Executive function and emotional focus in autobiographical memory specificity in older adults

Carol A. Holland, Nathan Ridout, Edward Walford, Jennifer Geraghty,

Psychology, School of Life and Health Sciences, Aston University, Birmingham, B4 7ET, UK

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Correspondence should be addressed to Carol Holland, Psychology, School of Life & Health Sciences, Aston University, Birmingham, B4 7ET, UK. E-mail: c.holland1@aston.ac.uk.

Telephone 0121 204 4063, Fax, 0121 204 4090

Abstract

The current study examined the role of executive function in retrieval of specific autobiographical memories in older adults with regard to control of emotion during retrieval. Older and younger adults retrieved memories of specific events in response to emotionally positive, negative and neutral word cues. Contributions of inhibitory and updating elements of executive function to variance in autobiographical specificity were assessed to determine processes involved in the commonly found age-related reduction in specificity. A negative relationship between age and specificity was only found in retrieval to neutral cues. Alternative explanations of this age preservation of specificity of emotional recall are explored, within the context of control of emotion in the self-memory system and preserved emotional processing and positivity effect in older adults. The pattern of relationships suggests updating, rather than inhibition as the source of age-related reduction in specificity, but that emotional processing (particularly of positively valenced memories) is not influenced by age-related variance in executive control. The tendency of older adults to focus on positive material may thus act as a buffer against detrimental effects of reduced executive function capacity on autobiographical retrieval, representing a possible target for interventions to improve specificity of autobiographical memory retrieval in older adults.

Introduction

Autobiographical memory refers to the recollection of personal experiences, or events related to the self. According to Conway and Pleydell-Pearce (2000), an autobiographical memory is not directly stored within a memory system, but is a "transitory dynamic mental construction generated from an underlying knowledge base" (p261). They suggest that the autobiographical knowledge base is constructed in a hierarchal manner, in three layers, ranging from momentary *event-specific knowledge* of actual experiences, rich in detail including time and place of occurrence, through accumulations into summaries or categories of repeated experiences (*general events),* which are then clustered into *lifetime periods,* making up the top level of the hierarchy, representing the thematic knowledge of one's life.

Under normal circumstances most people navigate smoothly through the hierarchy in order to access the required level of specificity for the task in hand, access beginning at the top of the hierarchy (retrieving the general level first). However, a number of participant groups, notably patients with depression, encounter problems accessing the most specific level of the hierarchy, tending to retrieve general categorical memories from the middle layer (See Williams, Barnhofer, Crane, Hermans, Raes et al., et al., 2007 for a review). The tendency to retrieve over-general memories has also been demonstrated in older adults (Holland & Rabbitt, 1990; Piolino, 2002; Ros, Latorre & Serrano, 2009). Since the tendency to retrieve over-general autobiographical memories has been shown to impair social problem solving (Beaman, Pushkar, Etezadi, Bye & Conway, 2007; Goddard & Dritschel, 1997), predict greater negative emotional response (depression) to traumatic life events (e.g. Gibbs & Rude, 2004; Van Minnen et al., 2005; see Raes et al., 2006 for a review) and mediate the relationship between chronic daily hassles and depression (Anderson, Goddard & Powell, 2010), this issue may have significant effects on quality of life for older adults.

Autobiographical memory has traditionally been studied experimentally using cueing paradigms such as Williams and Broadbent's autobiographical memory test (AMT; Williams & Broadbent, 1986), whereby participants are presented with cues (usually words) and asked to retrieve a specific memory relating to each cue. Johnson (1992) proposed that self-initiated memory retrieval involves three processing stages: elaboration of a cue into its related contexts; search for a specific event memory associated with the elaborated cue; and final verification to ensure the retrieved memory matches the requirement of the task in hand. If not, the process repeats itself until a suitable memory is formed. Such complex processing clearly requires a system that is able to control and monitor the flow of information, as well as inhibiting task irrelevant processing. It has been suggested (e.g. Conway & Pleydell-Pearce, 2000) that these functions are performed by the central executive element of working memory.

Executive function & autobiographical memory retrieval

It may be hypothesised that inhibitory and updating elements of executive function are particularly involved in the verification stage of generative retrieval, where retrieved memories are checked to ensure they meet the requirements of the task (Johnson, 1992), with task requirements updated and irrelevant recall inhibited. The importance of executive functions in general in autobiographical memory retrieval was highlighted by Dalgleish et al. (2007), who reported that poorer performance of depressed patients on tasks demanding of executive control was linked to increased tendency to retrieve over-general memories, although executive function was not specified into constituent elements in this previous study. Importantly, Dalgleish et al. (2007) demonstrated (in Studies 1-4) that measures of executive function and general cognitive resources directly predicted autobiographical memory specificity regardless of the presence of depression or other psychopathology.

Given the almost universal findings of reduced executive function and inhibitory control in older adults (e.g. West, 1996; Craik, 2000; MacPherson, Phillips & Della Salla, 2002) it would seem likely that these deficits may result in an age-related over-general memory effect. Consistent with this proposal, there is evidence that impaired executive function influences autobiographical memory specificity in older adults. For example, Holland and Rabbitt (1990) found that specificity of autobiographical memories retrieved by a sample of older adults was related to measures of cognitive resources, in particular a measure of complex span (Daneman & Carpenters' 1980 sentence span). Once this measure was controlled for, a measure of general cognitive resources (they used the AH4, Heim, Watts & Simmonds 1970) did not explain additional variance in their regression, and they concluded that level of executive function, and not general cognitive resources per se, may be the key factor involved in producing specific memories. Other studies have also demonstrated a relationship between specificity and cognitive function in older age, but have rarely separated out the executive function components from general resources or performance scores (e.g. Beaman et al., 2007). A further limitation of these studies was that they also did not control for depression, although Phillips and Williams (1997) and Birch and Davidson (2007) found evidence in older adults that any differences in number of specific memories is related to working memory or general cognitive performance, not severity of depression.

More recently, Piolino, Coste, Martinelli et al. (2010) have explored the role of executive function in autobiographical memory in older adults in more detail. They examined the contribution in regression analyses of aspects of executive function to access to different levels of autobiographical retrieval, based on the hierarchy outlined above. They demonstrated that age-related deficit in specific levels of recall of autobiographical memories is mediated by the updating and inhibitory functions of the central executive. Importantly, once variance due to neuropsychological measures was accounted for in performance at the specific levels of their autobiographical memory test, age contributed little further independent variance. That is, this is a cognitive performance dependent, rather than an age dependent effect, and not simply an effect of older adults having experienced more examples of memories to sort for each cue.

The crucial role of updating and inhibiting in autobiographical retrieval raises the question of what kind of information is being processed and inhibited, and why difficulty in inhibiting non-task information, or updating progress or verification may result in observed lack of specificity in recall. One explanation is that in order to progress from general to specific memories, unneeded categorical descriptions from the intermediate level of the hierarchy must be inhibited (Dalgleish et al, 2007). Failure to do so effectively results in chronic activation of a series of general events, which Williams termed ‘mnemonic interlock’ (Williams, 1996). An alternative, or additional, possibility is that executive functions are involved in regulating the influence of emotion on retrieval. In line with this notion, there is evidence to suggest that emotion regulation plays a significant role in autobiographical retrieval. For example, the affect regulation account of over-general memory retrieval in depression suggests that a protective mechanism is activated to avoid access of specific negative emotions (Raes, Hermans, Williams & Eelen, 2006; Williams, 1996), which, over time, becomes overprotective, blocking access to all specific memories. Furthermore, the emotional content of the memory cue can influence specificity of retrieval.

For example, Ros, Lattore and Serrano (2009) found that specific memories were more likely in response to positive word cues than negative. With this in mind, the aim of the current study was to examine the possibility that executive function is involved in regulating the influence of the emotional content of memories during the process of specific retrieval.

Emotion and autobiographical memory retrieval

St. Jacques and Levine (2007) and also Zajonc (1980) found a retentive superiority for emotion-related memory, and Zajonc concluded that affective material may require less cognitive effort to recall and retain. On the other hand, Conway (1990) found that emotional stimuli were among the least powerful cues for high autobiographical memory specificity. This paradox may be explained by considering the role of executive functions in memory retrieval within the hierarchical model described. As noted by Conway and Pleydell-Pearce (2000), memories of intensely emotional events are associated with 're-living' these experiences and have the potential to disrupt the on-going goal of retrieving a specific memory, namely that accessing memories of highly emotional experiences can lead to the reinstatement of previous goals, which can then disrupt current goal-related activity.

Therefore the SMS works to employ executive control processes to regulate these intrusions. Supporting this notion, studies of autobiographical memory in healthy individuals have consistently shown that participants exhibit a bias against retrieving intensely emotional memories (Conway & Pleydell-Pearce, 2000).

However, Carstensen (1999) observed that healthy older adults exhibit a greater tendency than younger individuals to focus on emotional rather than non-emotional material in many paradigms. They proposed a social-emotional selectivity theory to account for this, which argues that because older adults have less time remaining than younger adults, emotionally-related experience (e.g. relationships) becomes more important than knowledge-related goals.

With this in mind, it would be expected that older adults would be more likely than younger participants to retrieve emotional memories to cues, including neutral words. In addition, given the potentially disruptive nature of emotional memories in terms of ongoing processing, highlighted above, it might be expected that older adults' emotion focus would result in the retrieval of fewer specific memories.

However, it has also been suggested that, relative to younger adults, older participants exhibit greater efficiency in their inhibition of emotional, especially negative, material (Hahn, Carlson, Singer & Gronlund, 2006). Other evidence also suggests that control of emotion may not be as costly, in terms of cognitive resources, for older adults as it is for younger individuals (Scheibe & Blanchard-Fields, 2009). If this is the case, then we might expect that measures of inhibitory ability would predict specificity of older adults' recall in response to neutral, but not emotional, cues. In contrast, the tendency to focus on emotional stimuli in older adults may be related to a reduced ability to inhibit emotion because of reduced executive function. In this case, we might expect that that poorer executive function, (particularly inhibition), would be related to *greater* specificity for emotional cues in comparison to neutral. This study sets out to examine these alternative outcomes, using a measure that distinguishes between inhibitory and updating ability, rather than a composite executive function measure, to elucidate on these alternatives.

Furthermore, current work on age related recall and processing from the cognitive ageing literature in general, highlights a “positivity effect” in which older adults have been shown to be biased toward recalling positive information. In an autobiographical memory paradigm, Piolino et al. (2010) found that high memory specificity in older adults was associated with their selection of positive memories to proceed with to the next level of their progressively more specific task, and that difficulty in accessing specific episodic details was associated with retrieval of negative events.

Thus the aim of the current study was to examine the role of executive function (focussing on updating and inhibition) in retrieval of specific autobiographical memories in older adults, with particular regard to any interaction with the emotional content of the cues/ retrieved memories.

In line with previous research, it was expected that older adults would show poorer executive control than younger adults, and that younger participants would retrieve a greater proportion of specific autobiographical memories than would older participants. Any effect of age on recall of specific autobiographical memories was expected to be greater for non-emotional memories than emotional memories. Performance on the executive task was expected to predict autobiographical memory specificity. However, as age group differences were expected in the manner in which executive functions regulate emotional content of memories, this relationship was also predicted to vary as a function of group and emotional valence of memory cue. It was also anticipated that older adults may not show characteristic age-related slowing (e.g. Salthouse, 1996) in response to emotional cues. Finally, given the findings of a positivity effect in older adults, it was expected that there would be differences in the relationship between executive function, particularly of inhibition, and specificity of memories retrieved in response to positive and negative cues.

To this end, two groups of participants (younger adults aged 18 – 35 and older adults aged 55+) were presented with positive, negative and neutral word cues and were asked to retrieve a specific memory in response to each cue. Participants completed an objective measure of executive function with one simple task giving measures of both inhibition and updating selected (random number generation task; Towse & Neill, 1998), as opposed to a combination of different measures, to reduce the effects of fatigue and variability within the older adults specifically. This test produces a number of different measures of randomness, with three selected as key measures that load on the two components described by Towse and Neil as "prepotent associates" and "equality of response usage", alternatively described by Miyake, Friedman, Emerson, Witzki, Howerter and Wager (2000) as an "inhibition factor" and an "updating factor", respectively. Participants completed the Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) to enable control for any effects of depression on autobiographical memory and executive function.

Method

Participants

Twenty-five young adults aged between 18 and 35 years of age (mean age 21.60 years, *SD*= 4.65) and 21 older adults aged 55 years and above (maximum age 87 years; mean age 69.52 years, *SD*= 10.52) were recruited from the local community and a university in Birmingham, UK. All participants were screened with the Mini Mental State Examination (MMSE) (Folstein, Folstein & McHugh, 1975) to exclude possibility of dementia. No participant scored less than 26 points (the criterion level indicating possible cognitive impairment, Folstein et al., 1975), *M*=29.21 (*SD*=0.99). The participants' mood was assessed using the Hospital Anxiety and Depression Scale (HADS, Zigmond & Snaith, 1983), with scores on the anxiety and depression subscales ranging from 0 to 21. A cutoff score of ≥8 on each subscale is commonly used to indicate possible clinical levels of depression or anxiety (Herrmann, 1997; Snaith, 2003). In the current study, older adults reported significantly higher levels of depression (*M*=3.19, *SD*=2.42) than did younger adults (*M*=1.44, *SD*=1.86; $t(44)=3.15$, $p<0.01$). However, no participant in either group scored high enough to reach the criterion of clinical concern. Further, both groups scored low relative to published UK norms (3.68) for the HADs depression subscale (Crawford, Henry, Crombie & Taylor, 2001). Participants did not differ in terms of anxiety, $t(44)=1.08$, $p > .05$.

Informed consent was obtained from all participants. The study was conducted in accordance with Aston University's Research Ethics Committee and British Psychological Society ethical guidelines. A power calculation was carried out using estimation of mean and standard deviations from Williams et al. (1999). $\delta = 4.8$ with 27 participants in total with about equal sample size for each group. Power as a function of δ at a significance level of 0.05 is 0.99, which demonstrated that there is only 0.01% chance of making a Type II error (Howell, 1997). Participant characteristics are presented in Table 1.

Table 1 about here

Materials

Autobiographical memory test (AMT)

Autobiographical memory specificity was assessed using a modified version of the

AMT (Williams & Broadbent, 1986). Participants were presented with fifteen words and were asked to retrieve a different specific autobiographical memory in response to each cue. Five cue words were neutral (hammer, apple, cup, bread, chicken), five were positive emotional (happy, interested, safe, successful, surprised) and five were negative emotional (angry, clumsy, hurt, lonely, sorry), (from Williams & Broadbent, 1986, see also Dalgleish et al., 2007).

A specific memory was defined as an event that occurred at a specific time and place and lasted less than a day. Examples were given to ensure understanding. For instance, for the cue word "computer", a specific memory would be "I went to the computer shop and bought a laptop for myself last week". Participants were given a maximum of 60 seconds to retrieve each autobiographical memory (see Dalgleish et al., 2007). In cases where participants retrieved general information that was not a memory (e.g. "I love surprises") or if the type of memory they recalled was unclear, they were prompted (e.g. can you think of a specific occasion? Or, can you tell me a bit more about that memory?) until they retrieved a rateable memory or until the 60 seconds elapsed, again, following precedent (Dalgleish et al, 2007). The end response was used as the memory to be rated. Although the number of prompts given were few, older adults seemed to need more prompts than younger adults ($M= 1.6$, versus $M=0.92$ for the younger group) although this was not a statistically significant difference: $F(1,44)= 1.08$, $p>0.05$. There were also no significant differences in numbers of prompts for each cue type. Two practice trials were given to ensure participants understood requirements. Memories were recorded on a digital recorder for later rating of specificity. Word cues were presented randomly. After each retrieved memory, participants were asked to rate the memory in terms of vividness. Vividness refers to the clarity of the scene recalled. A guideline was given to participants that a very vivid memory would resemble looking at an actual photograph of that scene. Vividness was scored on a 5-point scale, with 5 meaning very vivid and 1 very hazy. Participants were also asked to rate the pleasantness related to each retrieved memory on a 5-point scale, with 5 meaning that the memory evoked a very positive feeling, 1 meaning the memory was associated with a very negative feeling and 3 indicating that the memory evoked a neutral or non-emotional response.

A recalled event was labelled as a *specific memory*, if it was similar to the example given above. If the recalled event covered a period of time more than a day, (e.g., my holiday in Spain) it was labelled as *over-general extended memory.* If the recalled memory referred to repeated events rather than a specific occasion (e.g., I always used to have an apple for my lunch) it was labelled as an *over-general categorical memory*. If no memory was retrieved after 60 seconds, it was labelled as an *omission* and scored as 0. Inter-rater reliability correlation between two raters (Holland & Geraghty) calculated on a random selection of 75 memories, was 0.87, with one or other of these two raters being used to rate all memories. Proportion of specific memories retrieved out of total memories retrieved was used as the dependent variable. Response latency was measured as the time between presenting the stimuli and the beginning of a participant's response.

Random number generation task

The random number generation task was utilised to index the inhibitory and updating control aspects of executive function. Three measures were selected: RNG index, Adjacency, and Redundancy. The *RNG index* describes how frequently certain pairs or triplets of numbers have occurred. Low (good) scores on RNG index indicate that no patterns were evident from the number generation, thus the string of numbers is more random. This score provides insight into how well executive function is inhibiting certain patterns. The *Adjacency (A*) score describes when the digits appear to be in a sequence. (e.g., 2, 3, 4, 5). The A score indexes ability to inhibit well-learnt patterns. Adjacency measures are available as ascending, descending and combined scores. Combined scores were used here. Low (good) scores on A imply more randomness. Both *RNG index* and *A* load on the inhibition factor in Miyake et al.'s analyses. The *Redundancy (R)* score indexes how frequently each digit has occurred. High R scores indicate a certain number has occurred more, or less frequently than others, indicating poor randomness. To achieve a low (good) R score, one must remember which number has been said previously, monitor when it was said, and suppress repeats or remember to produce new numbers. This measure loads on the updating factor in Miyake et al.'s analyses.

Participants were required to generate and vocalise a random series of numbers from the range of 1 – 9 for one minute. An illustration was given by asking participants to imagine a number being drawn from a hat. After it had been read out, the number would be placed back into the hat, and another number drawn and so on. When producing the sequence, participants were asked not to say numbers in any well known sequence (e.g. 1, 2, 3 or 3, 6, 9), but to try and produce them randomly. Rgcalc software (Towse & Neil, 1998) was used to assess randomness of the sequences produced by participants.

Procedure

Participants were first screened with the MMSE and the HADS. They then completed the AMT and finally the random number generation task. Each participant received a debrief session at the end of the visit.

Results

Plan of analyses

The sample was first examined to determine any relationships or group differences that may introduce confounds (anxiety or depression) or indicate an unusual sample (generally better executive function for younger groups would be anticipated). Repeated measures ANOVAs were then used to examine age group and emotional valence differences in specificity, in self-rated vividness and pleasantness of recalled memories, and in response times. This was to confirm previously reported age differences in AMT performance, and to specifically examine any age x emotion interactions. Finally, the relative influence of age and executive function on AMT performance for the different cue valences was examined using regression techniques, guided by initial correlation analyses, carefully explicating differences between the age groups in the correlations between memory specificity and executive function.

Controlling for depression

Neither anxiety nor depression scores were correlated with proportions of recalled memories that were specific, for positive, negative or neutral cues. However, for neutral cues, there was a correlation between depression score and response latency: $r(45) = 0.29$, $p = .05$. In analyses that follow, depression score will therefore be used as a covariate in analyses of response times.

Executive function

On the random number generation task, younger adults showed better performance than older adults [lower scores = better], on R and A: $t(44)=-2.47$, $p<.01$, and $t(44)=-2.18$, $p<.05$ respectively, but no difference between the age groups on RNG index (see Table 1). These measures indicated greater difficulty with this task with increasing age, with R identified as relating to the updating function and adjacency as relating to inhibition, suggesting that both inhibition and updating were affected by age.

Autobiographical memory specificity

The mean proportion of specific memories and standard deviations are shown in Table 2.

(Table 2 about here)

A 2 (age group) x 3 (type of cue) repeated measures ANOVA demonstrated that younger adults retrieved significantly more specific memories (*M*=0.84*, SD*= 0.07) than the older adults (*M*=0.69; *SD*=0.12); $F(1, 44) = 8.45$, $p < .01$, partial $\eta^2 = 0.16$. Observed power for the age difference was 0.81, confirming appropriateness of sample size. To double check that the difference in depression score on the HADS measure between the older and younger groups was not influencing the specificity measure, HADS depression score was entered into this analysis as a covariate. It did not have a significant effect (*F*=.003) and the age effect remained significant.

There was a significant linear effect of emotion, $F(1,44)=6.45$, $p<.01$, partial $\eta^2 = 0.13$. Post hoc analyses illustrated that participants retrieved a greater proportion of specific memories to positive cues (M=0.83, SD=.19) than neutral (M=0.75, SD=.25) or negative (M=0.73, SD=0.28); $t(45)=2.53$, $p<.05$ and $t(45)=2.12$, $p<.05$ respectively. The interaction between cue type and age group was not significant ($F(2, 44)=1.61$, $p>.1$, partial $\eta^2 = 0.04$). However, given that we had a priori expectations concerning group differences in specificity to the different types of cue, we conducted post hoc t-tests (with Bonferroni corrected alpha). These demonstrated that young participants recalled a significantly higher proportion of specific memories than older participants for neutral cues; $t(45)=3.10$, $p<.017$, but not for either type of emotional cue ($p>.017$), supporting the hypothesis of a greater age effect for neutral than for emotional recall.

The pattern of valence effects is shown in Figure 1, illustrating that both age groups recalled more specific memories to positive cues, that older adults generally recalled fewer specific memories than younger adults across the valences, but that the age effect is greater for neutral memories.

Figure 1 about here

Given that some clinical populations have demonstrated a difficulty inhibiting categorical memories (Williams et al., 2007), the data were checked to determine whether this was a cause for the age differences found. Although older adults did recall more categorical memories than younger adults, this difference was not significant, $F(1,44) = 2.60$, $p=0.11$.

Retrieval times

Table 2 gives mean retrieval times (and standard deviations). A 2 (age group) x 3 (type of cue) repeated measures ANOVA demonstrated that younger adults were significantly faster to retrieve memories (*M*=6.89 seconds, *SD*=3.13) than were older adults (M=8.67 seconds; SD=4.45); $F(1,44)=4.26$, $p<.05$, partial $\eta^2 = 0.09$). However, given the above finding of a correlation between depression score and response time for neutral recall, the analysis was repeated with HADS depression score as a covariate, and the resultant lack of age effect ($F(1,44)=1.82$, $p>.05$) suggested that this effect was dependent upon the slightly higher depression scores in the older group (see above). There was no effect of type of cue: $F(2,86)=1.41$, $p>.05$. There was also no significant age group by type of cue interaction, $F(2,86)=1.00$, $p= .37$; that is, older adults were not less slowed for emotional recall, contrary to expectations

Vividness

Table 2 shows mean vividness ratings and standard deviations. A 2 (age group) X 3 (type of cue) repeated measures ANOVA showed no significant difference between age groups for vividness ratings: $F(1, 44) = 1.51$, $p>.05$. However, there was a significant effect of type of cue: $F(2,88) = 14.14$, $p<.001$, partial $\eta^2 = 0.24$, with memories recalled to positive cues rated as more vivid (*M*=4.21, *SD*=0.53) than those recalled to neutral (M=3.72, SD=0.70) or negative cues (*M*=3.89, *SD*=0.59), both tests $p<.001$. The age x type of cue interaction was not significant: $F(2,88) = 0.65$, $p=.52$.

Pleasantness

Table 2 shows mean pleasantness ratings and standard deviations. A 2 (age group) x 3 (type of cue) mixed ANOVA revealed no significant difference between the age groups in terms of rated pleasantness of retrieved memories, $F(1,44) = 1.18$, $p>.05$ and no age group by type of cue interaction, $F(2,88) = 1.16$, $p>0.05$. However, there was a large effect of cue type: $F(2,88) = 102.35$, $p<.001$, partial $\eta^2 = 0.70$, with participants rating memories recalled to positive cues as significantly more pleasant (M=3.98, SD=0.72) than those recalled to neutral (M=3.56, SD=0.64), or negative cues (M=1.91, SD=0.68); both tests <.001. Furthermore, memories recalled to neutral cues were rated as significantly more pleasant than those recalled to negative cues; $p<.001$. This confirms that participants were indeed recalling in line with the valence of cues given, in line with inspection of ratings for each individual cue and response. This also confirms that the choice of cues fulfilled the purpose for which they were chosen.

Relationships of random number generation measures with specific recall, response latency and vividness

Correlation analyses demonstrated significant relationships between the redundancy measure (R) and proportion of memories recalled to different types of cue that were specific;

positive (*r*(46) = -0.34, *p*<.05), neutral (*r*(46) =-0.31, *p*<.05), and negative (*r*(46)=-0.40, *p*<.01), suggesting a relationship between memory specificity and updating in working memory. Additionally, recall of specific memories to neutral cues was related to scores on the Adjacency measure of random number generation (*r*(46)=-0.31, *p*<0.05), implying that memory specificity for neutral cues is related to inhibition in working memory. There were also significant relationships between R scores and retrieval times for each type of cue: positive *r*(46)=0.33; neutral *r*(46)=0.33 and negative *r*(46)=0.29, all *p*<.05, reflecting the association between amount of processing and retrieval times. There were no significant correlations between the random number generation measures and the vividness or pleasantness ratings given by the participants to the memories they retrieved.

Table 3 about here

Given that our hypotheses predicted differential relationships with inhibition and updating for different age groups and emotional cues, separate correlations were computed for the two age groups, with a Bonferroni correction applied to the criterion alpha for multiple comparisons (see Table 3). For younger adults, there was a significant relationship of R with proportion of specific memories recalled to positive cues; R: r(25)=-0.54, p<0.025; the relationship with adjacency was not significant once the correction was applied: Adjacency: r(25)=-0.41, p>0.025. That is, for younger groups, updating abilities were related to positive emotional recall only, but neither inhibitory nor updating abilities were related to negative or non-emotional recall with these measures. The difference between relationships for positive and negative cues with R was significant, tested using Williams' method for testing differences between two non-independent rs (1959, cited in Howell, 1987), $t(24)= 2.42$, $p<0.05$. There were no such relationships with retrieval times.

For older adults, recall of specific memories was significantly related to R score, but only in response to neutral cues; $r(21)=-0.54$, $p<.025$. There was no evidence of any relationship in retrieval to positive cues [$r(21)=-0.10$, $p>.05$] and that to negative cues failed to reach significance once the alpha criterion correction was applied ($p=.049$). Furthermore, in order to confirm the importance of the relationship with R for older adults (an indication of the updating component of executive function), the difference between the non-independent rs between R and specificity in response to neutral cues and those between Adjacency and RNG (inhibition) and specificity in response to neutral cues were compared. This difference was significant ($p<0.05$) between the correlations with R and Adjacency, but not between correlations with R and RNG ($p=0.13$). Finally, group comparisons on the correlations between memory specificity and executive function were conducted using the Fisher z transformation. The relationship between Redundancy R and proportion of specific memories retrieved to positive cues was marginally significantly greater for young participants [$r(25)=-0.54$] than it was for older participants [$r(21)=-0.10$], $z= 1.59$, $p=0.056$. The relationship between Redundancy R and proportion of specific memories retrieved to neutral cues was marginally significantly greater for older participants [r(21)=-0.54] than it was for young participants [r(21)=-.16], z= -1.39, p=0.08. Retrieval times were not related to executive function measures.

Finally, multiple regressions were computed to examine the relative contributions of the executive function subscales and age to the proportions of specific memories and the response latencies. A summary of these regressions is presented in Table 4a, and b. It can be seen that the regressions for response times were not significant, although age group entered on its own did predict response times for recall to positive cues, with older adults being slower. However, regressions for proportion of memories recalled that were specific suggested that R score (updating) accounted for a significant proportion of the variance in the significant model for recall to neutral cues only.

Tables 4a and b about here

There were no relationships between executive function subscales and vividness ratings.

Discussion

The aim of the current study was to examine the role of executive function in retrieval of specific autobiographical memories in older adults, with particular regard to cuing by emotion. To that end, groups of older and younger adults retrieved memories of specific events from their past in response to positive, negative and neutral word cues. They also completed a random number generation task to assess different aspects of executive function. Results supported the hypothesis that older adults showed poorer executive function than did younger adults, with deficits in both updating and inhibition components. These findings are consistent with previous studies demonstrating age-related deficits in randomness (Van der Linden, Beerten, & Pesenti, 1998) and in updating and inhibitory components of executive function (Piolino et al., 2010). They are also consistent with proposals for an inhibitory deficit in older age (Hasher & Zacks, 1988).

The expectation that older adults would take longer than younger adults to retrieve autobiographical memories was not supported. However, as memory retrieval was terminated, by convention, after 60 seconds, then the longest retrieval times exhibited by some older adults will have been omitted from analysis, so actual slowing will affect the data on specific memories recalled, as opposed to response latency. Thus, our findings do not necessarily mean that this group of older adults were not slower than their younger counterparts. The same issue may also be responsible for the lack of interaction between age group and emotional valence of cue in response times, such that the proposition that older adults may find recalling specific emotional memories less demanding (and therefore quicker) than neutral was not supported, but data demonstrating no decline with age for proportions of specific recall to emotional cues but a decline for neutral, do support this.

Consistent with previous work in older adults (e.g. Holland & Rabbitt, 1990; Ros, Latorre & Serrano, 2009; Piolino et al., 2010), younger adults retrieved a greater proportion of specific autobiographical memories than did older adults. The replication of an age difference in autobiographical memory retrieval is important, given the different cohorts and nationalities of the studies cited. For example, this study compared very different age ranges (18 – 35 years compared with over 55s) to the participants in Holland and Rabbitt's original study (60-69 years compared with 70-79). This indicates progression of specificity reduction as age increases, and present results imply that reduction begins somewhere between age 35 to 55. This effect was not related to any difference in depression level.

In accordance with previous research, greater autobiographical specificity was found for recall to emotional cues, emphasizing the enhancement effect of emotion on episodic details demonstrated by St. Jacques and Levine (2007). However, this was only the case for memories retrieved in response to positive cues. This was further established by the self-rated vividness scores which also demonstrated an advantage for recall to positive cues, across the age range (no interaction with age). In line with Ros et al. (2009), there was no age by emotion interaction, suggesting an advantage for positive recall across the age range of non-depressed adults. In contrast to some previous research in which older adults' recall has been found to be more positively self-evaluated (Comblain, D'Argembeau & Van der Linden, 2005), there was no effect of age on the self-rated pleasantness of the recalled memories, and no age by cue valence interaction. This contradicts suggestions that any age advantage for recall of positive events is related to a fading affect bias (e.g. Walker, Skowronski, Gibbons et al., 2003). Older adults did not rate their negative memories as less negative than did the younger adults. This may not be the case where other methods of cuing are used, since the cuing paradigm clearly constrained participants to recalling as cued: there was a very large effect of cue valence, people recalling positive memories to positive words and negative memories to negative words.

A difficulty with contrasting emotional with neutral words in autobiographical memory cuing is the issue that previous researchers have found that more imageable words will lead to greater specificity (e.g. Williams, Healy & Ellis, 1999) and emotionally neutral words are generally more concrete, or imageable, than emotional descriptions. However, the finding that participants recalled more specific memories in response to positive cues in this study suggests that this issue did not affect our results.

The finding that older adults retrieved fewer specific memories than younger participants was as expected. Nevertheless, it is important to note that post hoc age comparisons indicated that age-related decline in specificity was not uniform across all cues. The decline was clear in response to neutral cues, but not for positive or negative cues. This finding is consistent with a socio-emotional selectivity theory (Carstensen, 1999) which proposes that older adults become more emotionally focused as they approach the end of their lives. However, the mechanism underpinning this focus has not previously been specified and this study contributes to this question. One explanation is that, due to age-related deficits in executive function, older adults may exhibit a reduced ability to inhibit emotion and monitor the retrieval process. If this is the case, then specificity of older adults' retrieval to emotional cues (only) might have been expected to be negatively related to measures of inhibition, such that poorer executive function should have resulted in *greater* specificity for emotional recall. That is, because older adults may have reduced executive control, they will have reduced ability to inhibit emotion during search and verification processes involved in retrieval of specific autobiographical memories, making them more emotion focused in their retrieval. Emotional cues should result in an increase in autobiographical memory specificity, relative to the more demanding neutral cues, but only for the older adults. The significant age effect for neutral cues, but not positive or negative cues, supports this prediction, but in order to determine the actual effect of executive function on emotional and neutral recall, relationships with measures of executive function were examined, and they clearly did not quite tell the same story.

The updating index within the random number generation measure used (R), was related to specific recall across the age groups, with relationships for each type of cue being evident for proportion of memories that were specific and also for response time. However, the inhibitory measures (Adjacency) were only related to neutral recall. What is significant here is that the relationships were *not* negative. It was not the case that poorer inhibition led to better recall of emotional material as may have been predicted by a model in which emotional recall is regulated and suppressed by executive function (reduced affect control, Conway & Pleydell-Pearce, 2000). Better updating and inhibition (lower scores) led to *higher* proportions of specific memories overall.

However, an alternative or additional hypothesis must be considered. That is, the suggestion that, for older adults, emotional processing is achieved in a less costly manner with less demand on executive control (Scheibe & Blanchard-Fields, 2009). The separate examination of the relationships for older and younger adults is the key factor that enables us to distil this effect. Although the contrasts between the age groups in the relationships with R were only marginally significant, the differentiation between relationships for young and old is clear. This study found that better updating abilities significantly predicted greater specificity for positive recall (only) for younger adults, but that better updating ability significantly predicted greater specificity for neutral recall (only) for older adults. Thus the salient finding of this paper is that although results confirm that executive function does predict specificity for older adults, this is not so for positive recall.

Given that the lack of relationship between executive function measures and emotional recall in older age is apparent for positive recall only, these findings not only add support for the notion of preserved emotional processing in older age, but also for more automatic processing of positive materials. That is, with positive cues, older adults may have been given a less demanding route to specific event recall, providing some explanation for the positivity effect (e.g. Mather & Carstensen, 2005), although the lack of a relationship with retrieval times here needs clarifying in further work given that the method for truncating search after 60 seconds will have led to any slowing effects, e.g. for neutral as opposed to positive recall, being reflected in proportions of specific memories retrieved, rather than very long response times (see above).

Furthermore, the fact that R score, as opposed to adjacency or RNG index, was associated with neutral specificity for older adults suggests that updating ability, rather than inhibition of "prepotent associates" (Towse & Neill, 1998), is the key issue in the relationship between specific recall and executive function for older adults, possibly indicating that the updating component of the verification process (the point at which task requirements are checked with retrieved memories, Johnson, 1992) is the source of the effect of age related changes in such retrieval.

A key question is the relative salience of the contribution of age and the different executive function components to autobiographical memory performance indices. The regression analyses demonstrated that age group was a significant independent predictor of response time for response to positive cues, with older adults being slower. However, neither age nor the executive function measures were significant predictors for proportions of specific recall to emotional cues (positive or negative), but were for neutral cues. Here, once the executive function measures were added to the model, age became no longer a significant independent predictor, but updating ability was, further highlighting the key finding of these analyses: the age effect in specificity of recall for neutral cues was largely related to updating components of executive function.

The hierarchical model (Conway & Pleydell-Pearce, 2000) remains a plausible explanation of memory retrieval. Different levels of specificity have been observed using manipulated cues. The current study has added strength to the model by showing that it acts together with executive functions, and the retrieval process can be influenced by emotion. Poor updating ability (high R score) does indeed predict lower specificity for neutral words for older adults. Reduction of updating ability may be producing less specific memory by causing interruption to the cue elaboration process, which disrupts its relation to the knowledge of when the event happened and prevents the implementation of appropriate details to the event, a suggestion with further support from previous data on text recall (Holland & Rabbitt, 1990), or on source memory (Davidson, McFarland, Glisky, 2006). Inhibition deficits seem less important for this process.

This study has suggested that this emotion focus, and the advantage/lack of age related deficit for response to positive cues, may actually be a positive buffer against the negative influences of reduced executive function on over general recall, which has been related to the long term possibility of depression (Williams et al, 2007). That is, this ability to use emotions to access specific positive memories may actually be a compensatory adaptation to reduced cognitive resources by older adults who are not suffering from significant cognitive impairment. This also suggests that encouraging greater emotion focus in older adults may lead to a beneficial outcome for older depressed adults in that more specific retrieval has been shown to be related to better therapeutic outcome (e.g. Brittlebank, Scott, Williams & Ferrier, 1993) and also to better social problem solving ability (e.g. Raes, Hermans, Williams et al. 2005). It is clear that the ability to use such emotion processing to access specific memories needs further exploration of its therapeutic potential; for example, longitudinal study is required to reveal the long-term effect of being emotionally focused.

In conclusion, younger and older adults have shown differences in producing specific autobiographical memory. While younger adults produce higher specificity in general, it is observed that age-related decline is less for both valences of emotional memories. This reduced age deficit, despite clear lower executive function, suggests that executive function is associated with control of the related emotion within the hierarchical structure of autobiographical memory. The finding agrees with the hierarchical model and role of SMS suggested by Conway and Pleydell-Pearce (2000). Nevertheless, a lack of relationship between executive function and specificity of emotionally positive recall for older adults (only) suggests that the age-related positivity effect is one way that the influences of reduced executive function may be compensated for. It has yet to be established if prolonged increases in emotional focus in older adults would bring beneficial effect in the long run. Further research is needed to examine its impact and interaction with older adults' well being.

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Tables

Table 1. Mean participant characteristics (standard deviations are presented in parentheses).

	Young Adults (n=25)	Older Adults (n=21)
Age	21.60 (4.65)	69.52 (10.51)
MMSE	29.36 (0.91)	29.04 (1.07)
HADS (Anxiety Subscale)	4.64 (2.59)	5.52 (2.59)
HADS (Depression Subscale)	1.44 (1.26)	3.19 (2.42)
Redundancy (R)	1.53 (1.52)	2.78 (1.93)
RNG index	0.19 (0.08)	0.19 (0.10)
Adjacency Score (A)	13.21 (10.44)	21.76 (12.73)

MMSE=Mini mental-state examination; HADS=Hospital Anxiety and Depression Scale

Table 2

Mean proportion of specific autobiographical memories retrieved, retrieval times, and ratings of vividness and pleasantness as a function of age group and valence of cue word (standard deviations are presented in parentheses).

Variable	**Cue Valence**	**Younger Adults** (n=25)	**Older Adults** (n=21)
Proportion of Specific Memories	Positive	0.88 (0.15)	0.79 (0.22)
	Neutral	0.84 (0.20)	0.63 (0.25)
	Negative	0.70 (0.23)	0.66(0.31)
Retrieval Time (seconds)	Positive	6.70 (3.31)	9.10 (3.95)
	Neutral	6.76 (3.00)	7.90 (3.87)
	Negative	7.22 (3.07)	9.01 (5.54)
Vividness Ratings	Positive	4.17 (0.46)	4.27 (0.61)
	Neutral	3.58 (0.74)	3.88 (0.62)
	Negative	3.83 (0.64)	3.96 (0.53)
Pleasantness Ratings	Positive	4.08 (0.55)	3.87 (0.88)
	Neutral	3.44 (0.56)	3.67 (0.71)
	Negative	1.86 (0.51)	1.96 (0.85)

Table 3

Correlations between specificity, quality of memory (vividness and pleasantness), response times, and measures from the random number generation task for young adults Y (n=25) as compared with older adults O (n=21)

	Age		Redundancy (R)		RNG index		Adjacency (A)		Proportion Specific (Positive cues)		Proportion Specific (Neutral cues)		Proportion Specific (negative cues)		Response time for positive cues		Resp time neut
	O	Y	O	Y	O	Y	O	Y	O	Y	O	Y	O	Y	O	Y	O
Age	-	-															
Redundancy (R)	.17	.34	-	-													
RNG index	-.13	.42	-.16	.15	-	-											
Adjacency (A)	.11	-.07	.35	.53**	-.15	-.41	-	-									
Proportion specific (positive cues)	.02	-.14	-.10	-.54**	-.37	-.09	.18	-.41	-	-							
Proportion specific (neutral cues)	-.34	.07	-.54*	-.16	-.19	.16	-.14	-.33	.21	.21	-	-					
Proportion Specific (negative cues)	-.06	.05	-.44	-.08	-.26	.20	-.12	-.23	.40	.41	.22	.47*	-	-			
Response time for positive cues	<-.01	.37	.22	.27	.15	.18	-.39	-.12	-.10	-.11	.16	.35	-.22	-.15	-	-	
Response time for neutral cues	-.13	.14	.22	.36	.26	.15	-.05	.25	.03	-.16	.20	.36	-.12	-.02	.38	.52**	-
Response time for negative cues	-.10	.13	.23	.27	.06	.10	.15	.08	.23	-.08	.29	.31	.03	.01	.50*	.67**	.34

*p<0.025, **p<0.01

Table 4a

Regression on proportion of memories recalled that were specific for each type of cue

Step		Positive cues F(1,45)=2.63, p<0.05			Negative cues F(1,45)=1.86, NS			Neutral cues F(1,45)=4.48, p<0.01		
	Predictor	R^2	B	Beta	R^2	B	Beta	R^2	B	Beta
1	Age grp	.067	-.10	-.26	.064	-.14	-.25	.18	-.21	-.42**
2	Age grp	.20	-.06	-.16	.15	-.07	-.13	.30	-.14	-.28
	R		-.03	-.29		-.04	-.26		-.04	-.32*
	RNG		-.57	-.26		-.31	-.10		-.20	-.07
	Adjacency		.00	-.01		-.00	-.09		-.00	-.10

*p<0.05, **p<0.01

Table 4b

Regression on response times for each type of cue

Step		Positive cues F(1,45)=2.44, NS			Negative cues F(1,45)=1.18, NS			Neutral cues F(1,45)=2.08, NS		
	Predictor	R^2	B	Beta	R^2	B	Beta	R^2	B	Beta
1	Age grp	.32	2404.07	.32*	.04	1787.55	.20	.05	1409.86	.22
2	Age grp	.44	1595.11	.21	.10	945.75	.11	.17	705.73	.11
	R		407.02	.20		549.52	.23		519.97	.29
	RNG		8100.72	.19		4544.08	.09		8083.31	.22
	Adjacency		40.47	.13		20.70	.06		7.38	.03

*p<0.05, **p<0.01

Figure 1: Proportion of specific memories in response to each cue type for each age group.