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Changes in Memory with Normal Aging: A Functional View

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One striking aspect of age changes in cognitive functioning is that age-related decrements vary enormously from one type of test to another. In the realm of psychometric assessment, tests measuring "crystallized" abilities such as vocabulary and knowledge of the world tend to hold up across the adult life-span, whereas tests measuring "fluid" abilities (i.e., tests requiring novel combinations and new learning) show substantial declines with age, sometimes starting as early as the mid-thirties. As examples, the Vocabulary test from the WAIS-R battery shows little change from the forties to the seventies, whereas scores on the Digit-Symbol substitution test drop precipitously from the twenties on (5). This differential pattern of loss within the same sample of subjects reduces the likelihood that observed age-related decrements are due simply to motivational differences, cohort differences, or lack of recent practice; it seems, rather, that certain kinds of cognitive *processes* remain intact, whereas others decline with age. Older people do well if the task involves running off routine, automatized, highly practiced sequences, but they do less well if the task requires manipulation of materials in novel ways or requires new inferences and abstraction from the information given.

Much the same features are found in memory tests, confirming the growing belief that memory is not some special faculty or separable mechanism but is, rather, one aspect of the total cognitive system. That is, memory involves the same processes that take part in perceiving, attending, thinking, and problem-solving. Before developing and illustrating this viewpoint mention should be made of some of the differential effects seen in the study of age changes in memory and some alternative accounts of these effects.

As summarized in a number of reviews (1,5), many tests of short-term memory (e.g., digit span or the Brown-Peterson paradigm in which three or four words or letters are recalled after 5 to 30 sec of interfering activity) show little or no age-related loss, whereas other laboratory tests (e.g., the ability to recall a list of 20 unrelated words in any order, immediately after presentation) show substantial losses. Why do these rather similar tasks show such marked differences? One obvious explanation is that the tasks draw on different memory mechanisms and that the mechanisms are differentially affected by the aging process. In the preceding example it

might therefore be suggested that digit span relies on "primary memory," which is unimpaired by aging, whereas the free recall of word lists relies heavily on "secondary memory" which *is* affected by the aging process.

As a second example, tests assessing memory for general knowledge show little decline, whereas tests of memory for specific occurrences in the person's past show substantial losses. Again, it seems possible that these two types of test rely on different memory systems, in this case the notions of semantic and episodic memory proposed by Tulving (7).

Such structural accounts of memory and memory disorders are clearly appealing and gain a great deal of support from the current neuropsychological literature. However, I wish to argue for an alternative point of view appealing to functions and processes rather than to mechanisms, systems, or modules. My argument is that it is the *type of processing* required by a particular task that determines the age decrement, not the involvement of one or another of several memory systems.

The principal line of evidence for this view is that age decrements are found or are not found in all memory stores and systems, depending on the operations required by a particular task. Specifically, if the task requires relatively passive "regurgitation" of material still held in consciousness (e.g., digit span) or can rely either on highly practiced routines or strong environmental cues, the older person's performance is relatively little impaired. If, however, the appropriate mental operations are not routinized or not guided by the environment and must therefore be initiated, organized, and executed by the older subject himself, age decrements appear, regardless of the store or system that is allegedly tapped.

Some experimental evidence on this point is presented later, but first more needs to be said on what memory *is* by the present view. Rather than think of memory in structural terms, e.g., in terms of fixed memory traces, we should think of *remembering* as an activity similar to perceiving. The acquisition or encoding end of memory thus simply involves the perception and comprehension of stimuli in light of past experience. There is good evidence (3) that later memory for an event can be excellent in the absence of any intention to learn, provided the learning task induces the subject to process the input semantically, in terms of organized and meaningful existing knowledge. Remembering or retrieval, in this framework, involves the recapitulation of the same mental configuration that occurred at the time of encoding. That is, retrieval operations attempt to reinstate the same pattern of mental (and presumably physiological) activities that took place at input. Retrieval operations are an attempt to reinstate encoding operations. It makes sense that remembering should be more effective to the extent that the environmental context is reinstated as completely as possible, and there is a great deal of evidence to this effect. Often, however, the original context is not present at the time of remembering, and in such cases the person must attempt to reinstate the appropriate mental configuration in a "self-initiated" manner.

Just as perceiving is determined jointly by incoming sensory stimulation and the learned machinery of mental operations, so remembering is jointly determined by the interaction of incoming stimulation (environmental context plus specific "retrieval cues") with the existing mental machinery that has been shaped by past ex-

periences. Remembering is therefore seen as involving the necessary interaction between external stimulation and mental operations. The process is effective and successful when the "appropriate" (i.e., initial encoding) operations are reinstated in part at least by re-presentation of the original event and context; the process is much more difficult and less successful when appropriate operations must be self-initiated rather than driven or induced by the environment. There is thus a complementary relation between environmental support and the need for self-initiated operations: more of one means less for the other. See Craik (2) for a fuller account.

With respect to aging, my suggestion is that older adults are less able to organize and execute these self-initiated operations and are therefore more dependent on environmental support. By this notion, different memory tests show age decrements to the extent that the task relies on self-initiated operations, but these decrements decline or vanish if performance can be adequately supported by the environment. It is well established, for example, that age differences are large in free recall, less in cued recall, and less again in recognition memory. These conditions reflect increasing amounts of environmental support. It is worth noting that these tasks *all* tap episodic memory, which thus shows large age differences in some circumstances but negligible differences in others. Similarly, studies of priming or implicit memory (e.g., word fragment completion, perceptual identification, or learning to read mirror-image script) show little or no age differences. These cases do not require the subject to remember details of the original experience—merely to complete the word or read the script—and involve substantial support and guidance from the stimulation itself. These ideas are summarized in Table 1, which shows some common laboratory memory tasks ordered in terms of the hypothetical amounts of environmental support they require.

EMPIRICAL EVIDENCE

Some experimental evidence on these points from my own and from other laboratories is discussed briefly. First, on the point that age differences in short-term

TABLE 1. *Memory Tasks showing Differential Effects of Aging*

Task	Environmental support	Self-initiated activity	Age-related decrement
Remembering to remember	increases		
Free recall	↓		
Cued recall			
Recognition			
Relearning			
Procedural memory (priming tasks)		increases	increases

memory tasks depend on the degree of manipulation and reorganization required, Mary Gick and I showed that the same samples of younger and older adults showed no differences on a standard digit span test, but a substantial age-related decrement on a task we called alpha span. In the latter task, subjects were given short lists of unrelated words and were asked to say them back in correct alphabetical order. The data are shown in Figure 1.

The same point is made by a recent study by Wingfield et al. (9). They also found no age difference in digit span, a slight age decrement in word span, and a larger age-related loss in working memory span. In the last task, subjects heard a series of sentences and had to remember and then repeat back the last word from each sentence. Again, age differences appear to reflect the type of operations required, rather than retrieval from a specific store or system.

Several studies confirm the notion that environmental support is particularly beneficial to older subjects. Waddell and Rogoff (8) asked middle-aged and older women to remember the spatial positions of 30 toy objects that were placed either in a featureless "mail-box" array of cubicles or in a model landscape. The younger group outscored the older in the former condition (0.73 and 0.36 correct, respectively); but in the landscape condition, which presumably affords greater contextual support, the respective scores were 0.75 and 0.72. A similar study by Sharps and Gollin (6) tested the free recall of 40 objects by young and elderly subjects. In one condition the objects' names were presented in a list; the young group recalled 18.0 on average and the old 9.3. In a second condition, actual objects were placed at various positions in a room and were studied in context by the subjects. In this case (which again presumably afforded greater environmental support), the younger group recalled 22.7 and the older group recalled 20.7. Again, greater environmental support virtually eliminated the age difference.

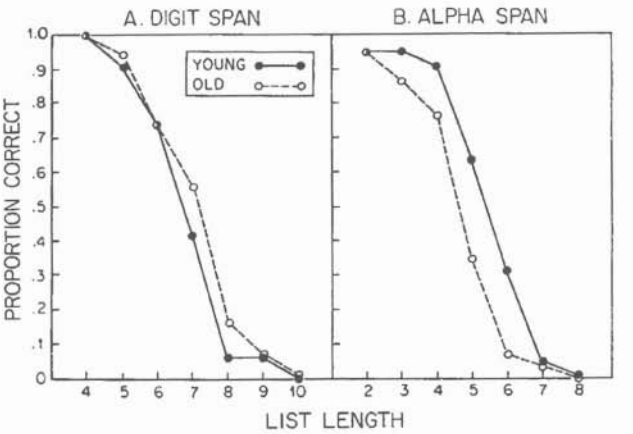

FIG. 1.

Paradoxically, it appears that whereas older people are more dependent on reinstatement of context, they may be less effective in the integration of events with their contexts during the encoding process. This point is made by a study of "source amnesia" in the elderly by McIntyre and Craik (4). In this experiment, younger and older people were asked some general knowledge facts and given the answers to questions they did not know. One week later, they were given a further test of general knowledge, with some new, easier questions mixed with the original questions; subjects were also asked to provide the source of their knowledge, e.g., book, television, newspaper, or the previous experimental session. The result of interest is that whereas the older group were more knowledgeable they remembered slightly fewer new facts and were considerably poorer at attributing their new knowledge correctly to the previous session. The older group remembered some new facts but were unable to recollect the source of their knowledge. A recent follow-up study has demonstrated that those older people who show the greatest degree of source amnesia tend to score highly on tests of frontal lobe dysfunction. Impaired frontal lobe functioning may therefore impair the ability to integrate events with their contexts and so reduce the effectiveness of episodic remembering.

In summary, I have argued for a processing view of memory and of memory disorders in the elderly. This view does not of course deny the reality of the underlying anatomy, physiology, and biochemistry but suggests that we should be looking for the brain's potential to reconstruct patterns of activity rather than be looking for fixed mechanisms and structures.

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