Working Memory and Older Adults: Implications for Occupational Therapy

Corinna Andiel, Lili Liu

Key words: aging • Alzheimer's disease

Atkinson and Shiffrin’s (1968) modal model of memory is still commonly used by rehabilitation professionals to evaluate memory impairment in older adults. However, research to date has been unable to indicate that short-term memory declines with age. These findings have led some rehabilitation professionals to mistakenly conclude that short-term memory is not affected by the aging process. This article reviews both the traditional concept of short-term memory, as outlined by Atkinson and Shiffrin, and the more recent conceptualization of short-term memory in terms of Baddeley and Hitch’s (1974) model of working memory. The implications of the concept of working memory has implications for occupational therapy interventions for older adults. For example, clients with dementia may experience difficulties in performing tasks that require drawing inferences. Similarly, language that contains vague references may present problems for these clients. In addition, changes in working memory in older adults suggest that they may experience difficulties with medication management and what Rule, Milke, and Dobbs (1992) called wayfinding. Therefore, evaluations of working memory would provide a better indication of older adults’ memory performance than the modal model.

Cognitive psychologists’ conceptualization of short-term memory has undergone significant changes in the past two decades. Currently, short-term memory tasks are commonly thought of as a continuum, with involvement of primary memory on one end and working memory on the other (Craik, Anderson, Kerr, & Li, in press). Although short-term memory is commonly evaluated in older adults, research has indicated that there is little change in this type of memory with age (Craik & Jennings, 1992). On the other hand, a substantial body of evidence has indicated that older adults display decrements in working memory (Hultsch, Hertzog, Small, & McDonald-Miszczak, 1992; Morris, 1986; Salthouse, 1992). Nevertheless, a review of the occupational therapy literature revealed little discussion of working memory and how or why it should be evaluated. The purpose of this article is to present a brief overview of short-term memory and working memory and the implications for memory evaluation in older adults.

Modal Model of Memory

In the occupational therapy literature on aging, memory is discussed in terms of a distinction between recall of events from the immediate past and recall of events from the distant past (Hansen & Atchison, 1993; Pedretti, 1985). Such references to memory reflect Atkinson and Shiffrin’s (1968) modal model of memory (see Figure 1). There are three structural components of memory in this model: the sensory register, short-term store, and long-term store. The sensory register is where an incoming stimulus is immediately registered in a form that is consistent with the sense modality of the stimulus (e.g., visually, auditorily). From the sensory register, information is transferred to the short-term store, which will be discussed in more detail. Finally, information is transferred from the short-term to the long-term store, where information storage is relatively permanent and the capacity for holding information is relatively large.

In contrast to long-term store, short-term store is assumed to have a much more limited capacity. It is the site of temporary memory processes, such as subvocal rehearsal or a mnemonic that is used when a list of items is to be memorized. It is believed by Atkinson and Shiffrin (1968) that the capacity of the short-term store is reflected in one’s performance on immediate memory span tasks, such as the digit span task. In the digit span task, a person is presented with a series of digits and then is asked to repeat the sequence of digits he or she just heard (Baddeley, 1989). The number of digits an individual recalls in the correct order reflects the short-term store capacity (Morris & Baddeley, 1988).

In their model, Atkinson and Shiffrin (1968) assumed that an item must pass through the short-term store before it can enter the long-term store. They also assumed that the longer the item is held in the short-term...
store, the greater the learning involving the item that will occur. However, the results of several studies question the assumptions of the modal model. For example, Craik and Watkins (1973) failed to find a positive correlation between the amount of time an item is held in short-term memory and the amount of long-term learning that has occurred. Moreover, patients with brain damage and severely impaired short-term memory have exhibited long-term learning (Baddeley, 1989).

Working Memory

Because of the problems the above research poses for the modal model, several alternative models of memory have been proposed. Since the 1970s, the concept of short-term memory has evolved into a continuum of memory, with primary memory at one end and working memory at the other. Primary memory is based on the more traditional notion of short-term memory as a unitary system involving the temporary storage of information (Morris & Baddeley, 1988; Salthouse, 1990). Its capacity is reflected in the amount of information that can be held in conscious awareness (Craik et al., in press). Primary memory is assessed by using tasks that require only passive storage of information, that is, tasks in which information is given to a person who is then required to repeat the information immediately. Thus, the information is given back in the same form it was presented, as in the digit span task (Craik et al., in press). Interestingly, research results have suggested that older adults display little performance decrement in primary memory tasks (Craik & Jennings, 1992). Despite this finding, memory span tasks are often used in assessments of memory of older adults. However, working memory tasks are seldom included.

Like primary memory, working memory is presumed to have a limited capacity (Salthouse, 1990). However, working memory is distinguished from primary memory by its simultaneous involvement in storing and processing information (Daneman & Tardif, 1987; Light, 1991; Salthouse, 1990; Salthouse, Babcock, & Shaw, 1991). Working memory function is exemplified in a mental arithmetic task in which two-digit numbers are multiplied without the aid of pen and paper. In this task a person is required to do the computations mentally, store the results of the computations, and coordinate between the storage and processing of that information to arrive at the answer (Salthouse, 1991).

Much of the research on working memory has been conducted within the context of Baddeley and Hitch’s (1974) three-component model, the Working Memory Model (see Figure 2). The model includes a processing component called the Central Executive System, along with two of what Baddeley and Hitch called slave systems, the visuospatial scratch pad and the articulatory loop. The latter two systems are part of the working memory’s storage component and are responsible for the temporary storage of visuospatial information and speech-based information, respectively (Baddeley, 1989). The Central Executive System is responsible for selecting and controlling processing of information (Light, 1991); because working memory is assumed to have a limited capacity, its allocation between the processing and storage components varies according to the demands of the task (see Figure 2).

The implications of this more recent conceptualization of short-term memory as including not only primary memory but also working memory are particularly noteworthy for the evaluation of older adults’ memory functioning. In general, the research to date has indicated that, for a memory task, differences between older and younger adults increase with the demands of working memory (as opposed to primary memory) (Craik et al., in press; Craik & Jennings, 1992; Morris, Gick, & Craik, 1988). This pattern is even more pronounced when older adults with Alzheimer’s disease are considered (Becker, 1988; Morris & Baddeley, 1988; Spinnler, della Sala, Bandler, & Baddeley, 1988).

The influence of working memory demands on older adults’ task performance is illustrated by Dobbs and Rule’s (1989) findings. In their study, 228 adults in 5 age groups (30–39 years, 40–49 years, 50–59 years, 60–69 years, and 70 years and older) were given a variant of a working memory task outlined by Kirchner (1958). Participants were presented a series of digits auditorily. In
the Lag 0 (control) condition, a participant repeated each
digit out loud immediately after it was presented. In the
Lag 1 condition, a participant repeated the digit heard
before the one just presented. In the Lag 2 condition, a
participant repeated the digit heard before the two digits
just presented. In the Lag 1 condition there was minimal
emphasis on storage, but some demands were made on
processing. In the Lag 2 condition, there was a slight
increase in the storage component with an increased em­
phasis on the processing component. When the authors
examined the number of correct responses produced be­
fore the first error, there were no age differences in per­
formance at Lag 0. However, participants in the 60–69
years and 70 years and older age groups performed sig­
nificantly more poorly than did the younger groups in
both Lag 1 and Lag 2 conditions, and they performed
significantly more poorly in the Lag 2 condition than in
the Lag 1 condition. These results support the hypothesis
that older adults have more difficulty performing a task as
the demand on working memory increases.

Working memory may also deteriorate in age-related
pathologies. Baddeley (1992) and Morris and Baddeley
(1988) have provided evidence to indicate that Alz­
heimer’s disease selectively involves the Central Execu­
tive System. These researchers have shown that with the
progression of Alzheimer’s disease, performance on spe­
cific phonological tasks remains intact, whereas perfor­
ence on combined tasks deteriorates when compared
to that of young and old control subjects without Alz­
heimer’s disease.

Implications for Occupational Therapy

Given the findings suggesting that older adults demon­
strate difficulty in working memory tasks, But not in pri­
mary memory tasks, the question that inevitably arises is
how these findings translate into perfor­ance of daily life
tasks. The research discussed thus far suggests that tasks
involving passive reproduction of information should be
spared. For example, older adults should demonstrate
little, if any, difficulty in looking up and dialing telephone
numbers (Craik et al., in press).

Intact working memory is required when a person
draws inferences in order to comprehend complex text or
Drawing inferences is especially problematic for older
adults who have Alzheimer’s disease (Craik & Jennings,
1992). Consequently, clients with dementia may expe­
cience difficulties when they perform tasks that require
inference. For example, Kortman (1992) found that the
success of splint treatments depends on a client’s ability
to recall and understand the regimen. Therefore, he rec­
ommended that short sentences be used when therapists
provide written instructions.

Literal language minimizes the amount of inference
required by a client with Alzheimer’s disease. For ex­
ample, “Sit down” may be easier for the client to under­
stand than “Take a seat.” Vague references such as “it,” “he” or
“she,” and “over there” should be avoided, and sentences
should be simple without being condescending.

Impaired working memory affects medication man­
agement. Deficits in working memory may make it diffi­
cult for older adults to follow instructions and plan their
medication schedules. For example, Kendrick and Bayne
(1982) found that some clients did not take their medica­
tions because they misinterpreted the instructions, and
Anderson (1993) reported that a group of older adults
was able to interpret medication instructions for intake if
the instructions required minimal inference. Consequently, Anderson (1993) argued that, to compensate for older adults’ decline in working memory, caregivers should monitor the pace and amount of information rendered. That is, older adults display better understanding of medications when they are given specific information in small amounts.

Researchers have also suggested that deficits in working memory may be at least partially responsible for older adults’ problems with what Rule, Milke, and Dobbs (1992) called wayfinding, because this activity is assumed to involve continual storage and processing of information (Aubrey & Dobbs, 1989; Kirasic, 1991; Kirasic, Allen, & Haggerty, 1992). Moreover, wayfinding may be especially difficult for older adults when they are in unfamiliar environments (Kirasic, 1991). Similarly, Liu, Gauthier, and Gauthier (1991) found that when persons in the early stages of Alzheimer’s disease are asked to find their way in new environments and in familiar ones, they are impaired in the new environments, but not in the familiar environments. In terms of Baddeley and Hitch’s (1974) model of working memory, more demands are placed on the slave system of the storage component of working memory (specifically, the visuospatial scratchpad) when a person is in an unfamiliar environment. Because of the additional load that is placed on the storage component, less of the limited working memory capacity is available for the Central Executive System’s processing component, which is required for organizing and integrating spatial information in wayfinding (Kirasic et al., 1992, Kirasic & Bernicki, 1990). This hypothesis suggests that wayfinding abilities of older adults may be improved by familiarizing them with an environment over a period of time so that demands on the storage component of working memory will be minimized. Alzheimer’s disease may affect the ability to process information despite an intact ability to store visual or verbal information. Alternatively, it is possible that Alzheimer’s disease affects both the slave systems and the Central Executive Systems.

Clinical Evaluation of Working Memory

Given the abundance of research indicating that working memory declines with age and therefore disrupts performance on a variety of tasks, the next question that arises for occupational therapists is how to evaluate working memory in the clinic. To date, there is no clear consensus on this issue for two reasons. First, researchers have disagreed on what component of working memory is responsible for age differences (Salthouse, 1991). Working memory is postulated to involve storage of information, processing of information, and coordination between storage and processing of the information; each of these factors has been proposed as a source of age differences in working memory task performance (Babcock & Salthouse, 1990; Foos, 1989; Salthouse, 1990). Second, researchers (Daneman & Tardif, 1987; Morris et al., 1988 Salthouse, 1990; Salthouse, 1991) have disagreed on whether working memory should be thought of as a domain specific or general purpose system. For example, is there one working memory system for reading and a separate system for mathematics, or is there a general working memory processor that is used for both tasks?

As a consequence of these issues, it is difficult to set strict guidelines for selecting an appropriate assessment instrument. Nevertheless, some general recommendations have been proposed. Some tasks are designed to tax the storage component of working memory, whereas others manipulate the processing component and still others the coordination between these two components. Therefore, occupational therapy practitioners are advised to evaluate working memory with a few instruments that test each of these components rather than relying on a single, global instrument (Craik et al., in press). For example, one type of working memory instrument was described in the Dobbs and Rule (1989) study discussed earlier. The emphasis of this lag task on the active manipulation of information with minimal storage demands suggests that it is a measure of the processing component of working memory. Clinicians may find the working memory task outlined by Dobbs and Rule (1989) useful because it is sensitive to aging and is easy to administer (Craik et al., in press). In addition, Salthouse (1990) provided a list of 10 working memory tasks that involve the simultaneous processing and storage of information. An example is the alphabet span task, in which participants are required to repeat out loud a series of words after arranging them in alphabetical order. The rearranging of the words alphabetically draws on the processing component of working memory; the storage component consists of holding in memory the list of words that were presented.

Most research on working memory has been conducted with auditory stimuli, thereby examining the articulatory loop of working memory. Less is known about the visuospatial scratchpad, which provides temporary storage and maintenance of visuospatial rather than verbal material (Farmer, Berman, & Fletcher, 1986; Morris & Baddeley, 1988). Occupational therapists who evaluate older adults’ working memory function in daily activities are advised also to consider visuospatial stimuli. Results from research that use visuospatial stimuli suggest that working memory is task specific. For example, Clarkson-Smith and Hartley (1990) found that bridge players between the ages of 55 and 91 years perform better on working memory tasks than persons who do not play bridge. An alternative explanation is that playing bridge has delayed the decline of working memory that accompanies aging (Clarkson-Smith & Hartley, 1990).

Currently, occupational therapists use standardized assessments to determine cognitive performance of cli-
ents. Examples of these are the Kitchen Task Assessment (Baum & Edwards, 1993) and the Allen Cognitive Level test (Allen, 1991). As these assessments do not address working memory, other standardized functional assessments that examine working memory need to be developed.

Conclusion

Some occupational therapy clinicians and researchers (e.g., Zoltan, 1990) may consider short-term memory in terms of Atkinson and Shiffrin’s (1968) model—as a passive, temporary storage system. When applied to the evaluation of older adults, this model may lead to the conclusion that short-term memory is not affected by age. One of the many tasks occupational therapists are required to perform is an evaluation of a client’s ability to perform daily life tasks. These evaluations should go beyond determining a client’s level of independence to determine why he or she may be experiencing difficulty (Robinson, 1992). We propose that a closer examination of working memory will not only enhance occupational therapy evaluation but also provide a better indication of what interventions are needed.

References


Hillsdale, NJ: Lawrence Erlbaum.


