

# Assistive Technologies for People with Dementia: Personal Review

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## Chapter 1 Memory and Memory Impairments

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### 1.1 What is Memory

**Memory is essential to human experience:** Memory is essential to the human experience, allowing us to integrate our past into who we are today and to imagine what we might be in the future (LaVoie & Cobia, 2007). Beyond controversy, memories have a great a great significance to human function. People later in life face a gradual loss of memory function. People are losing the ability to store new memories. This memory impairments are common in elderly people and is often related to the devaluing aspects of the social environment.

## 1.2 Classifications of memory

**Baddeley's Theory:** A popular theory speculates that memory is organized into encoding, storage, and retrieval processes (Baddeley, 1995; Bourgeois, 2007). Information to be remembered has to enter the system through the senses (visual, auditory, tactile etc.), then is held temporarily in a working memory or short-term memory place. In this holding area, the information is checked and comprehended. Long-term storage is thought to contain declarative (such as episodic, and semantic memory), and non-declarative or implicit memories (such as skills and habits acquired with practice).

**Episodic memory:** Episodic memory is defined as memory for personal experiences which are dated and located in subjective time and space (Tulving, 1972, 1983; Tulving, Schacter, McLachlan et al., 1988; Yasuda et al, 1997) (eg. remembering your high school graduation or what you had for dinner last night). Damage to the underlying brain structures disrupts one's ability to accurately recollect the events of one's past and encode new episodes (LaVoie & Cobia, 2007).

**Function and Lesion of Episodic Memory (Yasuda, 1997):** The frontal lobe or the basal forebrain are implicated with the following functional aspects of episodic memory: Appreciation of time-sequences, contextualization of the experience, retrieval of the context for each experience, and recollection of how an episodic memory was acquired. Recently, the precuneus, the splenial, the retrosplenial, the posterior cingulate and the diencephalic regions were also suggested as participating in a network with a distinctive role in episodic memory

**Semantic Memory:** Semantic memory consists of general knowledge about the world acquired through the media, education, and other sources of information (eg, knowing that tigers, but not leopards, have stripes). According to Tulving (1983), it includes memory for faces, melodies, topography, knowledge of language, and so on. Semantic memory is abstract and lacks associations to a learning context.

**Impairment of Semantic and episodic memory:** Evidence supporting the dissociation between episodic and semantic memory is rich, coming from researches done with amnesic patients (LaVoie and Cobia, 2007). This is exemplified by a patient (Fujita, Ishikawa, Kumakura et al., 1991) who mistook a TV scene for an event that had actually occurred, and in which he was personally involved. Although the content of TV or movie scenes would be classified as semantic memory, the patient misclassified them as his own episodic memory. In memory acquisition, strategic mediation by the frontal lobe is required (Yasuda et al., 1997).

**Working Memory (LaVoie & Cobia, 2007):** In contrast to the episodic and semantic memory systems, which refer to long-term memory systems, working memory refers to an memory system responsible for short-term storage of information used for cognitive processing activities. While this system can be compared to earlier notions of short-term memory (STM), it is a much more complex system as facilitator of higher order cognitive activities. This system exists both to support the maintenance of task-relevant information and to engage the appropriate processes during cognitive task performance. For example, the ability to perform multiplication problems (eg,  $173 \times 42$ ) requires the ability to hold the information in memory while also carrying out processes on those items.

**Anterograde Amnesia (Bauer, 2008):** A profound defect in new learning is called anterograde amnesia. The essential deficit is that that patient is impaired in deliberate recall of information initially learned after illness onset. Such patients may fail to recognize or learn the names of newly encountered persons. They may appear disoriented in place or time because they have failed to learn their location or have lost the ability to monitor. Amnesic patients are frequently capable of tracking routine

conversation, but their deficit becomes obvious when they are asked to recall an event that occurred only hours or minutes before.

**Prospective memory:** The ability to remember to carry out tasks in the future has been termed prospective memory (Sohlberg & Mateer, 1989). This kind of memory impairment is the one most frequently experienced as problematic by amnesic patients (Yasuda, 2002).

**Retrograde Amnesia (Bauer, 2008):** The amnesic patient usually also has difficulty in recalling information learned prior to illness onset, an impairment that is often worse for relatively recent events than for events that occurred in the remote past. Retrograde amnesia is forgetting the previously acquired semantic knowledge or autobiographical (episodic) memory.

**Source Amnesia:** In source amnesia, recollection of the informational source of a memory item is lost despite intact item (content) memory. For example, we might remember specific information about a book or movie but be unable to recollect where that information was learned (Bauer, 2008). The content and source of recollected information are potentially dissociable (Shimamura & Squire, 1987).

**Meta-memory and "Feeling of Knowing":** Hirst & Volpe (1982) reported the meta-memory program in Korsakoff patients. The most widely studied meta-memorial capacity in amnesic patients is the feeling-of-knowing (FOK) phenomenon. In a typical FOK experiment, subjects are asked to freely recall the answers to general questions of varying difficulty (e.g., "What is the tallest mountain in Japan?") until a certain number of failures occur. For these unrecalled items, subjects are then asked to judge the likelihood that they would be able to recognize the correct answer if it was presented. FOK predictions are then evaluated by a subsequent recognition test (Bauer, 2008).

**Basal forebrain amnesia:** This Amnesia would occur due to basal forebrain lesions in the anterior communicating artery. Some authors have described impairment in placing memories in proper chronological order ((Damasio, Graff-Radford, Eslinger et al., 1985). Confabulation appears to be characteristic, particularly in the acute period (Bauer, 2008).

**Procedural Memory (LaVoie & Cobia, 2007):** Non-declarative memory refers to a set of systems that cannot be accessed through consciousness, but rather express their contents through task performance. This system has been linked with the concept of procedural memory. Procedural memory is the memory system that supports motor, and perceptual skill learning. This system is characterized by gradual learning (eg, riding a bike, playing a musical instrument). With repetition, the performance of skills can become automatic.

**The Semantic Memory Remain in the Elderly (LaVoie & Cobia, 2007):** Dissociations have been reported in older adults, with episodic memory consistently showing significant age-related declines, but semantic memory showing little change across the life span. The deficits in episodic memory are linked to deficits in processing context-dependent memories. On the other hand, semantic memory is not a context-dependent system. The processing deficits are likely to have little impact on semantic system function, making semantic memory a relatively stable in old age.

**Procedural Memory Shows Little Decline (LaVoie & Cobia, 2007):** Procedural memory also shows little decline across the life span. While older adults are slower and less accurate relative to young adults when performing motor tasks, they do appear to retain new skills over an extended period of time. The procedural memory were well preserved and intact despite the age-associated differences in the amount of time needed to acquire and perform the task.

**Age-related Memory Declines:** As one effect of age-related cognitive decline, decreased prospective memory may lead to forgetfulness about routine daily activities, Activities of Daily Living (ADLs) and Instrumental Activities of Daily Living (IADLs). ADLs include basic tasks such as eating, drinking, bathing, and toileting, while IADLs include tasks such as managing medicines, managing money, lighting, preparing meals, and so on (Pollack, 2002). Working memory function is particularly sensitive to the effects of aging. Older adults perform more slowly and less accurately than young adults in a variety of dual-tasks (LaVoie & Cobia, 2007).

**The Types of Memory to be Impaired in Dementia (Bourgeois, 2007):** The types of memory that present challenges in dementia are those that require conscious encoding, or new learning. Episodic memories, such as what you ate for lunch, or

the answer to the question you just asked; overlearned or habitual memories, such as walking, playing the piano, or counting to 100, are more resistant to the effects of neurological disease because they have been stored and retrieved repeatedly over a lifetime, often unconsciously and without effort. Retrieval of memories from remote long-term storage is also relatively preserved: caregivers remark that persons may remember details from their childhood.

### **1.3 Dissociation between Episodic and Semantic Memory**

**Case Reports of episodic and Semantic memory impairments:** Though the semantic/episodic dichotomy has been questioned by several authors (Yasuda et al., 1997), De Renzi et al. (1987) reported for the first time a patient who showed a severe impairment of semantic memory for words, objects, famous persons, and public events in the absence of episodic or autobiographic memory impairment. A similar pattern of deficits was reported by Grossi, Trojano, Grasso et al. (1988). Their patient could not even give a vague definition of pedagogy, the main subject of her school curriculum, but she did recall that she had obtained remarkable grades on it. Yasuda et al. (1997) also report a patient who showed a dissociation between impaired semantic memory and preserved autobiographic memory. Yasuda et al describe patient M.N., who demonstrated significant impairments in the ability to recollect well-known historical events, historical figures, popular proverbs, technical terms related to her profession and other types of semantic memory. She was, however, able to freely recall events from her own past (eg, former boy friends, school field trips). Magnetic Resonance Imaging revealed bilateral lesions in the temporal lobes and in the right basal frontal lobe. Yasuda et al. (1997) hypothesize that bilateral lesions of the anterior half of the middle region of the temporal lobe plays a crucial role in causing deficits in semantic memory. Similar semantic memory impairments have been noted in four patients with non-progressive brain injury, two with severe head injury, and two with herpes simplex virus encephalitis (LaVoie & Cobia, 2007).

**Case Reports with Opposite Pattern:** The reversed pattern, selective impairment of autobiographic memory and preservation of semantic memory has also been reported (Damasio, Eslinger, Damasio et al., 1985; Tulving et al., 1988; Dalla Barba, Cipolotti & Denes, 1990). A patient of Tulving et al. (1988) could not recollect any events related to the time he worked at a company, yet remembered the meaning of the technical terms used in his job, whereas general knowledge such as technical terms or the content of a movie Three individuals were described as anterograde amnesia who suffered bilateral hippocampal damage. They all have a severe loss of episodic memory for recently experienced events. Specifically, all three patients report difficulty recollecting the location of objects that they have placed down, require frequent reminders of scheduled appointments and events (LaVoie & Cobia, 2007). Despite this impairment, however, all three individuals are able to acquire factual knowledge (eg, "What is the capital of Italy?"), demonstrating spared knowledge of vocabulary/language, all aspects of semantic memory. The double dissociation described above supports the semantic-episodic memory dichotomy (Yasuda et al., 1997).

**Lesion of Semantic Memory:** Binder, Desai, Graves, and Conant (2009) analyzed 120 functional neuroimaging studies focusing on semantic processing. These activations formed a distinct, left-lateralized network comprised of 7 regions: posterior inferior parietal lobe, middle temporal gyrus, fusiform and para-hippocampal gyri, dorsomedial prefrontal cortex, inferior frontal gyrus, ventromedial prefrontal cortex, and posterior cingulate gyrus. The expansion of these regions in the human relative to the nonhuman primate brain may explain uniquely human capacities to use language productively, plan, solve problems, and create cultural and technological artifacts.

**Lesion and Sub-categorization of Semantic Memory (Yasuda et al., 1997):** As to semantic memory, neuropsychological studies have indicated that the right hemisphere plays a predominant role for the following semantic memories (RH-dominant semantic memory): Topography, musical knowledge, memory of faces and various attributes of people. On the other hand, for proverbs, public events, words of songs, low frequency words, etc. are verbally related nature. These memories are likely to be mediated by the LH (LH-dominant semantic memory). Damage to the LH anterior half of the middle region (centered on area 21) plays a crucial role LH-dominant semantic memory.

Some researchers suggest that semantic memory is also represented in the prefrontal cortex, and in the parietal lobe. It is

important to note that the so far reported case of the semantic amnesia (L.P., T.J., M.N.) did have bilateral lesions. Although some cerebral laterality exists, deficits of semantic memory, including the RH-dominant semantic memory, may require bilateral damage. For instance, semantic memory for idioms may require the LH linguistic processing as well as the RH metaphorical/inferential processing. Bilateral impairment, which means hemispheric inability to reciprocal compensation may result in a severe deficit of semantic memory.

#### **1.4 Evaluation for Dementia, Proper Names and Discourse**

Hess, Dieberg, McFarlane, & Smart (2014) found improvements in global cognition (MMSE, ADAS-cog etc) and clinical dementia ratings (CDR). Across all of the studies, the measurements of global cognition were the most robust in terms of detecting significant changes in cognitive performance. It may be that global tests of cognition are inherently the most sensitive to changes in cognitive performance because they take into account numerous cognitive domains.

**Anomia for Proper Names:** Numerous studies have associated aging to cognitive decline, such as forgetting of proper names of close friends and family (Bonner & Idris, 2012), as well as deterioration in discourse processing, especially of complex information such as text, the thread of conversations/TV programs (Bonini & Mansur, 2009).

Proper names are of practical importance for verbal communication. For instance, they are indispensable for transmission of autobiographical information concerning a person. Yasuda, Nakamura, & Beckman (2000) have revealed that proper names are neuro-psychologically and anatomically processed in a manner which differs from the processing of common nouns. Proper names are labels attached to referents, as being without semantic meaning.

**Why are peoples' names difficult to retrieve (Yasuda et al., 2000):** Peoples' names were sufficiently comprehended by globally aphasic patients. Curiously enough, they are the most difficult words even for non-brain damaged people to retrieve. This is because proper names are associated with one person arbitrarily. Therefore, peoples' name anomia reflects a general inability in pairing an arbitrary label with a person.

Proper names consist of a one to one combination without intermediating semantic meaning. This combination implies that proper names would receive their activation only from a unique representation of the corresponding person. The single retrieval cue would make peoples' name retrieval more difficult than recall of common nouns, which consists of a one to many combinations. The experiment of Bredart (1993) supports the one to one hypothesis.

**Declining Memory for Discourse:** Regarding the relationship between memory and language, most of the studies have evaluated the memorization of word lists. Recent research in older listeners have revealed difficulties when engaged in complex tasks involving the auditory processing of naturalistic signals in realistic environments (Bonini & Mansur, 2009). Tasks affected include discourse activity in conversation or following a story in a book or on television, in which recognition, comprehension and storage of the material is impacted. The retention and comprehension of discourse involves diverse mechanisms. On the other hand, retention and comprehension of information from a discourse requires the participation of working memory in multiple degrees of processing such as lexical, syntactic or semantic, in order to obtain the sense of the discourse. The complexity of the task in natural situations involves additional challenges, because frequently events occur in situations of time pressure, as is the case with the news on the radio, in which the broadcaster transmits the message in a sequence of chained facts.

**Memory for Single Radio News (Yasuda, Hasegawa, & Ono, 1990):** Discourse comprehension involves a multiple level of processing such as lexical processing, syntactic analysis, and thematic analysis to yield a representation of the meaning of the discourse. Concurrent storage of that representation is also required. The most important finding of Yasuda et al. (1990) may be that aphasic subjects have been found to comprehend discourse better than they comprehend sentence stimuli. Sufficient comprehension

of discourse by the aphasic subjects also imply a preserved ability to store the representation of discourse. Psychological research claims that the ease of comprehension and storage depends on the resources (or capacity) available in working memory (Daneman & Carpenter, 1980; Light & Anderson, 1985).

**Memory of Serially-presented Radio News (Yasuda, Nakamura, & Beckman, 2000):** Sixteen mild aphasic subjects, eight age-matched normals, and eight younger normals listened to a single radio news story and four serially presented radio news stories. Half of the aphasic subjects performed as well as age-matched normals in a single-news-story comprehension task. However, they demonstrated a drastic deterioration in performance when asked to listen to a series of four news stories. Age-matched normals, and aphasic subjects, to a lesser extent, showed an impairment in the comprehension and storage of the news story heard last in a series of four news stories. It was shown that discourse retention seems to obey hierarchic importance with the main ideas occupying higher levels and details at the lowest levels. It was also noted that when comprehension and storing of information are simultaneously solicited in a task, aging presented preservation of comprehension yet loss of storage. These results were discussed in terms of the comprehension and storage resources of working memory (Bonini & Mansur, 2009).

Story recall was impaired in the left hemisphere damaged patients (see Frisk & Milner, 1990 for review). An issue to be explored is whether the discourse employed in the above-cited studies might have been still too simple or too short to reveal aphasic subjects' deficits. A remaining experimental issue is, therefore, whether aphasic subjects could maintain sufficient comprehension if they were exposed to longer discourse. We are likely to encounter serial discourse in daily life. For example, about four radio news stories are usually broadcast in a five-minute radio news program.

A large number of studies have examined the position effect on word-list recall (see Greene, 1986 for review). In the only investigation on discourse-list recall, the recency effect predominated over the primary effect (Tannenbaum, 1954). The Age-matched Subjects demonstrated a significant decline in comprehension of the news story in the last position, revealing a superiority of the primary over the recency effect. The High-Aphasic Subjects also displayed the same tendency, albeit less reliably. Conversely, the Younger Subjects showed a relatively better performance for the news story in the last position, thus suggesting an age-related difference in patterns. The classical primary, or short-term memory system models (see Greene, 1986 for review) appear to be inadequate for explaining the position effects described here.

The presence of an age-related reduction in working memory resources has been suggested (Salthouse, Mitchell, Skovronek et al., 1989). When comprehension and storage were concurrently required in a task, the elderly demonstrated preservation of comprehension while their storage was impaired (Cohen & Faulkner, 1981; Zacks & Hasher, 1988; Foos, 1989; Foos & Wright, 1992). The same may be said with regard to the Age-matched Subject's scores on the serial condition. Why did the High-Aphasic Subjects demonstrate both comprehension and storage deficits in the serial condition? The age-related reduction in working memory resources may be aggravated by a decrease in available resources as a result of brain damage (Daneman & Carpenter, 1980; Miyake, Carpenter & Just, 1994; Martin, Shelton & Yaffee, 1994).

**Memory for 30 min. Discourse (Yasuda, 2003):** There is a need to understand the abilities of human being in real and natural

settings. Radio or TV news stories are among the most typical kinds of popular discourse in daily life. Yasuda et al. (2000) investigated the comprehension of four serially-presented radio news stories, and a single radio news story by normal people, or people with mild aphasia. The next issue to be explored is whether the four news stories employed in the above study might have been still too simple or too short to reveal our comprehending abilities, since we often listen or watch spoken discourse or movie more than one or two hours long.

People with aphasia, or MCI, even middle-aged people sometime complain of difficulty to comprehend long novels, hour-long TV programs such as documentary film or, drama etc. Such hour-long materials may be more difficult to comprehend than serially presented radio news stories. Until now as far as we know, the six min. materials of four radio news stories was the longest materials which have been used to test comprehension ability of human beings. However, testing by using one-hour materials is difficult to perform in normal training session in our hospital.

Therefore, we tried to investigate the comprehending ability of 30min. discourse by normal people and people with aphasia. In order to evaluate the comprehension of long discourse, three kinds of participants (younger normal, senior normal and people with mild aphasia) were presented of 6 min. and 30min. discourse. And the following two main abilities were explored: 1) Compared to 6 min. news stories, to what degree are 6 min. discourse comprehended? 2) Compared to 6 min. news stories or discourse, to what extend are 30min. discourse comprehended by three groups.

We expected the performance of 30Min.discourse wild be worse, compare to 6Min.discourse. the 30Min.duiscourse is 5 times of 6Min.discourse, require more resources to comprehend and store the contents. Unexpectedly, the declining of scores 30Min.discourse was minimal in the two normal groups. The mild aphasic subjects only showed 5% decline. Compared to the serially presented news stories, people are suggested to be comprehending the 30Min.discourse very sufficiently.

As for the position effects within the 30Min.discourse, the score of the last position in two normal subjects group was slightly higher than those of the first position. On the other hands, mild aphasic subjects' group did not show this trend.

In order to comprehend discourse, working memory are required. Yasuda et al.(2000) proposed the discourse processing model, consisting of comprehension resources and Discourse storage resource unit (D unit). In comprehending serially presented news story, normal elderly people can maintain comprehension resources, while their D unit are declining its resources resulting poor performance of the last news.

The discourses used in this study were the freely spoken episodes. The contents were very redundant, the episode occurred in the same context. The information included was not much. On the other hands, the news story was spoken on written texts, in which the information is tightly packed, and each news are unrelated each other.

As the results of this study, capacity of D units is depending on the information quantity or density per time or a given length of time. The 30Min.discourse in this study, information density was low, therefore the last part declining was not observed. We need to explore the criteria to measure the density of information in a discourse. By using this criteria, we can forecast the comprehension and storage level of people in future.

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