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Effects on Episodic Memory of Stimulus Richness, Intention to Learn, and Extra-Study Repetition: Similar Profiles Across the Adult Life Span

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The ability to benefit from various kinds of cognitive support in episodic memory was studied in a population-based sample of healthy adults aged 35–80 years ($N = 1{,}000$). The participants studied pictures of faces and names of 10-year-old children with instructions to remember the faces and the surnames. After study, an implicit name stem-completion test was administered, followed by face- and name-recognition tests. There was a negative age effect across all task variables. Across age, recognition was higher for faces than for names. An age-invariant positive effect of intention to learn was observed. Also, name completion and recognition performance showed a positive relationship across the adult life span. Overall, the results are in agreement with the views that (a) age-related episodic memory deficits are highly generalizable and (b) effects of cognitive support on memory are typically of equal size across the adult life span.

KEY WORDS: aging; episodic memory; face recognition; stimulus richness; intentionality; dependence.

It is well documented that normal aging is associated with reduced performance on episodic memory tasks such as recall and recognition (e.g., Bäckman, Small, & Larsson, 2000; Kausler, 1991; Salthouse, 1991a, 1991b). The fact that age differences in memory performance remain even when age differences on various background factors such as education and health are controlled for (e.g., Nyberg, Bäckman, Erngrund, Olofsson, & Nilsson, 1996) suggests that impaired episodic memory is an inevitable and fundamental consequence of old age, possibly due to alterations in the brain systems that underlie episodic memory (e.g., Bäckman et al., 2000; Simic, Kostovic, Winblad, & Bogdanovich, 1997).

Much of the experimental research on aging and episodic memory has involved variations in the level of cognitive support provided at encoding (e.g., words vs. objects; random words vs. organizable words) and retrieval (e.g., free recall vs. cued recall vs. recognition). Although the bulk of relevant research indicates parallel gains from increasing levels of cognitive support in early and late adulthood (for overviews, see Bäckman, Mäntylä, & Herlitz, 1990; Craik & Jennings, 1992), some studies demonstrate larger gains from cognitive support in older than in younger adults (e.g., Bäckman & Larsson, 1992; Craik & McDowd, 1987) and still others show age-related reductions in the effects of support on memory performance (Puglisi & Park, 1987; Rabinowitz, 1989). The conflicting results likely reflect complex interactions between multiple subject-related and experimental variables.

The purpose of the present research was to provide furher evidence on the influence of cognitive support on memory in adulthood. In so doing, we examined the effects of two fundamental variables in memory research: the nature of the materials and

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intention to learn. This examination was done using data from a population-based study involving 100 persons from each of 10 cohorts between 35 and 80 years of age. Previous analyses of data from this study have confirmed the typical pattern of decreasing episodic memory performance with increasing adult age using global measures of memory (Nilsson et al., 1997). Of special interest here was whether potential effects of cognitive support on memory would be of similar magnitude across the age span examined. Note that the composition of the study sample makes it possible to examine potential age-related differences in the effects of cognitive support on episodic memory in a more detailed manner than in most related research in which extreme-groups designs are typically employed.

In brief, the experimental design was as follows. At study, participants were presented with pictures showing faces of 10-year-old children along with first names and surnames. The participants were specifically instructed to remember the faces and the surnames for a later test of memory. Hence, encoding of first names was incidental. Following the study phase, the participants were given an implicit stem-completion task. Half of the stems were possible to complete with family names from the study episode, but for each stem the participants were asked to generate the first surname coming to mind. Finally, the participants were given a free-choice recognition test of faces and a forced-choice recognition test of first names and surnames.

One set of analyses compared retrieval performance for faces and surnames. Both faces and surnames were intentionally encoded, and so we reasoned that any differences in retrieval performance between these materials could be attributable to the nature of the stimuli. Previous studies of the *picture-superiority effect* (e.g., Nelson, Metzler, & Reed, 1974; Paivio & Csapo, 1973; Spoehr & Lehmkule, 1982) have found that both younger and older adults remember pictures better than words, with a tendency for a slightly greater picture-superiority effect for the young, especially when tested with recall (see Kausler, 1991, for an overview). On the basis of these previous studies, we expected that performance would be higher for faces than for names, and of main interest was whether this stimulus effect would be of equal magnitude across the age span. Note that there was a difference in the way memory was measured for faces and names (free-choice recognition for faces; forced-choice recognition for names). However, forced-choice recognition is an easier test than free-choice recognition; thus, this difference worked against our prediction of a stimulus effect favoring faces over names.

A second set of analyses addressed the effect of intention to learn at study. Forced-choice recognition performance for first names was compared with that for surnames. Thus, in this comparison, type of test was held constant and the main difference had to do with whether verbal (name) information had been acquired in an intentional or incidental fashion. Cognitive studies have repeatedly shown that intention to learn is not critical per se (e.g., Hyde & Jenkins, 1969). Rather, what seems most crucial is that the stimulus material is processed in a task-relevant manner. In the present experiment, in which participants simultaneously were presented faces, first-names, and surnames, we expected that a main effect of the explicit instruction to encode surnames, in combination with the lack of intentional-encoding instructions for first names, would be to reduce the degree of task-relevant processing for first names. Hence, we predicted that retrieval performance would be higher for surnames than for first names. Of special interest was whether this would generalize across age. On the basis of findings that young as well as old adults benefit from deeper processing and intention to learn (Craik & Jennings, 1992) and that division of attention during encoding seems to impair retrieval performance for younger and older adults to an equal degree (Nyberg, Nilsson, Olofsson, & Bäckman, 1997), we expected an age-invariant positive effect of intention to learn.

A final set of analyses was concerned with the association between performance on the implicit stem-completion test and that on the episodic forced-choice recognition test of surnames. As noted previously, half of the stems were possible to complete with surnames that had appeared in the initial study list. We were interested in whether completion of a stem with a target name would be related to subsequent recognition performance, and if so, whether the degree of relationship would change across the adult life span. On the basis of studies of younger participants, it is well recognized that completion of a word stem or a word fragment with a study (target) word in an implicit memory test will increase the probability that it later on is recognized (e.g., Tulving, Schacter, & Stark, 1982). Most likely, this is because the generation of the target word in the completion test acts as a second study trial (e.g., Shimamura, 1985). There is limited evidence that the recognition performance of elderly can also benefit from the generation of study words in a preceding implicit test. Light, Singh, and Capps, (1986) reported a significant association between fragment completion and recognition performance for both younger and older adults, and more recently Börjesson, Karlsson, Adolfsson, Rönnlund, and Nilsson, (1999) reported a significant degree of dependency between fragment completion and recognition for elderly participants. On the basis of these studies, we predicted that there would be a significant association between performance on the stem-completion and recognition tests, and we expected that the degree of association would be of a similar magnitude across age.

METHOD

Participants

One thousand individuals from 10 different cohorts (100 35-year-olds; 100 40-year-olds; . . . 100 80-year-olds) participated in the study. Participants were recruited through the population registry in Umeå, a city of about 100,000 inhabitants in northern Sweden. The sampling procedure is described in detail in Nilsson et al. (1997). Briefly, sampling was random in each cohort except that persons with native languages other than Swedish, severe sensory handicaps (e.g., blindness), organic diseases known to affect brain functioning (e.g., dementia), or mental retardation (e.g., Down's syndrome) were excluded from participation.

All participants were assessed in two sessions, 1 week apart. The first session, which was conducted by a nurse, involved an extensive health examination, including blood sampling. In addition, an interview about health status was conducted, and questionnaires concerning social background variables and critical life events were distributed. Some cognitive tests were also administered during this session. The second session was devoted exclusively to assessment of memory and other cognitive functions, and done by persons well trained in memory testing. The duration of each session was about 2 hr. Because of inaccurate testing procedures, 18 participants in the 35-year-old cohort group and 16 participants in the 55-year-old cohort group had to be excluded. For the statistical analyses, the study sample was divided into five age groups: 35–40-, 45–50-, 55–60-, 65–70-, 75–80-year-olds. Sex distribution and educational background across these age groups are provided in Table I. An analysis of variance (ANOVA) indicated an effect of age for educational level, $F(4, 961) = 117.09$, $MSE = 11.13$, $p < .0001$. The age groups did not differ in sex distribution ($F < 1$; for further information regarding sex differences on cognitive functions in the Betula sample, please consult Herlitz, Nilsson, & Bäckman, 1997).

Table I. Participant Characteristics

Years of age	*n*	Male/female	Years of education ($M \pm SD$)
35–40	182	90/92	13.71 ± 3.15
45–50	200	114/86	11.58 ± 4.14
55–60	184	90/94	8.84 ± 3.21
65–70	200	102/98	8.19 ± 3.11
75–80	200	112/88	7.41 ± 2.94

Materials and Procedure

The materials consisted of 24 color pictures of faces of 10-year-old children. Half of the photographs portrayed girls and the other half portrayed boys. To ensure that the children on the pictures would be unknown to the participants participating in the study, the children on the photos lived in an another part of Sweden. The rationale behind selecting faces of children as test items was that prior research indicates a relationship between participant age and the age of the stimulus face in recognition memory. Typically, younger participants remember faces of younger persons more easily than those of older persons, whereas the reverse is true for older participants (Bäckman, 1991). Thus, the use of children's faces should be neutral with regard to availability of task-relevant prior knowledge. Below each presented face, a made-up first name and surname were printed in large bold type. The names consisted of a common Swedish given name and a common Swedish surname. Two sets of faces and names (Lists 1 and 2) were prepared, each involving 16 items. The two sets were counterbalanced such that half of the participants in each cohort studied one of these sets whereas the other half was presented with the other set.

During study, each face and name was presented at a rate of 8 s per picture. The participants were instructed to memorize the faces for a later recognition test and also to try to remember the surname for a later test of name recognition. The set of faces and names that was not presented at study served as distractor items in the recognition tests. At this test, memory for both first names and surnames was assessed. Because the participants were

Table II. Education-Adjusted Mean Proportions for Face and Name Recognition Across Age Groups

	35–40 ($n = 182$)	45–50 ($n = 200$)	55–60 ($n = 184$)	65–70 ($n = 200$)	75–80 ($n = 200$)
Face recognition (M)					
Hit rates	0.80	0.77	0.77	0.71	0.70
False alarm rates	0.15	0.16	0.20	0.20	0.30
d'	2.36	2.12	2.00	1.70	1.33
Name recognition (M)					
First names	0.56	0.51	0.51	0.48	0.42
Surnames	0.69	0.63	0.65	0.63	0.58

instructed to remember the surnames only, recognition of surnames constituted a test of intentional learning whereas recognition of first names was a test of incidental learning.

After approximately 16 min, during which other tests were administered, a name stem-completion test was distributed. In this test, each participant was given 24 two-letter stems (e.g., LA— for LARSSON) and instructed to complete the stems with the first appropriate surname that came to mind. Twelve of the surnames had been presented earlier (targets), whereas the remaining 12 had not (baseline). The stems were selected such that each stem could form at least 10 Swedish surnames.

After the completion task, other cognitive tasks were administered for a duration of approximately 10 min. Thereafter, participants were presented with the 12 study faces along with 12 distractors, and were asked to give a *yes–no* recognition judgment for each face. The first and last two items on the study list were excluded from the test list to avoid primacy and recency effects. For all studied faces, regardless of whether they were recognized, participants were presented with four combinations of first names and surnames. The distractor names were selected such that if a target name was, for example, Maria Larsson, the distractors were Marianne Larsson, Maria Lagergren, and Marianne Lagergren. The participants' task was to select the combination they thought had been presented earlier along with the face. Thus, it was possible to produce a correct response in recognition of first names, recognition of surnames, or both. A set of names was also provided in instances in which a participant falsely recognized an unstudied face. These "false alarms" were not considered in the analyses.

RESULTS

The data were analyzed with ANCOVAs, including education as a covariate. This analytic procedure was chosen to control for potentially confounding effects of age differences in level of schooling on the outcome measures. The data from the face- and name-recognition tests are presented in Table II.

As can be seen from this table, both face- and name-recognition performances decreased as a function of age (cf. Nilsson et al., 1997). To address the issue of whether recognition performance was higher for faces than for names, hit rates for faces and surnames were analyzed with a 5 (age) × 2 (type of materials: face, surname) mixed ANCOVA, with repeated measures on the last factor. The ANCOVA revealed main effects of age, $F(4, 960) = 10.03$, $MSE = 6.81$, $p < .0001$, and of type of materials, $F(1, 961) = 299.39$, $MSE = 3.07$, $p < .0001$. The interaction between age and type of materials was not significant ($p > .05$). Thus, all age groups remembered more faces ($M = 8.99$, $SD = 2.34$) than surnames ($M = 7.61$, $SD = 2.31$), which provided evidence for an age-independent effect of stimulus richness.

Next, the name-recognition data were submitted to a 5 (age) × 2 (type of name: first name, surname) mixed ANCOVA, with repeated measures on the last factor. The ANCOVA revealed main effects of age, $F(4, 960) = 11.44$, $MSE = 7.25$, $p < .001$, and of type of name, $F(1, 961) = 452.22$, $MSE = 2.86$, $p < .0001$. The interaction of age and type of name was not reliable ($F < 1$). Thus, in all age groups, performance was higher for surnames that were intentionally encoded ($M = 7.61$, $SD = 2.31$) than for first names that were incidentally encoded ($M = 5.98$, $SD = 2.35$). This outcome provided support for an age-independent effect of intention to learn.

To examine the degree of dependency between performance on the stem-completion test and the surname-recognition test, data were entered in 2 × 2 contingency tables. A given participant may (a) manage to recognize a given item and complete the name stem for this item with a studied name, (b) manage in name recognition but "fail" in stem completion (i.e., not complete the stem with a name from the study list), (c) fail in name recognition but "manage" in

Table III. Mean Surname Recognition (Hits), Name-Completion Rate (Hits), and Dependency Between Completion–Recognition Test Performance Across Age Groups

	35–40 ($n = 182$)	45–50 ($n = 200$)	55–60 ($n = 184$)	65–70 ($n = 200$)	75–80 ($n = 200$)
Surname recognition (*M*)	0.71	0.64	0.64	0.60	0.55
Name completion (*M*)	0.27	0.24	0.24	0.24	0.21
Yule's Q (*M*)	0.36	0.35	0.32	0.35	0.34
χ^2 ($df = 1$)	40.0	42.2	35.3	48.8	43.7

stem completion (i.e., complete the stem with a studied name), or (d) "fail" in both tasks (not recognize a name and complete the corresponding stem with a nonstudied name). Separate 2×2 contingency analyses were done for each of the two sets of study materials before collapsing across sets. Overall, there was a significant dependency between performance on the stem-completion and surname-recognition tests, Yule's $Q = 0.35$, $\chi^2(df = 1, N = 966) = 223$, $p < .01$. As can be seen in Table III, the degree of association was largely invariant across age.

DISCUSSION

The point of departure for the present research was demonstration that, although episodic memory performance decreases with increasing age, various kinds of encoding and retrieval support seem to have a positive effect on memory performance across the adult age span. The present findings from a large sample of healthy adults ranging in age between 35 and 80 years provide powerful additional support for this notion.

One set of findings concerned the effect of stimulus richness. Stimulus richness was manipulated by contrasting memory for faces with memory for names. Irrespective of participant age, faces were more easily remembered than names. This is consistent with results from studies of the picture-superiority effect, showing that both younger and older adults more easily remember pictures than the corresponding verbal labels (see Kausler, 1991). Many factors can potentially account for the superior memorability of faces over names. For example, names are arbitrary labels and many people share the same names, which may lead to increased problems in discrimination for names compared with faces (Cohen, 1990; Jones & Rabbitt, 1994). At the neural level it has been proposed that pictures activate more strongly/extensively brain circuits of relevance for episodic memory performance (Grady, McIntosh, Rajah, & Craik, 1998). Importantly, regardless of the basis for the superior recognition of faces over names, the present results show a "face-superiority effect" of similar magnitude for young and old people.

Evidence for age-invariant effects of cognitive support was also provided with regard to the influence of intention to learn. Episodic memory performance was higher for surnames, which were intentionally encoded, compared with first names, which were incidentally encoded. This pattern generalized across age, suggesting that younger and older participants benefited to the same extent from intentional encoding instructions. Admittedly, another difference had to do with type of name; first names were always encoded in an incidental manner whereas surnames were always intentionally encoded. Hence, it cannot be ruled out that type of name contributed to the effect (i.e., that surnames were easier to encode and recognize than first names). Yet, it is reasonable to assume that the encoding instruction had the effect that more attention was paid to surnames than to first names, and that this resulted in better recognition performance for the surnames. Most critically, older as well as younger adults were able to use the instruction as a guide to what was most important to memorize and direct their processing accordingly.

Finally, analyses of the degree of association between stem-completion performance and performance on the recognition test of surnames revealed a significant association. As with the other factors examined in this study, the degree of dependency was very similar across the examined age range. A significant degree of association between performance on an implicit completion test followed by an explicit recognition test is in line with previous research on young (e.g., Tulving, Schacter, & Stark 1982; Börjesson, Karlsson, Adolfsson, Rönnlund, & Nilsson, 1982) and old (e.g., Börjesson, 1999) participants. Analogous to the case in which an explicit test precedes an implicit test and dependency is observed, it might be argued that the observed dependency reflected the use of explicit retrieval strategies in the implicit test (e.g., Bowers & Schacter, 1990). However, based on theoretical (Roediger & McDermott, 1993) as well as empirical (Nyberg, Olofsson, Gardiner, & Nilsson, 1997) considerations, the use of explicit/intentional strategies in the stem completion test seems unlikely under the present test conditions (data-limited unconstrained cues). Although less extensively discussed in the literature, the positive association could also have resulted from implicit contamination of the explicit test (Habib & Nyberg, 1997). It has been argued that one basis for episodic recognition decisions is familiarity-based processes that heavily influence implicit completion performance (Jacoby, 1991), and such influences may have affected forced-choice recognition performance in this study. At the same time, the observation of a pronounced age effect suggests that the reliance on explicit/conceptual processes was substantial in the episodic tests (for a similar logic, see Russo & Parkin, 1993). Thus, the observed positive association between completion and recognition performance may largely be due to the additional study trial that stem completion with studied names resulted in (cf. Shimamura, 1985). The similar degree of dependency across age indicates that participants in all age groups were equally able to benefit from this "extra-study repetition" of target names.

Taken together, our findings of age-invariant effects of stimulus richness, intentionality, and repetition are in agreement with the bulk of research indicating similar gains from cognitive support in episodic remembering across adulthood (Bäckman, Mäntylä, & Herlitz, 1990; Craik & Jennings, 1992). The current results are also consistent with data from other large-scale studies suggesting that the age-related decline in episodic memory may have an early onset and proceed gradually across the adult life span (Salthouse, 1998). Evidence also suggests that the magnitude of this decline is similar in standard laboratoty tasks and tasks that more closely approximate the memory demands of everyday life (Allaire & Marsiske, 1999). Collectively, these observations provide strong evidence for the general nature of age-related episodic memory deficits.

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