adults' improved performance in the retrospective condition, but it is not clear why such an improvement would not also be observed in older adults.

We next considered the possibility that retrospectively sampled memories were recalled in more episodic detail, and were more distinctive, because the events were of a more social nature (eating out, birthday/Christmas), as opposed to the prospectively sampled events, in which participants frequently reported being alone. To investigate the prevalence of social events in younger and older adults' samples the memories in the prospective sampling condition were re-coded on a scale of 1—3, where 1 was an event that took place in social isolation (e.g. housework), 2 was an event in which the participant was alone, but the setting was public (e.g. going to the shops), and 3 was a social occasion (e.g. going to a restaurant with friends). In total, 100 memories were re-coded (48 from young adults and 52 from older adults). Because of unequal sample sizes, the number of memories in each category was converted to a percentage of the total memories for that age group. These data are presented in *Table 3.2.4.* There was a trend towards increased sampling of social events in the younger group but chi squared tests showed that the difference was not statistically significant. The social rating of events was, however, significantly correlated with the number of episodic details recalled (Spearman's $\rho=.20$, $p=.02$, 1-tailed) as well as with participants' ratings of event distinctiveness ($\rho=.22$, $p=.01$, 1-tailed), suggesting the possibility that this may account for the recall difference between prospectively and retrospectively sampled memories.

To examine this directly, we compared the number of details recalled about only the events that were social in nature (that is, only those with a social rating of 3) following the assumption that these events should be more similar to the events described in the retrospective sampling condition. One younger and two older participants could not be included in this analysis because none of their events were qualified as social activities. The number of episodic details recalled by both young and older adults was low (young adults: M=11.92, SD=6.78; older adults:

Table 3.2.4

Percentage of memories describing events experienced alone, in public, or with friends/family.

Social rating	Young adults	Older adults	χ^2
Alone	8.33	7.69	.00
Public	39.58	55.77	2.67
Social event	52.08	36.54	2.53

*p≥.10

M=11.65, SD=7.53), and did not differ between groups ($t(20)=.09$, $p=.93$). A univariate ANOVA examining the effects of sampling and age group on episodic recall found results similar to the original analysis, with main effects of sampling (retrospective>prospective; $F(1,42)=12.48$, $p=.001$, $\eta_p^2=.23$) and age group (young>older; $F(1,42)=6.77$, $p=.01$, $\eta_p^2=.14$), and a significant sampling by age group interaction ($F(1,42)=6.39$, $p=.02$, $\eta_p^2=.13$). We also considered that, in the retrospective condition, memories of birthdays and Christmas may have been rehearsed more than memories of eating out, for example during conversation with friends. For this reason, we repeated the analysis again using only data from the memories of eating out (i.e. prospectively sampled social events vs. retrospectively sampled memories of eating out), but this did not affect the pattern of results.[13] Distinctiveness ratings were also comparable for prospectively and retrospectively sampled memories for both younger ($t(21)=.42$, $p=.68$) and older adults ($t(21)=.49$, $p=.63$).

Given the relatively small sample sizes, one possibility was that the young adults in the retrospective sampling condition were simply better at recalling event details than the participants in each of the other three conditions. To investigate this possibility, we returned to the original

[13] This analysis again showed main effects of sampling (retrospective>prospective; $F(1,42)=8.93$, $p=.005$, $\eta_p^2=.18$) and age group (younger adults>older adults; $F(1,42)=5.83$, $p=.02$, $\eta_p^2=.12$) and a sampling by age group interaction ($F(1,42)=5.53$, $p=.02$, $\eta_p^2=.12$).

samples before they were matched on IQ score and identified 7 younger adults and 8 older adults who participated in both experiments. We then compared the relative recall scores of these individuals on both tasks. Although the sample was not large enough for statistical analysis, visual inspection of the means and standard deviations (see *Table 3.2.5*) suggested that the pattern of results was similar to the findings above. Younger and older adults recalled a similar number of episodic details in the prospective sampling task, but younger adults' episodic memory performance was more than twice as good for the retrospective sampling task, while for older adults there was only a modest enhancement. Semantic recall was similar across age groups and sampling conditions, although young adults recalled fewer semantic details in the prospective sampling condition. This pattern also looked similar to the findings presented above, suggesting that the differences in performance on each task could not be accounted for by individual differences.

Table 3.2.5

Mean number of episodic and semantic details recalled by the same participants under prospective and retrospective event sampling conditions (n=15)

Sampling method	Episodic		Semantic	
	Younger	Older	Younger	Older
Prospective	15.75 (18.50)	11.50 (6.49)	2.25 (2.02)	7.91 (6.00)
Retrospective	36.64 (23.59)	16.25 (6.08)	6.07 (3.98)	6.38 (4.76)

Discussion

This analysis investigated the difference in memory performance when to-be-recalled events were prospectively sampled, using a diary method, and retrospectively sampled, with the experimenter designating the event type. The specificity of the cue was equated across sampling conditions. The results showed that for young adults, retrospective sampling was associated with greater episodic detail than prospective sampling. For older adults, both retrospective and prospective sampling led to memories that were similar in episodic detail. In addition, there was an effect of age on episodic detail only when memories were retrospectively sampled. The overall pattern of results suggests that, rather than a specific older adult deficit in retrospectively sampled memories, young adults' autobiographical recall in this condition was particularly enhanced.

The cues in each sampling condition were equally specific, since they determined precisely which event was to be recalled, therefore the difference in performance on each task could not be due to cue specificity; at least in the example of this comparison, older adults' did not appear to perform more poorly because of impaired generative retrieval processing. Event distinctiveness ratings suggested that while retrospectively sampled memories were more salient, this was true for both younger and older adults' memories, and overall ratings for both groups were similar. In addition, when we compared prospective and retrospective sampling of only social events (i.e. those involving friends and/or family), the same pattern of episodic recall was observed, with equivalent performance across conditions, except for a young adult retrospective sampling enhancement. In this analysis, event distinctiveness was equated across prospective and retrospective sampling conditions. Thus, neither event distinctiveness nor the social quality of an experience can adequately account for young adults' recall enhancement for retrospectively sampled memories. It also did not seem to be the case that the participants in the young adult retrospective condition were particularly high performers, since even within the same individuals performance was better when memories were sampled retrospectively.

One possibility is that older adults are worse at resolving interference between even relatively distinctive events, whereas younger adults' recall is only negatively affected by interference from non-distinctive events (i.e. those that have been repeated many times or share similarities with many other events). This could be the case if, for example, the increased life experience accrued by older adults meant that even relatively distinctive events could have considerable overlap with other, previously experienced events. This argument is based on a view put forward by Ramscar et al. (2014), who suggested that "knowledge effects" can account for many findings in the ageing literature that are usually attributed to cognitive decline. Using mathematical models of statistical learning, Ramscar et al. suggested that older adults' poorer performance on many tests that tap into long-term knowledge actually reflect the natural consequence of accumulated lifelong experience (e.g. slower processing speeds and poorer performance on tests of executive function). This is a compelling argument because it allows for the possibility that age effects on cognitive tasks vary depending on the accumulation of relevant long-term knowledge. A simple extension of this idea raises an interesting question regarding how the relative group performance is conceptualised in the present study: rather than an absence of age-related deficit on the prospective memory task, it might be more accurate to describe younger adults' performance as exhibiting an elderly-type deficit. That is, young adults might perform more poorly on the prospective, compared to the retrospective, task because the to-be-remembered events are mundane, and therefore subject to more accumulated interference because similar events have been encountered many times previously.

For the most common events in everyday life, even young adults' experience may exceed some frequency threshold that makes it difficult to recall specific instances. For example, confronted with the task of remembering what one had for breakfast every day for the last year, the chances are that the memory of this morning's breakfast is relatively easily retrieved, but that the ease of retrieval diminishes the further back in time one searches. If breakfast consists of the same thing each day, how can the memory of one breakfast be separated from the memory of another? A good strategy might be try to recall other more peripheral details – what was on the radio that morning? What was I wearing? What plans did I have for the day? Did I finish the last of the bottle of milk? Asking these sorts of questions will only be helpful for a specific retrieval attempt if they lead to answers that differentiate the occasion in question. If the plan for the day was to go to work, as always, and if the last of the milk was not used, then these questions are unlikely to aid memory retrieval. This process of separating similar memory traces is demanding of executive function, and likely to be more so the higher the number of traces that must be separated. To relate this argument to the findings presented in this chapter, then, perhaps for the older adults, the specific memories of birthdays/Christmases and eating out exceed this hypothetical "interference threshold" (there is a large total number of lifetime experiences of these events). The lower number of lifetime experiences of the younger adult group may mean such memories have not yet reached the threshold. In contrast, for everyday events, the accumulated lifetime experiences may already be numerous enough to exceed the threshold in both groups. This argument is only speculative, however, and raises many more questions, such as how many experiences are needed to reach this hypothetical threshold, and how similar events need to be in order to be considered, for the present purpose, the same.

An issue that remains pertinent in sampling AMs is the difficulty of providing retrieval cues that are equally applicable to both younger and older groups. Ideally, prospectively and retrospectively sampled memories could be compared across a range of retention intervals and for events that range in frequency and distinctiveness. However, prospective sampling at long retention intervals is difficult to manage because the rate of participant attrition increases with interval length. Retrospective sampling is therefore most often used to retrieve memories at longer intervals. The difficulty with retrospective sampling is, however, that retrieval cues must be applicable to all participants. Often this means presenting participants with generic cues such as words, emotions, or time periods as discussed earlier in this chapter. In Experiment 3, we used specific cues that were applicable to all participants, but in order to ensure that these cues were as specific as the cues presented in the recent AM task of Experiments 1 and 2 (i.e. the event title), it was necessary to request that participants recalled “the *last* time you ate out” and “*last* Christmas”. Firsts and lasts are likely to stand out in memory far more than events such as “doing the weekly grocery shopping on Thursday 12th May”, while “eating out” and “Christmas” could refer to any of a number of events, thus the cues are less specific. This creates something of a cueing paradox: for each design confound that is corrected, a new confound is introduced. Experiments 4 and 5 attempt to address this issue by increasing the experimental control using staged events.

Chapter 4: Autobiographical memory for staged events

Two experiments measured the effect of a wearable camera, SenseCam, on the autobiographical memories reported by young and older adults. In each experiment, participants interacted in a staged event, which was recalled two weeks later, after viewing SenseCam images (experimental condition) or thinking about the event (control condition). When IQ and education were matched, young adults recalled more correct event details than older adults. Reviewing SenseCam images increased the number of correct details recalled, but did not affect the recall of incorrect details. This "SenseCam effect" was similar for both age groups. These results demonstrate an age-related memory deficit for novel autobiographical material, which can be supported, but not eliminated, by the use of SenseCam.

Section 4.1

Introduction

The present study compares autobiographical memory (AM) for staged events in a group of older and younger adults. Traditional AM tasks in which participants self-select personal events for recall result in idiosyncratic memory reports which are difficult to verify. In addition, it can be difficult to draw firm conclusions about the relative performance of older and younger groups when measuring memory for different experiences. The main aim of the current paper is to investigate whether older adults exhibit a deficit in AM for controlled staged events. The rationale in designing this study was to establish a baseline of AM capability independent of factors that potentially contaminate findings from more naturalistic studies, such as variability in event salience. In this paper we introduce a novel procedure in which all participants take part in the same staged event, which is scripted, video-recorded, and recalled after a period of two weeks. We concurrently evaluate the effect of a wearable photographic memory aid, SenseCam (SC), on memory performance.

Autobiographical memory is memory for information related to the self, comprising both episodic (i.e. details pertaining to specific life events) and semantic (i.e. personal knowledge) information (Brewer, 1986; M. A. Conway, 2001; M. A. Conway & Pleydell-Pearce, 2000; Renoult et al., 2012). Previous research has shown that older adults' AMs are less episodic than younger adults' AMs (B. Levine et al., 2002; Piolino et al., 2006, 2010), although a number of studies have been unable to replicate this age effect (Experiment 1; Aizpurua & Koutstaal, 2015; Habermas et al., 2013; Schryer & Ross, 2014). The factors contributing to a decline in episodic AM in old age are not clear, and to date there has been little emphasis on comparisons of different methods of eliciting AMs, although there is some evidence that, within the same sample of participants, young adults outperform older adults on some AM tasks but not others (Experiment 2). The measurement of AM in different age groups is complicated by the potential for a number of confounds, including memory age, typical life experiences and rehearsal. The present paper is aimed at measuring AM ability in older and younger adults independently of these variables.

Event type. Under typical AM retrieval instructions, participants self-select the events that they will describe based on criteria identified by the researchers, for example a particular time period (Aizpurua & Koutstaal, 2015; Habermas et al., 2013; Levine et al., 2002; Piolino et al., 2006, 2010). These events are, by nature, highly idiosyncratic, yet little is known about how participants select which events to describe. According to a study by G. Cohen and Faulkner (1988), the age of the participant at the time of encoding is related to the type of event recalled. Typically, the distribution of salient events across the life span is skewed towards early adulthood (Koppel & Berntsen, 2015; Rubin & Schulkind, 1997b), therefore naturalistic sampling of recent memories may disadvantage older adults. On the other hand, matching older and younger adults' AMs for age-at-encoding introduces retention interval as a potential confound. It is therefore difficult to eliminate confounding variables in naturalistic studies of ageing. The present study employs a staged event procedure in order to minimise the variation in event type and measure older and younger adults' AM for the same recently experienced material while holding retention interval constant.

A few previous studies have used staged events procedures to investigate older adults' memories. For example, Mueller-Johnson and Ceci (2004) found that older adults recalled fewer correct details than young adults about a massage received two weeks earlier, while West and Stone (2013) found that older adults recalled fewer details than young adults about a staged interruption to their test session just a few minutes earlier. In a control condition for a flashbulb memory study, Kvavilashvili, Mirani, Schlagman, Erskine and Kornbrot (2010) staged a phone call in which older and younger participants were told that they did not win a prize draw. After a delay of either 1-2 days or 10-11 days, older adults recalled fewer details (e.g. time, location, activity) about the event than younger adults, and their memories were less specific. These findings show a deficit in older adults' memory for a variety of staged events. In contrast, Hashtroudi, Johnson and Chrosniak (1990) measured older and younger adults' memory for events such as visiting a seminar room and packing a picnic basket, which were either perceived (i.e. physically carried out) or imagined. After a one-day retention interval they found no difference between older and younger adults in the total number of words produced or the number of ideas recalled, although younger adults recalled more sensory-perceptual details than older adults, while older adults recalled more thoughts and feelings, and made more evaluative statements than younger adults.

The aim of the current research diverges somewhat from these previous studies. Both Mueller-Johnson and Ceci (2004) and West and Stone (2013) presented deliberate misinformation to their participants, while Kvavilashvili et al. (2010) intended that their staged event was “mundane and trivial” (p. 397) in order to contrast it with flashbulb memory. In the present study, our focus is on the ability to recall the details of a complex autobiographical event, consistent with the type of events sampled in Experiments 1-3. To maintain this consistency we developed a procedure involving interactive tasks delivered to groups of participants in a multimedia environment, in which social interaction was encouraged, and we measured episodic and semantic recall after a retention interval of two weeks. In addition, the staged event procedure allowed for the measurement of incorrect details and source memory errors, which are difficult to identify in more naturalistic designs.

SenseCam. A second aim of this research was to measure the effect of a wearable camera, SenseCam (SC), used to aid retrieval from AM. SC is worn around the neck and captures still images automatically, from the wearer’s perspective, in response to external stimuli such as changes in light, motion and acceleration. The images can be uploaded to a computer and presented to the participant, providing a specific retrieval cue. Previous studies have shown that SC is an effective prosthesis for memory in patients with hippocampal amnesia (Berry et al., 2007; Loveday & M. A. Conway, 2011) and can increase the amount that is remembered by healthy young adults under some circumstances (e.g. Finley, Brewer & Benjamin, 2011; Sellen et al., 2007). However, a recent study investigating 144 young adults’ recall of unusual actions experienced during a staged walk found no benefit of reviewing SC images of the walk compared to either a diary condition or an unsupported control condition (Seamon, Moskowitz, Swan, et al., 2014). It is possible that no benefit was observed because recall performance was generally quite good, even in the control condition (mean proportion of correct responses = .68). Kalnikaité, Sellen, Whittaker and Kirk (2010) also found that SC was insufficient to support healthy young adults' memory for daily events sampled five weeks earlier, but despite no improvement in overall event recall, they found that event recall supported by SC was more *detailed* than unsupported event recall.

As yet there is little data on the potential benefit of SC for healthy older adults. In one study, Silva et al. (2013) investigated the effect of SC in a healthy older adult sample, and found a benefit of reviewing SC images that was transferable to a battery of neuropsychological tests (Silva et al., 2013). Interestingly, SC review appeared to eliminate the age-related deficit on a measure of word-cued AM; however, memory for events depicted by SC was not measured. In Experiment 1, we found that SC increased both episodic and semantic recall in both older and younger adults when the images were used as retrieval cues for recent events. However, both groups recalled a similar number of event details at baseline; it is therefore not clear whether SC has the potential to alleviate AM difficulties in older adults if there is a deficit at baseline. In a related line of work, St. Jacques et al. (2015) presented older and younger participants with photographic cues to reactivate memory for a museum tour, in a procedure that did not involve SC directly, but was based on previous SC work (St. Jacques & Schacter, 2013). Participants reviewed images either of museum exhibits they had visited on the tour, or different exhibits that had not been visited. Although both groups' performance was better on a subsequent recognition test if they had reviewed images of exhibits they had visited, the effect was greater for younger adults. There was also a high number of false alarms in both groups suggesting that discrimination was relatively poor.

Some of the most striking effects of SC have been observed in studies of amnesic patients (e.g. Loveday & M. A. Conway, 2011), which suggests that SC may be particularly effective when there is a memory deficit at baseline. However, in contrast to patient studies, most previous studies involving healthy participants have altered the sequence of images sampled by SC, for example by presenting only a small subset of images of each event (Finley et al., 2011; Sellen et al., 2007; St. Jacques & Schacter, 2013). As such, it is not yet clear why, and under what circumstances, SC benefits memory performance. For example, S. Hodges et al. (2011) suggested that SC may be a particularly effective prosthesis because it works in a similar way to AM – cues are visual, time-compressed, taken from the perspective of the wearer, form a temporally ordered sequence, and so on. Alternatively, they suggested that perhaps the wealth of information available in the sequence of images is enough to support successful retrieval. In Experiment 1, we found some evidence for a retrieval benefit when the images were presented in forward temporal order compared to random temporal order, which suggests that the sequential nature of SC cues may partly explain the success of the technology. However, AM recall in the random order condition was still superior to recall at baseline, and the effect of temporal order was relatively small, which suggests that the SC effect may be more influenced by the amount of information in the cue, or perhaps some other factor. Given the variation in events recalled under the naturalistic sampling procedure of Experiment 1, it remains a possibility that the temporal order effect was distorted by differences in the memorability of the events recalled within each condition (random order and forward order). In the present study we examined the temporal order effect under more controlled conditions, using memory for sections of the same event, and counterbalancing the retrieval condition for each event section. This allowed us to test whether the small effect observed in Experiment 1 is replicable.

The experiments presented in this paper therefore investigate the effect of SC as a memory aid for older and younger adults' free recall in a controlled study. This research had two main aims: first, to determine whether there is a deficit in older adults' memory for a prospectively sampled complex autobiographical event that is the same for all participants. In Experiments 1 and 2, we found that prospectively sampling everyday events from participants' own lives was associated with a comparable level of event recall across groups. While previous staged event studies have generally shown that older adults remember fewer event details than younger adults (e.g. Mueller-Johnson & Ceci, 2004; West & Stone, 2014), methodological differences (for example presentation of misinformation and differences in scoring protocol) have made it difficult to directly compare these results to our findings in Experiments 1 and 2. If the absence of age effect observed in our recent AM task was due to a feature of the design (e.g. event recency, or intentional and effortful encoding for subsequent memory test), then the same should apply to the present experiment, and thus older adults should perform as well as younger adults. If, however, the absence of age effect was due to some aspect of the naturalistic sampling of recent events (e.g. experience with previous similar events/low event salience) then we would predict that the same should not apply in the present experiment, in which case older adults should exhibit a deficit in event recall.

Based on our previous findings, we hypothesised that SC would improve recall performance in terms of increasing the number of details that are recalled overall, by both older and younger adults. Consistent with Experiment 1, we also predicted a temporal order effect, in which recall under a forward order cueing condition will be superior to recall cued by SC images presented in random order. However, predictions about an interaction of SC and age are more difficult to make given the mixed findings so far. If there is an age-related deficit in performance on this task then SC may attenuate the deficit by providing a mechanism of support.

Section 4.2

Experiment 4

Method

Participants. Eighteen young adults (age 19-32; *M*=23.72, *SD*=3.91; 15 female) and 25 older adults (age 64-83; *M*=72.32, *SD*=5.68; 19 female) participated for a payment of £8 per hour. Young adults were recruited via posters displayed around the university buildings and via social media. Twelve of the young adults were students at City University London, and the remaining six were external participants. Older adults were recruited from a pool of participants who had previously responded to a local newspaper advertisement and expressed an interest in taking part in memory experiments. All participants were native English speakers, with self-reported normal or corrected-to-normal vision. Older adults were screened for dementia using the Mini Mental State Examination (MMSE) using a cut-off of 24 (Folstein et al., 1975), and all participants completed the Geriatric Depression Scale (GDS; Yesavage et al., 1983) to give a rough estimate of depressive symptoms that may reduce memory specificity (Birch & Davidson, 2007). The National Adult Reading Test (NART; Nelson, 1982) was administered to all participants to give an estimate of IQ (Bright, Jaldow & Kopelman, 2002), and the number of years of formal education each participant had received was also recorded. The NART was used on this occasion (as opposed to the WASI used in all other experiments) because of the short amount of time taken to administer the instrument, which was necessary because participants were tested in groups. IQ was calculated from the number of reading errors using the following formula: Full Scale IQ = 128 - 0.83 x NART error score (Nelson, 1982) [14].

Design. The design of Experiment 4 involved two rounds of measurement, both in the form of written questionnaires (see *Appendix 4A*). In the first, a baseline measure of memory performance was obtained by recording the number of details that were recalled about the whole event, prior to any experimental manipulation. The second measure was related to the SC manipulation: a 2 (age group: young vs. old) x 3 (SC condition: control vs. random temporal order vs. forward temporal order) mixed factorial design was employed; in effect, the event to be recalled was split into three sections in order to test retrieval condition under repeated measures. The dependent variable in the second round of measurement was the number of *additional* details that were recalled (i.e. new details that were not recalled at baseline). The control condition measured the number of additional details recalled in the second questionnaire without viewing SC images, while the random order and forward order conditions measured the number of details freely recalled after reviewing photos from the event in random order and forward order, respectively. The number of episodic and semantic details was recorded, as well as incorrect details and source memory errors.

[14] The NART was used to measure IQ because of the time restriction caused by testing participants in groups. We did not collect WASI scores in this study, however both NART and WASI were measured in the sample of participants in Experiment 3. Pearson's correlations suggest a strong positive relationship between NART and WASI scores (r=.82, df=38, p<.0005). We also calculated the mean difference between WASI and NART IQ estimates and found that the NART tends to slightly underestimate IQ compared to the WASI. For younger adults, WASI scores were M=2.22 (SD=5.95) points higher than NART scores, and for older adults WASI scores were M=2.28 (SD=8.90) points higher. A t-test showed that the difference in scores was equivalent for both groups (t(38)=.03, p=.98).

Materials and Procedure

Encoding session. The recording event for the participants took place in six separate sessions. Each was attended by up to nine participants, who were split into three mixed-age groups of 2 or 3, and each participant was provided with a SC which they wore for the rest of the session. The event was designed to standardise the material that each participant would be asked to remember at test, as well as to ensure that the experience that participants would be reviewing in each of the review conditions would be comparable. For the latter reason, the event was split into three sections, each of which took place in a separate room with its own set of three tasks.

The tasks in each room were similar, with one visual task (name the flag), one auditory task (general knowledge questions) and one problem-solving task that was different in each room. The flags task involved coloured flags belonging to different countries, which were presented on an overhead projector, and participants were asked to guess the country the flags belonged to. In the general knowledge task, the experimenter read the questions aloud and asked participants to guess the answer. The problem-solving tasks involved participants working together to achieve a common goal. The tasks are described in more detail in *Appendix 4B.* The rooms were broadly colour-themed (red, blue and green) to minimise confusion at test because of the similarity of tasks in each room, and the theme was reinforced through coloured pictures on the walls of each room, as well as the colour of the flags in the flags tasks. Each room was managed by a task leader, who wore clothing to match the colour of their room.

Tasks were designed to be difficult so that recall advantages associated with prior knowledge of the material were not conferred on either group, and the materials for the tasks were determined in a pilot questionnaire which was completed online by 37 participants of mixed ages. In both general knowledge and flags tasks, participants were asked to provide an individual answer or guess first and then subsequently to choose an answer to submit as a group. This manipulation was designed to ensure that all participants attended to the stimuli and any failure to remember particular details at test was not due to attentional differences during encoding. The request for a group answer was included to encourage interaction between the participants in each group, thereby increasing the social autobiographical aspect of the task, as well as providing additional material that could subsequently be recalled at test. After group answers were provided, the task leader told each group some facts about the question they had just answered. This was designed to increase the volume of material that could be recalled at test, and the material was scripted to ensure that the same material was presented to each group in the same way. Where the group gave an incorrect answer, the correct answer was provided by the task leader.

Each group was allocated to one room (red, blue or green) to start. The groups moved around each of the three rooms but the task leaders always remained with their own room. The tasks within each room were administered in random order, and each group spent around 15-20 minutes completing the activities before moving to the next room. The order of the rooms was counterbalanced across sessions. Each room was video-recorded to enable participants' memories of non-scripted details to be checked for accuracy.

Recall sessions. Participants returned for the recall session fourteen days after their recording session, with the exception of one participant in the young adult group who was unable to attend the recall session and came in one day earlier. The recall session was held in a computer lab, and participants were met and debriefed individually. The recall test was a semi-structured questionnaire, divided into one section per room, which asked participants to remember details about the event. Most questionnaires were administered on the computer, although older participants who were not comfortable using computers were provided with a paper copy (n=9). Participants were reminded of the colour theme and the location of each room relative to the others, as well as the name of the task leader for each room. Questions probed for details about the visual environment, the task leader and the tasks in each room (see *Appendix 4A*), and participants were asked to write in as much detail as possible. Participants first filled out the full questionnaire (baseline; T1), in which the sections were ordered differently for each participant so that they matched the order in which they had visited the rooms two weeks earlier. Participants' personal SC photos taken within each room were then reviewed in one of three experimental conditions: control, random order, or forward order. In random and forward order conditions, participants reviewed all of the images from the corresponding room in random temporal order and forward temporal order, respectively. Image review was self-paced, with participants pressing a key on the keyboard to advance through the image sequence. In the control condition, participants did not review any images, and instead were asked to spend a few minutes thinking about the room in question before moving on. Immediately after the review of each room participants filled out the corresponding section of the questionnaire again on a new blank copy (T2).

Coding strategy. The number of episodic details recalled for each room was counted for each participant, with one mark awarded for each remembered visual item, action, interaction, thought, feeling or concept (e.g. remembering *the Somalian flag*, rather than *a blue and white flag*). A master coding sheet was created to ensure memories were coded consistently across participants. Episodic details were marked as visual (e.g. objects, colours, shapes etc.) or non-visual (e.g. interaction with other participants, internal thoughts, etc.). Details attributed to the wrong room were counted as source memory errors, and incorrect details were also counted. The threshold for incorrect responses necessarily varied with the type of information (e.g. the circumference of the earth in miles could be rounded to the nearest thousand, but the shapes on a flag had to be recalled correctly), but the master coding sheet ensured consistency across the sample. It should be noted that, where possible, the episodic category contained details that were verifiable by checking against scripts and video recordings. However, participants were encouraged to also recall thoughts and feelings that they had at the time, which we were unable to verify. We also counted semantic details, which were defined as those details not related to a specific episodic context (e.g. *I'm always on time*). See *Appendix 4C* for a coded example of a participant's response. For T2 questionnaires, details were classed as new if they had either not been previously reported, or had been reported differently, on the T1 questionnaire (e.g. an incorrect detail that was corrected after reviewing SC images).

In order to measure the reliability of the coding strategy, three additional raters coded a subset of six participants' questionnaires (three older adults and three younger adults). There was good agreement between the original and each additional rater, as determined by correlating the raters' scores for each participant (r=1.00, r=.98 and r=.97).

Results

Sample matching. Preliminary analyses showed that younger adults had more years of education (*M*=15.83, *SD*=2.57) than older adults (*M*=13.67, *SD*=3.21; *t*(40)=2.35, *p*=.02) but older adults had higher IQ scores (M_{older}=116.10, *SD*=7.56; $M_{younger}$=109.82, *SD*=6.93; *t*(40)=2.73, *p*=.009). There was no difference in GDS score between groups (M_{older}=8.24, *SD*=6.24; $M_{younger}$=6.56, *SD*=3.09; *t*(41)=1.05, *p*=.25). Correlation analyses showed that education scores were significantly positively correlated with T1 episodic recall (*r*=.42, *p*<.01; see *General Appendices G1*). In keeping with the previous experiments, and in order to control for any differences in performance that might be attributable to differences in education or IQ, we balanced our sample on these measures. Five older adults and two young adults were excluded from the sample on the basis of their education and IQ scores. The excluded older adults were those who had education scores below the group average but IQ scores above the group average, and the excluded young adults had the opposite pattern of results, with education scores above the group average but IQ scores below the group average. We also excluded one young adult and one older adult for whom IQ or education data were missing. T tests showed that in the matched sample (*n*=34; 15 younger, 19 older) there was no group difference in education ($M_{younger}$=15.33, *SD*=2.50; M_{older}=13.95, *SD*=3.50; *t*(32)=1.29, *p*=.205) or IQ ($M_{younger}$=110.13, *SD*=7.34; M_{older}=114.97, *SD*=7.38; *t*(32)=1.90, *p*=.066).

T1 data. Data from the T1 questionnaires were averaged across rooms. The number of episodic and incorrect details and source errors is presented in *Table 4.2.1*. Note that semantic details are not included because only 7 participants reported at least one. Semantic details were therefore excluded from all further analyses. Data were analysed in a 2 (age: young vs. old) x 3 (detail type: episodic vs. incorrect vs. source error) ANOVA. There was a significant main effect of age (*F*(1,32)=7.03, *p*=.01, η_p^2=.18), with young adults (*M*=8.38, *SD*=2.83) recalling more details than older adults (*M*=5.78, *SD*=2.84). There was also a main effect of detail type

($F(2,64)=100.10$, $p<.0005$, $\eta^2=.76$), whereby more episodic details were recalled ($M=17.55$, $SD=8.58$) than incorrect details ($M=1.63$, $SD=2.21$, $p<.0005$) and source errors ($M=2.06$, $SD=1.39$, $p<.0005$), but there was no difference between incorrect details and source errors ($p=.88$). There was a significant interaction between detail type and age group ($F(2,64)=8.68$, $p<.0005$, $\eta_p^2=.213$), which was investigated further with post hoc t-tests comparing older and younger adults' recall of each detail type. The p value was adjusted for multiple comparisons ($\alpha=.016$). Young adults recalled more episodic details than older adults ($t(32)=2.96$, $p=.006$) but the number of incorrect details ($t(32)=.63$, $p=.54$) and the number of source errors ($t(32)=1.59$, $p=.12$) did not differ with age. [15]

Table 4.2.1

Mean number of details recalled by young and older adults at baseline

	Young adults		Older adults	
Detail type	*M*	*SD*	*M*	*SD*
Episodic	21.90	9.68	13.19	7.48
Incorrect	2.21	1.65	1.91	1.13
Source error	1.02	2.33	2.23	2.08

However, we also looked at the proportion of errors-to-total recall, in order to control for differences in generativity. These data are presented in *Table 4.2.2*. Proportionally, older adults made significantly more recall errors than younger adults ($F(1,32)=4.86$, $p=.04$, $\eta_p^2=.13$) at baseline ($M=.13$, $SD=.08$ vs. $M=.07$, $SD=.08$). There was no significant interaction between age group and error type ($F(1,32)=.91$, $p=.35$, $\eta_p^2=.03$).

Table 4.2.2

Memory errors as a proportion of total recall at T1

	Young adults		Older adults	
Detail type	*M*	*SD*	*M*	*SD*
Incorrect	.08	.04	.13	.08
Source error	.05	.14	.14	.12

[15] The pattern of results at T1 was similar for the full sample, with main effects of age ($F(1,41)=8.59$, $p=.005$, $\eta^2=.17$) and detail type ($F(2,82)=141.41$, $p<.0005$, $\eta^2=.78$) and a significant interaction ($F(2,82)=14.67$, $p<.0005$, $\eta^2=.26$). There was also a significant effect of age on the proportion of memory errors ($F(1,41)=8.31$, $p=.006$, $\eta_p^2=.17$).

T2 data. The number of new episodic details produced at T2 (see *Figure 4A*) was analysed in a 2 (age: young vs. old) x 3 (condition: control vs. random order vs. forward order) x 2 (detail type: episodic vs. incorrect) ANOVA. No source errors were made at T2. There was a significant effect of recall condition on the number of details added ($F(2,62)=12.44$, $p<.0005$, $\eta_p^2=.29$), and Bonferroni-adjusted pairwise comparisons showed that more details were added in the random order condition ($M=4.46$, $SD=3.00$, $p=.001$) and the forward order condition ($M=4.42$, $SD=2.59$, $p<.0005$) compared to the control condition ($M=2.19$, $SD=2.17$), but there was no difference between random order and forward order conditions ($p=1.00$). There was no main effect of age ($F(1,31)=.01$, $p=.95$, $\eta_p^2<.001$, $M_{older}=3.67$, $SD=1.93$; $M_{younger}=3.71$, $SD=1.93$) and no age by condition interaction ($F(2,62)=1.88$, $p=.16$, $\eta_p^2=.06$). There was a main effect of detail type ($F(1,31)=79.97$, $p<.0005$, $\eta_p^2=.72$), with more episodic details ($M=6.27$, $SD=3.52$) recalled than incorrect details ($M=1.11$, $SD=.84$. Detail type did not interact with age ($F(1,31)=.30$, $p=.59$, $\eta_p^2=.01$), but did interact with condition ($F(2,62)=9.67$, $p<.0005$, $\eta_p^2=.24$). More episodic details were added in the random order ($M=7.66$, $SD=5.52$; $t(32)=3.98$, $p<.0005$) and forward order ($M=7.63$, $SD=4.81$; $t(32)=4.66$, $p<.0005$) conditions compared to the control condition ($M=3.53$, $SD=3.84$), but the number of incorrect details did not increase across conditions (all ps>.10; $M_{control}=.86$, $SD=1.37$; $M_{random}=1.27$, $SD=1.30$; $M_{forward}=1.20$, $SD=1.14$). The 3-way interaction between age, detail type and condition was not significant ($F(2,62)=1.59$, $p=.21$, $\eta_p^2=.049$).[16]

[16] In the full sample the T2 results were similar. There were main effects of condition ($F(2,82)=17.81$, $p<.0005$, $\eta_p^2=.30$) and detail type ($F(1,41)=78.11$, $p<.0005$, $\eta_p^2=.66$), but no main effect of age ($F(1,41)=.21$, $p=.65$, $\eta_p^2=.01$). Condition interacted with detail type ($F(2,82)=15.84$, $p<.0005$, $\eta_p^2=.28$) but did not interact with age ($F(2,82)=1.73$, $p=.18$, $\eta_p^2=.04$). Detail type did not interact with age ($F(1,41)=.73$, $p=.40$, $\eta_p^2=.02$) and the three-way interaction was not significant ($F(2,82)=2.23$, $p=.12$, $\eta_p^2=.05$). The results of the proportional analysis were also similar to the IQ-matched sample; there were no effects of condition ($F(2,64)=.17$, $p=.84$, $\eta_p^2<.01$) or age ($F(1,32)=3.22$, $p=.08$, $\eta_p^2=.09$) and no interaction ($F(2,64)=.74$, $p=.48$, $\eta_p^2=.02$).

Table 4.2.3

Incorrect details as a proportion of total recall at T2

	Young adults		Older adults	
Condition	*M*	*SD*	*M*	*SD*
Control	.12	.23	.24	.31
Random	.14	.13	.20	.19
Forward	.12	.11	.21	.19

Proportion of errors. As in the T1 data, we next looked at the number of memory errors as a proportion of total recall (see *Table 4.2.3*). Proportions could not be calculated in at least one condition for a total of six participants (three younger and three older), because they failed to add any new details at T2. The six participants were excluded from all three conditions and the following analysis therefore involves 12 younger adults and 16 older adults. A 2 (age group) x 3 (condition) found no significant effects of age ($F(1,26)=2.41$, $p=.13$, $\eta_p^2=.09$) or condition ($F(2,52)=.10$, $p=.90$, $\eta_p^2<.01$), and no age by condition interaction ($F(2,52)=.31$, $p=.73$, $\eta_p^2=.01$).

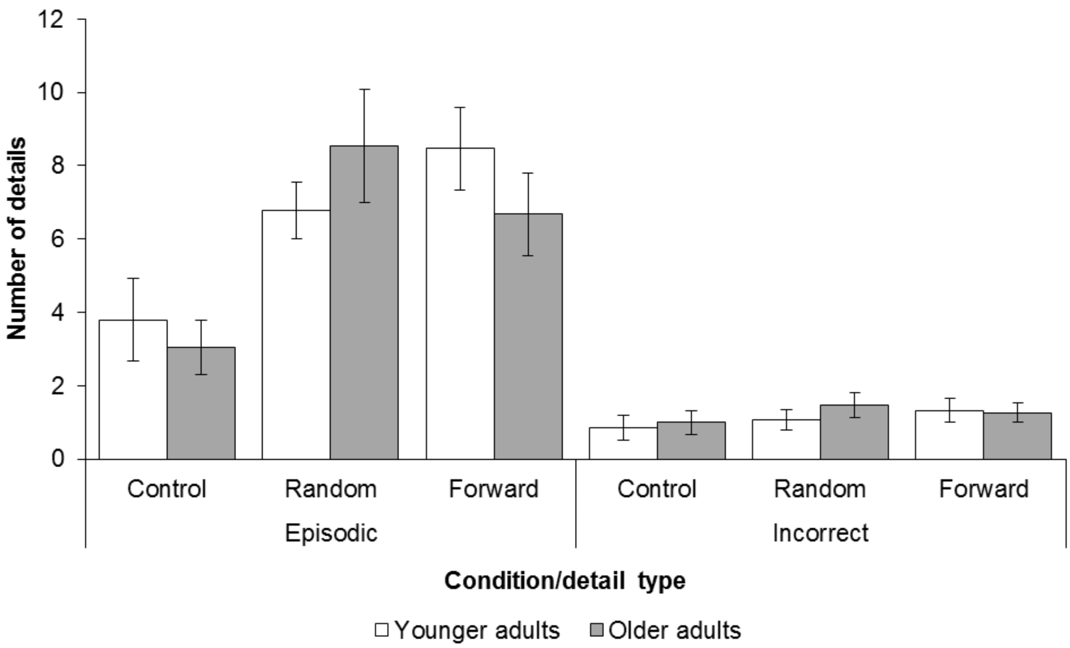

Figure 4A. New episodic and incorrect details reported at time 2, as a function of age group and condition. The number of episodic details added by both older and younger adults was greater after reviewing SenseCam images; manipulating the temporal order of the image sequence did not have an effect. There was no difference in the number of incorrect details added by older and younger adults in any condition. Error bars represent standard error of the mean. RTO = random temporal order; FTO = forward temporal order.

These results suggest that SC increases the number of episodic details both young and older participants recall about an event, but does not affect the number of memory errors. One possible argument, however, is that in the T2 questionnaires participants were reporting what they had just seen in the pictures rather than what they remembered of the original event. Since it was not possible to determine the source of the remembered details, a second round of analysis was carried out on the episodic details after excluding all of the visual details. This yielded a conservative measure of the number of details recalled, since it is highly probable that at least a proportion of visual details were not visible in the images themselves. Analysis of nonvisual details showed a small but significant main effect of condition ($F(2,62)=3.21$, $p=.047$, $\eta_p^2=.09$), but pairwise comparisons revealed no reliable differences between control, random order and forward order conditions (all *p*s>.05). There was no main effect of age ($F(1,31)=2.54$, $p=.12$, $\eta_p^2=.08$) and no interaction between age and condition ($F(2,62)=.73$, $p=.49$, $\eta_p^2=.02$).[17]

Power analysis. As in previous chapters, to further investigate the null findings, we conducted post hoc power analyses in G*Power (Faul et al., 2007) to determine the power to detect effects of different sizes given the reduced sample size, number of measurements, and correlations between measurements in the present study. For both the within-subjects factors (i.e. effect of SC review, detail type) and the interactions, there was 99.9% power to detect a large effect ($f=.4$), 87% power to detect a medium effect ($f=.25$), but only 18% power to detect a small effect ($f=.1$). Power was similar for the between-subjects factors, with 98% power to detect a large effect, 71% power to detect a medium effect, and 17% power to detect a small effect. This suggests that large and medium effects were likely to be detected, but null results may have been due to effects too small to be detected given the parameters of the experiment. In the full sample (prior to IQ-matching) there would have been an additional 4% power to detect a small effect. An

[17] In the full sample similar results were obtained for the analysis of nonvisual details. There was a main effect of condition ($F(2,82)=6.97$, $p=.002$, $\eta_p^2=.15$), but no effect of age ($F(1,41)=1.76$, $p=.19$, $\eta_p^2=.04$) and no age by condition interaction ($F(2,82)=1.13$, $p=.33$, $\eta_p^2=.03$). Pairwise comparisons found significantly higher nonvisual recall in random ($M=3.45$, $SD=3.28$, $p=.02$) and forward ($M=3.78$, $SD=3.30$, $p=.007$) conditions compared to control ($M=1.99$, $SD=2.61$), but no difference between random and forward conditions ($p=1.00$).

additional analysis suggested that to detect small effects with 80% power, a sample size of 178 would have been required.

Discussion

Experiment 4 demonstrated that when memory for the same staged event is tested, younger adults' AM performance is superior to that of older adults. At baseline, young adults recalled more episodic details than older adults. This result is consistent with the findings from several other studies of autobiographical and episodic memory that have found an age-related memory deficit in different tasks (Beaman et al., 2007; Ford et al., 2014; B. Levine et al., 2002; Piolino et al., 2006, 2010). Given the inconsistency with our recent AM task (Experiments 1 & 2), however, the following discussion highlights some ways in which the design and content of Experiment 4 departed from the previous work. We attempted to address these issues in Experiment 5.

Interview vs. questionnaire. One difference between this and our previous studies concerns the method by which participants were required to report their memories. Using the written questionnaire in a group setting it was not possible to emphasise the recall instructions verbally prior to every instance of recall, and therefore it was not possible to determine whether the instructions were well-understood. The responses of some participants were sufficiently brief to prompt the authors to consider whether the content of the written reports was necessarily an accurate reflection of the amount of information accessible in memory. Another issue with written questionnaires is that they are relatively labour-intensive for the participant, and particularly towards the end of the questionnaire fatigue may affect memory performance and/or cooperation. Since older adults tend to process information, read, write and type more slowly than young adults (Bosman, 1993; Cerella & Hale, 1994; Rodriguez-Aranda, 2003; Salthouse, 1984; Salthouse, 1996), fatigue and cooperation may have been a particular problem for the older group, for whom writing lengthy reports on a computer may be unusual. One-to-one interviewing allows the experimenter to reiterate and reinforce instructions, and, where appropriate, to prompt participants to recall more, while also avoiding any unnecessary confounds of processing or motor speed deficits in older adults, thus the replication in Experiment 5 employs an interviewing procedure in place of the written questionnaires.

Event content. In order to control the distinctiveness of material across conditions in Experiment 4, the tasks in each room were very similar. This probably resulted in retrieval competition and interference, which older adults may be less successful at inhibiting (Burke & Light, 1981; Hasher & Zacks, 1988; Dempster, 1992). Although highly similar events occur in everyday life, the interval between them would usually be longer (e.g. daily commute, weekly shop), enabling the separation of similar event memories on a temporal dimension (M. A. Conway, 2009). To reduce interference from task similarity, the tasks in Experiment 5 are revised so that they are different in each room.

The SenseCam effect. The results of Experiment 4 indicated that both young and older adults' memory benefitted from the use of SC, and there was some evidence that this effect held even when visual details were excluded from the analysis. This possibility is particularly compelling because visual details are considered to be a major component of AM (M. A. Conway & Pleydell-Pearce, 2000; Galton, 1879), yet the small effect size for nonvisual details prevents a confident conclusion that participants are not just reporting what they saw in the pictures. In Experiment 4 most of the tasks that participants completed had a strong visual element, description of which encouraged the recall of visual information. In addition, one of the questions included in the questionnaire asked explicitly that participants described the visual environment of the room in question, and two others ("Describe the task leader" and "Do you remember any of the flags from the [red/blue/green] room?") carried an implication that recall of visual information would be appropriate. To better examine the effect of SC on nonvisual memory, therefore, the tasks in Experiment 5 reduce the focus on visual information by increasing the amount of nonvisual information available to recall.

Although SC provided a general recall benefit, the order of images within the cue sequence did not make a significant difference to the magnitude of the effect. One previous study has shown that randomising the presentation order of a small number of SC images leads to worse subsequent recognition of images from the same group (St. Jacques & Schacter, 2013), but the large number of images included in the cue sequences in the present study (~100 per room) may have provided enough information to protect against any detrimental effect of a random sequence. Alternatively, because recall did not need to refer to any specific image from the SC sequence, then single images could cue recall of clusters of related details. S. J. Anderson and M. A. Conway (1993) suggested a mechanism by which a forward-order search from a recalled distinctive detail might result in the recall of further details related either thematically or temporally to the original. Under the present design it is possible that in the random order condition such a mechanism might provide a self-initiated temporal sequence for recall, thus explaining the similar performance in random order and forward order conditions. The results of the temporal order manipulation here are inconsistent with the temporal order effect observed in Experiment 1. This may be due to the increased control in the present study, which eliminates the potential confound of event variability. Alternatively, it may be that the effect of temporal order was too small to be detected in the present study, given the small sample size. In any case, the results presented both here and in Experiment 1 suggest that any effect of temporal order is minimal compared to the general recall benefit provided by SC. Since the random order condition did not lead to any observable difference in recall in Experiment 4 it is not included in Experiment 5.

Section 4.3

Experiment 5

In Experiment 5 we aimed to replicate and extend the findings of Experiment 4. In particular, we wanted to rule out the possibility that older adults' poor performance in Experiment 4 was related to the mode of recall (written questionnaire rather than interview) or a high degree of interference between rooms within the staged event, which may reduce the ecological validity of the design (see *Event Content* section, above). We also aimed to improve the design from the perspective of SC research, by facilitating the opportunity to recall "something more" than the information present in the SC images (Silva et al., 2016).

Method

Participants. Seventeen young adults (age 18-32; *M*=24.29, *SD*=4.70; 14 female) and 19 older adults (age 66-85; *M*=71.00, *SD*=4.18; 15 female) participated in return for a payment of £20. Young adults were predominantly undergraduate students recruited via an online sign-up system, while older adults were recruited from a panel of individuals who had previously responded to an advertisement in a local newspaper. Two of the young adults and six of the older adults also participated in Experiment 4. All participants had self-reported normal or corrected-to-normal vision. As in Experiment 4, older participants were screened using the MMSE and all participants scored well above the cut-off point of 24 suggested by Folstein et al. (1975). Both groups completed the Geriatric Depression Scale (Yesavage et al., 1983) as an indicator of depressive symptoms that may be associated with reduced memory specificity. The 2 subscale version of the Wechsler Abbreviated Scale of Intelligence (WASI; Wechsler, 1999) was administered to both groups to give an estimate of IQ.

Design. A 2 (age: young vs. older) x 2 (retrieval condition: control vs. SC) x 4 (detail type: correct vs. incorrect vs. source error vs. semantic) mixed design was employed with repeated measures on the second and third factors. In the SC condition participants viewed all of the pictures from their own device in forward temporal order, while in the control condition participants did not see any pictures. Memory performance was measured as the number of details produced in free recall before and after viewing SC images. More information about the types of details is presented in the *Coding* section, below.

Materials and procedure

Encoding session. The encoding session for Experiment 2 was similar to that of Experiment 1, but took place over two rooms instead of three, to reflect the number of retrieval conditions. Participants were placed in mixed-age groups of up to 10 individuals, and each participant was provided with a SC, which was worn for the duration of the encoding session. Each of the rooms contained three tasks, which were different from those used in Experiment 4, and were designed to provide more nonvisual material to be recalled at test. In addition, the likelihood that participants would be familiar with the material already was reduced by using stimuli that participants were unlikely to have encountered previously. Participants were therefore assumed to have equal knowledge of the stimuli at baseline. Secondly, the similarity between tasks in different rooms was reduced so that differences in memory could not be attributed to interference between similar tasks, which would be unlikely to occur at such temporal proximity in real life. Participants were in larger groups than in Experiment 4 to increase the social aspect of the event, which also served to provide more opportunity for the recall of nonvisual information at test. One final alteration from Experiment 4 was that in Experiment 5 there was only one task leader who took participants round both rooms, thus keeping that aspect of the event matched across both retrieval conditions. As in Experiment 4, participants were encouraged to interact and to discuss the different tasks throughout.

In Room 1, the tasks involved matching criminal mugshots to their crimes, folding an origami pigeon, and completing a problem solving task in which nine dots must be joined by drawing four lines (Maier, 1930). In Room 2, the tasks involved tasting chocolate and identifying the flavour, completing a word-search, and telling two truths and one lie about oneself. These tasks are described in more detail in *Appendix 4D*.

Since the temporal structure of real-world events would be the same for every individual, the decision was made not to counterbalance the order in which the rooms were visited or the order of the tasks within each room. This meant that the overall structure of the event was the same for all participants, and avoided any potential problems with task order effects. In order to control for any differences in room memorability, counterbalancing was implemented at the retrieval stage such that half of the participants saw photographs for Room 1 and the other half saw photographs for Room 2. At the end of the encoding session, participants returned their cameras and the stimuli were prepared for the retrieval session.

Retrieval session. The retrieval session took the form of a one-to-one interview 13-15 days after the encoding session. Participants were first asked to recall the room for which they did not see photographs. The retrieval instructions asked participants to recall as much as possible about the room, and specifically to describe the tasks, social interactions and thoughts or feelings they had at the time, while being as specific as possible and reporting details even if they seemed insignificant. To avoid excluding a large amount of data from the analysis, participants were not explicitly asked to recall visual information. Following free recall, participants were then prompted with open-ended questions according to a list of task details that was held by the experimenter. Importantly, participants were not provided with any extra information during prompting, for example if a participant could not remember one of the tasks then the experimenter did not remind the participant which task they had forgotten. On the other hand, if a participant had mentioned matching female criminals to their crimes but had not provided much detail, prompts might include: “Do you remember what any of the crimes were?” “Do you remember how you tried to match the criminals to their crimes?” “Do you remember any of the other information you were given about any of the women or their crimes?” Unprompted and prompted recall were recorded as two separate measurements of the same variable and were intended not as a measure of the effect of prompting, but rather as a check to establish whether or not the pattern of results was similar for unprompted and prompted recall. Unprompted recall was considered to be a measure of spontaneous memory, and prompted recall was recorded in order to establish whether the relationship between spontaneous and total recall was the same for young and older adults. Following the recall of one room without pictures, participants then viewed the pictures for the remaining room and after viewing the SC images the same procedure as above was followed, beginning with free recall of the room followed by specific prompting for more detail.

Coding strategy. The recall sessions were audio recorded, transcribed and coded for episodic and semantic details, incorrect details, and source memory errors. A master coding sheet was created for the scripted aspects of the event, to ensure that coding was consistent across all participants. Due to the idiosyncrasy of event recall it was not possible to anticipate memory for the non-scripted information, however care was taken to code recall for both types of information at the same grain of detail. Episodic details included actions (e.g. *folding an origami pigeon*) and visual details (e.g. *using blue origami paper*) related to the tasks, interactions with other individuals, auditory information (e.g. *hearing road works outside the window*), conceptual details (e.g. crimes committed), and thoughts and feelings that the participant had at the time (see

Appendix 4E for a coded example). Incorrect details were of a similar nature, but described things that either did not happen, or that were reported inaccurately (e.g. remembering five types of chocolate instead of four). Details that were conceptually correct but were reported as part of the wrong room were counted as source memory errors, while memory details that were not bound to the experimental context, or any other specific context (e.g. "I like chocolate"), were coded as semantic. As in Experiment 4, the reliability of the coding strategy was measured by comparing the original coding with that of three additional raters, who each rated the same subset of transcripts (*n*=6). There was a strong correlation between the original and each additional rater (*r*=.97, *r*=.93, *r*=.93).

Results

Preliminary analysis. Years of education did not differ significantly between younger (*M*=16.88, *SD*=3.10) and older adults (*M*=15.74, *SD*=3.35; *t*(34)=1.06, *p*=.29), but older adults (*M*=125.00, *SD*=8.89) had significantly higher IQs than younger adults (*M*=109.24, *SD*=13.74; *t*(34)=4.13, *p*<.0005). Young adults (*M*=8.76, *SD*=6.58) also showed significantly more indicators of depressive symptoms than older adults (*M*=4.37, *SD*=3.82; *t*(34)=2.41, *p*=.02). Recall of episodic details at baseline was significantly correlated with IQ (*r*=.40, *p*<.05), but there was no significant correlation between episodic recall and education (*r*=.21, *p*>.05) or GDS (*r*=-.18, *p*>.05). As in the previous experiments, to control for group differences in IQ, we balanced the sample by excluding the five young adults with the lowest IQ scores and the eight older adults with the highest IQ scores. This adjustment (*n*=24; 12 younger) left no significant group differences in IQ (*t*(22)=1.15, *p*=.26), education (*t*(22)=1.83, *p*=.08) or GDS (*t*(22)=.22, *p*=.83). Equivalent results for the full sample are presented in the footnotes.

Event memory. The number of each type of detail (episodic, incorrect, source error, semantic) recalled in each condition is presented in *Table 4.3.1*. Source errors and semantic details were not included in subsequent analyses due to the low numbers recalled by both groups. A 2 (age: young vs. old) x 2 (condition: baseline vs. SC) x 2 (detail type: episodic vs. incorrect) ANOVA found a main effect of condition (*F*(1,22)=12.77, *p*=.002, η_p^2=.37), in which more details were recalled in the SC condition (*M*=17.00, *SD*=7.75) compared to baseline (*M*=12.79, *SD*=7.22). There was also a main effect of age (*F*(1,22)=8.73, *p*=.007, η_p^2=.28), with younger adults (*M*=19.06, *SD*=8.33) recalling more details than older adults (*M*=10.73, *SD*=5.12), but

Table 4.3.1
Mean number of details recalled by young and older adults at baseline and after reviewing SenseCam images

	Young adults				Older adults			
	Baseline		SenseCam		Baseline		SenseCam	
Detail type	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Episodic	31.08	14.89	40.42	15.95	16.25	9.59	24.08	13.66
Incorrect	2.42	3.50	2.33	1.37	1.42	1.24	1.17	1.34
Source error	.17	.58	.17	.58	.83	2.59	.00	.00
Semantic	.58	.90	.92	1.31	.92	1.38	1.83	2.52

there was no interaction between age and condition (*F*(1,22)=.13, *p*=.73, η_p^2=.01). There was a main effect of detail type (*F*(3,66)=121.15, *p*<.0005, η_p^2=.85), with many more episodic details (*M*=27.96, *SD*=14.72) recalled than incorrect details (*M*=1.83, *SD*=1.71). Detail type interacted with both age (*F*(1,22)=9.33, *p*=.006, η_p^2=.30) and condition (*F*(1,22)=17.26, *p*<.0005, η_p^2=.44). The interaction with condition was driven by increased recall of episodic details with SC (*t*(23)=4.03, *p*=.001; $M_{baseline}$=23.67, *SD*=12.53; M_{SC}=32.25, *SD*=14.85), while recall of incorrect details was not affected by condition ($M_{baseline}$=1.92, *SD*=2.63; M_{SC}=1.75, *SD*=1.35; *t*(23)=.33, *p*=.75). The interaction with age was driven by younger adults (*M*=35.75, *SD*=14.98) recalling more episodic details than older adults (*M*=20.17, *SD*=9.81; *t*(22)=3.02, *p*=.006), while the number of incorrect details was not affected by age ($M_{younger}$=2.38, *SD*=2.08; M_{older}=1.29, *SD*=1.08; *t*(22)=1.60, *p*=.12). The 3-way interaction between age, condition and detail type was not significant (*F*(1,22)=.10, *p*=.76, η_p^2=.01).[18]

[18] In the original, non-matched sample the pattern of results looked much the same, apart from the absence of a main effect of age (*F*(1,34)=.44, *p*=.51, η_p^2=.01). There were main effects of condition (*F*(1,34)=25.42, *p*<.0005, η_p^2=.43) and detail type (*F*(1,34)=97.36, *p*<.0005, η_p^2=.74), and detail type interacted with condition (*F*(1,34)=24.94, *p*<.0005, η_p^2=.42), but not with age *F*(1,34)=.27, *p*=.61, η_p^2=.01). Age and condition did not interact (*F*(1,34)=.17, *p*=.68, η_p^2=.01) and there was no 3-way interaction (*F*(1,34)=.55, *p*=.46, η_p^2=.02). The proportion of incorrect details was not affected by condition (F(1,33)=.03, p=.86, η_p^2<.01) or age group (F(1,33)=.59, p=.45, η_p^2=.02), and there was no interaction (F(1,33)=.07, p=.80, η_p^2<.01).

Power analysis. As in the previous experiments, we further investigated the apparent absence of age by condition interaction using a post hoc power analysis run by G*Power (Faul et al., 2007). The results suggested that within the reduced sample there was 99.8% power to detect a large interaction effect (f=.4) and 84% power to detect a medium effect (f=.25), but only 19% power to detect a small effect (f=.1). In the original sample there was 27% power to detect a small interaction effect, but no interaction was observed. In order to obtain 80% power to detect a small interaction effect, a sample size of 130 would have been required.

Proportion of errors. We next looked at the number of recall errors as a proportion of total recall output; these data are presented in *Table 4.3.2*. The proportion of incorrect details was not affected by SC ($F(1,22)=.29$, $p=.59$, $\eta_p^2=.01$) or age ($F(1,22)=.61$, $p=.44$, $\eta_p^2=.03$), and there was no interaction ($F(1,22)=.31$, $p=.59$, $\eta_p^2=.01$).

Table 4.3.2

Incorrect details as a proportion of total recall in each condition

	Young adults		Older adults	
Condition	*M*	*SD*	*M*	*SD*
Baseline	.06	.06	.08	.06
SC	.06	.04	.06	.07

Nonvisual details. As in Experiment 4, it is possible that some of the additional episodic details participants reported were seen in the SC image sequence a few minutes previously, rather than details that the participant recalled from the encoding session two weeks earlier. To investigate this possibility, we excluded visual episodic details (e.g. objects, colours, shapes). As in Experiment 4, the decision to remove all visual details was a conservative measure because it was not possible to know which items were recognised by each participant in their personal image sequence. A 2x2 ANOVA analysed the effect of age and condition on the recall of episodic nonvisual details only. There was a main effect of condition ($F(1,22)=25.46$, $p<.0005$, $\eta_p^2=.54$), where again the SC condition was associated with more nonvisual episodic recall ($M=27.63$, $SD=15.12$) than the control condition ($M=18.71$, $SD=13.20$). There was also a main effect of age ($F(1,22)=7.10$, $p=.01$, $\eta_p^2=.24$), in which younger adults ($M=29.71$, $SD=14.86$) recalled more nonvisual details than older adults (*M*=16.63, *SD*=8.27). There was no age by condition interaction ($F(1,22)=.57$, $p=.46$, $\eta_p^2=.03$).

To investigate whether SC compensated for the age-related memory deficit, older adults' SC-supported recall was compared with the young adults' baseline performance. There was no significant difference in the number of episodic nonvisual details ($t(22)=.77$, $p=.45$), which indicates potential for SC to be used as a memory aid for older people.

Prompted recall. We also investigated the effect of prompting recall to rule out the possibility that the older adults were only worse at spontaneous recall. A 2 (age group) x 2 (condition) ANOVA was carried out on the number of correct details that were added to memory reports after specific verbal prompting from the experimenter. There was no effect of condition ($F(1,22)=.1.14$, $p=.30$, $\eta^2=.05$), no effect of age ($F(1,22)=1.72$, $p=.20$, $\eta^2=.07$) and no age by condition interaction ($F(1,22)=.16$, $p=.69$, $\eta^2=.01$), thus the pattern of results reported above was not affected by the use of specific prompts.

Discussion

The results of Experiment 5 showed that, similarly to Experiment 4, most of the details recalled by both young and older participants were episodic, with only a small number of incorrect details, source errors and semantic details. Young adults outperformed older adults when IQ was matched, and this was consistent with the results of Experiment 4, and other studies, which have demonstrated an autobiographical memory deficit in old age (e.g. Levine et al., 2002; Piolino, Desgranges, Benali & Eustache, 2002; Piolino et al., 2006, 2010). The findings are broadly inconsistent with the lack of age effect observed in Experiments 1 and 2, but the present study suggests that this is not related to the method of recall (interview vs. questionnaire) or interference between similar tasks within the staged event.

Experiment 5 also showed that viewing SC images increased the number of episodic details that were recalled about the part of the event for which the images were seen. This is also consistent with Experiment 4, as well as with previous studies (Experiment 1; Finley et al., 2011; Sellen et al., 2007), and provides support for the application of SC as a memory aid in healthy populations. The results of Experiment 5 demonstrated that even when visual details were excluded, participants still recalled more event details after viewing SC images compared to baseline. This rules out the possibility that the additional details participants report are simply what they saw in the SC images immediately prior to recall, and suggests that SC images provide a powerful cue for remembering, regardless of whether or not participants have a memory deficit at baseline. Memory errors were unaffected by whether or not participants had viewed SC images, thus in this study the increase in correct recall afforded by SC equated to a net gain in memory.

In contrast to our previous findings (Experiment 1, Experiment 2), the number of semantic details participants recalled was not affected by SC. Indeed, the number of semantic details reported was relatively low in comparison to other free-recall studies, particularly for the older group, who often recall more semantic details than younger adults (e.g. B. Levine et al., 2002). Our failure to replicate the age-related increase in semantic recall may be a consequence of the event novelty, which probably did not evoke schematic representations of familiar people, locations or event-types at the retrieval stage. This possibility is explored further in the general discussion. Alternatively, the fact that the experimenter was present at both encoding and retrieval stages may have negated the need to explain concepts or relationships that might normally help to improve the quality of the narrative (i.e. there is an implicit understanding of shared knowledge between the speaker and the listener).

The results of the verbal prompting demonstrated a similar effect in both young and older adults, and both control and SC conditions. This suggests that although participants do not spontaneously report the full contents of their memory, the relative number of details that are recalled spontaneously appears to be a fairly proportional reflection of the information that is accessible in memory. In addition, these results suggest that older adults' inferior memory performance cannot be explained simply by a tendency for less spontaneous recall.

Section 4.4

Chapter 4 Discussion

In the two experiments presented here older adults' recall of novel autobiographical information was impaired compared to young adults. The performance difference between age groups was accounted for by a reduction in the amount of episodic autobiographical information that older adults recall. This finding adds to an already complex picture of how memory changes with age. An age-related memory deficit is consistent with a wealth of episodic memory literature (Craik & McDowd, 1987; Head, Rodrigue, Kennedy & Raz, 2008; Sanders, Murphy, Schmidt & Walsh, 1980; Taconnat, Raz, Toczé, et al., 2009; Ward & Maylor, 2005), as well as with a number of studies of AM in ageing (B. Levine et al., 2002; Piolino et al., 2006, 2010).

The results presented here are inconsistent with our recent AM task (Experiments 1 and 2), in which we found no evidence of an age-related deficit when events were prospectively sampled two weeks in advance of the recall test. The approach taken here mirrored the recent AM task in both the prospective sampling technique and the two-week interval between event sampling and test, which suggests that neither factor can account for the absence of age effect observed in the recent AM task. While power analyses indicated low power to detect small effects in both Experiments 1 and 2, Experiments 4 and 5 were similarly powered. This suggests that, in order to be detectable, the age-related deficits in Experiments 4 and 5 were likely to be larger than any deficit in the Recent AM task.

One major difference between the current study and the recent AM task is that in the latter participants recalled events from their own life, whereas in the present chapter the events were staged, and therefore experimenter-led. The differences in memory performance between these two studies could reflect the degree to which the events fit into personal semantic frameworks, for example older adults may be able to remember more about events if the event details are consistent with pre-existing knowledge about themselves, their routines, and familiar people and locations. There is some evidence from the episodic memory literature to suggest that older adults are more reliant on schematic knowledge when remembering, compared to young adults (Hess &

Slaughter, 1990; Mather & Johnson, 2003; Mather, Johnson & De Leonardis, 1999), which could perhaps account for relatively improved memory for events for which a schema already exists than for events that are sufficiently novel that there is not yet a schema.[19]

Although the above argument is speculative, another interesting distinction between the results of the present study and our recent AM task concerns the recall of semantic information. In Experiments 1 and 2, as well as in previous studies from different laboratories (e.g. Aizpurua & Koutstaal, 2015; B. Levine et al., 2002), older adults recalled significantly more semantic memory details than young adults. Although it is not yet clear what purpose these semantic details serve in personal memory narratives, their relative absence in the memory narratives from the present two experiments may reflect a reduction in the extent to which participants retrieve pre-existing knowledge when recalling the staged events, as compared to personal events. Thus, if older adults rely more on personal semantic schemas to support episodic autobiographical remembering, we might expect that they would perform relatively well on tasks in which those schemas could be activated.

While the number of memory errors was similar in both groups, as a proportion of total recall older adults made more memory errors than younger adults in Experiment 4. This is consistent with findings from the episodic memory literature, which show a higher rate of false memory among older adults (e.g. Schacter, Koutstaal & K. A. Norman, 1997). Despite this, the number of memory errors was relatively small, and in Experiment 5 the difference between groups was not significant. This may be because Experiment 5 was specifically designed to reduce task similarities in order to better reflect events outside the laboratory, in which highly repetitive events are more likely to be more temporally dispersed (e.g. daily commute).

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[19] A related argument is that the staged events could be considered not truly autobiographical. For example, Bluck and Habermas (2000) suggested that true autobiographical memories have motivational or emotional links to the self over one's life. It may be argued that studies involving staged events are more accurately described as elaborate episodic memory experiments, since the staged event may not be incorporated into the life story. While this may certainly be true, the same argument could also be applied to the recent AM task in Experiments 1 and 2, which measures memory for relatively mundane everyday experiences. These, too, are less likely to have lasting significance in an individual's life, compared to retrospectively sampled AMs of important or emotionally significant past events.

Experiments 4 and 5 also demonstrated that SC is effective as a memory aid for both young and older individuals, which replicated the SC benefit observed in Experiment 1. In each of these experiments, the forward-order sequences of images captured by SC was not altered and participants simply viewed the images for the relevant part of the event at their own pace. The results obtained here suggest that SC can therefore be used relatively easily to benefit performance in healthy individuals, and for older adults, using SC can increase performance to approximately the young adult baseline. While the results regarding the temporal order manipulation were less consistent, it seems clear that the any effect of randomising the presentation of SC images is relatively small in relation to the general SC effect. It seems likely that when a large number of images are presented, as in the experiments described here, the primary cause of the mnemonic benefit is the wealth of information present and available to reactivate or cue memory (S. Hodges et al., 2011). This does not rule out the possibility that the function of SC is particularly compatible with AM, and features such as own perspective and temporal order may still be of benefit for particular patient groups or in experimental designs in which fewer images are presented.

In conclusion, older adults clearly exhibit a deficit in memory for novel event information, which can be somewhat attenuated by the use of SC without any negative consequence on recall accuracy. It is clear that in order to understand the pattern of age-related deficits in AM, continuing research needs to investigate AM under tighter controls. Building on the preceding chapters, the present experiments suggest that the capacity for remembering new information that is not bound to personal semantic schemas is impaired in older adults, although functional memory differences may not be as pronounced in the real world.

Section 4.5

Appendix 4A

Questionnaire items used in Experiment 4

Question number	Question
1	You had two minutes to look around the [red/blue/green] room. Please describe everything you remember seeing.
2	Please describe the task leader.
3	Do you remember any of the general knowledge questions from the [red/blue/green] room? Please describe anything that you remember about this task, including any other information you received from the task leader.
4	Do you remember any of the flags from the [red/blue/green] room? Please describe anything that you remember about this task, including any other information you received from the task leader.
5	Do you remember what the problem-solving task involved in the [red/blue/green] room? Please describe what your group had to do and the roles each person took to complete the task.

Appendix 4B

Encoding session tasks employed in Experiment 4

Room	General knowledge	Name the flag	Problem solving
Red	1. Which animal were the Canary Islands named after? 2. How many miles of blood vessels are there in the human body? 3. What is strange about the jellyfish species *Turritopsis Dohrnii*?	1. Morocco 2. Denmark 3. Turkey	*Lego task* One participant was a describer, the other one or two participants were builders. The describer sat behind a screen with a lego model, which he/she described to the builders. The builders had to make a replica of the model from the describer's instructions, without seeing the original.
Blue	1. What is the circumference of the Earth, at the equator, in miles? 2. In 1923, jockey Frank Kayes won a race at Belmont Park in New York. What was strange about his victory? 3. What are Australian Mist, Cornish Rex, Scottish Fold and Turkish Van types of?	1. Kazakhstan 2. Somalia 3. Greece	*Match stick puzzle* Participants presented with an array of sixteen match sticks arranged in two squares. They worked together to move four match sticks to create three squares.
Green	1. How many towns in Great Britain are called Newport or have Newport in the name? 2. What are the small circles of paper called that are cut out by a hole-puncher? 3. What is the world's biggest island?	1. Pakistan 2. Jamaica 3. Nigeria	*Word wheel* Participants provided with a nine-letter word wheel and asked to make as many words as possible with their group. Words had to be at least four letters long, and there was one nine-letter word to find.

Appendix 4C

Example response from Experiment 4, coded for detail type

The problem solving task involved a wheel with different letters in it **[V]** We had to come up with as many words as possible **[NV]** which had a minimum of 4 letters **[NV]** There was a 9 letter word which used all of the letters which we had to try and find **[NV]** It was quite easy to come up with words **[NV]** and we both worked well together **[NV]** The 9 letter word **[R]** which we did not guess **[NV]** was 'Celebrity' **[NV]** I remember thinking that I thought the word began with C **[NV]**

Note. V= correct visual detail (i.e. may be visible within SenseCam image sequence); NV = correct nonvisual detail (i.e. would not be visible within a SenseCam image sequence); R = repeated detail.

Appendix 4D

Encoding session tasks employed in Experiment 5

Room 1

Task 1: Criminal mugshots. Participants saw photographs of convicted criminals and had to match the faces to a list of crimes. The criminals were Australian females who were arrested between 1916 and 1928, and the photographs and crime data were downloaded from the forensic archive of Sydney's Justice & Police Museum (NSW Police Forensic Archive, retrieved May 2015). There were six criminals in total, and for each a front-view headshot and a profile shot were printed on an A4 sheet of paper, which was displayed on the wall. A list of the six crimes was displayed above the mugshots and the name of each criminal was printed below their photographs. Participants were provided with a response form on which the criminals' names were printed, beside which they were asked to write which crime they thought each individual had committed. A few minutes were allowed for completion of this task, and when every participant had answered, they swapped response slips with another participant and noted which answers their partner had correct. The correct answers were provided to the group as a whole, and the crimes were described in more detail in order to provide context and increase the amount of material available to remember.

Task 2: Origami. Participants were asked to fold an origami pigeon. They sat facing each other around a table, and each was provided with a coloured square piece of paper and a set of written instructions for folding the pigeon. A few minutes were allowed for this task and participants could ask the task leader, and each other, for help if they were struggling. The task was finished when every participant had made an approximation of the pigeon, and the group decided which pigeon they thought was best.

Task 3: Nine dots task (Maier, 1930). This was a spatial problem solving exercise in which each participant was provided with a small square of paper with nine dots printed in a grid. The task was to draw four lines to pass through each of the nine dots, without taking the pen off the paper. The solution was to take the lines beyond the boundary of the matrix, and participants were given the clue: "Think outside the box". After a few minutes the solution to the task was provided.

Room 2

Task 1: Chocolate tasting. Participants tasted four types of chocolate which were laid out on paper plates labelled A-D. Each participant was provided with a response slip and asked to try to identify the flavour of the chocolate. The four flavours were butterscotch, chilli, ginger and strawberry cheesecake. After a few minutes when every participant had completed the task, they swapped response slips with another participant and noted down the number of correct answers.

Task 2: Word search. Participants completed a word search, in which the names of wild animals were hidden in a grid of letters. The grid of letters was printed in large format and displayed on the wall, along with a separate list of the wild animals against which participants could check off those they had found. The groups were subdivided into two smaller groups to complete this task, and one participant had a marker pen to mark off the words that the group had found. After five minutes the number of words found by each group was counted.

Task 3: Two truths and a lie. Participants sat facing each other around a table and each thought of three statements about themselves to share with the group. Two of the statements were true and one was a lie, and the other participants had to decide which statement was untrue.

Appendix 4E

Example response from Experiment 5, coded for detail type

Okay so we had to taste chocolate **[V]** and I think there was a crystallised ginger chocolate **[NV]** … there was a strawberry one **[NV]** and I put raspberry **[NV]** and there was a chilli one **[NV]** which I got right **[NV]** and then there was a… I'll come back to that one **[X]** But anyway, I got like two and a half right **[NV]**

And then we sat down **[V]** and we had to tell lies about ourselves **[NV]** So I said that… yeah nobody believed **[NV]** that I'd got a physics degree **[NV]** and I said that I was Romanian **[NV]** and the other one was my age **[NV]** Someone else said "I can't use computers" **[NV]** and then it turned out that she worked with computers **[NV]** and she found it really funny **[NV]**

Note. V = correct visual detail (i.e. may be visible within SenseCam image sequence); NV = correct nonvisual detail (i.e. would not be visible within a SenseCam image sequence); X = non-memory detail

Chapter 5: Semantic Autobiographical Memory

In this chapter, the recall of semantic details in autobiographical narratives is explored. A common finding in AM research is the tendency for older adults to recall more semantic details than younger adults (Aizpurua & Koutstaal, 2015; B. Levine et al., 2002; Experiments 1 & 2). In some instances, this appears to be at the expense of episodic recall (e.g. B. Levine et al., 2002), but in other cases there is no correlated episodic deficit (Aizpurua & Koutstaal, 2015). Word-cue measures such as the Autobiographical Memory Test (AMT; J. M. G. Williams & Broadbent, 1986) are usually scored on a four-point scale ranging from semantic (at the lower end) to episodic. Older adults typically score more poorly, with recall of more memories towards the semantic end of the scale (Beaman et al., 2007; Holland et al., 2012; Ros et al., 2010). In addition, laboratory memory tests often show that older adults perform relatively well on measures of semantic memory retention, such as vocabulary and general knowledge (Bowles, Grimm & McArdle, 2005; Nyberg et al., 1996; Salthouse, 1982). In general, then, it is believed that older adults' semantic memory is well-preserved.

However, in the case of most AM tasks, semantic recall is not required in order to perform well. Indeed, the majority of published research on the topic of AM in older adults focuses on the ability to recall specific information about single events, thus only episodic recall is considered to be relevant event information. Why, then, do older adults consistently recall more semantic information than their younger counterparts? We begin by introducing a number of hypotheses concerning age differences in semantic recall, as it applies to AM research. We present correlational evidence from Experiments 1-5 which enables some of these hypotheses to be rejected, and we introduce Experiment 6, which investigates how the recall of semantic details is perceived by layperson readers. Finally, we present a reanalysis of semantic details from previous studies in Section 5.2, which investigates how subdividing the category of semantic details can help us understand more about the types of functions they might serve.

Section 5.1

Introduction

One of the most enduring hypotheses concerning age-related cognitive decline suggests poor performance on a range of cognitive tests can be explained by an inhibition deficit (Hasher & Zacks, 1988). This idea is based on the well-established finding that cognitive control/executive function is impaired in older people (Clarys et al., 2009; Fisk & Sharp, 2004; Lee et al., 2012; Piolino et al., 2010). The inhibition deficit hypothesis has been used to explain why older adults' narratives often contain more "off-topic speech" than younger adults' narratives (Arbuckle & Gold, 1993). In this context, off-topic speech is defined as any speech that relates to something other than the target topic. Given that most AM task instructions require only sufficient recall of episodic event details, the presence of semantic details within an AM narrative might be considered "off-topic". Indeed, Ford et al. (2014) specifically manipulated task instructions to draw attention to the difference between specific episodic memories and more general semantic memories. They found that under instructions to recall more general event details, there was no difference between older and younger adults' memories. In contrast, when participants were instructed to recall only specific episodic events, younger adults recall was more episodic than older adults' recall, suggesting that older adults were less able to comply with the specificity instruction. The age-related increase in recall of semantic details might thus be another by-product of the decline of executive function, or more precisely, another outcome of a specific inhibition deficit. The ability to recall episodic AM details has been linked to performance on executive function tests (Dalgleish et al., 2007; Piolino et al., 2010), but it is not clear whether poor executive function can also explain increases in semantic AM. One obvious prediction of an inhibition deficit hypothesis is that older adults should report more semantic details regardless of

Table 5.1.1

Pearson's partial correlations between semantic recall in different conditions of Experiments 1-3, controlling for age group

Experiment	Conditions	Pearson's *r*
1 (*df*=38)	Baseline—random order	.49***
	Baseline—forward order	.39*
	Random order—forward order	.50***
2 (*df*=37)	Recent AM—age 11-17	.22
	Recent AM—past year	.40*
	Age 11-17—past year	.43**
3 (*df*=33)	Remote—recent	.38*
	Remote—specific	.62****
	Recent—specific	.57****

*p<.05; **p<.01; ***p<.005; ****p<.001

the particulars of the memory task. That is, if older people are unable to suppress the retrieval of semantic information in one AM task, the same should hold true for AMs measured in other tasks, regardless of the retention interval, the type of cue used to elicit the memory, or any other factor.

Table 5.1.1 shows the inter-task correlation of semantic recall in Experiments 1, 2 and 3, as partial correlations controlling for age group. Overall, there tends to be a positive relationship between the number of semantic details recalled across different tasks and/or different conditions of the same task. This suggests that the tendency to recall semantic details is not a transient, task-specific phenomenon, but rather a narrative trait that is relatively stable across recall attempts.

Table 5.1.2

Correlations between Matrix Reasoning and average semantic recall

Experiment	Pearson's *r*
1 (*df*=38)	.14
2 (*df*=37)	.34*
3 (*df*=33)	.33[§]

*p<.05; [§]p=.06

However, it is difficult for this hypothesis to explain the finding that older adults did not report any semantic details in Experiments 4 and 5, when the to-be-recalled events were staged (*Chapter 4*). If semantic recall were the result of faulty inhibition processing then it should be observed to some degree in all tasks, yet when recalling staged events, older adults showed a remarkable capacity to remain focused on the target event.

The inhibition deficit hypothesis would also predict that measures of executive function, and particularly those tapping the inhibition function, should be inversely related to the recall of semantic details. Although we did not include any executive function measures in Experiments 1-3, it is possible to relate the number of recalled details to the raw score obtained on the Matrix Reasoning subtest of the WASI. In this test, participants are presented with a pictorial design consisting of geometric shapes, with one section of the design missing. Five tiles are presented below the main design, each of which contains a different pattern, and the participant must decide which of the five tiles would fit best in the space missing from the main design. In each design there is a latent logical pattern, which involves sequences of shape, colour, size, orientation, and location information, in any combination. Good performance requires the ability to generate complex rules against which the five possible answers can be tested. In order to test these rules, participants must be able to maintain and manipulate information in working memory (for example, mentally rotating images), as well as to inhibit old rules that are no longer relevant. As the test progresses the patterns become more complex and the possible answers frequently vary on only one dimension (e.g. orientation). The participant must therefore be able to inhibit responses that appear at first to be sufficient but in fact do not satisfy all of the rules. Although not a specific measure of inhibition, then, individuals with an inhibition deficit would not be expected to perform well on the Matrix Reasoning test. As can be seen in *Table 5.1.2*, correlations between Matrix Reasoning raw scores (i.e. not adjusted for age) and the average number of semantic details recalled in Experiments 1-3 are generally positive, which poses a problem for the interpretation of semantic recall as the result of a simple inability to inhibit irrelevant information during retrieval.

Another hypothesis is that older adults recall more semantic details because they are compensating for a deficit in episodic recall ability. This is difficult to justify, since an increase in semantic recall can be observed even in the absence of a decrease in episodic recall (Aizpurua & Koutstaal, 2015), and research has shown that the age-related increase in contextualising memory details in narratives occurs in middle age, before the onset of measurable episodic decline (Habermas et al., 2013). Furthermore, if semantic details served to compensate for an episodic deficit, we might expect the recall of semantic details to correlate negatively with the recall of episodic details. As *Table 5.1.3* shows, in Experiments 1-3, on tasks in which episodic and semantic details were measured as separate independent variables there was no clear relationship between them. There was, however, a general positive relationship when recall was averaged across all tasks within an experimental battery. Perhaps the most likely explanation for this relationship is that some participants are simply more talkative than others; whatever the reason it seems clear that the increase in semantic recall does not usually serve a compensatory function.

Table 5.1.3

Correlation between episodic and semantic recall in each task of Experiments 1-3

	Condition	Pearson's *r*
Experiments 1-3 (*df*=114)	Total	.36***
Experiment 1 (*df*=38)	Baseline	.03
	Random order	.12
	Forward order	.04
	Total	.10
Experiment 2 (*df*=37)	Recent AM	.26
	Age 11-17	.05
	Past year	.65***
	Total	.49**
Experiment 3 (*df*=33)	Remote	.04
	Recent	.35*
	Specific	.36*
	Total	.39*
	School	.06
	Work	-.01
	Past year	.62***
	Past month	.05
	Christmas/birthday	.21
	Eating out	.56**

*p<.05; **p<.005; ***p<.001

Interestingly, despite the absence of a systematic relationship between episodic and semantic recall, the association does not appear to be completely random. *Figure 5A* plots episodic—semantic correlations on comparable tasks in different experiments (with different participant samples). These correlations are strikingly similar for self-generated memories from the past year and from school age, although the same does not appear to be true of more recent memories.

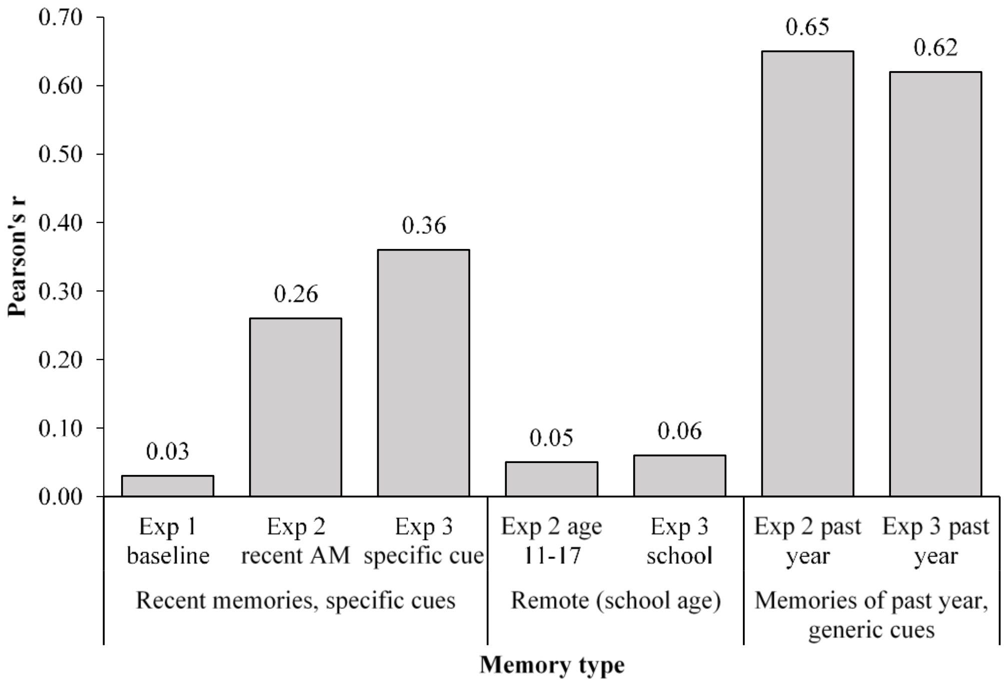

Figure 5A. Correlations between the number of episodic and semantic details recalled in comparable tasks administered in Experiments 1—3, controlling for age group. While the correlations for recently experienced events are somewhat inconsistent, there are striking similarities between correlation coefficients for self-generated memories from school age and the past year.

The accounts considered so far imply that older adults' increased semantic recall is a direct result or by-product of some unconscious process. However, it is possible that the increase in semantic recall in older adults is the product of a conscious decision, perhaps because the goals of communication change over the life span, with emphasis shifting towards personal narrative, reminiscence, and establishing their own identity (the pragmatic change hypothesis; Boden & Bielby, 1986; James et al., 1998), or because of perceived differences between older participants and young adult experimenters (Alea & Bluck, 2003), which may necessitate the provision of extra contextual detail to ensure memory narratives can be understood by the experimenter (hereafter referred to as the shared experience hypothesis).

Similarly to the inhibition deficit hypothesis, the pragmatic change hypothesis does not easily account for differences in semantic recall across different tasks, since a shift towards reminiscence and personal narrative would be expected regardless of the task. In contrast, the shared experience hypothesis predicts that semantic recall will be highest where the amount of perceived shared experience is lowest. This could explain why no semantic details were recalled in Experiments 4 and 5, when the same experimenter was present at both encoding and retrieval. However, another possibility is that these two explanations could be combined – changing communication goals in older age could mean that older adults engage in more narrative modification behaviour, adjusting their narrative more readily to reflect the degree of shared speaker—listener experience. In Experiment 6, we investigate how memories that vary in semantic detail are perceived by an independent group of younger and older adult raters, following a similar study by James et al. (1998). The reasoning behind this study is that if the increase in semantic details reflects a deliberate attempt to improve the quality of the story or to facilitate the understanding of the listener, then memories higher in semantic detail should be rated more favourably than those lower in semantic detail.

Section 5.2

Experiment 6

Perceptions of memory narrative in younger and older adults: Is there a role for semantic detail?

To date there has been little empirical work directly focused on the recall of semantic detail in AM, however a number of studies have examined what is known as “off-topic speech” in younger and older adults’ narratives. Off-topic speech is usually defined as speech whose meaning is not relevant to the topic, or not necessary to answer a particular question (Arbuckle & Gold, 1993; James et al., 1998; Trunk & Abrams, 2009). Most studies of off-topic speech have therefore been concerned with completely irrelevant information, which does not include semantic information that might help to clarify particular aspects of the story. However, semantic information may be considered somewhat off-topic if the task instructions explicitly ask only for episodic information, as is often the case in AM studies.

A number of studies have highlighted differences in older and younger adults’ narrative style, such as an increase in the amount of irrelevant information and corresponding reduction in “information density” among older adults (Juncos-Rabadán, Pereiro & Rodríguez, 2005), age-related decreases in story structure, story quality (Juncos-Rabadán, 1996) and global coherence (Wright, Koutsoftas, Capilouto & Fergadiotis, 2014), and a reduction in “audience design” with age, meaning that older adults are less likely to adapt their speech for particular addressees, such as a familiar conversation partner (Horton & Spieler, 2007). However, older adults also show an increased propensity to relate information to the overarching sense of self (Pasupathi & Mansour, 2006), and are more likely to refer to themselves as the speaker, and to refer to the listener, in their narratives (Allison, Brimacombe, Hunter & Kadlec, 2006). Thus, depending on the experimental aims and the way in which narratives are scored, older adults’ narratives may be rated more or less favourably than younger adults’ narratives.

A study by James et al. (1998) showed that, while older adults produced more off-topic speech than younger adults during recall of autobiographical events, the same was not true for picture descriptions. Moreover, an independent sample of older and younger participants rated older adults' speech as more interesting and more informative than younger adults' speech, despite the increase in off-topic information. The authors argued that this provided evidence for an age-related "pragmatic change" in speech, with different narrative styles in older and younger adults arising from differences in communicative goals (Boden & Bielby, 1983; Giles & Coupland, 1991). In particular, they suggested that older adults placed greater emphasis on finding meaning in their life experiences in favour of simply providing a concise description of the facts. This is consistent with a study by Habermas et al. (2013), which showed that an increase in a measure of "searching for meaning" in the life story was observable from around middle age.

However, Trunk and Abrams (2009) asked older and younger participants to rate their preferences for different types of communicative goals, either expressive/elaborative or objective/concise, and related this to the same participants' narratives on episodic and procedural topics. They found that younger speakers indicated clear preferences for expressive speech when discussing episodic topics, and objective speech for procedural topics, and these preferences predicted the amount of off-topic speech in their narratives. In contrast, older adults' preferences were less clearly defined and did not predict the amount of off-topic speech. Off-topic speech therefore did not appear to reflect older adults' communicative preferences.

As described above, off-topic speech typically means speech that is irrelevant, thus it is not clear whether or how this might relate to the increased recall of semantic AM details among older adults. Two studies distinguished completely irrelevant speech from that which was indirectly relevant (Baron & Bluck, 2009; James et al., 1998). In the study by James et al., indirectly relevant information was not explicitly defined, but in the examples provided in the appendix the category seems to have been applied whenever the participant reflected on the memory in some way. In contrast, Baron and Bluck's (2009) conception of indirectly relevant speech seems to converge more with the type of semantic memory investigated in the present thesis (e.g. background information and other supplemental information from similar events). In their study, Baron and Bluck asked participants to rate older and younger adults' specific autobiographical memories. Only completely irrelevant information was more prevalent in older adults' autobiographical memories, and it was present in the speech of only a minority of older adults. There was no age difference in the amount of indirectly relevant information reported, and the neither amount of indirectly relevant nor completely irrelevant information predicted ratings of story quality when other factors were taken into account. Interestingly, younger adults' memories were rated as more interesting than older adults' memories, and the level of episodic detail (i.e. place, time, perceptual, emotion/thought details) and rated personal significance of the memories were the best predictors of story quality.

The results of previous research are somewhat in conflict, then, although episodic detail, rater age and the amount of off-topic speech all ostensibly affect the quality of an autobiographical story in some way. It is not clear how the relative proportions of different detail types (rather than the total number or rating) might affect how memories are perceived, but this is an important consideration given that an increase in off-topic speech presumably reduces the proportion of episodic (i.e. on-topic) information contained in a narrative.

To our knowledge, no studies have yet evaluated how semantic memory details are perceived within autobiographical narratives, independently of the age of the speaker. In the present study, we therefore aimed to explore perceptions of semantic autobiographical recall in a fully factorial design. The autobiographical memories selected for inclusion in the present study were taken from Experiment 3, in which participants were asked to recall specific events – here we used memories from school and memories of the previous Christmas in order to standardise the material. Although older adults typically recall more semantic details than younger adults, in this study we used younger and older adults' memories that were either low or high in the proportion of semantic detail, which allowed for the analysis of the effect of speaker age independently of the effects of semantic detail, as well as any interactions between the two. We also explored rater-age differences in how the memories were perceived.

If older adults' propensity to recall semantic information during autobiographical tasks reflects a pragmatic shift towards communicating meaning, consistent with the view of James et al. (1998), then memories with a higher proportion of semantic details should be rated more favourably than memories with a low proportion of semantic details. On the other hand, Baron and Bluck's (2009) findings show that memories with more episodic detail are considered better stories. If this is so, then memories with a lower proportion of semantic details (and consequently a higher proportion of episodic details) should be rated more favourably. Alternatively, James et al.'s (1998) findings that older adults' stories were preferred over younger adults' stories may not relate at all to the distinction between episodic and semantic detail, in which case we may find effects of the speaker's age independent of semantic content. This would be the case if some other feature of older adults' speech accounted for the more favourable ratings for older adults, and this could prove problematic for the pragmatic change hypothesis since it would imply no communicative benefit afforded by the recall of semantic details.

Method

Design. A 2 (rater age: young vs. older) x 2 (proportion of semantic details: high vs. low) x 2 (speaker age: young vs. older) mixed factorial design was employed, with proportion of semantic details and speaker age as repeated measures factors. In each condition (young adult high semantic, young adult low semantic, older adult high semantic and older adult low semantic), participants rated one memory of a day from school and one memory of the previous Christmas day, thus eight memories were rated in total. For analysis, ratings were averaged across the two memories in each condition.

Participants. Twenty young (age 18-32, M=28.8, SD=2.93; 13 female) and 21 older adults (age 61-79, M=70.76, SD=4.83; 13 female) participated online in return for a £5 gift voucher. The number of years of formal education each participant had received was recorded as a proxy for IQ. There was no significant difference in years of education between young adults (M=16.20, SD=2.12) and older adults (M=16.62, SD=9.53; $t(39)$=.19, p=.85).

Table 5.2.1

Number of words and total details, and proportion of semantic details averaged across the two memories in each experimental condition

		Word count	Total details	Proportion semantic
Young speaker	High semantic	344.50	41.00	0.42
	Low semantic	474.50	40.00	0.09
Older speaker	High semantic	336.50	40.50	0.65
	Low semantic	379.50	38.50	0.20

Materials & Procedure. The memories selected for this experiment were a subset of eight memories that were recalled by participants in Experiment 3. Four of these memories described an event that happened while the participant was at school, and the other four described what the participant did the previous Christmas day. The proportion of semantic details in each memory was calculated by dividing the number of semantic details by the total number of details reported in each memory. To select memories for inclusion in the present experiment, those with the highest and lowest proportion of semantic details were identified, and then working through the list, pairs of young adult and older adult memories were identified in which the total number of details was the same or similar. The decision was made to keep the total number of details similar to avoid the possibility that raters would inadvertently rate more detailed memories as more interesting simply because they contained more information. It should be noted that the total number of details was a separate measurement from the word count (see *Table 5.2.1*), which measures participant verbosity rather than information content. The resultant memories were therefore those with the highest and lowest proportion of semantic details for which a similarly detailed counterpart could be found among the memories recalled by the other age group. The average number of total details in the memories was equated across conditions, so that only the proportion of semantic details varied (see *Table 5.2.1*). The questionnaire completed by the independent sample of raters was presented on an online platform that allowed participants to remain anonymous. Participants rated each memory on 12 different dimensions (*Table 5.2.2*) using a 7-point Likert scale. The first six questions were the same as the questions asked by James et al. (1998), and asked about the quality of the story in terms of information content and the clarity and focus with which it was told. The remaining six questions addressed some of the

Table 5.2.2
List of questions asked about each of the eight memories, and their short-form notation

Question	Notation
Was the story interesting?	Interesting
Was the story informative?	Informative
Was the story clear and easy to follow?	Clear/Easy
Did the speaker stay focused on the title?	Title-focus
Was the speaker talkative?	Talkative
Was it a good story?	Story quality
How emotive was the story?	Emotion
To what extent did the speaker try to ensure that the listener could follow the story?	Understanding
To what extent was shared knowledge between the speaker and the listener assumed?	Shared knowledge
To what extent did the speaker reflect on what he or she was saying?	Reflection
To what extent did the speaker focus on just the facts?	Fact-focus
How well do you think the speaker could remember the event?	Memory

hypotheses about the role of semantic recall in autobiographical narratives introduced at the beginning of this chapter. Specifically, raters were asked additional questions about whether the story was simply factual (*Fact-focus*) or displayed an element of "search for meaning" (*Reflection* and *Emotion*; Habermas et al., 2013), and whether or not the speaker tried to ensure the listener understood (*Understanding*) or assumed that there was shared knowledge or experience between the speaker and listener (*Shared knowledge*). Raters were also asked to judge how well they believed that speaker remembered the event (*Memory*). The order of presentation of the memories was randomised, but the order of questions was constant across participants and memories in order to keep the task as straightforward as possible. The task took approximately 30 minutes to complete.

Results

Following the procedure used by James et al. (1998), separate ANOVAs were carried out for each of the 12 ratings. The proportion of semantic details (high vs. low) and the age of the speaker (young vs. older) were entered into the ANOVA as repeated measures factors, and the age of the rater (young vs. older) was entered as a between-subjects factor. The following results are presented as answers to our main research questions.

Proportion of semantic details. Memories that were lower in semantic detail were rated as more interesting (*M*=3.86 vs. 3.58; $F(1,39)=4.61$, $p=.04$, $\eta_p^2=.11$), more informative (*M*=4.34 vs. 4.02; $F(1,39)=5.75$, $p=.02$, $\eta_p^2=.13$), clearer and easier to follow (*M*=4.60 vs. *M*=4.07; $F(1,39)=13.17$, $p=.001$, $\eta_p^2=.25$), more title-focused (*M*=4.90 vs. *M*=4.58; $F(1,39)=6.03$, $p=.02$, $\eta_p^2=.13$), more reflective (*M*=3.90 vs. *M*=3.62; $F(1,39)=5.90$, $p=.020$, $\eta_p^2=.13$), more fact-focused (*M*=4.18 vs. *M*=3.84; $F(1,39)=9.23$, $p=.004$, $\eta_p^2=.191$), better remembered (*M*=5.18 vs. *M*=4.48; $F(1,38)=41.47$, $p<.0005$, $\eta_p^2=.52$), more emotive (*M*=3.97 vs. *M*=3.38; $F(1,39)=20.05$, $p<.0005$, $\eta_p^2=.34$), and better stories (*M*=3.66 vs. *M*=3.33; $F(1,39)=5.83$, $p=.021$, $\eta_p^2=.13$) than memories with a higher proportion of semantic detail.

Speaker age. Older speakers' memories were rated as more interesting (*M*=3.86 vs. *M*=3.58; $F(1,39)=4.61$, $p=.04$, $\eta_p^2=.11$), more informative (*M*=4.38 vs. *M*=3.97; $F(1,39)=8.29$, $p=.006$, $\eta_p^2=.18$), more fact-focused (*M*=4.26 vs. *M*=3.76; $F(1,39)=14.48$, $p<.0005$, $\eta_p^2=.27$), and better remembered (*M*=5.03 vs. *M*=4.63; $F(1,38)=10.09$, $p=.003$, $\eta_p^2=.21$) than younger speakers' memories.

Rater age. Older adults rated memories higher on attempts by the speaker to ensure the listener's understanding (*M*=4.27 vs. *M*=3.61; $F(1,39)=7.20$, $p=.011$, $\eta_p^2=.16$), shared knowledge (*M*=4.11 vs. *M*=3.29; $F(1,39)=5.49$, $p=.024$, $\eta_p^2=.12$) and fact-focus (*M*=4.61 vs. *M*=3.41; $F(1,39)=17.99$, $p<.0005$, $\eta_p^2=.32$). There was also a trend that approached significance for the older adults to rate memories as maintaining more title-focus (*M*=5.02 vs. *M*=4.45; $F(1,39)=3.83$, $p=.06$, $\eta_p^2=.09$).

Interactions. Two of the main effects were qualified by two-way interactions between speaker age and the proportion of semantic details (reflection ($F(1,39)=9.40$, $p=.004$, $\eta_p^2=.19$), memory ($F(1,38)=7.35$, $p=.010$, $\eta_p^2=.16$)). Young adults' memories that were lower in semantic details (*M*=4.05, *SD*=1.01) were rated as more reflective than those that were higher in semantic details (*M*=3.33, *SD*=1.33; $t(40)=4.08$, $p<.0005$), but for older speakers the level of semantic detail did not affect reflection ratings ($t(40)=.84$, $p=.41$; *Figure 5B,* panel *A*). Older speakers were rated as remembering the event better when their memories contained less semantic detail

(M=5.56, SD=.87) compared to more semantic detail (M=4.50, SD=1.02; $t(40)=6.66$, $p<.0005$), but for younger speakers the amount of semantic detail was not related to memory ratings ($t(39)=1.54$, $p=.13$). These results suggest that semantic details are perceived differently in older and younger adults – in particular, they appear to be associated with poorer perceived memory in older adults, and poorer reflection in younger adults.

Re-coding semantic details. The interactions described above raised the possibility that younger and older adults use semantic details in different ways. Semantic details within autobiographical narratives typically form a heterogeneous category including autobiographical knowledge, repeated or extended events, general knowledge and information about routines (Renoult et al., 2012). To investigate possible age differences within the sample of 8 memories included in this study, the semantic details were re-coded into different subcategories. The subcategories covered six broad themes: Scene-setting, character development, environmental development, repeated activities, facts, and common reference. The coding protocol and examples are provided in *Appendix 5A.* In total, older adults' narratives contained 60 semantic details and

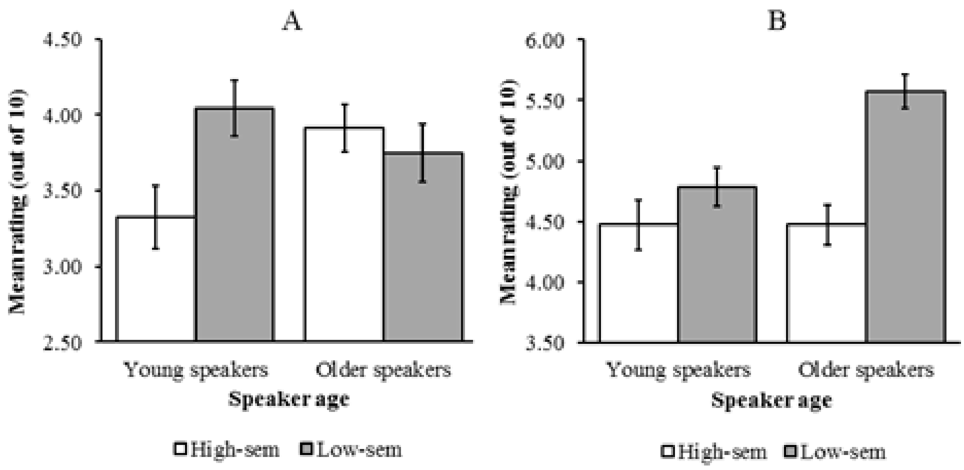

Figure 5B. Two-way interactions between speaker age and the proportion of semantic details for ratings of Reflection (A) and Memory (B).

younger adults' narratives contained 39. *Figure 5C* shows the percentage of each type of semantic detail for each age group. There were not enough data to compare older and younger adults statistically on each subcategory, but visual inspection suggests the majority of semantic details reported by younger adults provided information about characters (which included the speaker themselves), while older adults seemed to use semantic details for a wider range of functions, including describing the environment, setting the scene, and sharing facts with the listener.

Reliability and principal components analysis. We next conducted a reliability analysis to test the reliability of the questionnaire as a general measure of story quality. To avoid averaging responses to questions across repeated measures conditions, we instead created a separate data file in which each question was represented by a single column containing rating data for each memory. This meant that each participant was represented eight times in the dataset. While this was not ideal, it was consistent for all participants and allowed an estimate of reliability to be calculated without losing information by averaging across conditions[20]. The reliability analysis found an overall Cronbach's α of .88. Two items (how talkative was the speaker/to what extent was shared knowledge between speaker and listener assumed) were flagged as potentially equivocal because Cronbach's α remained the same or increased if they were deleted. We next conducted a principal components analysis to examine the structure of the questionnaire in more detail and to establish whether the flagged items should be omitted. Three factors were extracted, explaining a total of 64.38% of the variance in responses. *Information transfer* reflected how informative, clear and easy to follow, title-focused, fact-focused and well-remembered the stories were, as well as the extent to which the speaker tried to ensure the understanding of the listener. *Entertainment* reflected how interesting and emotive the stories were, and the extent to which they were considered "good stories". A third construct, *social/interpersonal*, contained only the two flagged items: ratings of how talkative the speakers were and the extent to which shared knowledge between the speaker and listener was assumed. Factor loadings of <.50 were omitted from the analysis, and reflection did not load sufficiently highly onto any factor. We next checked the reliability of the individual subscales. *Information transfer* had an internal reliability score of α = .85 and the mean item-total correlation was .64, *Entertainment* α = .87 and mean item-total

[20] To check for differences, we also ran these analyses on the data averaged across conditions, with each participant therefore represented by a single row. We achieved a similar overall reliability score (α = .91). The factors were similar to those reported above, with the exception that reflection loaded roughly equally onto the first and third factors. Together, the three factors explained 73.93% of the variance. Although these statistics seem to improve on those reported above, the method above was favoured for ease of interpretation, since it did not involve averaging across multiple observations.

correlation was .74, and *Social/interpersonal* α = .39, and mean item-total correlation was .26. This result suggested that the *social/interpersonal* construct was not well-represented by the questionnaire, thus leaving two main aspects of memory, Information and Entertainment, that were reliably assessed.

Since we were interested in potential differences in the way older and younger raters perceived the memories, we next split the file by rater age group and ran the reliability and principle component analyses again. For the younger raters, there was an overall reliability of α = .78, with four factors explaining 67.32% of the variance. Principal components analysis revealed an *Entertainment* factor (α = .81, mean item-total correlation = .63), comprising how interesting, emotive, and reflective the speakers were, and whether or not the memories were considered a "good story". There was also a *Memory Detail* factor (α = .60, mean item-total correlation = .42) which reflected how informative and talkative the speakers were, and how well they remembered the events. A third factor that emerged was *Clarity/focus* (α = .57, mean item-total correlation = .38), which reflected the extent to which the story was clear and easy to follow,

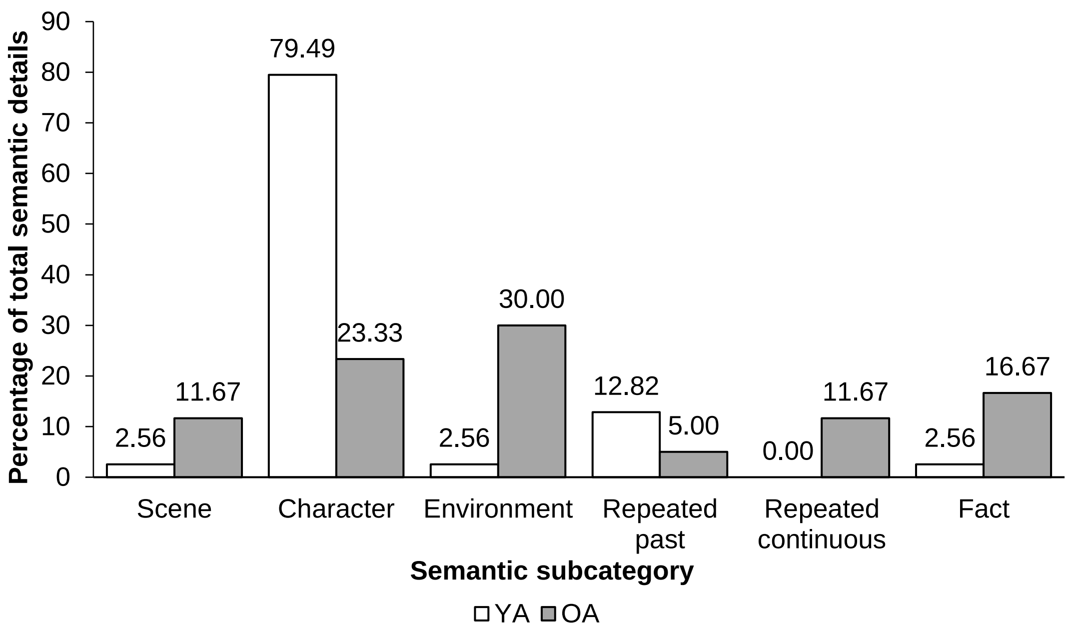

Figure 5C. Percentage of total semantic details reported in each subcategory, as a function of age group. More than three quarters of the young adults details described story characters in more detail, while the semantic details recalled by older adults seemed to be more varied, including descriptions of the physical environment, routine information and facts.

title-focused and fact-focused. The fourth factor comprised the extent to which the speaker was judged to ensure the understanding of the listener, and a negative loading for the amount of perceived shared knowledge between speaker and listener. Perceived shared knowledge was reverse coded as a positive value, and this fourth factor was therefore taken to represent *speaker—listener dynamics* ($\alpha = .53$, mean item-total correlation = .36).

The older adults' ratings were somewhat more reliable, with an overall α of .92, but only two factors explaining 65.31% of the variance. A *Story quality* factor ($\alpha = .91$, mean item-total correlation = .77) comprised how interesting, informative, clear and easy to follow, and emotive the stories were, and how good the stories were judged to be. *Story content* ($\alpha = .83$, mean item-total correlation = .61) reflected how title-focused, fact-focused, talkative and reflective stories were judged to be, as well as how well the speaker was judged to have remembered the event, and the extent to which shared knowledge between speaker and listener was assumed. Perceptions of the extent to which the speaker tried to ensure the understanding of the listener loaded roughly equally onto both factors. Comparison of the factor analyses for younger and older adults suggests differences in the way each group perceived the memories, or at least differences in the way the task was approached by each group. In particular, older adult raters seemed to distinguish between how engaging the stories were for the listener, and the more objective content of the stories (i.e. *what* speaker said, and *how* they said it). In contrast, the approach of younger adult raters seemed to be more complex, distinguishing how engaging a story was from the amount of information the stories contained, and how focused the recollections were. Perhaps the most notable distinction for the present purpose is that older adults' ratings did not seem to reflect any preference for concision (i.e. focus, talkativeness, memory and reflection all loaded onto the same factor), which suggests that the criteria by which title-focus and fact-focus were judged may have been more relaxed in the older group.

Discussion

The present experiment set out to explore the possible function of semantic details in autobiographical memory, since older adults reliably recall more of these details in autobiographical tasks despite instructions to recall only specific events (Ford et al., 2014). We tested the hypothesis that semantic recall within autobiographical narratives serves the purpose of improving story quality, which could provide support for the pragmatic change hypothesis. The results showed that, conversely, narratives containing a high proportion of semantic details were rated less favourably than memories that were low in semantic details, independent of the age of the speaker or the age of the rater. In particular, memories that were lower in semantic detail were rated as more interesting, more informative, clearer and easier to follow, more title-focused, more fact-focused, better stories and the speakers of such memories were rated as reflecting more on what they were saying. These findings overwhelmingly suggest that semantic details do not serve to improve the quality of communication, and instead memories that contained a higher proportion of episodic detail were rated more favourably. This is broadly consistent with the results of Baron and Bluck (2009), who showed that memories higher in episodic detail were rated higher on a global story quality index. We therefore found no support for the pragmatic change hypothesis in relation to semantic recall in AM.

The results also showed that older speakers were rated as more interesting, more informative, more fact-focused and as remembering the events better than younger adults, independent of the proportion of semantic details. However, it is important to note that older adults typically recall more semantic details than younger adults, thus taken together with the findings above, the propensity to recall more semantic details could offset overall age-related gains in story quality ratings.

There were also rater age effects on ratings of focus, shared knowledge and understanding, with older adults giving higher scores. This may reflect a shift in criterion level with increasing age, such that the criteria by which older adults judge these factors are more lenient. It is possible, therefore, that older adults deem semantic recall to be more relevant to autobiographical recall tasks than younger adults do. The absence of an interaction between rater age and semantic details suggests that the rater age effects are not specific to highly semantic memories, however, and the overall pattern of episodic preference for story quality remains. It is also possible that rater-age effects reflect differences in the comprehension of the transcripts. A number of studies have shown that older adults' retain the capacity to process, update and remember higher-order meaning in text samples, at the expense of more surface-level features (e.g. Bailey & Zacks, 2015; Radvansky, 1999; Radvansky & Dijkstra, 2007) and one study found that older adults outperformed younger adults on a theory of mind task involving abstracting implied meaning from written texts (Happé, Winner & Brownell, 1998; but see Sandoz, Démonet & Fossard, 2014). Thus, it could be that older adults rated understanding and perceived shared knowledge as higher because of an increased tendency to infer meaning from the stories.

In this study we also examined the way the questions were interpreted by older and younger raters, by way of exploring the relationships between ratings. While both groups appeared to identify a measure of how engaging the story was for a listener, some interesting differences were observed. For younger raters, the content of the story appeared to be measured along two constructs – detail and focus/clarity, while for older raters there seemed to be no such distinction. In addition, younger raters seemed to identify speaker/listener dynamics as a separate construct (i.e. the extent to which the speaker/listener relationship affected the story), while for older adult raters this merged into the general construct of story content.

These differences suggest that the concept of focus may be interpreted differently by older and younger adults, which is consistent with differences in focus ratings observed in this experiment and the study by James et al. (1998). Age differences in the interpretation of focus in speech may explain in part why older adults' memories consistently contain more semantic detail in autobiographical recall tasks (Aizpurua & Koutstaal, 2015; Levine et al., 2002; also Experiments 1-3 in this thesis), as well as increased verbosity and more off-topic speech (Arbuckle & Gold, 1993; James et al., 1998). What is often considered a failure to inhibit irrelevant information may instead reflect that older adults are not trying to inhibit such information, because they do not consider it to be irrelevant.

In the small sample of memories included here, younger and older adults tended to use semantic details differently. Four fifths of the younger adults' semantic details provided further detail about characters within the story, either the speaker or someone else, in contrast to less than a quarter of older adults' semantic details. The function of older adults' semantic details was more varied, and this could have contributed to the observed interactions between the age of the speaker and the proportion of semantic detail the memories contained. Because of the small sample involved here it is not possible to draw conclusions, but in *Section 5.3* we investigate the subdivision of a larger number of semantic details from Experiments 2 and 3.

Semantic details remain a consistently-reported feature of older adults' autobiographical memories, despite no clear reason for their inclusion under instructions to recall specific, one-off events. Previous findings have questioned the inhibition deficit hypothesis, since older adults appear able to inhibit irrelevant information when the task is not autobiographical or when the described event is not from real life (as in Experiments 4 and 5; see also Baron & Bluck, 2009, and James et al., 1998, for comparisons of off-target speech in autobiographical and non-autobiographical tasks). This study found no evidence for a communicative benefit of semantic details, and in fact memories that were lower in semantic details were rated as better-communicated overall.

Section 5.3

Reanalysis

Subdividing semantic details in autobiographical memory reports

The analyses presented in Experiment 6 suggested that semantic autobiographical memory may be used and perceived differently by younger and older adults. In the introduction to this chapter it was also shown that the relationship between episodic and semantic recall is complex. Although in the most general terms (i.e. averaging across multiple tasks and experiments) there is a positive correlation between the two, the magnitude of the association varies from task to task. These apparently erratic findings at first may make it seem as though the production of semantic recall within AM narratives is random. However, when comparing similar tasks across different experiments, the relationship between episodic and semantic recall appears to be surprisingly stable. It is difficult to conceive of a memory system that is able to account for the pattern of semantic recall observed thus far, without further consideration of the possibility that semantic detail, as it is measured in AM tasks, measures more than one type of memory representation (e.g. Renoult et al., 2012).

To begin with, it seems likely that the type of semantic details will vary according to the type of event that is recalled. For example, in a memory test in which participants are told precisely which event to recall (e.g. *Going out for lunch last Tuesday*), it is possible that specific memory failures will occur, in which case semantic information may serve to support episodic recall or to "fill in the blanks" (e.g. *Usually when I meet friend X we go to restaurant Y*). In contrast, such specific memory failures are less likely to be a problem when participants are free to self-select events, since any memory failure could be bypassed simply by selecting an alternative event. In addition, very remote events may require more contextualisation (e.g. *In those days school teachers were strict*) than more recent events, and events that were repeated multiple times (e.g. *sitting on the back row in science class*) may be more difficult to separate from one another than highly novel experiences (e.g. one's own wedding day, or the birth of a child). The former may thus be characterised by the recall of repeated event details. If semantic details serve a range of functions in AM then it will be useful to understand how they are employed in different tasks.

The next issue is that, in attempting to classify semantic details as a single category, separate from and opposed to episodic details, the task feels intuitively difficult. Some types of semantic detail are closer to episodic memory than others. Take, for example, the case of repeated event memories. The conventional criteria for classifying an AM as episodic are that it describes (1) a single, specific event, (2) lasting less than a day, and (3) situated in time and space (Holland et al., 2012; B. Levine et al., 2002; Matuzewski, Piolino, de la Sayette, et al., 2006; McDonough & Gallo, 2013; Piolino et al., 2002; 2006). While some semantic details (e.g. *John is my brother*) satisfy none of these criteria, memories of repeated activities satisfy both the second and third points. The example, "We used to play on the beach when we went on holiday", is situated in time and space and describes individual events lasting less than a day, but it is not unique. A difficult question, then, is what happens to the memory of an event that has been experienced more than once. According to the strict criteria outlined above, just two experiences of the same event context (e.g. visiting the same restaurant twice) would mean that memory of that context (the layout of the restaurant, what was on the menu, etc.) is considered to be semantic, regardless of whether detailed memories of the two experiences can be easily retrieved. That is, regardless of how an individual actually experiences the memory, the above criteria dictate that the very fact that they have had a similar experience before means that the details shared by both events cannot possibly be episodic. It is difficult justify a single category of semantic details broad enough to include both details of this type, and highly abstracted general knowledge.

Renoult et al. (2012) highlighted this heterogeneity problem of "personal semantics" in a review. They suggested either a continuum of episodic—semantic memory, along which different types of personal semantic details lie, or a component process approach, in which different types of personal semantic details share different subsets of components with episodic and semantic memory. The key point is that both of these approaches require that the category of personal semantics be subdivided to reflect differences in, for example, the perspective of the rememberer, and the availability of sensory details. Recognition of this issue seems to be gaining traction (e.g. Coronel & Federmeier, 2016; Grilli & Verfaellie, 2014, 2016; Rubin & Umanath, 2015), and may help to elucidate the apparent "semanticisation" of older adults' memories, as well as the relationship between episodic and semantic recall.

In what follows, we re-analyse details from the both recent AM task and the AI (lifetime periods) task from Experiment 2. The aim is to explore the effects of age and recall task on the subcategories of semantic detail reported.

Method

Design. The present analysis used a 2 (task: recent AM vs. AI) x 2 (age group: younger vs. older) mixed design, with task as the repeated measures factor. The dependent variables were the number of details in each subcategory of semantic details, which were treated as independent. Separate analyses were therefore carried out for each of the following categories: scene-setting, characters, environment, repeated past, repeated continuous, historical fact, and contemporary fact. Detailed information on these subcategories, including the coding strategy, is presented in *Appendix 5A*.

Participants. The participants in this study were the same as those described in Experiment 2. Twenty older and 20 younger adults were recruited and tested, but as in Experiment 2, the analysis reported here includes only data from an IQ-matched subsample of the original participants. Thus, the sample of memories analysed in this study came from 17 younger and 16 older participants.

Materials & procedure. This experiment consisted of a reanalysis of data collected in Experiment 2. In the AI task there were two memories for each participant – one from the previous year and one from between the ages of 11 and 17. The original intention was to analyse these memories separately, however the relatively small number of semantic details that were reported meant that this was not possible. The recent AM task included four memories per participant, which were prospectively sampled by the participants using an event diary completed two weeks prior to recall.

For each memory transcript, the semantic details were identified (using the data from Experiment 2) and re-classified according to the coding protocol set out in *Appendix 5A*. The semantic subcategories were: scene setting (e.g. situating the event in time and space), character descriptions (including descriptions of the speaker themselves), environmental descriptions, repeated or extended past activities (i.e. temporally abstracted event memory), repeated or extended continuous activities, historical facts, and contemporary facts. These seven categories accounted for all of the semantic details in both tasks.

Results

In the sample of memories included in this study, older adults reported more semantic details than younger adults in the recent AM task (M_{older}=32.10, *SD*=21.72; $M_{younger}$=9.95, *SD*=6.82; $t(31)=4.35$, $p<.0005$), but there was no difference in the total number of details recalled in the AI task (M_{older}=15.00, *SD*=11.20; $M_{younger}$=10.94, *SD*=12.60; *t*(31)=.98, *p*=.34). The number of details in each semantic subcategory is presented in *Figure 5D.*

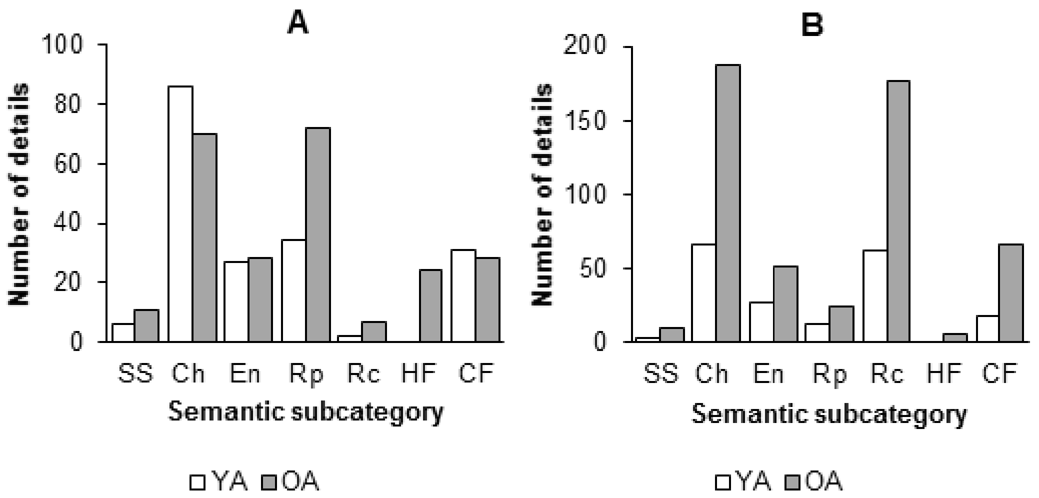

Figure 5D. Total (unadjusted) number of details recalled by younger and older adults in each semantic subcategory, in the lifetime periods task (A), for which two memories were recalled, and the recent AM task (B), for which four memories were recalled. *Note.* SS = scene-setting, Ch = character details, En = environment details, Rp = repeated/extended past event details, Rc = repeated/extended continuous event details, HF = historical facts, CF = contemporary facts. See *Appendix 5A* for further information and examples of these subcategories.

We conducted separate loglinear analyses on the number of details recalled in each of the semantic subcategories, with age group and task as independent variables. However, because participants recalled four memories in the recent AM task and only two memories in the AI task, we adjusted for this difference by dividing recent AM scores by two. In addition, as there were only 16 participants in the older group but 17 in the younger group, older adult scores were divided by 16 to give an average individual score, which was then multiplied by 17 to give a score comparable to the younger adult sample. The adjusted data and loglinear results are presented in *Table 5.3.1*. There were effects of both age group and task on the number of temporally abstracted details recalled, with more repeated past details recalled in the AI task and more repeated continuous details recalled in the recent AM task. Older adults recalled more of both types overall. There were also effects of both age and task on the number of historical facts reported. Older adults recalled more historical facts than younger adults, and historical facts were more likely to be recalled in the AI task than in the recent AM task. There was a significant task by age interaction in the number of contemporary facts and character details recalled. Older adults recalled more contemporary facts (χ^2 =15.36, *df*=1, *p*<.0005) and character details (χ^2 =32.51, *df*=1, *p*<.0005) on the recent AM task, but there was no difference between groups for either measure (both χ^2<1) on the lifetime periods task. There was also a small effect of task on the number of scene-setting details recalled, with more in the lifetime periods task.

Discussion

The present analysis sought to characterise semantic details within autobiographical recall in terms of the function they serve, in order to gain a better understanding of how older and younger adults use these details in different types of memory. The most striking difference

Table 5.3.1

Number of details belonging to each semantic subcategory

	Recent AM task		AI task		χ^2 (*df*=1)		
Semantic subcategory	Young	Older	Young	Older	Task	Age	Task*age
Scene setting	1.50	5.31	6.00	11.69	**5.00***	3.78	.34
Character	33.50	99.88	86.00	74.38	n/a	n/a	**25.13*****
Environment	14.00	27.63	27.00	29.75	2.33	2.74	1.94
Repeated past	6.00	13.28	34.00	76.50	**70.85*****	**19.59*****	.001
Repeated continuous	31.00	94.03	2.00	7.44	**118.06*****	**36.55*****	.06
Historical fact	0.00	3.19	0.00	25.50	**19.74*****	**39.77*****	.00
Contemporary fact	9.00	35.06	31.00	29.75	n/a	n/a	**10.57****

***p<.0005; **p<.005; *p<.05

Note. Values in the recent AM column were divided by 2 to adjust for the number of events recalled in this task. Older adult (*n*=17) values were subsequently divided by 17 and then multiplied by 16 to enable direct comparison with the younger adult group (*n*=16).

concerned the recall of temporally abstracted information, which was higher among older adults. Temporally abstracted details are those which describe repeated or extended events, and can either be continuous (i.e. still ongoing at the time the memory is retrieved) or past (i.e. pertaining to a particular period of time in personal history). Perhaps unsurprisingly, temporally abstracted past details were more common in the lifetime periods task, in which the recalled events were more temporally remote, while temporally abstracted continuous details were more likely to be recalled in the recent AM task, in which the recalled memories were just two weeks old. Both types of detail can provide background information to situate the to-be-remembered event within a meaningful context, but it is not clear why older adults should contextualise specific events more than younger adults. It seems more likely that the increase in temporally abstracted details reflects either a shift towards greater schematic representation in the older group (i.e. focusing on the similarities rather than the differences between events), or a self-initiated strategy for retrieval support (i.e. generating a schematic framework within which specific episodic details can be recalled). In the general discussion for this chapter we consider these possibilities in greater detail.

The results showed that the number of historical facts was higher for older adults, and greater in the lifetime periods task than in the recent AM task. In the lifetime periods task, participants recalled one memory from the previous year and one memory from age 11-17. It is likely that the increase in historical facts in this condition reflects a particular type of historical contextualisation, for example, explaining what things were like 50 years ago, in order to ensure the story makes sense to a young adult listener. Thus, the recall of historical facts within AM narratives probably increases as a function of retention interval. Historical facts recall may be higher among older adults because their memories were, on average, older.

There was also an interaction between task and age group for character details and contemporary facts. In both cases, older adults' recall was higher in the recent AM task but there was no difference in the lifetime periods task. However, it also seemed to be the case that younger adults recalled particularly few of these detail in the recent AM task, rather than older adults recalling a particularly high number. The reporting of facts within a narrative suggests that the speaker assumes themselves more of an authority on a given subject. This is understandable in the context of AM narratives given that speakers are talking about their own lives. Thus, it may be that in the recent AM task the younger adults assumed that the similarly-aged experimenter already has some knowledge of the subjects discussed. Interestingly, in the lifetime periods task younger adults reported more factual information than in the recent AM task, possibly indicating that in the lifetime periods task the experimenter was not assumed to have prior knowledge of the subject. This might be because the reported events were situated within contexts that varied more from the spatial and temporal context of the test session, or of the current lifetime period, than did the everyday events.

It is not immediately obvious why young adults should describe their story's characters in less detail than the older adults in the recent AM task. Some studies (e.g. Habermas et al., 2013) have shown that an increase in "search for meaning" in autobiographical memory starts to be observable in adults from around middle age, which may suggest that character descriptions (including those relating to the speaker him/herself) reflect the speaker's attempts to ground recall within a meaningful context (e.g. I went to the museum with Tom *because he's particularly interested in Roman history*). However, in the lifetime periods task there was no difference in the number of character details recalled by each group.

It is possible that the characters involved in the older adults' stories (including the speakers themselves) were better known to the speakers, for example if the story characters had been involved in longer relationships (e.g. old friends or family members vs. relatively new friends met at university). This may be particularly the case if the characters in older adults' stories were part of a network of friends and family that were interrelated, therefore information about the characters may have been more available. Younger adults may not yet have acquired such a close-knit social network. Alternatively, older adults' memories may simply focus more on social aspects of events, if they prioritise emotionally meaningful social interactions (Carstensen, 1995; Pasupathi & Carstensen, 2003).

The subdivision of semantic recall in this experiment highlighted some interesting differences in the way semantic memory is incorporated into autobiographical narratives depending on the type of memory or event, and the age of the participant. There are a number of hypotheses concerning the role of semantic recall, which in previous studies have been difficult to investigate. The results of the present analysis suggest that part of the problem in interpreting the results of studies that measure semantic recall may be the heterogeneity of the category. The semantic details investigated here belong to a category with a narrower definition than has been used in some previous studies. For example, in B. Levine et al.'s (2002) "external" category, along with semantic details the authors included repeated event details and also details that were linked to one specific context, but just not the event in question. As is the case generally in AM research, interpretation of previous findings may therefore be hindered by the lack of consensus regarding the best methodological approach, and how to operationalise key concepts. In the final section of this chapter, we review some of the ideas covered so far, linking the present findings to research from related fields, and finally we outline a framework for understanding schematic memory and how it relates to specific event memory.

Chapter 5 Discussion

In this chapter, we investigated some of the possible functions semantic details serve within AM narratives. Although the recall of semantic details appears to be relatively stable across different tasks at the level of the individual, the relationship between semantic details and episodic recall varies. For some tasks there is a strong positive correlation between episodic and semantic details, while for other tasks there is no observable pattern at all. Interestingly, though, the magnitude of the relationship seems to be replicable, which suggests that semantic recall is more than just a random by-product of recalling specific events.

In the introduction to this chapter, a number of hypotheses were outlined concerning the common (but not without exception) finding that older adults recall more semantic autobiographical details than young adults. The evidence presented so far has led us to conclude that older adults' semantic recall does not primarily represent a generalised inability to inhibit irrelevant information, since the age-related increase in semantic detail is not observed in all tasks or under all conditions. Nor does it appear to reflect a general pragmatic change in older adults' communication goals, since Experiment 6 found that memories containing more semantic information were rated comparatively poorly by both younger and older adults. In addition, if older adults included semantic details in order to make their stories more interesting or comprehensible, presumably they would do so consistently across all tasks. At least in the case of retrospectively sampled memories, recall of semantic details cannot be considered to compensate for a deficit in episodic memory, since individuals who report more semantic details on such tasks also recall more specific event information. In prospectively sampled recent memories, there appears to be no relationship between episodic and semantic recall, and none of the tasks employed was associated with an inverse relationship, as might be expected if semantic details were compensatory.

Importantly, however, the fact that semantic details can be subdivided into smaller, more coherent categories challenges the practice of including all details together in a single heterogeneous group. In support of a subdivision, Renoult et al. (2012) proposed two options: either a continuum of ‘personal semantics’ (i.e. semantic information pertaining to the self), at one end similar to typically episodic memory, and at the other similar to general (i.e. non-personal) semantic details, or a component process explanation, in which different types of personal semantic details engage different combinations of processes – some overlapping more with episodic memory and others overlapping more with general semantic memory. Using evidence from neuropsychological, neuroimaging and cognitive studies, they argued that some personal semantic details, such as information about repeated events, are likely to be mediated by episodic memory. For example, medial temporal lobe lesions disrupt memory for both single and repeated events (St-Laurent, Moscovitch, B. Levine & McAndrews, 2009) and Rubin, Schrauf and Greenberg (2003) found little difference in the way memories of single and repeated events were rated by participants at the time of retrieval – both contained visual imagery and other contextual information. In contrast, some personal semantic information appears to be much more factual (e.g. *I have three cats*), and is not recalled in association with a particular context. The difference between these types of representation seems to be the degree of abstraction from the experience of an event – repeated events are more “experience-near” than autobiographical facts.

The results of the reanalysis in *Section 5.3* showed that older adults recalled more details pertaining to repeated or extended events than younger adults, and this was the case regardless of whether the memories were recent everyday events or remote, retrospectively sampled events. This type of detail would fall towards the episodic end of Renoult et al.’s (2012) continuum of personal semantics – in the case of repeated events they are details abstracted from the level of a single event to include summed or averaged information about multiple similar instances, but importantly they still situate the information within a certain context, either past or present. Repeated event details are not semantic in the sense of context-free organised knowledge, as described by Tulving (1972) and others. The reanalysis in *Section 5.3* showed, therefore, that older adults tend to recall more temporally abstracted information than young adults. To put it another way, older adults’ memories appear to be represented more schematically than younger adults' memories. In the following paragraphs, we argue that this shift towards schematic representation may be a function of experience rather than of age.

Schematic event representation

For the present purpose, we take the view that episodic and semantic memory fall at opposite ends of a continuum, as suggested by Renoult et al. (2012). Between these extremes, we suggest that it is possible for information to be represented "more episodically" or "more semantically", as depicted in *Figure 5E*. Representation towards the episodic end of the continuum is more "experience-near" (Grilli & Verfaellie, 2016), which means it more closely resembles recollection of a specific experience. Such memory details (e.g. repeated events) are

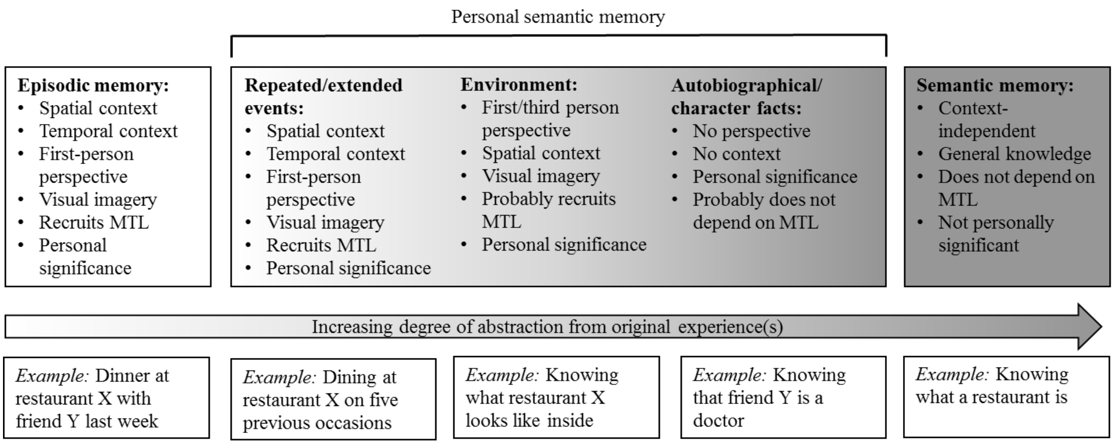

Figure 5E. A continuum view of personal semantic memory based on the one proposed by Renoult et al. (2012). Towards the left of the personal semantics box, information is more "experience-near" (that is, more similar to episodic memory), and following the arrow to the right, information becomes more abstracted (i.e. divorced from specific spatiotemporal context).

more likely to be experienced from a first-person perspective, contain visual or other sensory detail and be situated within a spatial and/or temporal context, but do not qualify as strictly episodic details because they draw on material from more than one episode. In contrast, representation towards the semantic end of the continuum is more likely to be abstract and context-independent, and is probably experienced without a particular perspective, since the material is not experience-near. For example, recalling that a particular friend is a doctor will not elicit concrete sensory details unless the knowledge is accompanied by a more episodic memory of, for example, seeing that friend at work. Knowledge towards the semantic end of the continuum may therefore be qualified by one or more episodic experiences (e.g. *I know that Madrid is the* *capital of Spain because I visited the government buildings there last summer*), but the knowledge itself can be retrieved without reference to any particular occasion.

The present argument assumes that the schematisation of memory is an active process (Bartlett, 1932) and reflects the continuous updating of knowledge structures, which is necessary to support the accrual of a huge amount of data derived from continuous conscious experience. Without schematisation we would need the capacity to store huge numbers of memory traces separately, yet to somehow link the traces conceptually in order to render them useful for interpreting and guiding future behaviour. Within such a system, retrieval from memory would be a laborious and extremely inefficient process. Schematisation might therefore be viewed as an adaptive process, enabling probabilistic learning of information about our physical and social environment. Bartlett (1932, p.204) suggested that, "in a world of constantly changing environment, literal recall is extraordinarily unimportant". Similarly, evolutionary arguments suggest that mnemonic success depends on the ability to organise information about previous experiences in a way that is useful for understanding the present and predicting the future, rather than to accurately record the details of every previous experience (Howe, 2011; Schacter, Guerin & St. Jacques, 2011). In the domains of language acquisition and inductive reasoning, the ability to generalise from a few specific examples to a conceptual representation is a positive goal; in learning to identify and use a pen or a cup, an individual is not expected to recall every separate instance in which these items have been encountered previously. Thus, if one of the primary functions of memory is to facilitate our current and future existence, then the schematisation of experience would be a necessary adaptive goal.

Experience drives schematic abstraction

One way to investigate the schematisation of information is to study how people learn to classify abstract material. Homa, Cross, Cornell, Goldman and Shwartz (1973) studied participants' ability to classify patterns of dots that were distortions of an unseen prototype. They found that the greater the number of patterns participants had to sort in the first session, the more they were able to correctly classify the prototype itself and new distorted patterns in a subsequent task, and the better their memory for the prototype was after a delay. This suggests that increased experience leads to the abstraction of a more reliable or more stable schematic representation. Since recognition of the prototype itself was dependent on the number of patterns that were originally sorted, the authors argued that the abstracted prototype must be a dynamic construct that evolves with each new exposure to a related pattern. Although this research was intended to explain how concepts are acquired over time, a clear parallel can be drawn with autobiographical memory: the prototype is conceptually similar to a schema (Rumelhart & D. A. Norman, 1978), and the distorted patterns that were sorted in Homa et al.'s experiment are conceptually analogous to repeated experiences of similar, yet different, events. Thus, with more experiences the schema becomes stronger or more reliable. Homa et al. also showed that memory for the original patterns that were sorted declined over a delay period, yet memory for the prototype remained unchanged. In the AM analogy, the original patterns that were sorted represent episodic memories, which are lost over time, while semantic information is retained.

Developmental studies also offer an interesting perspective on schema acquisition. During early schema construction, after one or two instances of an event, children are able to recall both detailed episodic accounts of a single instance, and generic schema information (Fivush, 1984; Nelson & Gruendel, 1981; Hudson & Nelson, 1986). Thus, these two types of memory can co-exist. Increasing children's experience of a staged repeated event, in which the components are identical on each repetition, improves memory for those repeated components, but leads to poorer memory for subsequent variations of the event in which altered components are experienced only once (Farrar & Goodman, 1992). Outside the laboratory, Hudson & Nelson (1986) found that even 3- and 5-year old children had difficulty recalling event-specific information about routine events, and reported more general information about everyday events than specific recall of individual event instances. In a second experiment they showed that as event familiarity increased, memory reports became more generic and included less specific detail. These findings suggest that schematic representation becomes more dominant with increasing experience of an event.

Multiple overlapping traces represent memories of similar events

The idea of increasing schematic representation with experience is consistent with multiple trace theory (MTT; Nadel & Moscovitch, 1997). According to MTT, repeated activation of a memory (e.g. via rehearsal, recall, or during sleep) leads to the formation of multiple memory traces, each of which differs slightly from the others due to differences in the way the memory is reactivated (e.g. in a different context). Over the course of repeated activations, information that is represented in these multiple traces becomes semanticised – that is, the original context is lost and the core "facts" are abstracted. The idea of a process of semanticisation implies the existence of an intermediate representation, between episodic and semantic, which dovetails with Renoult et al.'s (2012) continuum of personal semantics. Thus, in theory, the more a memory has been reactivated, the more abstracted the information will be, and further towards the semantic end of the personal semantics continuum its representation will be (see *Figure 5E*).

A simple extension of this theory could explain how repetition of similar experiences, such as memories of Christmas day on consecutive years, are merged together to form a "Christmas" schema. Separate memories of Christmas day each year would involve considerable overlap – the locations, the spatial layout, the other people present, the order of events, and the food that is eaten may be largely the same from year to year. But there will also be a number of details that are specific to each individual memory – one year the roast potatoes were burnt, somebody's new partner was present, and the house had been redecorated. If two or more events share some of the same features, it is reasonable to assume that their associated memory traces will overlap to some extent (Moscovitch et al., 2005). For example, evidence from the neuroscience literature has shown that certain networks of hippocampal neurons respond selectively to specific spatial locations (Ekstrom, Kahana, Caplan, et al., 2003; O'Keefe & Dostrovsky, 1971; O'Keefe, 1976), landmarks, and people (Quiroga, Reddy, Kreiman, Koch & Fried, 2005). Thus, memories of events that happened in the same place, with the same person, or with similar sensory input will recruit some of the same neuronal networks, and experience of one such event will partially reactivate memories of prior occurrences. The memory traces will have a network of common activation, but each will have unique components in addition (*Figure*

5F). Through repeated co-activation, the shared components of the memories become strengthened (Moscovtich et al., 2005), while connections to unique event-specific information may be weakened via synaptic downscaling (Lewis & Durrant, 2011). A greater number of similar experiences therefore presumably leads to a stronger schematic representation of common event features

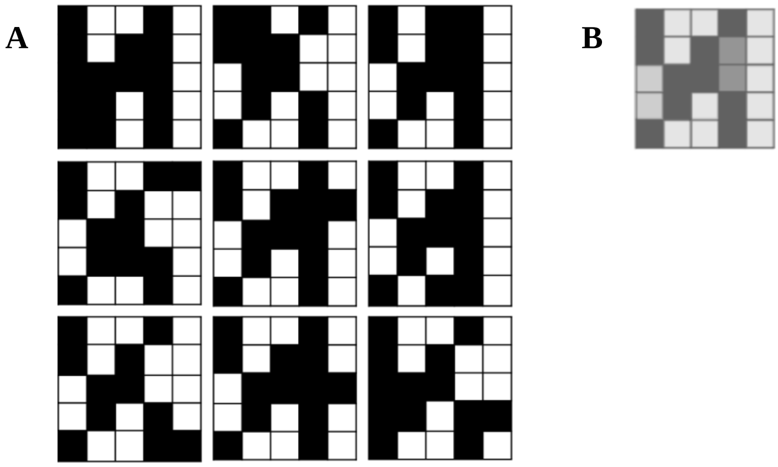

Figure 5F. Schematic representation of nine memory traces for nine similar events **(A).** Event features are represented by black cells. Certain features are shared by all nine events, while others are shared by only some events and some features are unique to a single event. In **B**, the nine matrices are superimposed, thus the darker cells represent the event features that are shared by more memory traces. Consistent with Hebb's theory of learning (Hebb, 1949), in which repeated co-activation strengthens associations between neurons, darker coloured cells (associated with a greater number of events) would be more strongly associated with one another than with lighter coloured cells (associated with a smaller number of events). The darker cells constitute the event schema, the mid-grey represents repeated event memories, and the lightest cells the event-specific information. Lewis and Durrant (2011) suggested a model in which repeated activation of similar event memories strengthens connections between shared features and weakens connections to event-specific information via synaptic downscaling during sleep.

Experience and expertise

The account presented so far has argued that the strength of a schematic representation is related to the number of experiences on which that representation is built. Yet each new experience does not simply contribute to the mass of past similar experiences – previous experiences also affect the way in which new information is processed (Bartlett, 1932). Thus, the strength of pre-existing schematic information may affect the schematisation of new material. If one outcome of older adults' increased life experience is more robust or stronger schematic memory for past experiences, then this should also affect how new experiences are processed. The effect of prior knowledge on new learning has been reported previously in studies comparing the recall of experts and non-experts on a particular topic. For example, in one study, individuals with and without a high degree of knowledge about American football were presented with a list of animals that were also the names of football teams (Castel, McCabe, Roediger & Heitman, 2007). The experts recalled more of the presented animal names than the non-experts, presumably because the information was consistent with a football schema that could be used to support memory performance. However, the experts also falsely recalled more football team animal names that were not presented, compared to the non-experts. This latter effect could be due to over-application of the relevant schema, or interference from related relevant material. In a separate measure, both experts and non-experts performed comparably on a list of body parts. Similar results have been obtained with experts in other domains, such as investment (Baird, 2003), baseball, and geography (Arkes & Freedman, 1984). Thus, experts' superior knowledge of a particular topic can have both positive and negative consequences.

A number of studies have investigated age differences in the effects of prior knowledge or schematic support on memory. The results have varied, but generally suggest that older adults rely on schemas more than younger adults (Hess & Slaughter, 1990; Mather & Johnson, 2003), and while this can support older adults' performance on associative memory tasks where the materials are naturalistic (Castel, 2005), semantically related (Badham et al., 2012) or congruent with pre-existing knowledge (Badham & Maylor, 2015), it can also lead to increased false memory for information that was not presented in a word list paradigm (Balota, Cortese, Duchek, et al., 1999). In some respects, then, older adults appear to be much like "knowledge experts" (Umanath & Marsh, 2014, p.418), and comparative studies of younger and older adults that employ literally or conceptually familiar stimuli may struggle to separate the effects of knowledge/experience and age, since each increase together.

With regards to the general increases in semantic autobiographical recall among older adults described in this chapter, we suggest that the tendency to represent information more schematically is a reflection of older adults' greater lifetime experience with a large number of similar events. This hypothesis would predict that everyday events would be represented more schematically than events that are more novel or less similar to other experiences. While this should be the case regardless of the age of the rememberer, it is unclear whether the magnitude of such an effect should be expected to vary with age. On one hand, the difference between memory for frequent, mundane events and memory for novel, interesting events may be more pronounced for older adults, given their greater experience with similar events overall. On the other hand, if the wealth of life experience means that very few of the older adults' experiences are perceived as genuinely novel, then the magnitude of such an effect may be relatively small.

Predictions of an experience-driven schematisation hypothesis

The main prediction of an *experience-driven schematisation* (EDS) hypothesis is that as event experience increases, encoding of schema-relevant aspects of new events becomes more efficient, such that the more experience an individual has with a particular event type, the more readily new events will be interpreted and stored in relation to existing schematic information. This idea is similar to one proposed by Ramscar, Hendrix, Love and Baayen (2015), who suggested that experience drives an individual to find information that best predicts their environment, thus informative cues are given more weight, while the individual learns to ignore uninformative cues (i.e. "background" information). Interestingly, J. R. Anderson and Schooler (1991) showed that the probability a particular memory will be needed in future reflects the frequency and recency of prior exposures. By studying linguistic information from newspaper headlines, a database of children's verbal interactions and the distribution of messages in an email inbox, they showed that this "need probability" (p.400) is also mirrored in the structure of the environment. Thus, they argued that human memory is optimally adapted to the environment it serves. Although they did not propose a specific mechanism to account for the processing of need probability, it seems that the relative strengthening of central, repeated event components could be a reasonable candidate. Since both schematic and episodic event information can be represented concurrently (Hudson, Fivush & Kuebli, 1992), the basic EDS hypothesis does not make any predictions about the availability of episodic event details. However, event-specific information that cannot be integrated into a relevant schema must be subject to a great deal of interference, and the amount of interference must in turn be related to the amount of experience accrued by an individual (Ramscar et al., 2014). Thus, the more experience an individual has amassed, the more difficult it should be to recall specific details of a single one. The exception to this may be details of specific events that have been well-rehearsed, for example those that are personally or emotionally significant. The degree of rehearsal a memory has undergone should predict the availability of specific event details because the memory trace is strengthened via rehearsal, in the same way that shared components are strengthened via experience of similar events. Importantly, this hypothesis does not assume separate "stores" for episodic and semantic memory, and instead differentiates different degrees of schematisation in terms of the strength of connections between concepts and the amount of interference from competing activations.

As described above, events that are more routine (i.e. have more overlap with other similar events) are likely to be represented more schematically than events that are more novel (i.e. have less overlap with other experiences). The extent of overlap with other experiences could be determined on one level by the number of conceptual features shared by different events (e.g. events taking place in a restaurant, or those involving a particular friend), but may also be determined by spatial or perceptual features that are similar in multiple different contexts (e.g. many restaurants are fairly dark, with tables arranged in twos and fours; the foyer area at many cinemas consists of a row of ticket desks and a popcorn stand; most public parks contain trees, grass and a paved walkway). Potential mechanisms for encoding and retrieving event novelty/similarity are considered in the next, and final, chapter, which attempts to draw together the evidence from Experiments 1-6 and the reanalyses in Chapters 3 and 5, within the framework of the EDS hypothesis.

Section 5.5 – Chapter 5 appendices

Appendix 5A

Subdivisions within the category of semantic details

Code	Category Name	Subcategory	Example/more detail
SS	Scene-setting	Time/Era	What year, month, week it was Participant's age at the time "It was just after X" "It was just before Y" "It was around the time I…"
		Location	Country, region, city, town
CD	Character development	Physical description	What the character (speaker or other) looks like
		Typical behaviour	What the character (speaker or other) usually does/always does/sometimes does. Methods, events, speech, reactions, thoughts, beliefs, intentions.
		Character facts	What type of person the character (speaker or other) is, what they like/dislike, where they live, what their job is, what their hobbies are, things the character is good at, things the character is bad at.
		Relationship with other characters	Friends, family, closeness between speaker and other characters, or between two characters not involving speaker
ED	Environmental development	Physical description	What the environment looks like. Geographical features or man-made. Rooms, stairs, halls, dark, light, roads, buildings, windows. Trees, hills, rivers, rocks, beaches, sea, paths.
		Spatial relationships	Relationship between environmental features. Behind, above, around, close by, distant.
		Functional relationships	Information about route, how to get there, transport options
		Clothing	Physical/functional descriptions of clothing
RP	Repeated/ Extended/ "Temporally Abstracted" activities	Past activities	Something that happened on several occasions, or lasted a long time, but has now finished. Also includes knowledge of plans made over several occasions (e.g. travel plans) "We used to do X" Also factual information abstracted from several occasions. "In rehearsals we learned that X"
RC		Continuous activities	Something that has happened on several occasions, or has been happening for some time, and is ongoing. "Usually we do Y" Also factual information abstracted from several occasions. "There's a man that walks the other way round the same route as me".
HF	Facts	Historical fact	Fact about the past, with unstated origin.

Chapter 6: General discussion

This thesis has investigated how autobiographical memory changes with age. Specifically, we have addressed the pattern of episodic and semantic details in older and younger adults' recall of autobiographical events, and some of the effects of different methods of measuring AM in different age groups. The general discussion begins with a recap of the main findings and discussion points from each of the experiments and reanalyses. Following this, we attempt to link the key ideas into a coherent narrative concerning both the nature of AM and how a novel approach to understanding AM generally – namely Rubin and Umanath's (2015) concept of *event memory* – might contribute to our understanding of how age affects function. Finally, we discuss some of the limitations of this work, along with some ideas for how to develop this line of research in the future.

Autobiographical memory is a rich and complex form of memory. In the introduction, we described how AM differs from traditional laboratory approaches to studying memory, and how difficulty with laboratory measures does not necessarily equate to memory difficulties outside the lab. Because of the inherent complexity of AM, experimental control is hard to achieve, and where it can be achieved it may be at the expense of ecological validity. In everyday life, people engage in a wide range of different activities, and even two people engaged in the same event will experience that event differently. Previous research has shown that a whole host of factors, such as prior experience, semantic knowledge, expectation, and motivation can affect attention to, perception of, and memory for, new information (J. R. Anderson, 1981; Arbuckle, Vanderleck, Harsany & Lapidus, 1990; Bartlett; 1932; Desrichard & Köpetz, 2005; Dijksterhuis, van Knippenberg, Kruglanski & Schaper, 1996; Hambrick & Engle, 2002; Jacoby & Kelley, 1987; Kim & Rehder, 2011; Mather & Carstensen, 2005; McDonald & Hirt, 1997; Saive, et al., 2015; Summerfield & Egner, 2009; Sutherland, Pipe, Schick, Murray & Gobbo, 2003).

Throughout this thesis we have drawn a distinction between episodic AM and semantic AM. This distinction is consistent with a number of previous studies of AM in ageing (Aizpurua & Koutstaal, 2015; Ford et al., 2014; Gaesser et al., 2011; B. Levine et al., 2002; St. Jacques & B. Levine, 2007; St. Jacques et al., 2012), and corresponds roughly to the episodic/semantic distinction in laboratory measures of memory, as well as the specific/general distinction in AM (e.g. Beaman et al., 2007; De Beni et al., 2013; Piolino et al., 2006). Although one of the key concerns of this thesis is how these types of information interact and overlap, in the interests of both consistency and coherence the summary is presented separately for episodic and semantic details.

Section 6.1

Episodic AM

Experiment 1 measured older and younger adults' memory for self-selected, prospectively sampled events. Participants wore SenseCam (SC) to record a series of typical everyday events over the course of a week, and returned to the laboratory to recall those events in an oral recall session two weeks later. The results showed that older and younger adults recalled a similar number of episodic details. Experiment 2 replicated this finding without SC, in a multi-task design that showed that a large age-related episodic AM deficit could be observed in the same session with the same participants completing different AM tasks. To our knowledge, this study was the first to show that relative age effects in AM are task-dependent, and the subsequent studies were developed as a means of testing the relationship between task characteristics and relative performance in young and older adults. We identified retention interval as a possible contributing factor, since memories are generally understood to become "semanticised" over time (e.g. Moscovitch, Nadel, Winocur, Gilboa & Rosenbaum, 2006). We also suggested that generative retrieval difficulties, mediated by a decline in executive function among older adults, may lead to worse performance on some tasks.

While Experiment 3 showed that fewer episodic details were recalled for remote, compared to recent, memories, we also found that despite older adults' remote memories being on average 40 years older than younger adults' remote memories, the relative performance of the older adults did not appear to suffer; when retention interval was matched, a similar deficit was observed. This suggested that while long retention intervals have a negative effect on episodic recall, this is probably not the reason for the age-related episodic deficit. We also measured the effect of providing a specific cue (event title) compared to a general cue (broad time period), and found that the relative performance of older and younger adults was not affected by this manipulation. However, the general cue was associated with better recall overall, which we suggested was due to the fact that participants were able to select distinctive events to describe in that condition.

In *Chapter 3* we reanalysed data from Experiments 2 and 3, in order to compare prospectively and retrospectively sampled memories for which the cues were similarly specific. The results showed that retrospectively sampled events were recalled in greater episodic detail than prospectively sampled events. The retrospective sampling advantage could not be explained by differences in retention interval, the social content of events, the probability of social rehearsal, or individual differences, but the finding was correlated with an increase in distinctiveness for retrospectively sampled events. Interestingly, older adults' performance was relatively consistent across tasks, while younger adults performed similarly to older adults on the prospective sampling task, but exhibited significantly better performance on the retrospective task. At the end of *Chapter 3* we introduced the idea of knowledge effects (Ramscar et al., 2014) as an account of older adults' poor performance on many cognitive tasks, and suggested that a similar effect may be responsible for the young adults' elderly-like performance on the prospective sampling task.

Experiments 4 and 5 increased the experimental control in a staged events procedure, in which the aim was to eliminate the confounding variable of event distinctiveness. These staged events therefore measured older and younger adults' memory for the same novel event, when other factors were held constant. We found that in both studies, older adults' event recall was markedly impaired relative to younger adults. This suggests that differences in the distinctiveness of everyday events do not explain the age-related deficit. Older adults' deficient memory for these novel events poses an interesting issue for the idea that experience drives knowledge effects which account for poor memory performance. One might expect that if such a knowledge effect explains poorer memory for events that have been repeated many times, then such an effect should be absent here. Section 6.2, below, explores the meaning of a "repeated event" in terms of how overlap between different events could be characterised, and the possibility that perceptions of event similarity (either conscious or unconscious) may themselves be altered by experience.

Cross-study comparisons

In order to better understand how these results fit together, we need to be able to compare the manipulations employed in each study. Of interest is whether different studies that involved similar retrieval conditions produced comparable results. Experiments 1 and 2 both involved the prospective sampling of everyday events, followed by free recall after a two-week retention interval. In both tasks, younger and older adults recalled a similar number of episodic details, and the number of details was replicated across both studies. Similarly, both Experiments 2 and 3 included a condition in which participants recalled a specific event from the past year. As *Table 6.1.1* shows, the number of episodic details recalled by younger and older adults was similar in both studies. Comparison of the two staged event studies (Experiments 4 and 5) also reveals a similar pattern of results in each, although the number of details was higher Experiment 5, which may have been due to verbal recall as a replacement for the written questionnaire in Experiment 4. What these comparisons show is a replicable variation in the pattern of results obtained by different methods of testing AM. Thus, comparing the relative performance across tasks could shed light on the reasons for these differences.

One point that was made first in *Chapter 3* is that, rather than the older adults performing particularly well in the prospectively sampled recent AM tasks (Experiments 1 and 2), the number of details recalled by younger adults appears to be particularly low. It is not clear precisely why this should be, but the two groups' relative performance on other tasks, as well as existing hypotheses concerning age-related memory decline, provide a good starting point from which we

Table 6.1.1
Mean number of episodic details recalled in a cross study comparison of similar memories.

Experiment/condition	Younger adults	Older adults
Experiment 1 Recent AM	12.59 (10.35)	9.38 (6.07)
Experiment 2 Recent AM	13.18 (12.72)	9.77 (4.21)
Experiment 2 Past year	37.94* (29.93)	27.06 (15.64)
Experiment 3 Past year	37.73 (25.15)	24.75 (16.88)
Experiment 4 Staged event	21.90 (9.68)	13.19 (7.48)
Experiment 5 Staged event	31.08 (14.89)	16.25 (9.59)

*one participant was excluded from this average because his data represented an outlier, with 144 details recalled (>3 SD above the group mean) can develop an argument encompassing all of the findings above. First, however, the findings relating to semantic autobiographical recall are revisited.

Section 6.2

Semantic AM

In AM research, particularly that which concerns older adults' abilities, the majority of the focus has been on the ability to recall specific events (i.e. episodic information). Yet even under instruction to recall only specific event details, participants often recall information that is auxiliary to the target event. Such information may take the form of general semantic information (i.e. non-personal facts about the world), but more often concerns facts relating to the speaker in some way, and information relating to repeated or temporally extended events (Renoult et al., 2012).

In Experiment 1, when participants were asked to recall self-selected prospectively sampled events, older adults recalled more semantic details than younger adults, and this finding was replicated in the recent AM task of Experiment 2. Older adults' semantic recall was consistent across the three measurements in Experiment 2 – recent AM, memory from the past year, and memory from age 11-17 – while younger adults' semantic recall for two retrospectively sampled events (past year and age 11-17) was increased. There was, therefore, no significant effect of age on semantic recall for memories of the past year and age 11-17.

In Experiment 3, both older and younger adults' semantic recall was relatively high when recalling remote events (possibly because of semanticisation/schematisation occurring over time, e.g. Cabeza & St. Jacques, 2007; Moscovitch, Cabeza, Winocur & Nadel, 2016; Rosenbaum, Priselac, Köhler, et al., 2000), and relatively low when recalling recent events to a specific cue. One reason for producing fewer semantic details in the specific cue condition might be the ubiquity of the event types that were cued (e.g. eating out). Such events are more likely to follow a clear structure that is understood by both speaker and listener, whereas the idiosyncrasy of self-selected events may necessitate the reporting of a greater number of auxiliary descriptions. The only observed age effect was in recent memories recalled in response to a general cue, and in this condition older adults recalled more semantic details than younger adults.

Based on the findings of Experiments 1-3, we suggested that semantic recall may be related to the degree of perceived overlap in knowledge and/or experience between the speaker and listener. The reason for this is that verbal autobiographical recall is an inherently social activity (Alea & Bluck, 2003; Nelson, 1993; Pasupathi, 2001), and one that depends on the effective communication of ideas. We hypothesised that older adults may need to contextualise their narratives to a greater extent than younger adults, possibly because the experimenter was closer in age to the younger adults and therefore there was likely to be less shared speaker/listener experience. This hypothesis appeared to be supported by the absence of semantic recall by both groups in the two staged events experiments (4 and 5), since the shared speaker/listener experience was at a maximum under staged event conditions when the experimenter was present both during the event and at test. However, in those studies the events were also particularly distinctive, involving a novel combination of tasks, companions and locations, and therefore an absence of semantic recall might equally indicate that there was no existing schema or script for events of this type.

In *Chapter 5* we examined semantic AM directly, in an online study in which we asked independent older and younger participants to rate memories that were lower and higher in semantic detail. We tested the hypothesis that older adults recall more semantic details than younger adults because of a shift in communicative goals with increasing age (the Pragmatic Change hypothesis; James et al., 1998), such as an increase in searching for meaning and contextualising events within the life story. In addition, if semantic details reflect attempts by the speaker to reduce misunderstandings caused by a lack of shared speaker/listener experience, then memories low in semantic details should be rated less favourably by people of the opposite age group (e.g. older adult raters should rate young adults' low-semantic memories as lower quality stories). While older adults' memories were generally rated more favourably than younger adults' memories, this was not due to the presence of semantic details, since memories high in semantic details were rated less favourably on almost all of the measured dimensions. This suggests that semantic details actually detracted from story quality. In addition, older participants generally rated the memories more favourably, but the rater age did not interact with the amount of semantic detail or the age of the speaker, which was inconsistent with the idea that semantic details are required to bridge misunderstanding caused by a lack of shared speaker/listener experience. These factors could not, therefore, explain the persistent reporting of semantic details in AM narratives, and their increased incidence among older adults' memories on some tasks.

In a reanalysis of data from Experiment 2, we subdivided semantic details into smaller categories, which, we proposed, reflect different types of long-term knowledge. The reasoning behind this was that details pertaining to repeated or temporally extended events are more similar to episodic details than semantic details (Renoult et al., 2012), while autobiographical facts are less "experience-near" and therefore more like semantic details (Grilli & Verfaellie, 2016). We suggested that the complexity of the pattern of semantic recall across tasks might reflect differences in some, but not all, of these sub-types. The results showed that certain types of detail were more prevalent in each task. When participants recalled events from past lifetime periods, they reported more scene-setting details (e.g. *This was during the time that…*) and more details about repeated past events (e.g. *We used to do X*). Older adults additionally recalled historical factual information in this condition (e.g. *Food was rationed during the war*). In contrast, when participants recalled recent AMs they reported a greater number of details about repeated events that were continuous (e.g. information about current routines). Older adults also recalled more contemporary facts about the people involved in the events and general factual information compared to younger adults in this condition. Overall, across both conditions, older adults recalled more temporally abstracted details than younger adults – that is, details pertaining to repeated events either past or present.

These results show that both schematic event descriptions and facts are reported more often by older adults, but the pattern of results depends on the demands of the particular task, which may explain inconsistencies when comparing semantic recall across tasks. It seems likely that the reporting of factual information serves the purpose of elaborating or explaining parts of the story, and may therefore reflect attempts to bridge the gaps in shared speaker/listener experience. The recall of repeated event details is less straightforward to explain, but in *Chapter 5* we suggested that older adults may rely on more schematic event representation as a result of increased lifetime experience. In *Section 6.4*, we use this argument to draw together the findings concerning episodic and semantic AM presented thus far.

Section 6.3

Supporting memory with SC

In Experiments 1, 4, and 5, we measured the effect of SC on recall of events in younger and older adults. In each study, participants were able to recall more event details after viewing SC images of the event compared to a baseline condition in which they were asked to recall the event without support. This does not seem surprising, given that the large number of SC images provides a good deal of information at test that was present during the original experience of the event. However, particularly in Experiments 1 and 5, we were able to show that participants recalled information that was not presented in the images themselves. In Experiment 1, participants recalled the events at the same time as viewing the images, and recognised details were not included in our analysis unless the participant provided some elaboration. In Experiment 5, we reported an analysis in which all visual details were excluded, therefore the only details were those that could not possibly have been depicted in the images. In both cases, the effect of SC remained significant, suggesting that in healthy younger and older adults SC support promotes recall of "something more" than simply what the cue provides (Silva et al., 2016).

Findings relating to the randomisation of the temporal order of the sequence of SC images were mixed. Specifically, we tested two competing hypothesis proposed by Hodges et al. (2011): that SC supports retrieval either because the sequence of images that forms the cue provides a large amount of information, or because the sequence is particularly compatible with autobiographical memory. Our results showed a small effect of temporal order in Experiment 1, but no observable effect in Experiment 4. This suggests that the primary reason for the SC benefit, at least in healthy individuals, is the amount of information contained in the cue. This does not rule out other possibilities, however, and for practical reasons (e.g. to reduce the amount of time taken to review events) it would be beneficial for further work to explore the mechanism of the SC effect.

One result that we failed to observe was a specific retrieval benefit for older adults. In Experiment 1, we suggested that the effect of SC was similar for both groups because both groups performed similarly at baseline. However, even in Experiments 4 and 5, when older adults remembered only around half the number of event details as younger adults at baseline, the effect of SC was the same for older and younger participants. This seems to suggest that older adults' poorer recall does not simply reflect difficulty retrieving information from memory (Dijkstra & Kaup, 2005), and may instead be a result of faulty or insufficient encoding processing or consolidation. Ofen and Shin (2013) characterise memory changes in ageing as an entrenchment of stable state patterns generated by predictions from semantic knowledge, which reduces capacity for generating new representations. Our experience-driven schematisation hypothesis (*Chapter 5*) takes a similar view, but suggests that experience and not age *per se* is the driving force behind this change. If experience alters the way memories are represented (i.e. a shift from specific to schematic), then perhaps retrieval support should be expected to provide little special benefit to experienced individuals. Accordingly, when recall in both groups was poor, in Experiment 1, the benefit of SC did not appear to be particularly large, as might expected when performance is low. Indeed, the effect of SC was of similar magnitude in both Experiment 1 and Experiment 5.

Section 6.4

Additional considerations

The prospective memory paradox. To some extent, the findings reported here appear to be consistent with what is known as the *prospective memory (PM) paradox*: older adults tend to perform better than expected – and often better than younger adults – on PM tasks when the task is naturalistic rather than laboratory-based (e.g. Kvavilashvili et al., 2013; Rendell & Thomson, 1999). The reason for this surprisingly good performance is not known. Schnitzspahn et al. (2011) suggested that it may be due to older adults' higher motivation and metacognitive awareness. In addition, they found that on the days their study was running, younger adults reported being much more absorbed in their daily activities than older adults. When this measure was included as a covariate in their analysis it completely eliminated older adults' performance advantage. On the other hand, Kvavilashvili et al. (2013) suggested that older adults might perform better on naturalistic PM tasks because they can be processed relatively automatically, and may be cued incidentally by environmental stimuli. An interesting study by Aberle, Rendell, Rose, McDaniel and Kliegel (2010) showed that providing extrinsic motivation (the chance to win a lottery prize) in a naturalistic PM task eliminated the age-related benefit by improving only younger adults' performance. The same study found that in a laboratory task simulating a virtual week older adults performed as well as younger adults if the PM task was repeated several times, but not if it was unique.

Some key findings relating to the PM paradox are presented in *Table 6.4.1*, below. The definition of a naturalistic task varies between studies, but there are few cases in which memory for personally meaningful future intentions has been examined. In some experiments, completion of a laboratory-type task in the participants' own home is considered to be naturalistic (Dobbs & Rule, 1987; Kvavilashvili et al., 2013), while many studies involve contacting the experimenter or logging the time or other information using a diary or other electronic device (Cavuoto, Ong, Pike, Nicholas, & Kinsella, 2015; Rendell & Craik, 2000; Rendell & Thomson, 1999; Schnitzspahn et al., 2011). In each of these studies, the task to be performed is specified in advance by the experimenter. However, a recent study investigated age effects in everyday PM performance using a diary method in which participants provided the experimenter with their plans for the following 24 hours, and the next day indicated whether or not they had carried out their intended tasks (Schnitzspahn, Scholz, Ballhausen, et al., 2016). The results showed that overall, older adults remembered to carry out more of their planned tasks than younger adults. However, further analyses found that the age benefit was driven by better performance on social tasks only, and was associated with greater perceived importance of the planned intention for older compared to younger adults. As such, this finding might equally be framed in terms of increased motivation in the older group, and in this sense dovetails with the findings of Altgassen et al. (2010) and Schnitzspahn et al. (2011).

The prospective memory findings therefore suggest that older adults perform comparatively well where there is intrinsic or social motivation to remember, and where the to-be-remembered task is routine or repetitive. Both factors could also contribute to performance on retrospective memory tasks, and may explain why in the present work, a large age-related deficit was observed for memory of staged events (Experiments 4 and 5), but not for naturalistic memories of a similar age (Recent AM task of Experiments 1 and 2). It is difficult, however, to extend this argument to the variable age effect in prospectively versus retrospectively sampled personal memories. As discussed in *Chapter 3*, retrospectively sampled memories tend to be more distinctive and are less routine than prospectively sampled memories. While older adults seem to recall prospectively sampled events *comparatively* well, in fact both older and younger adults recall fewer details about these events overall, compared to the more distinctive, and less routine, retrospectively sampled memories (see Reanalysis in *Chapter 3*). This is inconsistent with Aberle et al.'s (2010) finding that both older and younger adults' prospective memory for irregular (i.e. not repeated) tasks is *worse* than for regular tasks. However, PM for routine tasks may be more comparable to retrospective memory of repeated events, rather than retrospective memory of unique events. This is because both routine PM tasks and repeated event memory are supported additively by exposure to multiple similar experiences. That is, a greater number of similar experiences will strengthen memory for aspects of those experiences that remain unchanged. In contrast, retrospective memory of a unique event depends on the ability to resolve interference between multiple similar experiences, therefore a greater number of similar experiences should render each individual experience more difficult to remember. The extent to which findings from the PM paradox relate to retrospective memory for unique events is less clear.

Table 6.4.1
Key findings relating to older adults' performance on prospective memory tasks

Paper	Naturalistic PM task	Key findings
Aberle et al. (2010)	Contact the experimenter repeatedly over the course of 1 week.	Age-related benefit for older adults eliminated when younger adults were motivated by financial incentives.
Altgassen et al. (2010)	In lab, press a key whenever 2 min had elapsed. Participants in a "high social importance" condition were told that the experimenter needed to know how many tasks participants could complete in 2 min.	Younger adults generally outperformed older adults, but social importance instruction improved only older adults' performance, thereby reducing age effect.
Bailey et al. (2010)	Respond to alarm on PDA requesting completion of a digital questionnaire	Older > younger at responding to alarm – but worse at remembering a specific instruction regarding the questionnaire
Cavuoto et al. (2015)	Press a button on a wearable device twice daily (bed-time and rise-time)	PM more accurate at bed time than rise time. Performance better in week 1 than week 2. No younger group.
Dobbs & Rule (1987)	Write date and time in top left corner of questionnaire (at home)	Younger > older
Kvavilashvili et al. (2013)	Write date and time in top left corner of questionnaire (at home); put wrist watch back on after experiment	Older > younger on wristwatch task; no age effect on date & time task
Masumoto et al. (2011)	Call the experimenter several times throughout a week; schedule varied in complexity	Older adults used external memory aids to facilitate performance when schedule was complex. No younger comparison group.
Rendell & Thomson (1999)	Log time at 4 set times during a week	Older > younger on naturalistic task; younger > older on lab task
Rendell & Craik (2000)	Log specific activities on a digital recorder (note that activities were generated by the experimenter and were not actually carried out)	Older > younger on naturalistic task; younger > older on matched virtual lab task
Schnitzspahn et al. (2011)	Send two text messages per day	Older > younger on naturalistic task; younger > older on lab task
Schnitzspahn et al. (2016)	Participants generated their own personal PM tasks	Older > younger, but only for social tasks. Effect driven by perceived importance of task.

Cohort effects. The studies presented in this thesis took a cross-sectional approach to studying memory in ageing, and therefore cannot account for differences between groups attributable to their membership of different cohorts. According to Baltes (1968) cohort effects can impair the internal validity of cross-sectional studies because it is not possible to separate generational differences from true age effects. One factor related to cross-sectional study that is of particular concern to ageing researchers is the *Flynn effect*, which refers to the widely-replicated finding that in the general population, performance on cognitive tests is generally improving (Flynn, 1987). McArdle, Fisher, and Kadlec (2007) found that in a sample of 17,000 participants studied between 1992 and 2004, there was a significant positive relationship between birth cohort and episodic memory score. Similarly, two recent studies pooled data from across two large US population-based studies between 1987 and 2015, covering four birth cohorts between 1902 and 1943 (Dodge, Zhu, Hughes, et al., 2017; Dodge, Zhu, Lee, Chang, & Ganguli, 2014). Controlling for education, they found significant cohort effects in immediate and delayed recall, psychomotor speed, executive function, and language, with performance improving between the earliest-born and the latest-born cohorts. In addition, Tampubolon (2015) reported similar findings from the English Longitudinal Study of Ageing, which examined almost 6000 participants aged between 50 and 80, over the course of 11 years (2002-2013). He found that there was a secular improvement in cognitive ageing across the cohorts, with episodic memory scores following a curvilinear function. On average, compared to a pre-Depression era cohort, participants born after World War 2 could recall around 4 more words from a 10-item list.

The reasons for the Flynn effect are not clear. If the effect could be understood to be stable (i.e. continuous improvement over time), it might suggest that the age effects observed in cross-sectional studies were exaggerated. That is, poorer performance among older participants may be due to a combination of the negative effects of ageing and the negative effects of membership of an earlier birth cohort on cognition. Indeed, in an analysis of data from the longitudinal Whitehall II study, Steel, Huppert, McWilliams and Melzer (2003) found that early cross-sectional results had overestimated the speed of cognitive decline. On the other hand, Salthouse (2015) argued that the time of testing is at least as important as birth cohort in studies of ageing. In two analyses of longitudinal datasets he showed that while age-matched performance on cognitive tests improved over time, the improvement was parallel for participants of different ages, and as such the relative performance between age groups (as captured by a typical cross-sectional study) was not distorted.

However, it is not clear that the Flynn effect is stable over time. For example, Teasdale and Owen (2005, 2008) found that in a Danish sample of 500,000 young men tested between 1959 and 2004, performance on IQ tests peaked in the late 1990s and then began to decline again. Similarly, a Norwegian study found that cognitive test scores increased from the 1950s up until the 1990s, but no later (Sundet, Barlaug, & Torjussen, 2004). Because of this instability it is difficult to draw conclusions about the effect of cohort membership on cognitive performance, and results should be interpreted with caution.

Section 6.5

Experience effects in episodic and semantic AM

The main results presented in this thesis can be summarised thus: older adults generally remember fewer event details than younger adults, except when everyday memories are sampled prospectively. It may be that age-related deficits still exist for prospectively sampled everyday memories, but were too small to detect given the power of the experiments presented here. In any case, any such age effects are likely to be smaller than the age effects observed in other AM tasks. We investigated a number of confounding variables that failed to explain the age-related deficit in typical retrospective sampling AM tasks. For example, we suggested that long retention intervals and low retrieval support in typical retrospective sampling tasks might disproportionately hurt older adults' performance, yet controlling for these factors did not reduce the deficit. In fact, both older and younger participants performed more poorly in the prospective sampling task, when retention intervals were shorter and retrieval support was greater. One might argue that some feature of the prospective sampling procedure itself, such as elaborative encoding (e.g. Bradshaw & J. R. Anderson, 1982; Winograd, 1981), might benefit older adults' performance, thereby reducing between-group differences; however, the two staged experiments that were reported in *Chapter 4* used a similar prospective sampling method, and older adults exhibited a significant memory deficit despite this. Moreover, in the case of the everyday memory task, it does not seem to be the case that older adults perform well – in contrast, younger adults seem to perform particularly poorly. The next question is therefore what aspect of the prospective sampling everyday memory tasks leads to this poor performance.

One key difference between prospective and retrospective sampling is that the former tends to capture high-frequency, low-distinctiveness events (because a typical week is filled with repetitive, mundane occurrences, with perhaps one or two more interesting events), while the opposite is true of the latter. The types of event that can be retrieved retrospectively, particularly when only general cues are provided, are those that are at least moderately distinctive and not, for example, eating breakfast at home alone nine months ago. This was supported by our finding, in *Chapter 3*, that retrospectively sampled memories were rated as more distinctive than prospectively sampled memories. As Galton (1879, p. 152) noted, "The subject must have a continued living interest in order to retain an abiding-place in memory. The mind must refer to it frequently, but whether it does so consciously or unconsciously, is not perhaps a matter of much importance." Accordingly, memories that are not personally important in some way are likely to be forgotten relatively rapidly (e.g. M. A. Conway, 2005; M. A. Conway & Pleydell-Pearce, 2000).

The pattern of findings reported here seems to be broadly consistent with an explanation that involves specific effects of experience on the ability to recall events. That is, the more event experience an individual has (i.e. with repeated similar events), the more difficult it is to recall specific details about one of those instances (see Ramscar et al., 2014; Yassa & Reagh, 2013), but the easier it is to access *decontextualised*[21] information learned from those experiences. As we argued in *Chapters 3* and *5*, because older adults are more experienced than younger adults we might expect that this affects their ability to remember (see Ramscar et al., 2014). These experience effects may be the reason for older adults' poorer performance on retrospectively

[21] *Decontextualised* is used here in the sense of being removed from the specific context of a single episode, rather than completely without context

sampled memory tasks because, for individuals who have many decades of life experience, even relatively distinctive memories may share multiple features with other memories. Older adults' increased propensity to recall temporally abstracted information under retrospective sampling conditions (see *Section 5.3*) may reflect an increase in the availability of decontextualised information with increasing experience. This explanation assumes that the recall of specific event details becomes difficult because of increasing interference (i.e. competition between overlapping memory traces; Yassa & Reagh, 2013), whereas the recall of decontextualised information is based on additive experience and may be sampled probabilistically (i.e. outcome *X* is the most likely). Importantly, there is no suggestion that one type of information necessarily precludes the other, but the availability of each type may be related to the amount of experience an individual has.

In associative learning studies involving pairs of words, some pairs (e.g. up/down) are easy to learn, while others (e.g. cabbage/pen) are harder. Two factors that are important in determining the ease with which associations can be learned are the frequency with which the cue (first item) is encountered without its paired item (Rescorla, 1968; Ramscar et al., 2015), and the probability, based on prior knowledge, of the paired item occurring after the cue (Kamin, 1969; Arnon & Ramscar, 2012). Such associative learning tasks could be considered simplified versions of the learning we engage in in everyday life, which is inherently associative (i.e. events take place within a particular context) and these findings suggest that prior experience can shape new learning in an important way. Of note is that ageing has more of an effect of the learning of the harder pairs, which Ramscar et al. (2015) argue is due to older adults' increased experience of language. Ramscar et al. suggest that as the frequency of experience with real-life pairs increases, it becomes harder, via competition, to recall novel pairs. To extend this argument to AM, this suggests that recalling what happened on a specific occasion (i.e. a novel combination of familiar stimuli) should be harder with increasing experience of *what normally happens*, while for novel experiences (i.e. those for which there is no prior knowledge of what normally happens) specific details should be easier to recall. This account is consistent with our findings concerning real-life events, which showed that everyday events were recalled in less specific detail than retrospectively sampled events, which were less repetitive. Direct comparison of real-life and staged events is likely to be confounded by differences in factors such as personal relevance (i.e. the extent to which the event fits into the life story and/or personal schemas) and intrinsic motivation (i.e. the reason for carrying out the activity), which are present to a greater extent in real-life events. However, it is difficult to explain why older adults' memory for staged events should be significantly poorer than younger adults' memory for the same events.

One possibility is that by the time an individual reaches old age, even novel events share many features with events that have been experienced before. For example, in the staged events we described in Experiments 4 and 5 (*Chapter 4*), although each event involved a unique combination of stimuli, the events took place in a series of rooms, with apparatus, materials, concepts and ideas that were likely to have been experienced before. It is difficult to characterise the potential overlap with previous experience, because it could happen at any level of detail (see *Figure 6A*) – the colour of the paint on the walls, the taste of chocolate, tables and chairs laid out in rows, receiving verbal instructions to follow, feeling apprehensive about what was to come next, thinking about the self in relation to others. These details could range from low-level sensory-perceptual information, through semantically meaningful units, to general abstract concepts. Moreover, although most people have a wealth of previous experience with a range of everyday objects, it is difficult to predict the circumstances under which that previous experience would interfere with the most recent experience. The parameters of such interference are likely subject to individual differences in the extent of previous experience, expectation, attention, motivation, and so on, and the complexity of the interaction for just one stimulus is multiplied when considering the possibility of interference across an entire event. Of course, no two experiences will ever overlap completely, and a pertinent question is therefore how similar experiences must be before they are categorised as functionally "the same" – that is, similar enough to create interference or competition, such as Christmas dinner on consecutive years. A related question, and of relevance to the study of ageing, is whether experience itself mediates some kind of similarity threshold, so that the more overall experience one has, the more similarity between different events might be perceived. Hampton (2001) notes that the categorisation of concepts is an important step in acquiring and using knowledge about the world, and for such information to be of maximum use it makes sense that categories evolve and adjust as new information is encountered. It might be argued, therefore, that the categorisation of event types also evolves and adjusts as more and more events are experienced.

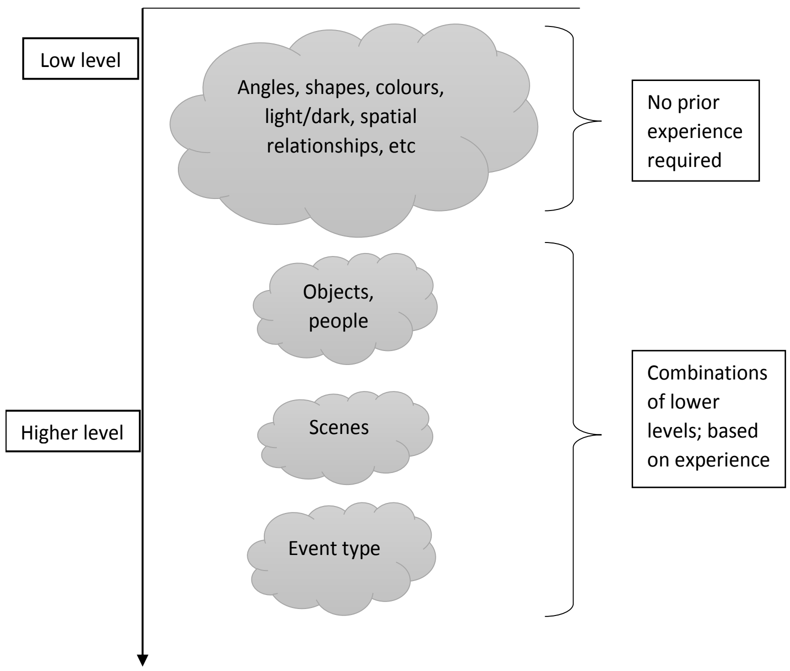

Figure 6A. Schematic diagram showing how lower level visual features might be combined, with experience, to create semantically meaningful objects, scenes and events (external)

Section 6.6

Counting and coding features in memory

What counts as a feature? It seems plausible that either the greater number of features that overlap with previous experiences, or the greater the number of previous experiences, the greater will be the interference effect. This raises the question of what constitutes one feature, since, for example, basic sensory information like shapes, colours and spatial relations can be grouped together into semantically meaningful objects (e.g. dog, television, screwdriver), but the way in which basic features are grouped together necessarily depends on prior knowledge.

In *Figure 6B*, below, the Buddha's hand fruit (A) – not commonly encountered in the UK – may be recalled as a yellow fruit, with a number of finger-like projections and a texture similar to that of a lemon. Such description, although possible, would not be necessary to remember the octopus (B). An individual who did not recognise the car engine (C) might note its overall colour and shape, and a number of interrelated sub-features, while somebody familiar with engines, for example, a mechanic, may simply note that it is an engine.[22] Interestingly, in categorisation tasks children tend to weight perceptual information more than abstract concept information, whereas the reverse is true of adults (Ofen & Shin, 2013; Tversky, 1985). This may be understood as evidence that experience with exemplars alters the way items and categories are mentally represented. The ability to use a semantic shortcut for familiar items may enable us to remember more information, or to learn more easily (similar to the chunking phenomenon in STM, e.g. Cowan, 2001; Gobet, Lane, Croker, et al., 2001; Guida, Gobet, Tardieu & Nicolas, 2012; G. A. Miller, 1956). For example, remembering the location of a new shop is likely to be easier if one is familiar with the town it is in. However, the same semantic shortcut is probably also the basis for reconstructive memory errors. Determining what constitutes one feature in memory is difficult because representation can occur at multiple levels simultaneously.

A further issue is that the level at which memories, or specific aspects of memories, are described is likely to be influenced by communicative goals. In verbal free recall of autobiographical information there are no pre-determined correct answers, and therefore the degree to which there is an assumption of shared knowledge between participant and experimenter may affect how the participant describes his or her memory. The assumption that the experimenter will not be familiar with objects, people, places, and so on might prompt the participant to describe these in more detail, while the perception of a common understanding might promote the use of semantic shortcuts. This is perhaps best illustrated by imagining trying to communicate an idea, such as Einstein's theory of general relativity, to someone who has no understanding of physics. It would take a great deal more time, and detail, to explain the concept to a non-physicist, whereas

[22] The exception to this might be qualifying information, for example if something about the familiar object stands out from what is normal or expected (e.g. an orange octopus, or a brand new engine).

in conversation with a physicist one might simply refer to it by name and know that it has been understood.

Thus, in determining how many features a memory contains, not only is the number of recalled features dependent on the prior experience of the participant (including the relevant language the participant has available to them), it may also be influenced by the knowledge the experimenter is perceived (by the participant) to have about what is being described. This idea was introduced in *Chapter 5* in relation to the recall of semantic details within memory narratives, which described the possibility that a mismatch in familiarity between the speaker and listener may be responsible for the recall of some (but not all) of the semantic details within an experimental AM narrative.

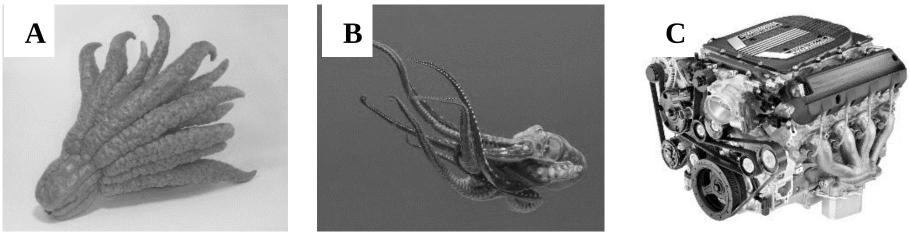

Figure 6B. Familiarity with objects may alter the way they are perceived, remembered, and described to others. The Buddha's hand fruit (A) is uncommon in the UK; a British observer might see that it is related to a lemon, and shaped a bit like an octopus. In contrast, octopuses (B) are well-known and therefore need little additional description (although qualifying information might be recalled). A car engine (C) is more likely to be recognised as such by someone who has experience of car engines; unfamiliar observers might note its complex structure of interconnected parts, without any understanding of what each part does and how they must be connected in order for the engine to function. For a mechanic, the engine would not function without each component part, and therefore the parts may be grouped together into a meaningful "chunk".

Detail coding in AM. The way we understand the representation of features in memory has obvious implications for how we code the number of details an individual is able to remember about an event. As described above, an individual with no prior experience may recall a large number of interconnected event features with little semantic grouping or chunking, while experience likely leads to the amalgamation of at least some of these features into coherent objects, scenes, people, events, and so on. To our knowledge, this experience effect has not been described before in the context of AM, although similar points have been made in various literatures, including semantic memory, short-term memory, habit-learning, and perception (e.g. Cowan, 2001; Gobet et al., 2001; Graybiel, 1998; Wickelgren, 1979). Anecdotally, when confronted with the task of recalling a mundane event, participants sometimes responded with phrases such as, “It was just a normal trip to the shop”; in familiar environments, usually no attempt was made to describe the context unless it was of direct relevance to the story (and presumably would therefore aid the experimenter’s understanding of the event). Moreover, if such information were described, it would likely have been coded as semantic, on the basis of being abstracted from the specific context of the event in question (e.g. *In my house the stairs are quite steep*). In this way it is as though there is less episodic information *available* to recall about familiar events, whereas in an event which is entirely novel almost all of the information may be construed as episodic.

At present, there is no system for coding the varying levels of representation in AM, and development of such a system would likely be an extremely complicated exercise. These issues are not often discussed in relation to episodic memory, since laboratory methods have the advantage of allowing the experimenter to set the correct answers at the desired level of representation. In such designs, an answer is considered correct only if it is precisely the answer the experimenter is looking for (e.g. in a study of word list learning, substituting a synonym for one of the words would simply be a wrong answer). In *Chapter 4*, in our studies of staged autobiographical events, we approached a greater level of experimental control, yet coding participants’ responses that were written or spoken in prose still involved a degree of interpretation on the part of the coders, and underscored the notion that autobiographical memory is essentially an approximation of a previous occurrence, and that it is difficult to measure without making inferences based on language.

Section 6.7

The episodic-semantic relationship

The findings described in this thesis have led to development of the idea that differences in accrued lifetime experience may drive age-related differences in memory performance. As outlined in the paragraphs above, this hypothesis is difficult to expand because of a general lack of understanding about the complex way in which previous experience might be represented, and thus how it might interact with current processing.[23] Despite this, evidence from the episodic memory literature shows that indeed prior experience affects task performance. For example, participants falsely recall having seen an unpresented target word among a list of semantic associates in the DRM paradigm (Roediger & McDermott, 1995), recollection is better for lists of words compared to non-words (Gardiner & Java, 1990), paired associates that are semantically related are easier to learn than those that are not (Naveh-Benjamin, Hussain, Gues & Bar-On, 2003), and one's own cultural understanding can negatively influence the accuracy of recall of prose from another culture (Bartlett, 1932). This type of study works on the premise that all participants share the same prior experience to some extent (e.g. knowledge of words). In naturalistic AM studies, such assumptions are difficult to make, in part because of the sheer amount and variety of experience accrued by any one individual, but also because of the complexity of the stimulus in a naturalistic setting, such that prior experience is likely to vary widely for different aspects of the same event (e.g. people, places, objects, etc.). Moreover, there is a growing appreciation of the idea that seemingly episodic AM may be based on knowledge about more than a single event (e.g. Rubin & Umanath, 2015).

Flexible representation in memory

The process of encoding, consolidating, retrieving and reconsolidating memories is now believed to be much more flexible and dynamic than was once thought (Alberini, 2011; Nadel, Hupbach, Gomez & Newman-Smith, 2012; Nader, 2015). AM theorists have acknowledged this flexibility in describing AM as a transient construction (M. A. Conway & Pleydell-Pearce, 2000), but in empirical work the most frequently-used terminology suggests that a memory, or memory detail, exists in one state at any given time; it is either consolidated or labile, either episodic or

[23] The complexity of mental processing during encoding was hinted at by Galton (1879), who described taking a leisurely walk along Pall Mall and allowing thought association to occur naturally while observing his surroundings. He noted that, "samples of my whole life had passed before me, that many bygone incidents, which I never suspected to have formed part of my stock of thoughts, had been glanced at as objects too familiar to awaken the attention. I saw at once that the brain was vastly more active than I had previously believed it to be, and I was perfectly amazed at the unexpected width of the field of its everyday operations." (p. 150).

semantic, either "remembered" or "known". While such distinctions are useful for guiding experimental design and for interpreting broad patterns in the data, they have difficulty accounting for the complex data produced in autobiographical free recall narratives. In the developmental literature, Hudson et al. (1992) have argued that children show evidence of both schematic and episodic representation of the same events when those events are repeated. Therefore, just because an individual recalls a piece of schematic information (e.g. *I usually walk to the shop*) does not mean that they cannot also recall corresponding episodic information (e.g. *On this occasion I cycled to the shop*).

Similarly, even if an event has been experienced only once, a schematic representation may be retrieved if there is an expectation that the details would be the same on subsequent exposures to the same event (e.g. Hudson et al., 1992; Hudson & Nelson, 1986). For example, on a visit to the Natural History Museum in London, an individual might note the large, high-ceilinged atrium that houses the skeleton of a T. Rex, and the wide stone staircase at the rear of the hall. The individual might report: *"I remember walking up to the foot of the stairs, where I waited for my friend to catch up with me"*; quite clearly, this would be classed as episodic detail. Alternatively, he or she might report: *"There is a huge stone staircase at the back with a statue of Charles Darwin seated at the top"*. This type of information is difficult to interpret – is it episodic if the individual has only experienced it on a single occasion? He or she may have previously seen photographs of the museum's interior, or it may have come up in conversation with a friend. It is possible that even after a single exposure, the individual may not be able to mentally place themselves back at the scene – rather, he or she may simply *know* that these details are true without being able to visualise them. Similarly, is this information semantic if the museum has been visited several times? The individual may still be able to place themselves at the scene (i.e. "mental time travel"; Tulving, 1983), and may be able to recall additional details from this particular visit, for example: *"I stood half way up the steps to make myself visible to the friend I was meeting there"*. In this case, the episodic memory (*standing half way up the steps*) is embedded within the semantic knowledge accrued over multiple experiences (*there are steps there*). It might be possible, using a remember/know procedure, to probe for details of the recollective experience for each reported detail, but this would be incredibly laborious, and may be particularly difficult to determine in naturalistic studies. If an individual "remembers" the statue of Darwin, they would need to make an additional source judgement (i.e. *do you remember seeing the stairs on this particular visit, or on a previous visit, or from a photograph, conversation*, etc.) Not only would this be a difficult task, there may not be a single correct answer since, as described above, a "remember" experience could be based on multiple representations simultaneously. For this reason, Rubin and Umanath's (2015) distinction between event memory and semantic memory appears to provide a better account of freely-recalled AM than the classic episodic/semantic distinction. Adopting such a distinction could have implications for the reinterpretation of findings relating to older adults' AM, since we showed in *Chapter 5* that older adults tend to report more temporally abstracted event information than younger adults. Under the classic episodic/semantic distinction, this temporally abstracted information has been classed as semantic, on the basis of its relation to more than one context (e.g. repeated instances). However, under the Rubin and Umanath (2015) event/semantic distinction, this information would be classed as event memory. The concept of event memory therefore has the potential to re-frame the way we think about age-related changes to memory.

Section 6.8

Conclusions and directions for future research

In this thesis, we have examined the AM narratives produced by both younger and older adults in response to varying cues, under different instructions, from different time periods, and for different types of event. Although purporting to measure the same phenomenon – autobiographical memory – these different conditions lead to consistently different patterns of recall, and consistently different relative performance for younger and older adults. To our knowledge, this is the first work to systematically examine age effects on performance across different AM tasks, and our findings highlight the complexity of AM that is familiar to researchers in this field, but not often acknowledged in published work. Indeed, whether or not autobiographical information is successfully encoded and retrieved probably depends in part on a whole range of factors – how long ago the event occurred, how important the event was, how often it has been rehearsed, and so on. One thing that many, if not all, of these factors relate to in some way is the well-established idea of interference in memory (M. C. Anderson, 2003; McGeoch, 1932; Izawa, 1980; Yassa & Reagh, 2013). We have attempted to explain our findings within an interference framework developed by Ramscar et al. (2014), which suggests that what is often interpreted as cognitive decline in old age instead reflects the natural consequences of accruing a lifetime of experience. This argument is therefore not new, but to our knowledge it is the first time it has been applied specifically to AM, and particularly as an explanation for the pattern of age-related deficit in AM.

If knowledge effects explain both age-related episodic deficits on traditional AM tasks, and poorer performance on measures of everyday memory compared to memory for more distinctive events, then it is not clear how older adults' memory might be improved. Ramscar et al. (2014, p.1) call this "the myth of cognitive decline" and argue that reduced memory performance should be expected when accrued lifetime experience is high, yet this conclusion may not be of much comfort to individuals who perceive that their memory is not as good as it used to be. It may be that to some extent older adults are already able to control and regulate their memory in order to capitalise on the information that is more emotionally important to them (Mather & Carstensen, 2004). If this is the case, then future work to develop understanding of how such regulation occurs naturally could provide further insight into how to support memory for material that is of practical importance. It seems likely that such an approach would target encoding or consolidation rather than providing retrieval support.

The work presented here, along with a number of recent papers from other laboratories (Ramscar et al., 2014, 2015; Renoult et al., 2012; Rubin & Umanath, 2015; Ofen & Shin, 2013; Umanath & Marsh, 2014), represents a changing tide with respect to the way AM, and by extension, age effects in AM, are viewed. Continuation of this field of research may benefit from a step away from a young-adult-centric approach, where deviations from a young adult norm are considered to be undesirable consequences of cognitive decline. Instead, there may be rich possibilities in considering age effects in memory from the opposite perspective, namely the positive effects of accumulating a life's worth of knowledge. Of course, there is still the issue of facilitating older adults' day-to-day interaction with the wider world, which can be challenging for an ageing population in a typically young-centric environment. However, recent and continuing technological advances, such as the next generation of wearable devices like SC, may be able to help in this regard. Finally, by better understanding the positive outcomes associated with the accumulation of lifelong experience, it may be possible to promote the idea of successful ageing and to support and integrate an ageing population.

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Appendix G1

Correlations between age group, education, IQ, and memory measures in Experiments 1-5. Note that Experiments 3 and 5 used the same sample of participants. Note also that correlations were calculated for the full sample in each experiment, prior to any sample-matching adjustments.

Table G1.1

Experiment 1 (n=42)

Measure	Age group (*ρ*)	IQ (WASI)	Education
Episodic	-.22	.16	.23
Semantic	**.43*** **	.19	.17
Specificity	-.12	.24	.18
Age group (*ρ*)	~	.16	-.18

*p<.05; **p<.01; ***p<.005; ****p<.001

Table G1.2

Experiment 2 (n=40)

	Measure	Age group (*ρ*)	IQ (WASI)	IQ (NART)	Education	GDS
Recent everyday memory	Episodic	.04	.30	**.37***	.13	.06
	Semantic	**.64********	**.44****	**.43****	-.05	-.14
Remote AM (age 11-17)	Episodic	**-.41****	-.13	-.13	.10	.16
	Semantic	.28	.17	.09	-.24	-.15
Recent AM (past year)	Episodic	-.04	.17	.21	.01	.11
	Semantic	.27	.26	.20	.05	-.06
AMT	Episodic	**-.59********	.13	.05	**.44****	.05
Word list	Episodic	**-.48******	.26	.07	.31	-.03
Age group (*ρ*)	~	~	**.37***	**.48****	**-.35***	-.03

*p<.05; **p<.01; ***p<.005; ****p<.001

Table G1.3

Experiment 3 (n=36)

Measure		Age group (*ρ*)	IQ (WASI)	Education	GDS
Recent specific cue	Episodic	**-.18**	**.40***	**.33***	-.12
	Semantic	**.31**	**.49******	.11	-.32
Recent time period cue	Episodic	-.08	**.35***	.16	-.15
	Semantic	**.57********	**.39***	.04	**-.40***
Remote cue	Episodic	**-.60********	.12	.21	.24
	Semantic	**.42****	**.34***	.18	**-.38***
Age group (*ρ*)		~	**.56********	-.18	**-.40***

*p<.05; **p<.01; ***p<.005; ****p<.001

Table G1.4

Experiment 4 (n=44)

Measure	Age group (*ρ*)	IQ (NART)	Education	GDS
T1 episodic	-.50***	.06	**.42****	-.12
T1 source error	.54****	.11	-.04	.06
T1 incorrect	-.10	-.01	-.05	.27
Age group (*ρ*)	~	**.42******	**-.35***	.04

*p<.05; **p<.01; ***p<.005; ****p<.001

Table G1.5

Experiment 5 (n=36)

Measure	Age group (ρ)	IQ (WASI)	Education	GDS
Baseline episodic	-.12	**.40***	.21	-.18
Baseline source error	.15	.13	-.02	-.16
Baseline incorrect	.15	-.06	.10	-.08
Age group (ρ)	~	**.56********	-.18	**-.40***

*p<.05; **p<.01; ***p<.005; ****p<.001

Appendix G2

Post-experimental questionnaire and Vividness of visual imagery questionnaire administered at the end of Experiment 1.

The following questionnaire is designed to get some feedback on your experience of using Vicon Revue. If you have any further comments please write them on the back of this sheet.

1. Before using Vicon Revue, how would you rate your overall memory on a scale of 1-10? (1 = very poor, 10 = excellent) [ ]
2. Before using Vicon Revue, how would you rate your memory compared to other people the same age, on a scale of 1-10? (1 = much worse than peers, 10 = much better than peers) [ ]
3. How would you rate your experience of using Vicon Revue on a scale of 1-10? (1 = hated it/thought it was pointless, 10 = loved it/found it very helpful) [ ]

4. Did Vicon Revue have any noticeable effect on what you could remember? (Please circle) **YES / NO / UNSURE**
5. Did the order in which you saw the photographs have any effect on what you could remember? (Please circle) **YES / NO / UNSURE**

   5a. If "YES" did you find it easier to remember when the photographs were in the correct order or when they were mixed up? (Please circle) **CORRECT / RANDOM**

6. Were the memories you experienced while looking at the photographs different in any way from the memories you normally experience? (for example, sometimes people report remembering things from a different perspective than normal, or with emphasis on different senses) **YES / NO / UNSURE**

   6a. If "YES" please give details:

7. On a scale of 1-10, how vivid would you say your memories normally are **without Vicon Revue**? (1 = not vivid at all, 10 = very vivid) [ ]
8. On a scale of 1-10, how vivid were your memories **when using Vicon Revue**? (1 = not vivid at all, 10 = very vivid) [ ]

Figure G2.1. Post-experimental questionnaire administered to participants at the end of Experiment 1.

Responses to post-experimental questionnaire. Mean ratings are presented in *Table G2.1* (ratings out of 10) and *Table G2* (yes/no ratings). A 2 (before vs. after SC) X 2 (young vs. older) ANOVA was conducted, investigating the effect of SC on self-rated memory vividness (items 7 and 8). There was a main effect of SC (F(1,36)=42.69, p<.0005, η_p^2=.54) but no age effect (F(1,36)=.06, p=.80, η_p^2<.01). The interaction approached significance (F(1,36)=3.49, p=.07, η_p^2=.09).

Table G2.1
Experiment 1 post-experimental questionnaire ratings (each out of 10)

Item	Young adults (n=20)	Older adults (n=18)
1. Own memory rating	7.20 (1.11)	6.56 (1.04)
2. Own memory compared to peers	6.80 (1.64)	6.22 (1.44)
3. Overall experience of using SC	8.00 (1.45)	8.00 (1.46)
7. Vividness without SC	6.60 (1.14)	6.83 (1.58)
8. Vividness with SC	8.10 (1.17)	7.67 (1.50)

Note. There were no significant differences between groups

Table G2.2
Ratings of effects of SC (general) and temporal order

		Percentage	
Item	Response	Young adults	Older adults
4. Effect of SC	**Yes**	**80**	**67**
	No	10	17
	Unsure	10	17
5. Effect of order	**Yes**	**65**	**56**
	No	15	33
	Unsure	20	11
5a. Effect of order	**Forward better**	**70**	**61**
	Random better	0	6
	Unsure	30	33

Please rate the vividness of each image using the rating scale shown below:

1	2	3	4	5
No image at all (only "knowing" that you are thinking of the object)	Vague and dim	Moderately clear and vivid	Clear and reasonably vivid	Perfectly Clear and as vivid as normal vision

Think of some relative or friend whom you frequently see (but who is not with you at present), and consider carefully the picture that comes before your mind's eye. Then rate the following items:

1	The exact contour of face, head, shoulders, and body.
2	Characteristic poses of head, attitudes of body, etc.
3	The precise carriage, length of step, etc., in walking.
4	The different colours worn in some familiar clothes.

Visualize a rising sun. Consider carefully the picture that comes before your mind's eye. Then rate the following items.

5	The sun is rising above the horizon into a hazy sky.
6	The sky clears and surrounds the sun with blueness.
7	Clouds. A storm blows up, with flashes of lightning.
8	A rainbow appears.

Think of the front of a shop to which you often go. Consider the picture that comes before your mind's eye. Then rate the following items.

9	The overall appearance of the shop from the opposite side of the road.
10	A window display including colours, shapes, and details of individual items for sale.
11	You are near the entrance. The colour, shape, and details of the door.
12	You enter the shop and go to the counter. The counter assistant serves you. Money changes hands.

Finally, think of a country scene which involves trees, mountains and a lake. Consider the picture that comes before your mind's eye. Then rate the following items.

13	The contours of the landscape.
14	The colour and shape of the trees.
15	The colour and shape of the lake.
16	A strong wind blows on the trees and on the lake, causing waves.

Figure G2.2. Vividness of visual imagery questionnaire (VVIQ; Marks, 1973), which was administered at the end of Experiment 1.

Responses to VVIQ. Two average scores were calculated: imagining something *familiar* and imagining something *novel*. The *familiar* score was calculated as the mean of items 1-4 and items 9-12, and the novel score was calculated as the mean of items 5-8 and items 13-16 (see *Table G3*).

A 2 (age group) x 2 (imagery type: familiar vs. novel) ANOVA found no main effect of novelty ($F(1,36)=.12$, $p=.73$, $\eta_p^2<.01$). There was a significant effect of age ($F(1,36)=5.56$, $p=.02$, $\eta_p^2=.13$) which was qualified by a significant age by imagery interaction ($F(1,36)=6.51$, $p=.02$,

η_p^2=.15). Post hoc tests revealed significant effect of age for novel imagery (t(36)=3.14, p=.003) but not for familiar imagery (t(36)=.72, p=.48).

Table G2.3
Mean self-rated vividness of visual imagery for imagined familiar and novel images (SD in parentheses)

Imagery type	Young adults	Older adults
Familiar	5.61 (1.00)	5.82 (.81)
Novel	5.24 (1.19)	6.31 (.86)

Appendix G3

A follow-up was carried out one year after Experiment 1. All original participants were contacted and asked to recall all of the events from Experiment 1 again. Thirteen older adults and 9 younger adults participated in the follow-up. Each participant was sent a form with the title of each event recalled in Experiment 1, and asked to write down as many details as they could remember about each event. We looked for long-term differences in recall for events that had originally been reviewed using SC (forward and random order) and those that had not.

Results. A 2 (age group) x 3 (condition: baseline vs. random vs. forward) x 2 (detail type: episodic vs. semantic) ANOVA was carried out. There was a main effect of detail type (F(1,20)=36.64, p<.0005, η_p^2=.65), but no main effect of original review condition (F(2,40)=.59, p=.56, η_p^2=.03) or age group (F(1,20)=.90, p=.35, η_p^2=.04) at the one-year follow-up.

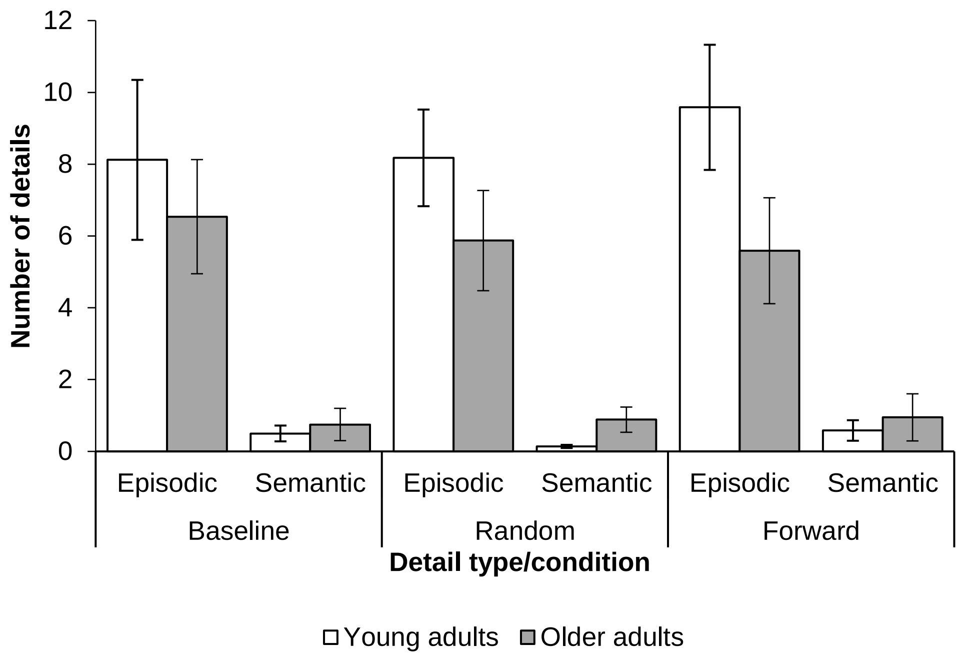

Figure G3.1. Episodic and semantic recall of events originally recalled in Experiment 1, at one-year retention interval. Retrieval conditions (baseline, random order, forward order) refer to manipulations in original experiment. There were no retrieval manipulations in the follow-up study. Error bars represent standard error of the mean.

Significantly more episodic (M=7.31, SD=5.06) than semantic (M=.63, SD=1.32) details were recalled. There were no significant interactions.

Appendix G4

Experiment 2 also included a names and faces memory test. Participants were presented with 10 black and white portraits of unfamiliar people (5 male, 5 female; mixed ages). Each portrait was serially presented, in random order, with a first name and surname underneath. Participants were asked to read the full name aloud, but remember only the first name. They were advised that a memory test for the first name would follow. Participants self-paced the stimulus presentation, and therefore could spend as long as they liked studying the material. However, they were only allowed to view each face-name presentation once (i.e. they could only move forward in the presentation, not back). Immediately following presentation, participants were presented with a booklet containing the same 10 black and white portraits and asked to write both the first name and the surname of the person next to each picture. Memory for the first name was intended to be a measure of intentional memory, and the surname was intended to be a measure of incidental memory.

Results were entered into a 2 (age) x 2 (intentionality) ANOVA. There was a main effect of intentionality (F(1,37)=123.02, p<.0005, η_p^2=.77), with intentionally learned names (*M*=6.74, *SD*=2.15) recalled better than incidentally learned names (*M*=2.06, *SD*=2.01). There was no significant effect of age (*F*(1,37)=2.94, *p*=.10, η_p^2=.07), and there was no interaction (*F*(1,37)=2.25, *p*=.14, η_p^2=.06). The means are presented in *Table G4.*

Table G4.1
Recall of intentionally and incidentally learned names

Item	Young adults	Older adults
First name (intentional)	6.85 (2.08)	6.63 (2.27)
Surname (incidental)	2.80 (2.04)	1.32 (1.70)

Appendix G5

The participants who took part in Experiments 3 and 5 (the same sample) also completed the Big 5 Personality Inventory, which was not reported in the main results. We were specifically interested in whether extraversion was associated with recall of more event details, and if so whether group differences in extraversion could explain the pattern of recall in older and younger adults. Personality trait scores are presented in *Table G5.1*, and correlations between personality traits and episodic and semantic memory measures are presented in *Table G5.2*. There were four significant correlations in total: agreeableness was inversely correlated with semantic recall for the staged event (Experiment 5), while conscientiousness and emotional stability were positively correlated with semantic recall in memories for the past year (Experiment 3). There was also a positive correlation between emotional stability and semantic recall in remote memories (Experiment 3). Given the large number of correlations (30) that were calculated, we would expect that some would be significant by chance (5% = 1.5). Since there were no significant correlations between extraversion and any of the memory measures, we had no theoretical reason to investigate these correlations further. We therefore do not comment on possible reasons for the significant correlations.

Table G5.1
Personality traits self-rated by younger and older adults

Trait	Young adults	Older adults	t (df=34)
Extraversion	24.94 (10.97)	28.00 (6.26)	1.04
Agreeableness	34.06 (3.63)	33.95 (4.09)	.09
Conscientiousness	25.88 (5.96)	28.79 (6.11)	1.44
Emotional stability	21.28 (7.02)	27.32 (8.01)	2.43*
Openness to experience	26.35 (7.31)	28.05 (6.57)	.74

Note. Maximum score for each trait = 35. Emotional stability is the inverse of neuroticism.
*p<.05

Table G5.2
Pearson correlations between personality traits and memory measures (Experiments 3 & 5)

Trait/memory measure	Remote episodic	Remote semantic	Recent episodic	Recent semantic	Staged episodic	Staged semantic
Extraversion	-.01	.13	.18	.23	.30	.18
Agreeableness	.12	-.05	.06	.18	.05	-.57***
Conscientiousness	-.18	.16	.09	.43**	.06	-.02
Emotional stability	-.03	.39*	.18	.43**	.23	.02
Openness to experience	.08	.14	.10	.29	.03	-.06

***p<.0005; **p<.01; *p<.05

Appendix G6

In Experiment 3 we also asked participants to rate the vividness of each memory after recalling the event details. The reported results are for the IQ-matched sample from Experiment 3, and are presented in *Table G6.1*. First, vividness ratings were analysed in a 2 (age group) x 2 (cue type: remote period, recent period, recent specific) ANOVA. There was a significant effect of age group ($F(1,21)=13.23$, $p=.002$, $\eta_p^2=.39$), with older adults ($M=8.77$, $SD=.86$) rating their memories as more vivid than younger adults ($M=7.07$, $SD=1.32$) overall. There was also a significant main effect of cue type ($F(2,42)=21.47$, $p<.0005$, $\eta_p^2=.51$), with higher vividness ratings for the recent time period cue ($M=8.69$, $SD=1.30$; $p<.0005$) and the recent specific cue ($M=8.19$, $SD=1.45$; p<.0005) compared to the remote time period cue ($M=6.89$; $SD=1.97$), but no difference between recent time period and recent specific cues ($p=.14$). There was no interaction between age and cue type ($F(2,42)=.51$, $p=.60$, $\eta_p^2=.02$).

Table G6.1
Vividness ratings for memories recalled in response to different cues

Cue type	Younger adults	Older adults
Remote period	5.88 (1.93)	7.91 (1.43)
Recent period	7.92 (1.29)	9.45 (.65)
Recent specific	7.42 (1.38)	8.95 (1.13)

We next investigated whether vividness was associated with objective measures of recall, namely the number of episodic and semantic details, and the age of the memory. To avoid averaging the scale ratings, correlations were calculated for each of the six memories independently. As can be seen in *Table G6.2*, there were was virtually no relation between vividness ratings and any objective measure; none of the correlations was significant.

Table G6.2
Pearson partial correlations (controlling for age) between vividness ratings and objective memory characteristics

Cue type	Episodic	Semantic	Memory age
School	.10	.34	-.21
Work	.08	.10	.08
Past year	.38	.25	-.06
Past month	-.02	.09	-.09
Last time ate out	.08	-.36	-.03
Last birthday or Christmas	-.03	.09	-.24

Appendix G7

At the end of the recall session for the staged event in Experiment 4, we asked participants to answer the general knowledge questions and name the country for each flag encountered during the staged event. This was a separate measure from the recall reported in *Chapter 4*, and took place after the recall and review data were collected. This test was intended as a measure of the retention of new semantic information over the two-week retention interval, and was administered via a computer-based questionnaire. For the general knowledge questions, participants were asked the same general knowledge questions that were asked during the staged event, and wrote their answers in blank box. For the flags task, participants were first asked to identify which nine flags they had seen two weeks earlier from a visual array of 20 flags (9 old, 11 new; episodic recognition task). They were then asked to select the country that each flag belonged to from a drop-down list. Participants chose a country for each of the 20 flags.

The number of correct responses to both semantic retention measures was pooled, and entered into a 2 (age) x 3 (condition: baseline, random order SC, forward order SC) ANOVA. There was no effect of condition ($F(2,76)=.99$, $p=.38$, $\eta_p^2=.03$), and no condition by age interaction ($F(2,76)=.09$, $p=.92$, $\eta_p^2<.01$), but there was a main effect of age ($F(1,38)=14.62$, $p<.0005$, $\eta_p^2=.28$). Younger adults correctly answered more questions ($M=4.28$) than did older adults ($M=2.92$).

Table G7.1
Semantic retention and episodic recognition results from Experiment 2

Task	Young adults	Older adults
Previously seen flags (/9)	6.83 (2.09)	3.77 (2.27)
Unseen flags (/11)	6.72 (3.32)	3.27 (1.80)
General knowledge retention (/9)	6.00 (1.53)	5.00 (1.75)
Flag recognition: % hits	70.98 (34.54)	67.17 (25.08)
Flag recognition: % false alarms	9.09 (12.47)	17.36 (14.55)

Younger adults appeared to retain the flag—country associations better than older adults ($t(38)=4.40$, $p<.0005$), although they also correctly named the country of the new flags more accurately than older adults ($t(38)=4.18$, $p<.0005$), which suggests that they may have better baseline knowledge of flags. The number of general knowledge questions answered correctly approached, but did not reach, significance ($t(38)=1.90$, $p=.07$). The flag recognition task was measured as the percentage of hits and false alarms, since there slightly the number of old and new items was not equal. There was no difference in the hits ($t(38)=.40$, $p=.69$), and there was a non-significant trend towards a higher number of false alarms in the older group ($t(38)=1.90$, $p=.07$), suggesting that older adults discriminated less.