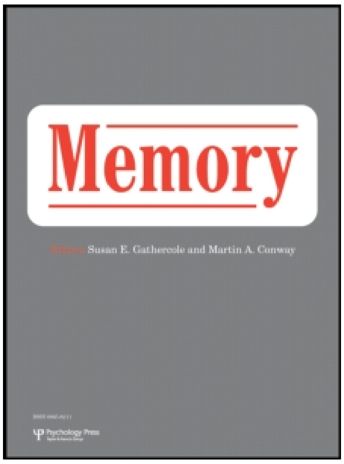

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Pictorial superiority effects in oldest-old people

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Pictorial superiority effects in oldest-old adults

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We examined memory for pictures and words in middle-age (45–59 years), young-old (60–74 years), old-old (75–89 years), and the oldest-old adults (90–97 years) in the Louisiana Healthy Aging Study. Stimulus items were presented and retention was tested in a blocked order where half of the participants studied 16 simple line drawings and the other half studied matching words during acquisition. Free recall and recognition followed. In the next acquisition/test block a new set of items was used where the stimulus format was changed relative to the first block. Results yielded pictorial superiority effects in both retention measures for all age groups. Follow-up analyses of clustering in free recall revealed that a greater number of categories were accessed (which reflects participants' retrieval plan) and more items were recalled per category (which reflects participants' encoding strategy) when pictures served as stimuli compared to words. Cognitive status and working memory span were correlated with picture and word recall. Regression analyses confirmed that these individual difference variables accounted for significant age-related variance in recall. These data strongly suggest that the oldest-old can utilise nonverbal memory codes to support long-term retention as effectively as do younger adults.

Keywords: Episodic memory; Healthy ageing; Oldest-old; Picture superiority effect; Verbal recall.

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Age-related declines in episodic memory are well documented in the cognitive ageing literature (for reviews, see Craik, 2000; Zacks, Hasher, & Li, 2000). Much of the prior work on memory ageing consists of studies where younger (20s to 30s) and older adults (60s to 70s) were compared on various episodic memory tasks. In recent years measures of episodic memory have been included in multidisciplinary studies of oldest-old people that assess cognitive, psychosocial, and physiologic variables (see Bäckman, Small, Wahlin, & Larsson, 2000, for review). Prior work confirms that oldest-old people benefit from task-relevant memory support in the form of prior knowledge (e.g., Wahlin et al., 1993) and retrieval cues (e.g., Bäckman & Wahlin, 1995). Other evidence has shown that demographic and lifestyle variables influence the extent to which older adults benefit from cognitive support to enhance episodic memory (Hill, Wahlin, Winblad, & Bäckman, 1995). These studies highlight the critical role of individual difference and task variables in episodic memory functioning in late life, consistent with a contextualist view of episodic memory (Bäckman, Mantyla, & Herlitz, 1990).

One issue that has received scant attention in studies of episodic memory in late adulthood is whether oldest-old people demonstrate pictorial superiority effects in retention. The pictorial superiority effect (PSE) refers to the finding that concrete items are better remembered when presented in a pictorial format than in a verbal format. Paivio (1971) advanced the dual-coding theory to explain the memorial advantage of pictures relative to their verbal referents. This theory holds that pictures can be dually represented in memory by visual and verbal codes, whereas words are represented primarily by verbal codes. Pictures are better remembered than words, on the assumption that two codes are better than one. An alternative explanation for the memorial efficacy of pictures is that the sensory codes for pictures are richer than those of words, leading to a more differentiated representation that is less susceptible to interference (Nelson, Reed, & Walling, 1976). It has also been suggested that pictures benefit from greater conceptual processing than do words (Stenberg, 2006). Whether code redundancy, a richer sensory representation of items in picture format, or enhanced conceptual processing of pictures accounts for the pictorial superiority effect is a matter of theoretical interest and debate (Mintzer & Snodgrass, 1999; Paivio, 1991). Differing theoretical perspectives notwithstanding, the PSE is widely recognised as a reliable and robust episodic memory phenomenon. Accordingly, researchers have used pictures and words as memory stimuli in many studies of implicit and explicit retrieval processes (e.g., Weldon & Roediger, 1987), false recognition (e.g., Dodson & Schacter, 2002), and in more recent neuropsychological studies using brain-imaging techniques (e.g., Springer, McIntosh, Winocur, & Grady, 2005). The finding that pictures are better remembered than words is also a matter of practical importance, as pictures may be useful in educational contexts to aid in retention of written material (Cherry, Park, Frieske, & Smith, 1996).

Ample experimental evidence documents the reliability and generality of the PSE across numerous participant populations and memory measures. For instance, PSEs have been found for children and adolescents (Whitehouse, Maybery, & Durkin, 2006) and for college students in free recall (e.g., Toglia, Hinman, Dayton, & Catalano, 1997), paired associate recall (e.g., Nelson et al., 1976), and recognition (e.g., Snodgrass & Asiaghi, 1977). Persons with mental retardation show a PSE, as do their normal-intelligence counterparts (Cherry, Applegate, & Reese, 2002). Other evidence indicates that healthy older adults demonstrate PSEs, as do younger adults in free recall (Rissenberg & Glazner, 1986; Winograd, Smith, & Simon, 1982) and recognition (Park, Puglisi, & Sovacool, 1983). To our knowledge, the present study is the first to examine evidence for pictorial superiority in oldest-old people, defined here as individuals aged 90 years and older. Whether nonagenarians show a pictorial superiority advantage in long-term retention is an important issue, having both theoretical and practical implications. From a theoretical perspective, evidence of a PSE would suggest that oldest-old people form and utilise nonverbal (i.e., imaginal/visuospatial) memory codes as well as do their younger counterparts to support long-term retention. Evidence of a pictorial advantage in memory would also suggest a direction for the development of mnemonic aids to improve everyday retention in very old adults.

In this article we examine episodic memory from a contextualist perspective, focusing on the role of individual differences, stimulus format, and retrieval task characteristics (Bäckman et al., 1990). To ensure an adequate representation of the age variable, the experimental design included comparison groups of middle-age adults (ages 45–59 years), young-old adults (ages 60–74 years), old-old adults (ages 75–89 years), and the oldest-old adults (age 90 years and over). Participants were enrolled in the Louisiana Healthy Aging Study (LHAS), a multidisciplinary study of the determinants of human longevity and healthy ageing. Our primary objective was to determine whether oldest-old people show a pictorial superiority effect in measures of long-term retention, as do their younger counterparts. Participants studied and later remembered simple black and white line drawings and their matching verbal referents from the Snodgrass and Vanderwart (1980) corpus. Free recall and recognition were tested. We expected that the oldest-old people would perform more poorly than their younger counterparts on these long-term memory measures, consistent with prior research on episodic memory in late life. Further, the oldest-old people should show a pictorial superiority advantage in free recall and recognition, in line with earlier studies with young-old adults (e.g., Park et al., 1983; Winograd et al., 1982). Based on expectations issuing from a contextualist perspective (Bäckman et al., 1990; Craik, Byrd, & Swanson, 1987), we hypothesised that the oldest-old people would benefit more than their younger counterparts from pictures as memory stimuli coupled with recognition as the retrieval task. Such a pattern of outcomes would confirm the reliability and generality of the pictorial superiority effect, as well as demonstrate the context sensitivity of episodic remembering well into the ninetieth decade of life.

Our second objective was to examine the contributions of cognitive status and working memory capacity to episodic memory performance. The Mini Mental State Exam (MMSE, Folstein, Folstein, & McHugh, 1975) was selected as an index of cognitive status in the present research based on several considerations, including adequate psychometric properties (Tombaugh & McIntyre, 1992), frequency of use in other large-scale studies of cognition in very old adults (cf. Luszcz, Bryan, & Kent, 1997; Wahlin et al., 1993), and ease of administration. The MMSE also offers a broad glimpse of cognitive functionality in that it comprises seven subscales (orientation, registration, attention and calculation, recall, language, repetition, and comprehension). Prior research has shown that MMSE scores of 25 and above are predictive of episodic memory in very old age (e.g., Wahlin et al., 1993), implying that mild deficits in cognitive status may contribute to episodic memory impairment. We included the MMSE as a predictor of memory performance to shed further light on this issue. With respect to working memory as an individual difference variable, the digit span tests from the WAIS (Wechsler, 1981) and the size judgement span task (SJS, Cherry, Elliott & Reese, 2007) were included as indices of short-term retention and working memory capacity. The SJS has been shown to account for greater amounts of age-related variance than the backward digit span test in several different episodic memory tasks across a variety of participant groups (Cherry et al., 2007). As a result, SJS was selected to represent the working memory construct in this study. Regression analyses were conducted to determine the amount of variance accounted for by MMSE and SJS in word and picture free recall as criterion measures of episodic memory. We also examined the proportion of age-related variance that could be accounted for by SJS and MMSE to clarify the contribution of these individual ability differences to episodic memory performance in late adulthood.

METHOD

Participants

A total of 160 individuals participated in this study. The four age groups included middle-age adults ($M = 51.7$ years, $SD = 3.5$, age range 45–58 years), young-old adults ($M = 69.7$ years, $SD = 3.2$, age range 61–74 years); old-old adults ($M = 80.5$ years, $SD = 3.8$, age range 75–89 years); and the oldest-old adults ($M = 92.4$ years, $SD = 1.8$, age range 90–97 years). All were enrolled in the LHAS, a multidisciplinary study of the determinants of longevity conducted in collaboration with LSU Health Sciences Center in New Orleans, the University of Alabama at Birmingham, and the Pennington Biomedical Research Center in Baton Rouge, LA. LHAS participants are sampled randomly from the Voters Registration 2000 files for those aged 20 to 64 years, and from the Medicare Beneficiary Enrollment Data file of the Center for Medicare and Medicaid Services (CMS) for those aged 65 years and above for the eight parishes (counties) constituting the Greater Baton Rouge community. Corrected binocular visual acuity was assessed with a standard Snellen eye chart. All participants in this study were visually capable and free of neurological impairment due to stroke or adult dementia. All scored at least a 25 or higher on the Mini-Mental State Exam (MMSE; Folstein et al., 1975). Table 1 presents a summary of the individual difference and self-reported health characteristics of the sample.

We conducted one-way analyses of variance (ANOVAs) and chi-squared tests of independence (when indicated) on the individual difference data with age group as a between-group factor. An ANOVA on the MMSE scores yielded a significant age group effect, $F(3, 156) = 20.42$, $MSE = 1.28$, $p < .001$. Pairwise comparisons (Tukey) confirmed that the oldest-old adults' mean MMSE score was lower than the three comparison groups' scores ($p < .05$ for each comparison, see Table 1). A short-form of the Wechsler Adult Intelligence Scale Vocabulary subtest (Jastak & Jastak, 1965) was given as a measure of verbal intelligence. Analyses of the vocabulary scores yielded a non-significant age group effect ($p = .23$). Participants' scores on the Geriatric Depression Scale (GDS; Sheikh & Yesavage, 1986) indicated that the majority (93%) were within the normal range at the time of testing. An ANOVA on the GDS scores yielded a significant age group effect, $F(3, 155) = 2.83$, $p = .04$, favouring the oldest-old adults whose mean GDS score was numerically higher than the other groups, yet well below the cutoff score of 6 representing mild depression.

Participants rated their level of education on a 7-point scale (see Table 1). A chi-squared test of independence revealed no significant association between educational attainment and age group ($p = .2$). Participants' responses to a demographic questionnaire that contained a subset of self-perceived health questions from the Older American Resources and Services Multidimensional Functional Assessment Questionnaire (Duke University Center for the Study of Aging and Human Development, 1975) indicated that most were generally in good health. Analyses of the ratings for health at the present time and age group yielded a non-significant association by a chi-squared test ($p = .21$). For health prevents activities, the chi-squared test for independence related to age groups showed a significant association ($p = .006$), owing to the oldest-old adults who rated their health as standing in the way of doing things they want to do more often than the other age groups. The chi-squared test for independence of health compared to others and age groups showed a significant association ($p = .0002$). The oldest-old adults rated their health as better than their age mates more often than did the younger groups. Analyses of the social activity ratings measured by the number of clubs and social organisations yielded a significant association to age groups by chi-squared test ($p = .02$) due to the middle-age group who reported fewer clubs and social organisations compared to their older counterpart groups. Analyses of the number of hours per week spent outside the home also yielded a significant association to age groups by chi-squared test ($p < .001$), favouring the middle-age group who reported more hours per week spent outside their home compared to the other groups.

Participants rated their satisfaction with social support they receive for dealing with day-to-day problems. Analyses of the social support ratings yielded a significant association to age groups by chi-squared test ($p = .002$), due to the middle-age adults whose social support ratings were lower than the other groups' ratings. Participants indicated whether they had a confidant, described as someone they can talk to about issues that concern them. Analyses of the confidant ratings yielded a non-significant association to age groups ($p = .15$).

Individual differences measures

Three measures of working memory span were administered that required participants to simultaneously hold and process auditorily presented information. These measures included the Forward Digit Span (FDS) and Backward Digit Span (BDS) tests from the WAIS (Wechsler, 1981). Digit span tests were scored by giving full (set size) credit for sequences where both of the two trials were correct and half credit if only one trial per set size was correct. The Size Judgement Span (SJS) test (Cherry et al., 2007) required the manipulation of visuospatial information. Participants heard progressively longer sequences of individual words whose referents could be easily visualised (e.g., frog–piano–hairpin) and repeated the sequence of words in order of the referents' relative physical size, from the smallest to the largest item (e.g., hairpin–frog–piano). Two practice trials were given (two-item sequences). After practice, participants were given three trials of two, three trials of three, and so forth, until they missed three consecutive trials within a sequence length. The SJS test was scored by giving full credit to sequence levels where at least two out of

TABLE 1
Summary of individual difference characteristics

	Age group							
	Middle-age (n = 40)		*Young-old (n = 40)*		*Old-old (n = 40)*		*Oldest-old (n = 40)*	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
MMSE[a]	29.7	0.69	29.1	0.82	28.5	1.28	27.8	1.52
Vocabulary[b]	25.2	7.7	25.4	7.1	24.4	7.7	22.4	6.2
GDS[c]	1.60	2.16	1.45	1.78	1.60	1.58	2.62	2.39
	Middle-age (n = 40)		*Young-old (n = 40)*		*Old-old (n = 40)*		*Oldest-old (n = 40)*	
	%		%		%		%	
Years of education								
<7th grade	0.00		0.00		0.00		2.50	
7th to 9th grade	0.00		0.00		5.00		7.50	
10th to 11th grade	0.00		2.50		7.50		10.50	
High school	37.50		40.00		17.50		22.50	
Partial college or training	30.00		25.00		32.50		25.00	
College degree	17.50		15.00		27.50		25.00	
Graduate degree	15.00		17.50		10.00		7.50	
Health at the present time								
Excellent	30.00		17.50		10.00		12.82	
Good	55.00		70.00		72.50		61.54	
Fair	12.50		12.50		17.50		25.64	
Poor	2.50		0.00		0.00		0.00	
Health prevents activities								
A great deal	5.13		10.00		7.50		23.08	
A little/some	39.90		30.00		60.00		46.15	
Not at all	58.97		60.00		32.50		30.77	
Health compared to others								
Better than	50.00		55.00		62.50		97.44	
The same as	45.00		42.50		37.50		2.56	
Worse	5.00		2.50		0.00		0.00	
Number of clubs and social organizations								
None	25.00		5.00		2.50		10.26	
1–3	65.00		77.50		65.00		72.92	
4–6	5.00		12.50		25.00		10.26	
More than 6	5.00		5.00		7.50		2.56	
Number of hours per week spent outside of home								
None	0.00		0.00		2.50		2.56	
1–5	0.00		20.00		17.50		38.46	
6–12	7.50		30.00		20.00		15.38	
13–19	10.00		20.00		20.00		12.82	
More than 19	82.50		30.00		40.00		30.77	
Social support								
Very satisfied	45.00		77.50		75.00		87.18	
Fairly satisfied	40.00		17.50		22.50		7.69	
A little satisfied	15.00		5.00		0.00		5.13	
Not satisfied	0.00		0.00		2.50		0.00	
Confidant	97.50		95.00		87.50		85.00	

[a]Mini-Mental State Exam (Folstein et al., 1975). [b]Vocabulary (Jastak & Jastak, 1965). [c]Geriatric Depression Scale (Sheikh & Yesavage, 1986).

three trials were correct and half credit if only one of three trials was correct.

Materials

Stimulus items were simple black and white line drawings and matching words. The drawings were taken from a standard corpus and matched for image and name agreement (Snodgrass & Vanderwart, 1980). The total stimulus pool consisted of 64 pictures and matching words, representing eight taxonomic categories with eight exemplars per category. Four acquisition lists of 16 items were created. Two lists contained target items presented for study (one picture list, one word list). For each participant, 16 study items were presented in picture format and the other 16 in word format. The non-presented lists served as distractor items in the picture and word recognition tests. Acquisition lists were counterbalanced so that each item appeared as a study item and a non-presented item equally often across participants and stimulus formats. All study and test stimuli were presented individually on 6 × 9 inch index cards.

Design

The design was a 4 × 2 mixed factorial with age group (middle-age, young-old, old-old, oldest-old) as a between-groups variable and stimulus format (words, pictures) as a repeated measures factor. For half of the participants the study/test materials were pictures in block 1 and words in block 2. For the other half this order was reversed to control for presentation order effects. A total of 40 persons were tested in each between-group condition.

Procedure

Participants were tested individually. At the beginning of the session an example item was shown (a picture or a word, depending on presentation order assignment) to familiarise the participants with the stimuli. A three-item practice task followed. Participants named each item aloud as it was shown to ensure that all stimuli were encoded and that we had a record of possible unique verbal labels assigned to pictures (e.g., naming the "sofa" as "a couch" or "davenport"). They recalled the study items orally and the experimenter recorded their responses. A practice recognition task followed, where six items were presented in turn (three target items and three foils interspersed). Participants made a yes/no judgement for each item.

On the first block of the experiment proper, 16 items were presented for study (5-s rate). A 2-minute distractor task followed, where they described their favourite foods (block 1) and favourite holidays (block 2). Following the distractor task, participants orally recalled as many of the studied items as possible. Recognition followed, using a mixed list of 16 studied items and 16 foils randomly interspersed, presented in turn (8-s rate). Participants made yes/no judgements for each item. On the second trial the stimulus format was changed relative to the first trial (i.e., from pictures to words or vice versa). The working memory measures were administered next.

Debriefing followed.

RESULTS

Overview of scoring and analyses

For each participant, the working memory measures were scored as discussed previously. Free recall was scored as the proportion of items correctly recalled (out of 16). Recognition was scored by calculating hit and false alarm rates that were used to derive a measure of corrected recognition (hits minus false alarms). Separate analyses of variance (ANOVAs) were conducted on the dependent measures as a function of age group and stimulus format accounting for within-participant variability. Correlations among these variables were calculated, followed by sequential regression analyses that examined the independent contributions of age, cognitive status, and working memory span to word and picture free recall performance.

Mixed model analyses of variance

Free recall. Mean proportion correct by age group and stimulus format appears in Table 2 (upper panel). A mixed model type ANOVA with random participant effect, age group and stimulus format main effects, and age group × stimulus format interaction, was conducted. On the free recall scores, a significant main effect of age

TABLE 2
Mean free recall and recognition as a function of age group and stimulus format

	Stimulus format			
	Words		*Pictures*	
	M	*SD*	*M*	*SD*
Free recall				
Age group				
Middle-age	0.52	0.17	0.64	0.18
Young-old	0.39	0.19	0.56	0.18
Old-old	0.35	0.19	0.53	0.17
Oldest-old	0.19	0.14	0.34	0.16
Group mean	0.36		0.52	
Recognition				
Age group				
Middle-age	0.87	0.14	0.95	0.07
Young-old	0.83	0.12	0.95	0.07
Old-old	0.83	0.14	0.95	0.06
Oldest-old	0.65	0.24	0.89	0.10
Group mean	0.80		0.94	

Free recall scores reflect mean proportion correct. Recognition scores reflect corrected recognition (hits minus false alarms).

group, $F(3,\ 156) = 31.73$, $MSE = 0.04$, $p < .001$, was found. Mean recall performance was highest for the middle-age adults (0.58), followed by the young-old (0.47), old-old (0.44), and the oldest-old adults (0.27), as expected. The main effect of stimulus format was also significant, $F(1,\ 156) = 117.91$, $MSE = 0.02$, $p < .001$. Recall of pictures exceeded that of words, with means of 0.52 and 0.36, respectively. This is an important finding, which confirms the pictorial superiority effect in free recall with the present materials and procedures. The age group × stimulus format interaction was non-significant; thus, all groups showed a pictorial advantage of comparable magnitude in free recall.

To provide insight into participants' organisational strategies on the free recall task, we conducted clustering analyses using the Scoring Options for Recall Tests (SORT) program, version 2.0 (Elie & Payne, 1999). Two dependent measures were of particular interest. That is, we examined the number of taxonomic categories accessed, which is assumed to reflect participants' retrieval plan, and the number of items recalled per category, thought to reflect participants' encoding strategy (Bäckman & Wahlin, 1995). Table 3 presents the age group means for the number of categories accessed and the number of items recalled per category. For the number of categories accessed, a significant effect of age group occurred, $F(3,\ 156) = 33.68$, $MSE = 0.80$, $p < .0001$. Means for the middle-age (3.64), young-old (3.34), and old-old adults (3.17) were greater than the mean for the oldest-old participants (2.29). The effect of stimulus format was significant, $F(1, 156) = 47.78$, $MSE = 0.53$, $p < .0001$, favouring pictures compared to words. Means, in order, were 3.39 and 2.83 for pictures and words. The age group × stimulus format interaction was significant, $F(3,\ 156) = 3.17$, $MSE = 0.53$, $p = .03$. As can be seen in Table 3, all four groups accessed a greater number of categories with pictures compared to words. The significance of the interaction is attributable to the middle-age adults whose performance was near ceiling for the number of categories accessed. For the number of items recalled per category a significant effect of age group, $F(3,\ 156) = 18.52$, $MSE = 0.52$, $p < .0001$, was found. Means for the middle-age (2.53), young-old (2.17), and old-old (2.15) participants exceeded the mean for the oldest-old adults (1.69). The effect of stimulus format was significant, $F(1,\ 156) = 84.53$, $MSE = 0.25$, $p < .0001$, favouring pictures compared to words. Means, in order, were 2.39 and 1.88 for pictures and words. Taken together, the results of these analyses are suggestive of deficits in both encoding and retrieval processes for the oldest-old participants, compared to their younger counterparts (see Bäckman & Larsson, 1992; Bäckman & Wahlin, 1995, for similar outcomes). These data also imply that the PSE observed for

TABLE 3
Analyses of clustering in free recall

	Number of categories accessed		*Items per category*	
Age group	*Words*	*Pictures*	*Words*	*Pictures*
Middle-age	3.55	3.73	2.34	2.72 *
Young-old	3.03	3.65 **	1.91	2.42 **
Old-old	2.88	3.45 **	1.87	2.43 **
Oldest-old	1.85	2.73 **	1.39	1.98 **
Mean	2.83	3.39	1.88	2.39

Stimulus lists comprised four taxonomic categories with four exemplars per category.
* $p \leq .01$, ** $p \leq .001$.

all age groups in this study may be mediated at least in part by participants' organisational strategies applied at both encoding and retrieval.

Recognition. The analysis of corrected recognition scores yielded a significant effect of age group, $F(3, 156) = 15.56$, $MSE = 0.02$, $p < .0001$. Means for the middle-age (0.91), young-old (0.89), and old-old (0.89) participants exceeded the mean for the oldest-old adults (0.77). The main effect of stimulus format was significant, $F(1, 156) = 112.88$, $MSE = 0.01$, $p < .0001$ due to the superior recognition of pictures compared to words. Means, in order, were 0.94 and 0.80 for pictures and words. Importantly, the age group × stimulus format interaction was significant, $F(3, 156) = 6.49$, $MSE = 0.01$, $p < .001$ owing to the disproportionate memorial benefit of pictures compared to words for the oldest-old participants, as the means in Table 2 indicate. However, interpretative caution is warranted, as means for the three younger comparison groups are approaching ceiling in the picture condition. As a result, our analytic strategy presented in the sections that follow will be confined to word and picture free recall as the principal measures of episodic memory, neither of which is hampered by ceiling or floor effects.

Working memory analyses

Span estimates for the forward and backward digit span, and size judgement span tests appear in Table 4. An ANOVA on the forward digit span scores yielded a significant effect of age group, $F(3, 156) = 6.16$, $MSE = 1.00$, $p = .0006$. Pairwise comparisons confirmed that the span estimate for the middle-age adults was significantly higher than that of the young-old, old-old, and oldest-old adults, who did not differ from each other. An ANOVA on the backward digit span scores yielded a significant age group effect, $F(3, 156) = 4.11$, $MSE = 0.96$, $p = .008$. The middle-age adults' mean span estimate was significantly greater than the oldest-old adults' span estimate

TABLE 4
Span estimates for the working memory measures

	Age group			
Measure	*Middle-age*	*Young-old*	*Old-old*	*Oldest-old*
Forward digit span[a]				
M	6.20	5.49	5.54	5.30
SD	1.11	0.96	1.05	0.88
Backward digit span[b]				
M	4.54	4.24	4.19	3.78
SD	1.03	0.97	0.97	0.94
Size judgment span[c]				
M	4.70	4.36	3.99	3.53
SD	1.00	0.70	0.73	0.90

[a,b]From the Wechsler Adult Intelligence Scale (Wechsler, 1981). [c]From Cherry et al. (2007).

TABLE 5
Correlations among age, cognitive status, and memory measures

	1	*2*	*3*	*4*	*5*	*6*	*7*
1. Age	–						
2 MMSE	−.54***	–					
3. FDS	−.32***	.31***	–				
4. BDS	−.26**	.29***	.53***	–			
5. SJS	−.46***	.44***	.49***	.45***	–		
6. Word recall	−.57***	.54***	.34***	.29***	.54***	–	
7. Picture recall	−.51***	.49***	.17*	.21**	.39***	.62***	–

MMSE indicates mini-mental state exam; FDS indicates forward digit span; BDS indicates backward digit span;SJS indicates size judgement span. $N = 160$.
* $p < .05$, ** $p < .01$,*** $p < .001$.

($p = .004$). An ANOVA on the size judgement span scores yielded a significant effect of age group, $F(3,\ 156) = 14.44$, $MSE = 0.71$, $p < .0001$. Pairwise comparisons confirmed that the middle-aged adults' mean span estimate was significantly greater than the old-old and oldest-old adults' span estimate ($p \leq .001$ for all). Similarly, the young-old adults' mean span exceeded that of the oldest-old adults ($p < .001$). Together, the results of these analyses confirm that the size judgement span test reliably discriminated among the comparison groups more effectively than did the forward and backward digit span measures (see Cherry et al., 2007, for a similar result).

Relationships among age, individual difference and memory measures

Correlation analyses. Table 5 presents the correlations among chronological age, MMSE, FDS, BDS, SJS, and word and picture free recall.[1] Three aspects of these data warrant mention. First, age was inversely correlated with all of the memory measures, as expected. Second, for word recall, correlations with FDS, BDS, and SJS were all significant and the correlation coefficients are larger in comparison to those obtained for picture recall, implying that picture recall may be less resource demanding than word recall. Third, of the three span estimates, SJS showed the strongest relationships to word and picture free recall, implying that SJS is the optimal variable to include in the sequential regression analyses reported next. In addition, a variable selection procedure was conducted using multiple regression and the all possible submodels selection method (SAS System for Linear Models, 1991). The best model was selected based on maximal R^2 and minimal MSE values, yielding a model that contains age, MMSE, and SJS for inclusion in the regression analyses with free recall as the criterion response variable presented next.

Regression analyses. Sequential regression analyses were conducted to assess the independent contributions of age, MMSE, and SJS to episodic memory using two criterion measures of performance (i.e., free recall of words and pictures). In all, four models were conducted separately for each criterion measure. In the first model age alone was entered. In the second and third models we wanted to determine the amount of variance in memory performance accounted for by age after adjusting for MMSE (Model 2) and SJS (Model 3). The fourth model was conducted to determine whether the MMSE and SJS were still predictive of memory performance after age had been statistically controlled for.

Results of the regression analyses appear in Tables 6 and 7. The cumulative R^2 associated with the addition of subsequent variables entered into the regression equation is given in the first column. The increment in R^2 associated with each additional variable appears in the second column. The beta weight associated with each

[1] Because level of education is a categorical variable we conducted Spearman's correlations among the educational attainment scores (rated on a 7-point scale) and the memory measures reported here. As expected, level of education was positively correlated with MMSE, FDS, BDS, and SJS performance (*r*s between .19 and .39 and all *p*s $< .02$). However, level of education was not significantly correlated with picture free recall ($r = .08$, $p = .32$) and only marginally so with word free recall ($r = .14$, $p = .07$). Further, the age groups were no different in self-reported educational attainment. On the basis of these outcomes, educational attainment was not included in the sequential regression analyses.

TABLE 6
Summary of sequential regression analyses for word free recall

	R^2	*Increment in* R^2	β	*F*	*P*
Model 1					
Age	.326	–	–.571	77.14	<.0001
Model 2					
MMSE	.295	–	.543	77.61	<.0001
Age	.403	.108	–.391	28.58	<.0001
Model 3					
SJS	.288	–	.537	77.9	<.0001
Age	.420	.132	–.412	35.72	<.0001
Model 4					
Age	.326	–	–.571	94.6	<.0001
MMSE	.403	.077	.33	22.59	<.0001
SJS	.463	.060	.286	17.25	<.0001

The increment in R^2 is associated with the inclusion of additional variables entered into the regression equation. The *F* statistic denotes the statistical significance of R^2 for the first variable or the increment in R^2 associated with each additional variable entered into the regression equation. For all *F* statistics, the degrees of freedom were 1 and 156.

variable upon entry into the equation appears in the third column. The *F* statistic and *p* value that show the statistical significance of R^2 for the first variable or the increment in R^2 for each additional variable, appear in the fourth and fifth columns.[2]

As can be seen in Table 6 (Model 1), age accounted for 32.6% of the variance in word recall. In Model 2 MMSE was entered first, accounting for a significant 29.5% of the variance. Following the statistical control of MMSE, the variance accounted for by age was reduced to 10.8%. This finding indicates that individual differences in MMSE account for some of the age-related variance in word recall. To be precise, the drop in variance accounted for by age, from 32.6% (Model 1) to 10.8% (Model 2) after MMSE was controlled for, can be interpreted to indicate that MMSE accounts for 66.9% of the age-related variance in word recall—i.e., (.326 – .108)/.326. In Model 3 SJS accounted for a significant 28.8% of the variance and the contribution of age was reduced to 13.2%, confirming that SJS accounts for a sizeable portion of age-related variance in word recall. That is, the reduction in variance accounted for by age, from 32.6% (Model 1) to 13.2% (Model 3) after SJS was controlled indicates that SJS accounts for 59.5% of the age-related variance in word recall—i.e., (.326 – .132)/.326. This is a noteworthy finding, indicating that SJS accounts for nearly as much age-related variance in word recall as does MMSE. Note, however, that cognitive status (MMSE) and working memory resource (SJS) influence word recall, but do not account for age effects completely because the 10.8% (Model 2) and the 13.2% (Model 3) of the variance accounted for by age in these models was significant ($p < .0001$ for all). In Model 4, following the addition of age, the R^2 values associated with MMSE and SJS remained significant, but were reduced to 7.7% and 6.0% of the variance consecutively. Thus, MMSE and SJS accounted for unique variance in word recall beyond that already accounted for by age.

Inspection of Table 7 (Model 1) reveals that age accounted for a significant 26.0% of the variance in picture recall. In Model 2, MMSE accounted for a significant 23.7% of the variance in picture recall. Following the statistical control of MMSE, the variance accounted for by age was reduced to 8.6%. The drop in variance accounted for by age, from 26.0% (Model 1) to 8.6% (Model 2) after MMSE was controlled, can be interpreted to indicate that MMSE accounts for 66.9% of the age-related variance in picture recall—i.e., (.260 – .086)/.260. In Model 3, SJS accounted for a significant 15.0% of the variance. The contribution of age was reduced to 13.9%, confirming that SJS accounts for age-related

[2] Type I Sum of Squares as well as the residual means square from the full model was used in calculation of the *F* and *p* values for the first variable and for each additional variable. The purpose of this procedure was to permit direct comparisons across regression models (Hocking, 1985). We used this procedure in the analyses of word free recall (Table 6) and picture free recall (Table 7).

TABLE 7
Summary of sequential regression analyses for picture free recall

	R^2	*Increment in* R^2	β	*F*	*P*
Model 1					
Age	.260	–	−.510	55.55	< .0001
Model 2					
MMSE	.237	–	.487	55.04	< .0001
Age	.323	.086	−.349	19.97	< .0001
Model 3					
SJS	.150	–	.387	33.07	<.0001
Age	.289	.139	−.421	30.74	<.0001
Model 4					
Age	.260	–	−.510	61.05	<.0001
MMSE	.324	.064	.299	14.83	<.001
SJS	.335	.011	.128	2.80	<.1

The increment in R^2 is associated with the inclusion of additional variables entered into the regression equation. The *F* statistic denotes the statistical significance of R^2 for the first variable or the increment in R^2 associated with each additional variable entered into the regression equation. For all *F* statistics, the degrees of freedom were 1 and 156.

variance in picture recall. The drop in variance accounted for by age, from 26.0% (Model 1) to 13.9% (Model 3) after SJS was controlled, indicates that SJS accounts for 46.5% of the age-related variance in picture recall—i.e., (.260 – .139)/.260. Note, however, that MMSE and SJS do not account for age effects in picture recall completely because the remaining 8.6% (Model 2) and the 13.9% (Model 3) of the variance accounted for by age in these models was significant ($p < .0001$ for all). In Model 4, following the addition of age, MMSE made a small but significant contribution (6.4%), although SJS did not account for additional variance in picture recall beyond that already accounted for by age and MMSE.

DISCUSSION

The principal new findings of this study are as follows. First, we found clear evidence of a PSE for all age groups, implying that oldest-old people utilise nonverbal or visuospatial codes as well as their younger counterparts to support long-term retention. Follow-up analyses of clustering in free recall revealed that a greater number of categories were accessed and more items were recalled per category for pictures than words for all. Second, cognitive status and working memory were correlated with word and picture recall. Third, sequential regression analyses indicated that age, cognitive status, and working memory predicted word and picture recall. Cognitive status and working memory also accounted for significant amounts of age-related variance. These results are discussed more fully next.

Pictorial superiority effect

The first finding was the PSE in free recall and recognition for all age groups. Our findings join others in the cognitive ageing literature where a pictorial superiority advantage was observed for healthy young-old adults (Park et al., 1983; Rissenberg & Glazner, 1986; Winograd et al., 1982). To our knowledge, this study is the first to show a PSE for oldest-old people, defined here as persons over 90 years of age. Nonagenarians showed a PSE in both free recall and recognition, confirming the reliability and generality of the finding. Consistent with a contextualist perspective, a significant age interaction occurred where the memorial benefit of pictures was the greatest in size for nonagenarians when retention was tested using a recognition task. Interpretative caution is warranted, as the younger age groups were approaching ceiling in picture recognition, accounting for the significance of the interaction (see Table 2, lower panel). Thus we confine our discussion of episodic memory in healthy ageing to word and picture free recall.

Follow-up analyses of clustering in free recall revealed a possible mechanism of the memorial benefit of pictures; namely, a greater number of categories were accessed and more items were recalled per category when pictures served as stimuli compared to words (see Table 3). These clustering indices were proportional for the nonagenarians compared to the other age groups, although number of categories accessed and number of items recalled were somewhat lower for the oldest-old participants. The results of the clustering analyses imply that nonagenarians engage in qualitatively similar organisational strategies in support of recall as do the younger age groups.

Overall, the finding that nonagenarians show a PSE is intriguing, having noteworthy theoretical and practical implications. Specifically, the results imply that oldest-old people utilise nonverbal or visuospatial codes as do younger age groups to support episodic memory. These findings also suggest that oldest-old people may draw on semantic memory knowledge (i.e., the taxonomic category membership of the to-be-remembered items) to enhance episodic memory in a manner similar to their younger counterparts (Bäckman & Wahlin, 1995). The finding that all showed greater use of categorical organisation in free recall of pictures compared to words further implies that pictorial material may facilitate application of semantic memory skills, but more research is needed. From a practical perspective, our results imply that oldest-old people may benefit from pictorial illustrations to support retention of textual material, an exciting possibility that offers a direction for memory remediation in the everyday lives of very old adults.

Role of individual differences

Our second finding concerned the influence of cognitive status and working memory span estimates on episodic memory performance. Correlation analyses indicated that age was negatively related to performance on all memory measures, as expected. Of greater interest were the correlations among the cognitive status and working memory variables, word and picture free recall. To be precise, the *r* values were higher for MMSE, SJS, and word recall, compared to the *r* values obtained for these variables and picture recall (see Table 5). This aspect of the data implies that word recall may be more resource demanding than picture recall, consistent with a contextualist perspective. Words may offer less cognitive support for remembering compared to pictures, which are richer in stimulus properties important for retention, such as visual distinctiveness. Pictures may also invite a more elaborative or richer encoding than words by comparison, resulting in memorial gains such as those observed here.

The present findings, among others, attest to the powerful role of individual differences and cognitive support in episodic remembering in old age (Bäckman et al., 2000). One should note that preliminary analyses with educational attainment in this study revealed no significant age group differences in level of education, nor any significant relationships with secondary memory performance. This aspect of the data conflicts with earlier reports where educational attainment was related to memory performance (Bäckman & Wahlin, 1995; Hill et al., 1995; Wahlin, Bäckman, & Winblad, 1995). Community-dwelling older adults who self-select to participate in cognitive ageing research typically vary in educational attainment, among other general intellectual and sociodemographic variables (Park & Cherry, 1989). The sampling strategy used in this study may have corrected for a potential selection bias. Alternatively, Hassing, Whalin, and Bäckman (1998) have since made the point that demographic variables may be less important to memory performance in very old age when participants have been extensively screened for health status. Further research to examine the dynamic relationship between health status and episodic memory performance seems warranted.

The third finding pertains to the sequential regression analyses. These results confirmed that cognitive status and working memory accounted for substantial amounts of age-related variance (see Tables 6 and 7), although age made an independent contribution to both word and picture free recall (see Bäckman & Wahlin, 1995, for a similar result). Further, the age-related variance accounted for by MMSE, the cognitive status measure, exceeded that of SJS, the working memory span measure, in both word and picture free recall. Specifically, MMSE accounted for 66.9% of the age-related variance in both word and picture recall. The same estimates for SJS were 59.5% and 46.5%, for word and picture recall, respectively. The MMSE provides a global index of cognitive status, perhaps having more executive function involvement than does SJS, where participants merely arrange a list of auditorily presented items in order of physical size. Further research is necessary to understand the contributions of the executive component to performance on the present episodic memory task.

On a cautionary note, variance-partitioning procedures such as the sequential regression analyses used here have been questioned on technical and substantive grounds (see Lindenberger & Pötter, 1998). With this caveat in mind, our data imply that MMSE may be preferable to SJS alone as an index of cognitive functionality. These two measures were significantly correlated ($r = .44$, $p < .0001$), although the correlation was reduced when age partialled out ($r = .26$, $p = .0012$). The differential predictive utility of the MMSE over the SJS suggests that it is the better choice when the analytic strategy is to account for age-related variance in episodic memory performance.

In closing, this study provides new evidence on the PSE as an episodic memory phenomenon that persists well into the ninetieth decade of life for healthy older adults. Two methodological limitations of the study warrant brief mention. First, self-reports of strategy use on the free recall task were not solicited, which might have provided valuable information on how participants approached the acquisition and retrieval tasks. Second, the younger groups were at ceiling in picture recognition, a typical problem in studies using pictorial stimuli and recognition tasks in the cognitive ageing literature. Future research to address these limitations and explore the generality of the present findings is warranted.

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