CHAPTER 3.3

Age-Related Changes in Memory

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It is commonly believed that memory declines in old age. This chapter examines evidence from laboratory-controlled studies of ageing memory and asks whether changes are universal (i.e., associated with all types of memory) or whether certain types are more affected than others. Before describing the data, it is useful to begin with a brief outline of some recent theoretical approaches to ageing memory, followed by a summary of the ways in which memory has been subdivided in the literature.

THEORETICAL OVERVIEW

Effects of old age on memory have been interpreted in terms of three main theoretical frameworks, namely, limited processing resources, reduced processing speed and impaired inhibitory functioning. The limited processing resources approach (e.g. Craik, 1986) supposes that older people are limited in the resources they have available for encoding information into memory and then for retrieving information from memory. Thus they are less able to carry out resource-demanding operations such as linking items together on a list or organizing retrieval in a systematic way. This self-initiated processing is particularly required when the environment itself does not provide many cues at either encoding or retrieval. Evidence consistent with this general view comes, for example, from the finding that age deficits are greater in memory tasks that are more demanding of processing resources, such as recalling an item rather than simply recognizing it as having been encountered earlier (Craik and McDowd, 1987).

The reduced processing speed hypothesis stems from the ubiquitous observation of mental slowing in old age. Salthouse (1996: 403) proposed two mechanisms that underlie the relationship between processing speed and age differences in cognition. The *limited time mechanism* suggests that ‘cognitive performance is degraded when processing is slow because relevant operations cannot be successfully executed’; the *simultaneity mechanism* proposes that ‘products of early processing may no longer be available when later processing is complete’. Thus, even when allowed unlimited time, older adults’ performance in a memory task may not match that of young adults. Support for the processing speed theory comes, in part, from studies in which the age-related deficit in memory is greatly attenuated when a simple measure of perceptual motor speed is statistically taken into account (see Salthouse, 1996).

On the impaired inhibitory functioning view (Hasher and Zacks, 1988), the claim is that older adults have less inhibitory control over the contents of their memory than do young adults. Inhibition is required both to prevent distracting or goal-irrelevant information from entering memory, and to prevent information remaining in memory when no longer relevant. With impaired inhibitory functioning in old age, memory is assumed to be cluttered up with distracting information during both encoding and retrieval of goal-relevant information. The inhibition deficit hypothesis has created much debate (see discussion papers in the *Journal of Gerontology: Psychological Sciences*, 1997, 52B: P253–83) but also supportive evidence from a variety of paradigms as summarized by Hasher *et al.* (1999).

TYPES OF MEMORY

The vast literature on ageing memory is best understood by considering effects on different types of memory as traditionally categorized by memory researchers. First, there is the distinction between *short-* and *long-term memory* (STM and LTM). STM refers to the retention of information for just a few seconds, whereas LTM refers to the retention of information over longer periods, from seconds or minutes to many years. STM can be further subdivided into *primary memory* (associated with the passive retention of information) and *working memory* (where stored information is actively manipulated in some way).

Several distinctions have been drawn within LTM. For example, *episodic memory* refers to memory for specific autobiographical events, such as recalling what you did on holiday in Paris last year or what you had for breakfast this morning, whereas *semantic memory* refers to the store of general knowledge about the world, such as knowing that Paris is the capital of France or that breakfast is the first meal of the day. Also relevant to an understanding of ageing memory is the distinction between *explicit memory* (which requires the conscious recollection of a particular prior event) and *implicit memory* (as revealed by enhanced performance on a task as a result of an earlier encounter with the stimulus). Finally, the recall or recognition of information from the past is termed *retrospective memory*, whereas remembering to perform some action in the future without any external prompting is termed *prospective memory*. As we shall see, at least some of these distinctions have revealed striking dissociations in terms of the effects of normal ageing.

STM: (1) PRIMARY MEMORY

The capacity of primary memory is commonly assessed by memory span, which is the longest sequence of unrelated items (digits, letters or words) that can be reproduced in the correct order immediately after presentation on at least 50 per cent of occasions. Some early studies claimed that memory span was largely unaffected by increased age. But more recently, small to moderate age-related declines have been observed in memory span. For example, Salthouse (1991) showed that adults in their 60s–70s performed approximately one standard deviation below the level of those in their 20s, with decline slightly greater for word span than for digit span.

Maylor *et al.* (1999) presented young and older adults (mean ages of 20 and 65, respectively) with lists of seven letters at a rate of one letter per second. Participants were required to recall each list immediately in serial order by writing their responses in seven boxes from left to right. Figure 1 shows correct responding as a function of serial position for both auditory and visual presentation. The young group outperformed the older group in both modalities (75% and 63% correct overall for young and older adults, respectively). Typical serial position curves were evident in both age groups, with early and late serial positions better recalled than middle positions and a more pronounced increase in recall of the final item for auditory presentation than for visual presentation. Finally, the age-related deficit was greater in the early and middle serial positions than in the later serial positions for auditory presentation, whereas the reverse was true for visual presentation. Clearly, primary memory declines with age. But to what extent can this be attributed to decline in a single factor such as processing speed? In Maylor *et al.*'s (1999) study, the correlation between age and STM performance was −.43. When a standard measure of perceptual motor speed was partialled out, the correlation dropped to zero, consistent with the reduced processing speed hypothesis. However, this general hypothesis is unable to predict the precise pattern of age differences in both correct and erroneous responses by serial position. For this, Maylor *et al.* applied a computational model of memory for serial order and found that, by altering two parameters, which could be construed as corresponding to slower encoding and slower output, they could simulate the detailed pattern of age deficits in performance.

Other STM data consistent with a generalized slowing account come from a study by Multhaup *et al.* (1996). A widely accepted view of memory span is that items are entered into a passive phonological store that holds speech-based information for approximately 1.5–2.0 seconds before it decays. An active articulatory rehearsal process based on inner speech can refresh the memory trace so that memory span corresponds to the number of items that can

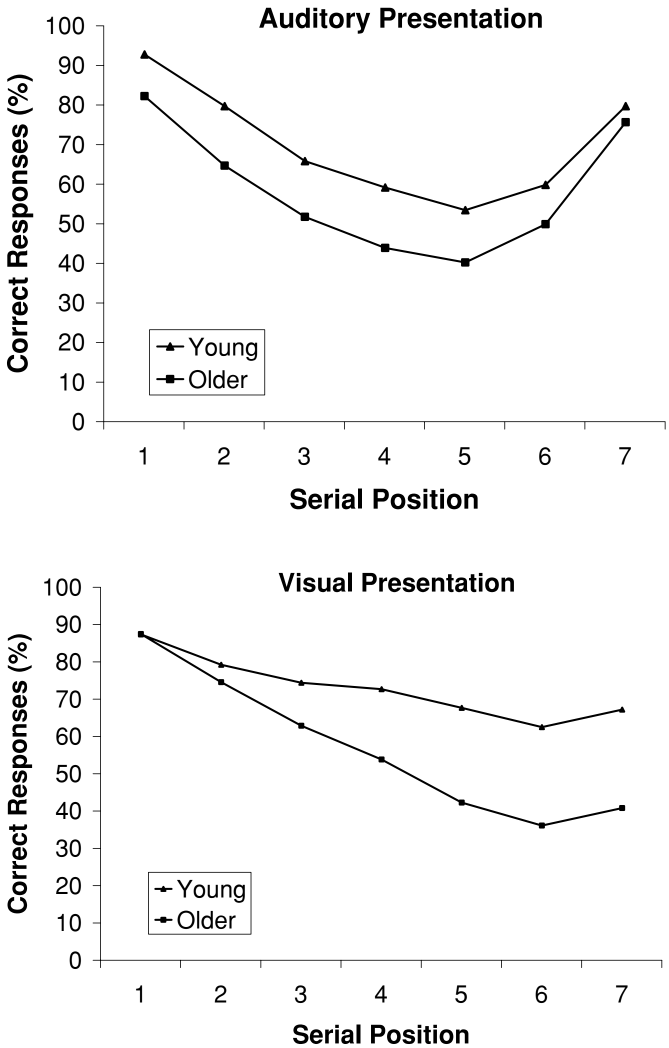

Figure 1. Immediate serial recall of sequences of seven letters presented auditorially (upper panel) and visually (lower panel): mean percentages of correct responses as a function of serial position for young and older adults. Data from Figure 1 of Maylor *et al.* (1999).

be articulated in 1.5–2.0 seconds. Older adults are known to have slower articulation rates than young adults and therefore we would expect their memory spans to be correspondingly lower. Multhaup *et al.* examined the relationship between memory span and speech rate in young and older adults (mean ages of 22 and 68, respectively). The stimuli were words and nonwords of three different lengths – short, medium and long – and items were presented at a rate of one per second. Speech rate was measured by asking participants to repeat pairs of items ten times. The results confirmed a linear relationship between memory span and speech rate (see Figure 2) and, as expected, young adults had larger spans and faster speech rates than older adults. Crucially, the functions for the two age groups were collinear – in other words, the reduction in memory span for older adults was predictable on the basis of their slower speech (and therefore rehearsal) rate. To conclude, there is small to moderate age decline in memory span that is at least consistent with the generalized slowing account of ageing (see Maylor *et al.*, 1999, for further discussion).

STM: (2) WORKING MEMORY

In contrast to primary memory, working memory involves both the storage and the processing of information, such as would be required in a mental arithmetic task. Craik (1986), for example, examined age differences on a primary memory task (digit span) and a working memory task (alpha span) in which the to-be-remembered list of words had to be rearranged into alphabetical order before recall. The age deficit was found to be greater for alpha span than for digit span. On the other hand, researchers have not always observed greater age deficits for backwards span (where items must be recalled in reverse order to that of presentation) and standard forwards span (see Salthouse, 1991, and Verhaeghen *et al.*, 1993, for examples of similar age deficits for forwards and backwards span).

More traditional (and more resource-demanding) measures of working memory usually involve the sequential presentation of a series of problems that require processing (e.g., *Cows eat grass – true or false? Spoons are made of paper – true or false?*). At the end of the series, the task would be to recall the last word of each statement (*grass*, *paper*, etc.) in the correct order. Working memory span is the longest series that can be remembered reliably, assuming also that the problems were processed correctly (in this case, the true/false responses). Results from many studies consistently show substantial age-related decline in working memory span (see Salthouse, 1992).

The general conclusion on STM is that age-related decline is less striking in tasks in which lists of items simply have to be reproduced in the presented order (primary memory) than in more demanding tasks requiring the simultaneous storage and processing of information (working memory). This pattern can therefore be readily interpreted in terms of the limited processing resources view. On the reduced processing speed hypothesis, the correlations with age either drop to zero (primary memory; Maylor *et al.*, 1999) or are considerably attenuated (working memory; Salthouse, 1996) when speed is taken into account. In other words, there is evidence that slower processing is a fundamental underlying mediator of age differences in STM.

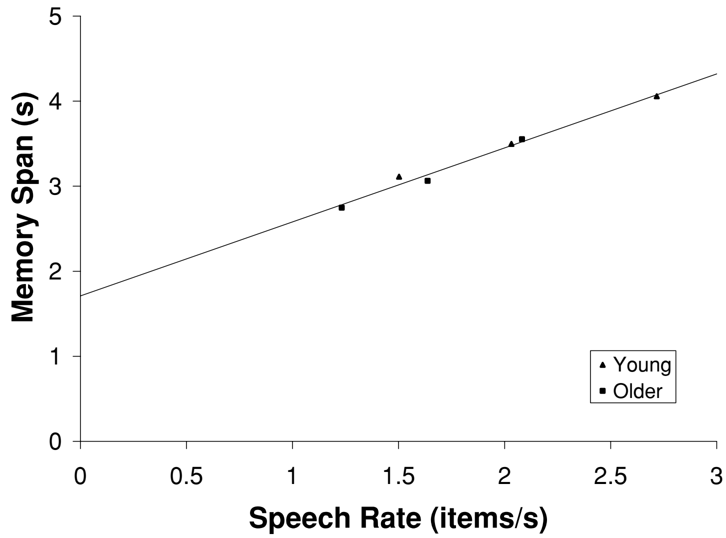

Figure 2. Memory span as a function of speech rate for young and older adults. For each age group, long items are represented by the leftmost point, medium items by the middle point, and short items by the rightmost point. Data from Table 1 of Multhaup *et al.* (1996), averaged across words and nonwords. The linear regression function shown is y = 0.87x + 1.71 ($R^2 = 0.98$).

Recently, May *et al.* (1999) observed that memory span procedures typically start with short lists and then gradually increase in length until a participant fails consistently at a particular length. To perform well, participants must focus on the current list and suppress previous lists; otherwise proactive interference (PI) occurs. If older adults are less able to avoid PI (as suggested by the inhibition deficit hypothesis), then as the lists increase in length, performance will suffer earlier as a result of accumulating interference from previous items.

TABLE 1. Reading span for young and older adults in which lists either increased in length (standard condition) or decreased in length (descending condition). Data from Experiment 1 of May *et al.* (1999)

Condition	Young	Older
Standard	3.1	2.6
Descending	2.9	3.0

May *et al.* (1999) employed a reading span task in which participants read printed sentences aloud while remembering the final word in each sentence for recall at the end of the list. In the *standard* condition, trials were presented in the usual ascending order (2-, 3-, then 4-sentence lists); in the *descending* condition, trials were presented in the reverse order (4-, 3-, then 2-sentence lists). Table 1 shows the mean list lengths reliably recalled (i.e., reading span) by young and older adults (mean ages of 19 and 67, respectively) under these two conditions. There was a significant age deficit under the standard condition. However, there was no age difference under the descending condition where PI was minimized at the longest list length. This provides support for the view that at least some age-related deficits in working memory may be attributable to failures in clearing working memory of information that is no longer relevant to the current task.

LTM: (1) SEMANTIC VS EPISODIC MEMORY

As mentioned earlier, the semantic memory system can be considered as analogous to the contents of a combined dictionary and encyclopaedia, whereas the episodic memory system is more similar to a personal diary. This is an important distinction with

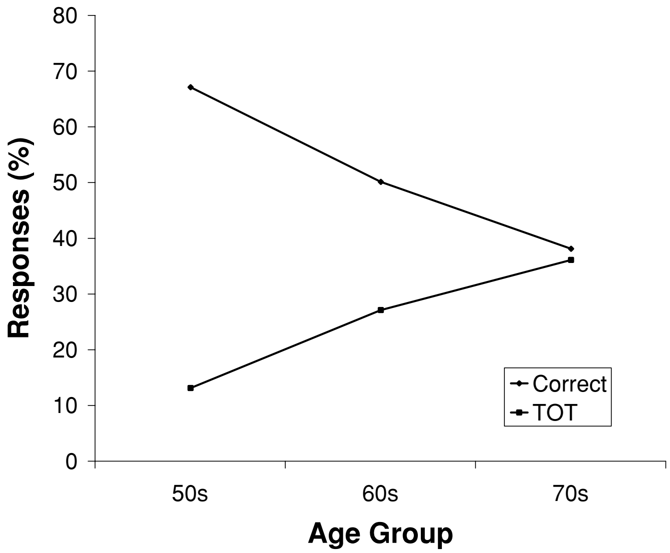

Figure 3. Percentages of faces recognized as familiar that were correctly named or received a tip-of-the-tongue (TOT) response for 50-, 60- and 70-year-olds. Data from Figure 1 of Maylor (1990c).

respect to ageing because it is often claimed that, in contrast to episodic memory, semantic memory shows little or no age-related decline. For example, there are few systematic age effects on measures of general knowledge as included in various IQ tests (see Salthouse, 1991). Similarly, scores on vocabulary tests remain relatively stable in old age. However, this may depend to some extent on the demands of the particular test employed. Thus, Maylor (1990b) observed the usual result of no significant decline with age on a vocabulary test requiring the selection of a synonym for the target word; in contrast, older adults performed more poorly than younger adults when required to identify a word from its definition (see Table 2 for examples). This finding within semantic memory mirrors the observation noted earlier that tests of recognition are less affected by ageing than are tests of recall because of their differing processing demands.

Consistent with their subjective complaints, older people are more susceptible to the experience of finding themselves temporarily unable to retrieve a familiar name or word – the well-known 'tip-of-the-tongue' (TOT) state (e.g. Burke *et al.*, 1991). This is illustrated in Figure 3 by data from a study by Maylor (1990c) in which participants were shown photographs of famous people and were asked to name each person within 50 seconds. Clearly, while the numbers of correct names decreased with increasing age, the numbers of TOT states correspondingly increased. It is important to note that almost all TOT states are eventually resolved in both younger and older people, suggesting that the semantic knowledge base remains intact but speeded access to it is impaired by ageing. Moreover, these temporary retrieval failures from semantic memory in old age are not unique to proper names. However, TOT states associated with people's names may be particularly noticeable because there are no synonyms available. Name retrieval failures may also be more frustrating because of their obvious social significance and therefore may be more memorable.

TABLE 2. Examples of items from two vocabulary tests used by Maylor (1990b), with correct answers shown in italics. Age-related decline from 50- to 70-year-olds was absent for the multiple-choice test but present for the word identification test

Multiple-choice vocabulary test
Choose the word that is closest in meaning to:
FECUND
esculent profound sublime optative *prolific* salic
ABNEGATE
Contradict *renounce* belie decry execute assemble

Identifying words from definitions
What is the word meaning:
'Something out of keeping with the times in which it exists' (*anachronism*)
'House of rest for travellers or for the terminally ill, often kept by a religious order' (*hospice*)

There is considerable evidence that episodic memory declines markedly with age as revealed, for example, by the common laboratory task of free recall in which a long list of unrelated items is presented for subsequent recall in any order (see Verhaeghen *et al.*, 1993). Moreover, older adults are not only less able to recall items that were presented, they are also more likely to recall items that were not presented. For example, Norman and Schacter (1997) elicited high rates of false remembering by presenting lists of words (e.g., *door*, *glass*, *pane*, *shade*, *ledge*, *sill*. . . .) that were each thematically related to a word that was not presented (in this case, *window*). Figure 4 shows that recall of presented words was much higher than recall of nonpresented theme words for young adults (mean age of 19), whereas recall was approximately equally likely for presented and nonpresented words for older adults (mean age of 68). Thus, it seems that older adults are more susceptible to this false memory effect. One explanation assumes that, during initial presentation, the theme word is automatically activated through semantic priming. At recall, this nonpresented theme word may be retrieved, but, perhaps because of limited processing resourses, older adults are less likely or able to carry out strategic retrieval or monitoring processes that are required to evaluate its source (i.e., internally rather than externally generated). This would be consistent with the general view that age-related deficits are particularly striking for contextual details of events (see Spencer and Raz, 1995). Older people themselves often report that, while their memory is poor for what happened yesterday, they have very clear recollections of events that happened a long time ago, perhaps in childhood or during the war. In fact, older people's own perceptions of their memories seem to follow Ribot's law, which states that recent memories are forgotten but remote memories are preserved. However, there are obvious problems is assessing such reports: (1) personal memories recalled from the distant past are often highly selective events that are personally salient – in other words, they are typically not the routine daily occurrences of the sort that are currently being forgotten; (2) the remote events are more likely to have been frequently rehearsed and recounted; (3) remote memories are probably liable to unconscious distortion and embellishment.

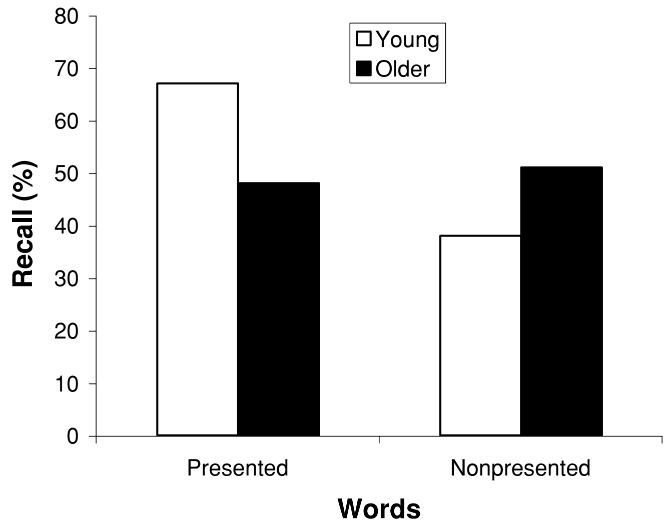

Figure 4. Free recall of lists of thematically related words in young and older adults: percentages of presented words correctly recalled and nonpresented theme words falsely recalled. Data from Table 1 of Norman and Schacter (1997).

Cohen *et al.* (1994) investigated ageing episodic memory dating back a year by examining people's recall of their personal circumstances associated with a notable public event, namely, the resignation of Margaret Thatcher as Prime Minister. Young and older volunteers (mean ages of 22 and 72, respectively) were asked to give detailed accounts of how they first heard the news that Margaret Thatcher had resigned. They were initially tested within 10–14 days of the resignation and were subsequently retested approximately one year later. The question of interest was whether the two accounts were consistent or inconsistent (see Table 3 for an example of each). The results revealed that, whereas 90 per cent of young participants were highly consistent in their accounts, only 42 per cent of older participants were highly consistent. Thus, it seems that older people are indeed mistaken in their impressions of generally preserved remote memories.

LTM: (2) IMPLICIT VS EXPLICIT MEMORY

The memory tasks considered so far explicitly asked participants to recall or recognize information

TABLE 3. Examples of people's accounts of how they heard the news of Margaret Thatcher's resignation after a few days (test) and after approximately a year (retest). Data from Cohen *et al.* (1994)

Consistent example
Test: 'While waiting in the supermarket till queue, a supervisor spread the news to the till operators.'
Retest: 'While waiting in the till queue in Sainsbury's Oxford store, a supervisor informed the till operators of the resignation.'

Inconsistent example
Test: 'I was at the school in which I work, and I entered the Bursar's office to see her put down the telephone and then announce very excitedly "she's resigned" . . .'
Retest: 'I was in the office of the school in which I work when a colleague burst in and in a very loud voice announced that Mrs Thatcher's resigned . . .'

encountered earlier. In contrast, consider an experiment in which participants are asked to read some words (e.g., *mechanism*), perhaps in a passage of text. Later in the session, they may be presented with a word stem (*mec*------) or fragment (-*e*-*h*-*n*-*s*-) and asked to complete it with the first word that comes to mind – note that there is no reference to the prior study period. Implicit memory is revealed by an increased likelihood of completion for studied words (*mechanism*) relative to unstudied words. Several studies have shown striking dissociations between no significant age differences on implicit memory tests and significant age differences on explicit memory tests (see Light *et al.*, 2000, for examples).

Age differences on implicit memory tests may not reach significance but they usually favour the young, at least numerically. This raises the possibility that there is some decline in implicit memory with increasing age, which individual studies are unable to detect because of insufficient power. Combining multiple studies together in a meta-analysis reveals slight, but nevertheless significant, age-related decline for implicit memory (Light *et al.*, 2000). This pattern of impaired explicit memory but relatively spared implicit memory can be interpreted in terms of the view that explicit and implicit forms of memory depend on different memory systems that are associated with distinct regions of the brain and that these different brain areas are differentially impaired by ageing. An alternative view is that different processing resources are involved, with explicit memory tasks requiring consciously controlled recollective processes that are effortful and demanding, and implicit memory tasks relying on automatic processing. For further discussion and evidence that ageing impairs conscious recollection but not automatic retrieval or familiarity, see Light *et al.* (2000).

LTM: (3) RETROSPECTIVE VS PROSPECTIVE MEMORY

Compare the task of describing what happened in a television soap opera last night to a friend who missed it, with remembering to set the video-recorder to tape tonight's episode. These are tests of retrospective and prospective memory, respectively. We have already seen examples of age-related deficits in laboratory tests of retrospective memory. In recent years, there has been increasing interest in prospective memory, which can be defined as remembering at the appropriate point in the future that something has to be done, without any prompting in the form of explicit instructions to recall. Craik (1986) suggested that age-related deficits should be particularly evident in such tasks because prospective remembering by definition places heavy demands on self-initiated retrieval processes.

Early naturalistic studies of prospective memory, in which volunteers were asked to make telephone calls or mail postcards at particular times over the course of several days, revealed that older people can perform at least as well as young people provided that they employ efficient cues (e.g. Maylor, 1990a). These probably work well for important appointments, but alarm clocks, memos and so on are impractical for many everyday tasks. Thus, it is significant that older people perform less well in prospective memory tasks conducted in the laboratory. However, not all of these studies have observed age-related decline – it appears that prospective memory tasks, like retrospective memory tasks, vary both in their processing demands and in the salience of the cues provided by the environment at retrieval (see, for examples, Einstein *et al.*, 1995; Maylor *et al.*, 2002). Age-related deficits in prospective memory tasks are therefore most pronounced in situations where participants are engaged in demanding activities and self-initiated processing is required to recognize the appropriate conditions for action.

CONCLUSIONS

There is clearly some variation in the effects of normal ageing on memory, depending on the type of memory in question:

- For short-term memory, there are small to moderate age deficits for primary memory but larger age deficits for working memory. In both cases, the data are consistent with the reduced processing speed hypothesis, although there is also evidence that impaired inhibitory functioning may play a role in the working memory deficit.
- For long-term memory, although semantic memory is considerably less affected by ageing than episodic memory, it is not completely spared – for example, speeded access is impaired, resulting in noticeable and frustrating temporary retrieval failures. Episodic memory decline is well documented and includes an increased susceptibility to false memories and inaccurate remote memories (contrary to subjective reports).
- The implicit–explicit memory distinction shows the most striking difference with respect to ageing, with little or no decline for implicit memory in contrast to robust decline for explicit memory.
- Prospective memory in old age is a relatively new area of research but the evidence so far indicates that qualitatively similar principles probably apply to the impact of ageing on remembering things from the past and on remembering to do things in the future.

Finally, in addition to variation in age-related changes across different types of memory, there is considerable variability across individuals such that some older people are less adversely affected than others (Morse, 1993). It is also worth repeating Verhaeghen *et al.*'s (1993) cautionary note that age-related deficits in the laboratory 'do not necessarily imply the breaking down of everyday memory functioning in old age' (p. 168). They suggest that the memory system of young adults 'functions at a level much higher than is needed for survival. Even though a decrease in functioning can be irritating, depressing, or upsetting for the older person who experiences it, the consequences of the decrease for daily life performance may be rather trivial, precisely because the culminating point of functioning in young adulthood is situated way above survival level' (p. 168).

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