AGE AND IQ ON IMMEDIATE MEMORY

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SUMMARY

One of the most frequently reported problems with advancing age is the decline of memory functions. However, the reasons for this decline are not yet clear. Recent studies seem to suggest that the major decline appears when unfamiliar tasks or materials are proposed. Also, the intellectual level of subjects may play some role in memory performance. Two groups of normal elderly subjects (N=32, mean age 69 yr.) with different IQ levels, and one group of young subjects (N=16, mean age 20 yr.) were tested on four different types of short-term memory tasks. The findings show a significant difference between young and old subjects and between the two elderly groups, i.e. memory performance is proportional to IQ levels. The results are discussed in the light of Salthouse's hypothesis of a general decline in the information processing rate with age.

INTRODUCTION

The deterioration of memory observed in normal ageing has been amply demonstrated in research (cf. Salthouse, 1985). The extent and causes of this phenomenon remain, however, largely unknown. One theory is that this particular decline is due to a progressive loss of cortex cells as age advances, but this loss does not seem to be restricted to elderly subjects. In fact, between the ages of 20 and 30 a decline can be observed in many of the psychophysiological parameters, and the loss of neurons does not in itself seems a sufficient cause to account for mental deterioration (Moscovitch, 1982). Moreover, together with the elimination of many synapse connections, neuron impoverishment is a constant factor in the evolution and development of the brain from childhood on. It cannot therefore be taken as a purely negative factor, but as a factor in synapse enrichment and specialisation (Easter, Purves, Rakic & Spitzer, 1985). Reduction of the neuron patrimony cannot, therefore, be taken to account for the decline in mental efficiency. Consequently, we must take a variety of other factors into account, including cultural-educational background, power of concentration and the ability to forge effective strategies spontaneously. The poor performance of elderly people may be due to partial loss of the habit of learning new material, anxiety factors, a slowing down of mental processes and lack of confidence.

A recent theory attributes the specific phenomenon of declining memory efficiency to deficiencies in the coding and retrieval mechanisms, while storage does not seem to be affected (Birren, Cunningham & Yamamoto, 1983). Memory deficiencies occur mainly in relation to the memorization of new or non-structured material, or material not directly relating to the environment (Craik, 1984). In contrast, semantic memory and memory of information stored in the past or imprinted through exercise appear to be relatively well preserved (Burke & Light, 1981; Read, 1987).

Another theory is that there is, in fact, a qualitative rather than quantitative difference between the information processing capacities of the young and old (Rabbitt, 1981; cf. Salthouse, 1988 for a different interpretation). This difference seems to emerge in the different ways of applying previously acquired knowledge or the relative degrees of efficiency of the response strategies

adopted. Memory strategies are essentially the conscious, deliberate processing of mnestic material to facilitate and improve storage; since this is an active, non-mechanical process, the application of strategies requires considerable cognitive sources to draw on and, significantly, these are related to the level of mental development. If the poor performance of the elderly were in fact due to their inability to organise information efficiently, then assistance in organisation supplied by an external source should eliminate age differences. However, even in these conditions the elderly still display diminished performance (Burke & Light, 1981; Jackson & Schneider, 1985). Salthouse (1985) suggested that inefficient application of strategies may be due to a more general slowing down in the performance of mental operations. This slowing down can be observed mainly in the case of relatively complex tasks (Cerella, 1985), and it is in fact here that the difference between the young and the elderly becomes most apparent (Salmaso, Lucioli and Mecacci, 1985).

Researchers in the psychology of ageing have also hypothesised a differential decline in spatial and verbal skills, the former being particularly affected. This suggests that there should be a similar effect in the case of memory capacities, but the hypothetical basis has yet to be confirmed by experiment (cf. Villardita et al., 1985; Read, 1987). In fact, recent work by Benton, Eslinger and Damasio (1981) shows the opposite effect, and our work on reaction timing (RT) (Salmaso, Lucioli and Mecacci, 1985) has not revealed significant differences between the spatial and verbal factors involved in one and the same task.

Another factor to consider in the assessment of memory in the elderly is intellectual and educational level (cf. Rabbitt, 1988; Orsini et al., 1986; Arbuckle et al., 1986; Parnetti et al., 1985; Perlmutter, 1978), together with the degree of mental activity and effort required of the subject by the environment. However, this factor also fails in itself to account for the decline of mnestic functions since, as Baltes et al. have demonstrated (1986), the performance of elderly people with a high level of intelligence is still inferior to that of young adults with comparable IQ's.

Obviously, assessment of memory and its underlying processes is an extremely complex matter. It has been suggested that it may be useful to study the subjective assessments subjects offer of their own capacities, but work so far carried out in this direction (e.g. Perlmutter, 1978; Sunderland et al., 1983; Squire et al., 1979) has shed no further light on the fundamental mechanisms of deterioration since little correlation with objective measurements has emerged (Hermann, 1982; Sunderland et al., 1983; Arbuckle et al., 1986; Salmaso et al., 1988). Moreover, self-assessment

seems to be correlated with personality traits and influenced by states of anxiety or stress (Larrabee & Levin, 1986).

Finally, when tackling the memory problem it is important to determine which are the most appropriate tasks to detect possible deficiencies, and the type of structure these tasks should assume. A relevant point here is the observation (Benton et al., 1983) that a serial learning task yields a greater degree of discrimination than a simple span determination task. As Rabbitt pointed out (1981), many hypotheses on ageing are largely based on clinical experience or experimental models not subject to full control. It is quite possible that more accurate studies on healthy elderly subjects may totally belie expectations, or at any rate lead to radical modifications of the proposed theories.

In the present work, carried out with normal subjects, we have endeavoured to take all these points into account. This approach was also determined by the eventual aim of developing appropriate diagnostic tools. The following variables were considered: a) intellectual and educational level of subjects; b) type of memory skill involved (verbal or non-verbal); c) the difficulty of the task; d) the effectiveness of the memorization strategies.

METHOD

SUBJECTS

The two groups observed consisted of neuropsychologically normal elderly subjects, who were self-sufficient and relatively active in social and cultural pursuits. Each group consisted of 16 individuals, with no appreciable statistical difference in average age (71 vs. 66). The subjects of one group (10 m. and 6 f.) were from Centres for the Elderly (CE), and the other (7 m. and 9 f.) were taken from University courses for the Elderly (UE). The subjects in the 2nd group showed a higher educational level, and this difference was matched by a significant difference in IQ (Raven Progressive Matrices; Raven, 1938); 119.4 vs. 98.4 ($t=7.10$; $df=30$; $p<.001$). The two groups of elderly subjects were compared with a group of 16 young persons (Y, 7 m. and 9 f.) from a professional nursing school. Their average age was 20, while their average IQ (104.8) did not differ greatly from that of the CE subjects.

Table 1
Summary of data on the three groups

Mean	CE	UE	Y
AGE	71	66	20
IQ	98.4	119.4	104.8

TEST

The three groups of subjects were subjected to the following battery of tests, some of which had been applied in a previous study (Bisiacchi & Salmaso, 1980).

1) Verbal and non-verbal learning tests. Both tests require the repetition of items in a series (presented at the rate of one every two seconds). The test ends after 2 consecutive correct repetitions or after the tester has submitted a maximum of 12 presentations. The verbal test consists of lists of 7 high frequency words, while the non-verbal test (7/25 fixing by Rey, 1968) consisted of 7 positions on a grid

of 25 squares. For both tests the number of correct items in the first repetition is scored, together with the number of repetitions necessary for learning. For the verbal test 2 equivalent lists were used and the items were to be repeated in the order in which they are presented.

2) Immediate repetition of words groupable into semantic categories. Subjects were asked to repeat lists of 9 high frequency words; the rate of presentation was one word every 2 seconds. In a preliminary control test (A) no information was given on the structure of the lists, while in the following test (B) it was pointed out that memorization could be facilitated by category grouping. The categories adopted were animals, plants and tools. Each test consists of 4 equivalent lists and the order of repetition was not taken into consideration.
3) Immediate repetition of words with and without visual aids. Also for this test we presented lists of high frequency words (at the rate of one word every 2 seconds) which had to be repeated immediately. The lists were of 6 different lengths (from 4 to 9 items). A control test (A) was carried out without any help, while for the second test (B) subjects were supplied with a series of drawings indirectly associated with the words presented (e.g. chair-armchair) (cf. Luria, 1966). No account was taken of the order in which items were repeated. Tests (A) and (B) were presented in balanced order.
4) Immediate repetition of words with different presentation rate. Subjects were again presented with lists of high frequency words which they were asked to repeat. The lists were of three different lengths (from 4 to 6 words) and the rate of presentation of the items varied: in one test the interval between one word and the next was fast (0.5 sec.), in the second medium (2 sec.) and in the third slow (10 sec.). For this test, too, we disregarded the order of repetition of the items and the order of presentation of the 3 tests was balanced.

The tests were submitted in a quiet room by one of the authors, who varied the order of presentation.

RESULTS

Analyses of the results were carried out on appropriate transformations (Kirk, 1968).

Age and IQ. The first general result concerns the age and IQ variables. In fact, all the tests showed a significant difference between the three groups: the overall percentage of words repeated in each test shows a gradual increase from group CE to group Y (see table 2).

Table 2
Overall results obtained by each group (%)

TESTS	GROUPS			
	CE	UE	Y	p <
1)Learning tests *	42.0 (sd=23)	55.9 (sd=24)	66.1 (sd=16)	.001
2) Semantic aid	37.2 (sd=8)	43.6 (sd=11)	49.2 (sd=8)	.001
3) Visual aid	63.5 (sd=12)	74.5 (sd=11)	83.0 (sd=9)	.001
4) Presentation rate	83.0 (sd=11	90.5 (sd=9)	95.7 (sd=4)	.001

* % calculated on the no. of items given in the first repetition

Verbal and non-verbal learning tests. Two different analyses were carried out: a) on the number of repetitions necessary for learning; b) on the number of items given in the first repetition. Factors taken into account were groups (3) and the tests (2). Table 3 shows how the number of repetitions necessary to learn the series gradually decreases from group CE to the group of young persons ($F=7.76$; $df=2,36$; $p<.005$).

Table 3
Results of the two learning tests

	CE	UE	Y
No. of repetitions	4.94 (sd=1.7)	4.05 (sd=2.4)	2.56 (sd=0.9)

Analysis of the number of items given in the first repetition shows a significant difference between the verbal and non-verbal tests for all three groups ($F=6.35$; $df=1,45$; $p<.05$) with poorer results for the non-verbal test (3.24 vs. 4.23). However, this difference disappeared as we proceeded to study the repetitions required to learn the lists.

Immediate repetition of words groupable into semantic categories. Analysis of variance was performed between the groups (3) and tests (2), the average number of words repeated from the 4 lists being assessed for each test. The two main effects were significant, while no interaction appeared to take place. All three groups showed weaker performance in test (B), when the possible category grouping of items was pointed out, than in test (A) ($F=25.84$; $df=1,45$; $p<.001$). The results are shown in table 4.

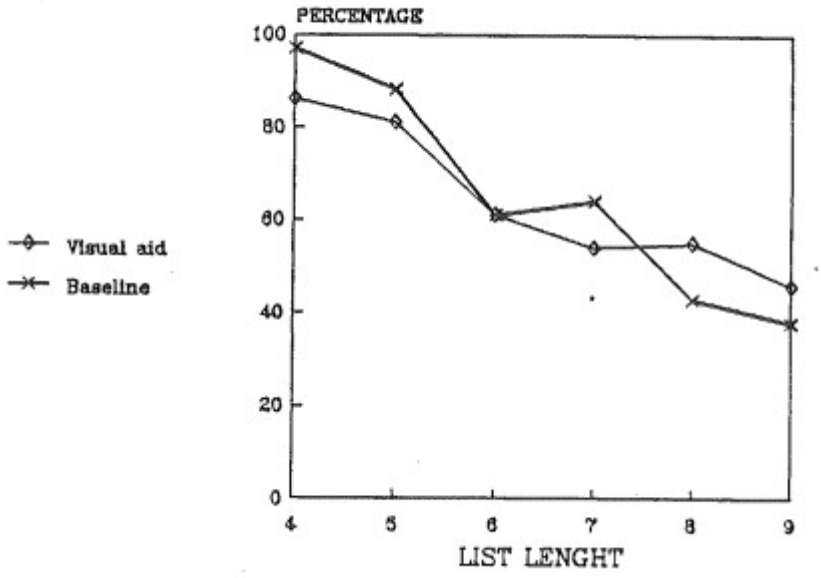
Table 4
Results obtained in the test with semantic category

	Without cue (A)	With cue (B)
% of words repeated	47.2	39.6

Immediate repetition with and without visual aid. Factors taken into consideration are the groups (3), the length of the lists (6) and the presence or absence of visual aid. All three groups showed weaker memory performance as the lists lengthened ($F=169.93$; $df=5,225$; $p<.001$). The two tests, with and without visual aid, showed a difference only for group CE, which reacted negatively to the presence of visual aid (59% vs. 68%; $F=7.41$; $df=1,15$; $p<.025$), while no difference emerged for the other two groups. Moreover, interaction between the length of the lists and tests with or

without visual aid occurred only in the case of the two elderly groups ($F=5.19$; $df=5,150$; $p<.001$). Figure 1 shows that the presence of visual aid impair performance for the short lists and improves it for the longer lists.

FIGURE 1. Percentage of words repeated by elderly subjects according to length of lists and presence or absence of visual aid. Visual aid tends to improve performance with the longer lists.



Immediate repetition of words with different presentation rate. Factors taken into consideration were again the groups (3), the lengths of the lists (3) and the interstimulus interval (3). The results in each case appear significant, while no interaction was observed. In fact, all three groups showed improved performance with the longer intervals ($F=5.55$; $df=2,90$; $p<.005$), as can be seen in table 5.

Table 5
Results obtained with different presentation rates

	Presentation rate		
	Fast	Medium	Slow
% of words repeated	88	89	93

As in the case of the test with visual aid, moreover, performance deteriorated as the lists became longer ($F=129.16$; $df=2,90$; $p<.001$).

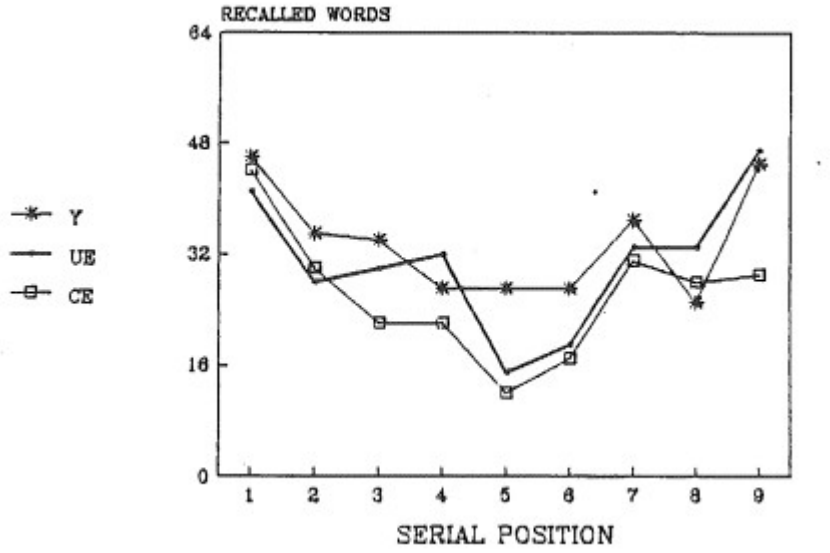
We therefore decided to carry out two further tests in addition to the those originally planned in order to determine: a) the effect of the request to repeat the items in the order of presentation; b) the effect of the serial position of items in the presentation list. Effect of the order factor on the repetition of items. In order to assess this effect we compared the results obtained by each group in two tests: in one test subjects were asked to repeat the items in the order of presentation (verbal learning test - first repetition), while this restriction was lifted in the second test (test on immediate repetition without visual aid - list of 7 items). Analysis of the variance shows that the "order" factor had a negative effect on performance: the order repetition showed an average of 60.4 items recalled against 69.0 in the free recall ($F=6.34$; $df=1,45$; $p<.025$). Again the groups showed significantly different levels of performance ($F=4.92$; $df=2,45$; $p<.025$): the CE group was weaker than the UE group which in turn produced poorer performance than the Y group (see table 6).

Table 6
Results obtained by groups in the above tests

	CE	UE	Y
% of items repeated	58.4	60.3	75.4

Effect of serial position. The last test was carried out to assess the frequency distribution shown by groups repeating items, without any restriction regarding order, on the basis of the serial position of items in the presentation lists. For this purpose we considered the results obtained in the test on immediate repetition without category formation, which consisted of the presentation of 4 lists, each containing 9 words. The chi-square test showed no difference between the distributions obtained by the three groups, which displayed the same primacy and recency effects (see fig. 2).

FIGURE 2. The graph shows the serial curves obtained by the 3 groups on the basis of the position of items (max=64).



DISCUSSION

In a recent report on the topic of senile dementia, Jorm (1986) pointed out that ageing may be associated by a steady deterioration in mental processes requiring a certain effort and attention, while the more automatic mental processes appear to be preserved. The experience of learning new material or the application of cognitive tests as in this research are therefore among the most appropriate conditions for the study of the rate of development in healthy adults. The tasks set for subjects in our research undoubtedly required the mobilisation of non-automatised processes and therefore represented a particularly sensitive means to detect any decline having occurred. All the test results pointed to the difficulty experienced by elderly people in general when faced with the task of learning and memorising lists of completely familiar words. However, chronological age does not appear to be the only, nor indeed the main, factor responsible for declining mnestic faculties.

At the psychological level, attention has become increasingly focused on other, more functional aspects, as also on the importance of the educational-cultural background in the cognitive performance of elderly subjects. This variable also proved significant in the present research, since the two groups of elderly persons showing no statistical difference in age but only in education and IQ nevertheless displayed substantially different memory performances. However, the education factor should be approached with some caution. In many social contexts it is difficult to make a precise distinction between education and mental activity in general, and it therefore becomes practically impossible to assess the relative weight of the two variables. This confusion appears particularly marked in the case of elderly persons, and more objective assessment of their capacities, e.g. IQ, may be preferable.

The two groups of elderly subjects studied in this research gave different results in all the tests, group CE proving weaker than group UE. As in the case of chronological age, intellectual level alone is also insufficient to account for the differences found in memory performance. In fact, while the UE group showed superior intellectual faculties, their performance did not come up to the level of the young group. On the whole, age seems to interfere with performance, better results being obtained by the young, but given the common factor of equal age in the elderly groups, the differences may be attributed to their different IQ's. On the basis of the significant difference shown by the two elderly groups we may rule out the possibility that other psychological

factors related to ageing, e.g. anxiety, are responsible for diminished performance (Larrabee & Levin, 1986).

In the introduction mention was also made of the hypothesis that decline in the spatial components of performance may be greater than the decline in verbal performance, and we pointed out that this hypothesis had not been clearly demonstrated. In fact, close examination of the variables involved reveals no general differences (Salmaso, Lucioli and Mecacci, 1985). Also in our research elderly subjects failed to show better results in verbal than in non-verbal learning. This type of difference only emerged on the first application of the two tests, and was obtained for young and old alike. This effect may be due to the fact that non-verbal tests generally involve less automatised processes than verbal tests.

Apart from the verbal-non-verbal factor, all the other variables taken into consideration proved to have some effect on subjects' performance. For example, the complexity of the task, rated on the basis of the length of lists to memorise, directly affects memory performance. In this case the drop was from 98% (lists of 4 items) to 45% (lists of 9 items). Moreover, this trend proved constant for all three groups. Similarly, when asked to repeat the items in the order of presentation all three groups again responded with weaker performance.

In the case of learning strategies introduced by an external source, we have seen that the attempt to facilitate memorization with a semantic strategy not only failed to produce any improvement, but actually represented a negative factor that worsened performance. Again, both young and elderly groups showed similar responses to this factor. A possible explanation is the fact that the use of a memory strategy appears to involve renewed processing of the material, requiring effort and hence more time. It therefore does not appear to be suitable for this type of immediate repetition task, where "direct" memorization functions proves more cost-effective.

This hypothesis is partly confirmed by the results of the test with visual aid, where a negative effect was observed with the short lists while, for the longer lists, there was a significant improvement when this aid was made available. Significantly enough, this effect was only observed with the elderly groups (more markedly with the UE group), and we may conclude that the introduction of visual associations can in fact improve the performance of elderly persons.

A positive effect on performance is also obtained with modification of the rate of presentation of items in the lists. In fact, all subjects showed improved mnestic capacity when the interval was increased. This result can probably be attributed to the greater opportunity subjects have to analyse each single item and eliminate interference between successive items (Luria, 1973). Another significant aspect of the time factor is the fact that inter-group differences can be considerably reduced if the group showing weaker performance is given longer intervals between words. For example, the UE group reaches an overall level of about 87% correct responses with rapid presentation, while the CE group reaches this level with the slower presentation rate. Similarly, when compensated by longer intervals the UE group is able to reach the same level as the Y group (94% vs. 95%). Moreover, the difference between these two groups is vastly reduced with decrease in the rate of presentation.

A last consideration applies to the serial position of items. Results obtained from analysis of the numbers of items repeated according to serial position appear to rule out the possibility that limitations in the elderly apply to short-term memory storage only, since the primacy and recency effects proved equal for all three groups (cf. Spinnler et al., 1988).

CONCLUSIONS

In the introduction mention was made of the hypothesis that ageing is attended by a general slowing down in the rate of information analysis. This factor appears to play a decisive role not only in tasks where reaction times are controlled, but more generally in all cognitive processes. The slowing down of operations involved in memorization processes, and especially in the articulation "loop" in action in the "working memory" (Baddeley and Hitch, 1974), may well produce qualitative and quantitative differences as age advances. The time factor may, in fact, be the cause of the differences observed in our research not only between young and old, but also between the two groups of elderly persons. Our results show that adjustment of this factor can reduce the differences between the age groups, thus confirming the findings of Burke and Light (1981) and Salthouse (1985). However, while the elderly subjects show a certain degree of recovery when given specific aid, the young nevertheless retain their overall superiority.

In conclusion, our work has yielded data that may serve for a best understanding of memory processes and more accurate differential diagnoses of pathological memory deterioration.

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