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Mnemonic strategies in older people: a comparison of errorless and errorful learning

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Abstract

Objective: to compare the efficacy of errorless and errorful learning on memory performance in older people and young adults.
Methods: face–name association learning was examined in 18 older people and 16 young controls. Subjects were either prompted to guess the correct name during the presentation of photographs of unknown faces (errorful learning) or were instructed to study the face without guessing (errorless learning). The correct name was given after the presentation of each face in both task conditions. Uncued testing followed immediately after the two study phases and after a 10-minute delay.
Results: older subjects had an overall lower memory performance and flatter learning curves compared to the young adults, regardless of task conditions. Also, errorless learning resulted in a higher accuracy than errorful learning, to an equal amount in both groups.
Conclusions: older people have difficulty in the encoding stages of face–name association learning, whereas retrieval is relatively unaffected. In addition, the prevention of errors occurring during learning results in a better memory performance, and is perhaps an effective strategy for coping with age-related memory decrement.

Keywords: *memory, cognitive decline, ageing, mnemonics, strategy training*

Introduction

Memory decline due to normal ageing has been widely reported [1, 2]. Generally, a deterioration in the encoding stages of mnemonic processes is found in healthy older subjects [3, 4]. Moreover, age-related decline is especially observed in tasks that require the explicit and conscious recollection of information, as in free recall of a word list that had been presented previously. In contrast, implicit testing of this material, for example, using a priming paradigm in which participants have to complete word stems, did not show an age effect. Here, older subjects were as likely as the younger participants to mention words from the previously presented list [5]. These results show that ageing affects both the encoding and retrieval stages of explicit memory, but that implicit memory is largely intact. Although the precise neural mechanisms underlying cognitive ageing are not fully understood yet, there is evidence that memory decline in older people might be linked to dysfunction of the hippocampal formation [6], a brain area that is generally important in the encoding of to-be-learned material. Furthermore, frontal-lobe dysfunction might also result in age-related memory loss, since this cerebral region is involved in retrieval strategies, executive control and the intentional encoding of information [7]. Also, it has been suggested that the underlying neuropathology in clinical dementia (e.g. Alzheimer's disease) is related to brain pathology responsible for cognitive deficits in normal ageing [8]. Since memory complaints in older people can greatly affect the quality of everyday life [9], there is a substantial interest in the treatment of these cognitive problems [10].

Several cognitive training programmes have been studied over the last decades specifically aimed at age-related memory loss, for example relying on unstructured practice, visual imagery (i.e. the method of loci), or external memory aids, such as computers [11, 12]. Meta-analyses, however, showed that these techniques produced only small to medium effect sizes, both on subjective memory measures [13] and on objective neuropsychological tests [14]. Moreover, although some techniques result in improvements on the trained tasks, treatment effects generally show little generalisation, and mnemonic strategies are often difficult to apply by subjects with memory problems. To overcome this difficulty, new techniques have been developed based on experimental-psychological task paradigms. One of the most promising methods is based on the elimination of errors during learning. Behavioural memory studies in animals have shown that errorless learning was superior to trial-and-error learning [15]. These findings were expanded in a thorough study in amnesic patients, compared to the performance in healthy young and older participants [16]. Here, it was found that errorless learning of a word list was more effective than errorful learning in the memory-impaired patients. A possible explanation for this effect lies in spared implicit learning capacity in people with amnesia, resulting in the consolidation of errors produced during the learning phase. The results on the healthy participants, however, were less clear in this study, since these were confounded by serious ceiling effects in the young group and a sub-sample of the older group.

In summary, although positive effects of errorless learning have been widely reported in amnesic patients, only one study has examined this technique in relation to cognitive decline in normal ageing [16]. It was the aim of the present study to further investigate the effects of errorless learning compared to errorful (trial-and-error learning) in normal ageing. The performance of the older group was compared with a control group of healthy young adults. Care was taken to prevent the occurrence of ceiling effects. Also, a different task was used compared to word-list learning in the original experiment, i.e. memory for people's names using face–name associations. This is one of the memory abilities that older subjects specifically would like to improve [17]. Since implicit memory is commonly unaffected by age, while explicit memory is, it is expected that the older group shows the largest benefit from the errorless learning approach. The older group is hypothesised to display a steeper learning curve in the errorless learning condition compared to the young adults. Also, the young group will outperform the older group on all tasks due to age-related memory loss in the latter.

Methods

Sixteen young adults (9 males and 7 females) and 18 older subjects (7 males and 11 females) were asked to participate in this study. All participants were recruited from a subject pool of the university containing healthy volunteers, and informed consent was obtained for each subject. Mean age of the young group was 20.9 years (SD = 1.8; range 19–25), mean age of the older group was 74.2 years (SD = 5.2; range 67–84). All subjects were screened by means of a semi-structured interview to exclude participants with severe subjective memory loss, dementia or psychiatric illness and were in good health at the moment of testing. Education level of each participant was scored using 7 categories, 1 being the lowest and 7 the highest (university degree) [18]. The mode for education was 5 for both groups (range in the young group 4–6 and for the old group 3–5). There was no significant difference in the distribution of the education level between both groups ($Z = 0.97$).

The face–name association memory task consisted of 60 cards (size 105×148 mm) containing grey-scaled photographs of unfamiliar faces. Each face was approximately the same size and photographed from the same position (the left side). Half of the cards showed young adults and half of the cards showed older persons. For each face, a second card was available showing the to-be-remembered name below the photograph as well. All names were common, easy to pronounce Dutch first names that were familiar to both the young and the older group (e.g. 'Paula', 'Bert'). Two stimulus sets were created, each containing 30 face–name pairs with an equal amount of men and women and an even distribution of young and old persons.

The total test session consisted of two task conditions, errorless learning (EL) and errorful learning (EF), based on the paradigm described previously [16]. In the EL condition, each trial started with a 5-second presentation of a card containing a face, with the instruction to study the face in detail. Next, a second card was shown containing the face together with the to-be-remembered name, which was also read aloud by the experimenter. Subjects were instructed to remember the face–name associations. In this condition, no errors could occur during learning since the correct names were given instantly. In the EF condition, each trial started with a 5-second presentation of a card containing a face and the first letter of the to-be-remember name was verbally given by the experimenter, serving as a cue. The subject was instructed to guess the correct name during the presentation of the card, and no feedback was given (i.e. 'Could you guess the name of this person, beginning with an L?'). Subsequently, a second card was shown containing the face together with the correct name, which was also read aloud by the experimenter. Hence, errors occurred during learning, since the subjects were unaware of the correct names and reported many incorrect names during the presentation of each card.

A within-subject design was applied, in that each subject participated in each condition. Half of the subjects started with the EL condition, the other half with the EF condition. Each condition consisted of two subsequent study-test phases. A delayed recall test phase followed after 10 minutes. In the test phases, the face cards were presented, and the subject was prompted to give the associated names. No letter cues were available during testing (see Figure 1 for a schematic overview of the task). The two sets of stimuli were presented in a counterbalanced design to overcome possible differences in difficulty between the two sets of face–name pairs. The order of presentation of the faces within each set was

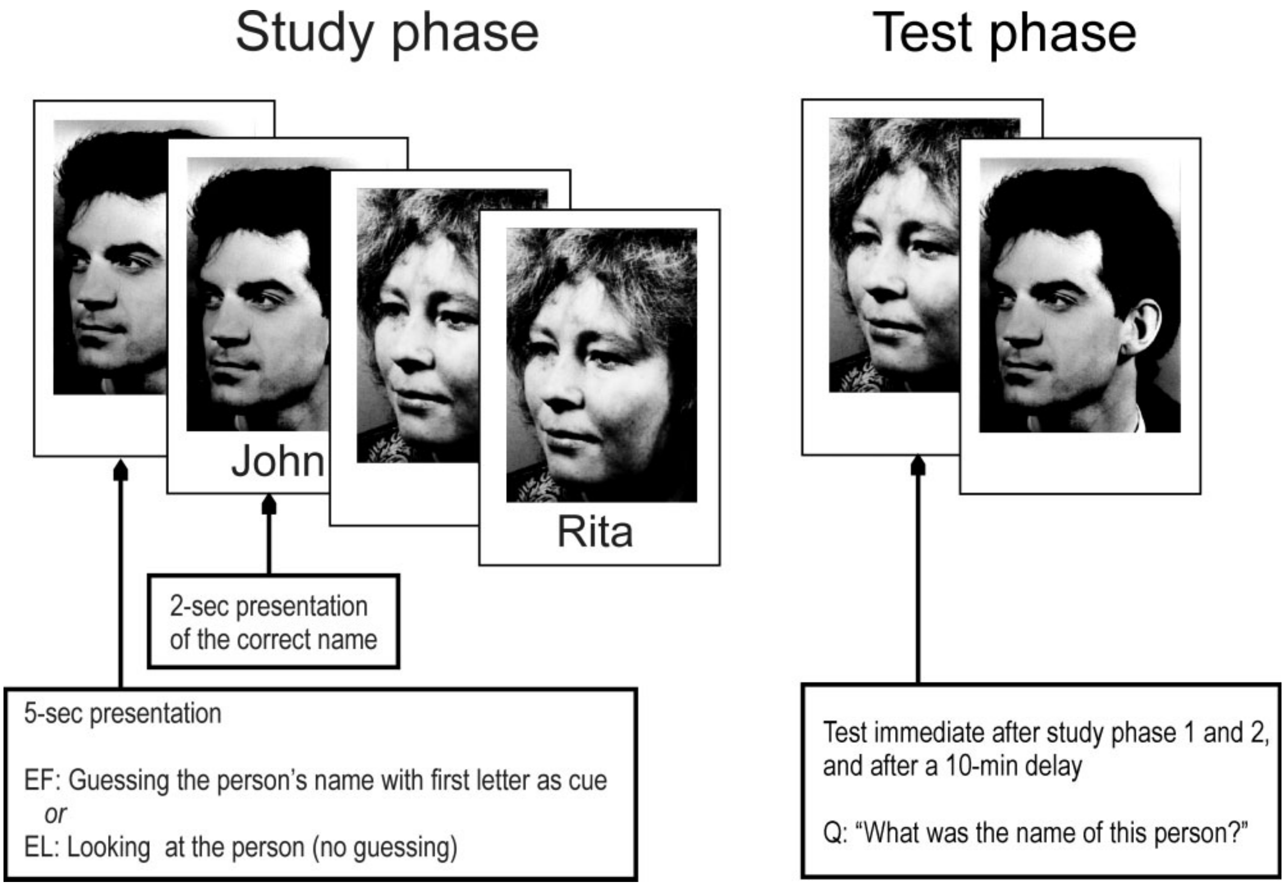

Figure 1. Schematic overview of the face-association learning task. In each study phase, participants were instructed to either guess the name of the person using the first letter as a cue (errorful condition –EF) or to study the face without guessing (errorless condition – EL). After each study phase, memory for the names of the faces was tested without letter cues. After two study phases and test phases, a 10-minute delay was introduced, followed by a test phase.

randomised in each test trial (both immediate and delayed). The number of correctly reproduced names (out of a maximum of 30) was used as dependent variable.

Results

Figure 2 shows the results for the two groups on the two task conditions. A $2\times3\times2$ analysis of variance with Task Condition (EL *versus* EF) and Trial (Immediate Trial 1, Immediate Trial 2 and Delayed Recall) as within-subject factors and Group (Young *versus* Older) as between-subject factor was performed. A significant main effect of Task Condition was found, in that the performance in the EL condition was overall better than the performance on the EF condition (F (1,32) = 18.1, $P < 0.0005$). Furthermore, a main effect of Trial was found (F (2,31) = 80.1, $P < 0.0005$). Pair-wise comparisons showed that the performance increased only across the first two test trials ($P < 0.0005$). Additionally, a main effect of Group was found (F (1,32) = 48.8, $P < 0.0005$); the Young group overall showed a better performance compared to the Older group. Finally, a significant Trial $\times$ Group interaction was found (F (2,31) = 12.5, $P < 0.0005$). Post-hoc analyses of variance showed that this interaction was only significant for the first two trials (F (1,32) = 18.87, $P < 0.0005$), and not for the delayed test compared to the second trial (F (1,32) = 0.05). This demonstrates that the older group's learning curve is relatively flat compared to the Young group. The Task Condition $\times$ Group interaction did not reach significance (F (1,32) = 3.10, $P = 0.09$). When looking at the effect sizes (Cohen's d) based on an aggregate measure of recall (i.e. the performance on Trial 1 and 2 taken together), the standardised difference between EL and EF is 0.78 in the younger group (a 'large' effect) and 0.51 in the older group (a 'moderate-to-large' effect). This indicates that the older group actually benefits to a lesser extent from the EL principle than the younger group. None of the other interactions were statistically significant (all Fs < 3.1).

Discussion

The present study focused on the efficacy of errorful and errorless learning in a group of older participants on a

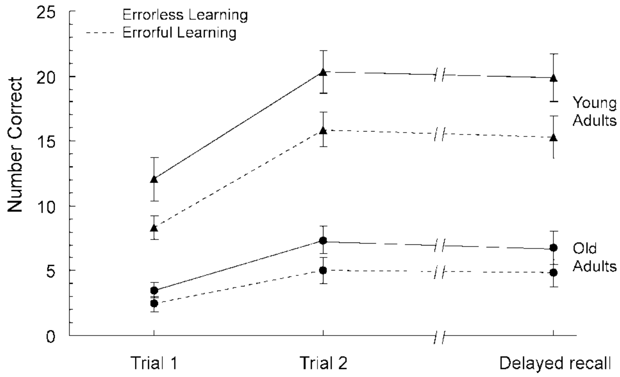

Figure 2. Mean numbers correct (±standard errors of the mean) for the errorful and errorless task conditions for the young and old groups on the three test moments (two immediate study-test trials and one delayed recall-only trial).

face–name association memory task, and the performance was compared with the performance of a young control group. With respect to the effects of ageing on episodic memory, the findings clearly show that an overall decreased memory performance on this task was present in the older subjects. More specifically, the learning curve in the older group is relatively flat compared to the young group, indicating that it is the encoding of new information that is vulnerable to age-related decline. Although the task is relatively difficult, the data do not show a floor effect in the elderly group. The introduction of a 10-minute delay did not result in a worse performance in both groups compared to the last trial of the immediate recall tests, showing that the retention of information is unaffected. These results are in agreement with recent research on ageing effects in face–name association, demonstrating that specifically the encoding stage was affected by age [19]. Moreover, the results are in line with earlier findings, which also reported flatter learning curves in combination with normal forgetting rates on a range of everyday memory tests in older subjects [20].

With respect to the effect of the learning conditions, the results show a clear benefit of errorless learning over errorful learning in both age groups. This extends previous findings [15], in which no overall difference between the two training methods was found on word list learning when comparing a healthy young and older group directly. As suggested by the authors, however, this was most likely due to a ceiling effect in the young group in their study. The current study was successful in eliminating this ceiling effect by using a more difficult task (i.e. face–name association). Moreover, the current findings are in agreement with those of studies in amnesic patients, which show that errorful learning results in a worse memory performance than errorless learning [16, 21–24]. In addition, error elimination in face–name association learning is probably more effective than other mnemonic strategies, such as the use of imagery techniques [25]. Thus, the present findings clearly demonstrate that the elimination of errors during learning is effective in improving the memory functions in healthy subjects in general. Possibly, the elimination of errors during learning may also be as a strategy to compensate for age-related memory decline.

Interestingly, there was no interaction effect for group and task condition. Based on previous findings in the literature, it could be hypothesised that older participants would benefit more from the errorless learning principle than the young control group. That is, there is abundant evidence that ageing results in a selective decline in explicit memory with sparing of implicit memory functions, a pattern that is similar to what is commonly found in patients with amnesia. However, the young and older group equally benefited from the errorless learning principle. The question is then, to what extent this effect is related to the dissociation between explicit and implicit memory, as formulated in the original paper by Baddeley and Wilson [16]. This was examined recently [22], focusing on implicit memory function and errorless learning. Here, it was concluded that the benefit of errorless learning did not correlate with spared implicit memory functions, but rather was related to residual explicit memory functions. In line with this, others conclude that the retrieval of implicit information in errorless learning situations is predominantly promoted by cued recall tests (i.e. by providing the first letter of a name) [21]. These studies indicate that the hypothesised relation between implicit memory functions and error elimination in learning remains to be investigated in more detail.

The results of this study may also have practical implications related to the development of memory training programmes for older people. As mentioned before, many training programmes use specific imagery-related mnemonic strategies [13], such as the method of loci (in which subjects have to remember items by associating them with familiar places). Apart from the limited effectiveness of these techniques, a major disadvantage of using imagery in learning is that this mnemonic strategy is often highly complex, and therefore difficult to apply in everyday life, especially in subjects who report memory problems [24]. Although the errorless learning technique is not a mnemonic strategy in a strict sense for it addresses the learning process rather than serving as a memory aid, the principle may be of assistance in everyday settings. That is, if one experiences memory failure (such as not remembering the name of a familiar person), one is intuitively tempted to guess until the correct name comes up, resulting in incorrect responses. The results of this paper and previous research clearly demonstrate that these might actually interfere with the memory traces (and thus produce higher error rates), and that the prevention of errors during learning or rehearsing information consequently results in a better memory performance.

Key points

- Older people show difficulties in the encoding stages of learning, resulting in a flat learning curve compared to a young control group.
- The occurrence of errors during learning of new episodic information interferes with the encoding of accurate information, resulting in a lowered memory performance in young as well as older people.
- More research is needed to establish whether the prevention of errors is a useful tool in remediating everyday age-related memory decline, and whether it is more effective than mnemonic strategies based on imagery.

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