AGE RELATED CHANGES IN AUDITORY MEMORY AND SEQUENCING

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CERTIFICATE

This is to certify that this dissertation entitled **Age Related Changes in Auditory Memory and Sequencing** is the bonafide work submitted in part fulfillment for the degree of Master of Science (Audiology) of the student **(Registration No. 10AUD022).** This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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June, 2012

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CERTIFICATE

This is to certify that this dissertation entitled **Age Related Changes In Auditory Memory and Sequencing** has been prepared under my supervision & guidance. It is also certified that this dissertation has not been submitted earlier to any other University for the award of any other Diploma or Degree.

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DECLARATION

This is to certify that this dissertation entitled **Age Related Changes In Auditory Memory and Sequencing** is the result of my own study under the guidance of Prof. Asha Yathiraj, Professor in Audiology, Department of Audiology, All India Institute of Speech and Hearing, Mysore and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysore **Registration No.:** 10AUD022

June, 2012

Dedicated to

my

Grandparents

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INTRODUCTION

Aging in humans has been referred to as a multidimensional process of physical, physiological and social change (Hamilton, 2006). It is reported to be deeply rooted in the genetic makeup and metabolic working of an organism (Braver & Barch, 2002) and sensitive to many environmental influences (Arking, 1991). As adults grow older, physical, sensory, emotional, psychological and social changes are reported to occur (Dugan & Kivett, 1994). The rate at which these changes occur and how they impact an individual are noted to be based on a number of factors.

Changes in the structure and function are also reported to occur throughout the peripheral and central auditory nervous system as a result of the aging process. Many investigators have examined age-related changes in processing non-speech signals (McCroskey & Kasten, 1982; Newman & Spitzer, 1983) and complex speech signals (Jerger & Hayes, 1977; Konkle, Beasley, & Bess, 1977; McCroskey & Kasten, 1982; Rastatter & Hood, 1986). Karlin (1942) noted that tests of conventional auditory acuity had little value in predicting auditory behaviour in more complex social situations in older adults. The effect of degenerative changes were reported to become evident only when older listeners were perceptually stressed, such as when they were required to listen to complex signals or in a noisy environment where more complex auditory processing was required.

Normal aging has also been associated with a decline in memory abilities and the phenomenon has been termed as age-related memory impairment or age-associated memory impairment. A large number of elderly individuals have been reported to live with mild memory problems that are a part of a normal aging process

(Schroder, Kratz, Pantel, Minnemann, Lehr & Sauer, 1998). Timothy (2009) reported that the steady decline in many cognitive processes is seen across the lifespan, accelerating from the twenties or thirties. The author claimed that due to aging, attention and memory were the most affected basic cognitive functions.

Age related decline in memory has been demonstrated in a variety of fields. It has been reported in research carried out in the fields of psychology (Chisolm & Willott, 2003), psychoacoustics and speech perception (Pichora-Fuller & Souza, 2003; Schcider & Pichora-Fuller, 2001) as well as linguistics and cognitive psychology (Wingfield & Tun, 2001).

Older adults have also been reported to exhibit deficits on temporal ordering tasks (Parkin, Walter & Hunkin, 1995). Neils, Newman, Hill, and Weiler (1991) found that elderly individuals performed significantly poorer than the young adults for auditory memory and sequencing of tones. Gregoire and Linden (1997) found that a major part of the adult lifespan was characterized by slight decline in memory abilities. Studies by Mitrushina and Satz (1991), Youngjohn and Crook (1993), Small, Stern, Tang and Mayeux (1999), Oberauer, Wendland and Kliegl (2003), Mechan, Wyss, Rieger and Mohajeri (2003) and Moral, Tomas, Bataller, Oliver and Navarro (2010) have also documented a significant decline in auditory memory with age.

Need for the Study

The ability to encode new memories of events or facts has been shown to decline in both cross-sectional and longitudinal studies (Park, 1996; Park 2002; Hedden & Gabrieli, 2004). Chisolm and Willott (2003) reported that the most prevalent but most often overlooked skill deficiency in elderly subjects was auditory memory. In a study by Schroder, Kratz, Pantel, Minnemann, Lehr and Sauer (1998), the prevalence of age-associated memory impairment was found to be 13.5% in individuals between the age range of 60 to 64 years. Hanninen et al. (1995) reported a higher (38.4%) prevalence of age-associated memory impairment using the National Institute of Mental Health criteria in an elderly population in Finland.

The vast majority of the studies regarding the auditory memory problems of the elderly have been done in other countries. In India, the auditory memory and sequencing problems have been studied more in children. The tests for auditory memory and sequence, developed in India (Yathiraj & Vijayalakshmi, 2006; Yathiraj & Mascarenhas, 2003) have focused on children and not on the older generation.

A high correlation between memory skills and educational level has been found (Gathercole, Pickering, Knight & Stegmann, 2004). It was found in the National Sample Survey report (2004-2005) that only 63.6% of the total population of India is literate. The literacy percentage of males and females was found to be 78.0% and 51.10% respectively. Hence, there is a need to see if age related changes seen in the older population in India are similar to that found in the other parts of the world where the literacy level is noted to be higher.

There is a need to have information regarding deficits in auditory memory and sequencing since these aspects can affect the audiologic rehabilitation goals and outcomes for older adults. Knowledge about the individual’s auditory memory and sequencing skills can help to plan the rehabilitation goals or modify the activities/tasks appropriately. Hence, it is necessary to see the relation between age and auditory memory.

Rehabilitation outcome can also be affected if there is a mismatch between the perceived degrees of memory impairment, as reported by the client and the actual degree of impairment, as indicated by the memory and sequencing test scores. Therefore, it is essential to study if there exists any relation between perceived and the actual degree of memory impairment in older individuals.

Aim of the study

The present study aimed to investigate the effect of age and gender on auditory memory and sequencing in older adults with normal hearing sensitivity and to compare them with young adults. The study also aimed to examine the relation between the perceived degree of memory impairment and the actual degree of impairment.

Hypothesis

The study hypothesized that,

- There was no significant difference in the auditory memory and sequencing abilities between the young adults and two groups of older adults with normal hearing sensitivity,
- There was no significant difference in the auditory memory and sequencing abilities between two groups of older adults, and
- There was no significant difference between genders in the auditory memory and sequencing abilities in all the three age groups.

Objectives of the study

The objectives of the study are as follows:

- To compare the auditory memory and sequencing test scores as well as the checklist scores of a group of young adults with that of two groups of older adults.

- To compare the auditory memory and sequencing test scores as well as checklist scores between the two older groups of adults.
- To compare the auditory memory and sequencing test scores as well as the checklist scores across genders in all the three age groups.
- To compare the 'Memory ability checklist' scores with that of the auditory memory and sequencing test scores.

In order to study the above objectives, a review of literature was carried out. The focus of the review was on auditory memory and sequencing problems in the elderly.

REVIEW OF LITERATURE

In literature, two different components of memory have been described, one being 'memory' and the other being 'sequencing'. 'Memory' has been defined as the ability to store, retain, and subsequently retrieve information (Berry, 1969). Information is reported to make its way into memory through the senses, get processed by multiple systems throughout the brain and then get stored for later use (Parente & Stapton, 1993). Auditory memory has been described as the ability to process information presented orally, which is analyzed mentally and stored to be recalled later (Winer & Schreiner 2010).

'Sequencing' has been described as the ability to remember, order or reconstruct information such as directions, lists, events, words or sounds that are presented. Most sequencing tasks have been noted to have a memory element involved. It is the ability to retain information in the correct temporal order (Turkington & Harris, 2002). The above, with reference to auditory signals has been termed as 'auditory sequencing' (Ling, 1972).

Auditory Memory

Different types of auditory memory have been reported in literature (Cowan, 1984). They include sensory memory, short term memory and long term memory. Details regarding each of these memories are provided below.

Auditory sensory memory: Auditory sensory memory or echoic memory refers to the brief storage of sounds which are perceived for a small duration. Studies have found that the echoic memory corresponds approximately to the initial 200-500 milliseconds after an item is perceived (Cowan, 1984, 1988; Massaro, 1975).

Auditory short-term memory: Auditory short-term memory has been reported to allow recall for a period ranging from several seconds to a minute without rehearsal (Schacter & Tulving, 1994). Its capacity is reported to be very limited with it being 7±2 chunks (Miller, 1956). Short-term memory has been believed to rely mostly on an acoustic code for storing information, and to a lesser extent on a visual code (Conrad, 1964). The basic processes which are believed to be operating in short-term memory are rehearsal, coding, decision and retrieval strategies. Without rehearsal, elaboration and contact with long-term memory, information is reported to be quickly lost from short-term memory (Pisoni & Geers, 1998).

Sternberg (1966) provided three important conclusions about the retrieval search in auditory short term memory. First, the search is exhaustive where it always includes the entire list of alternatives even though the item in question may have appeared early in the list. Second, the search is serial that proceeds through memory of one item at a time. Third, the search is very fast, which is about 25 items per second. Thus, Sternberg documented the search process underlying retrieval from short-term memory as a high-speed, serial, and exhaustive search.

Auditory long-term memory: The storage in sensory memory and short-term memory has been noted generally to have a strictly limited capacity and duration, which means that the information is not retained indefinitely. In contrast, long-term memory has been reported to store much larger quantities of auditory information for potentially unlimited duration (Baddeley, 1966). While short-term memory is believed to encode information acoustically and phonetically, long-term memory encodes it semantically. Baddeley (1966) discovered that after 20 minutes, participants had the most difficulty recalling a collection of words that had similar meanings (example - big, large, great and huge).

Auditory short-term memory has been reported to be supported by transient patterns of neuronal communication, dependent on regions of the frontal lobe (especially dorsolateral prefrontal cortex) and the parietal lobe. Auditory long-term memory, on the other hand, is reported to be maintained by more stable and permanent changes in the neural connections widely spread throughout the brain.

Techniques used to assess auditory short-term memory in adults

Several techniques have been utilized to assess short-term memory. Some of the techniques that have been used are free recall, paired association task, recognition task, and probe discourse task. These techniques, described by Baddeley (1966) are provided below.

Free recall task: During this task the participant is asked to listen to a string of items and then recall or write down as many items that they can remember. The task was described to be carried out by using numbers (Single-digit or multi-digit), alphabets, words (monosyllabic, bisyllabic or polysyllabic) or sentences.

Paired association task: In the paired associate memory task, listeners are required to learn a list of pair of words, and later they are given one of the words and are asked to recall the word which they learned as its pair. Over a number of lists of pairs, the recall of words in different positions from first to last in the list is tested to determine the number of words from each position that are successfully recalled.

Recognition task: In this task participants are asked to remember a list of words, after which they are asked to identify the previously presented words from among a list of alternatives that were not presented in the original list.

Probe discourse task: In the probe discourse task, a subject hears some discourse such as a long story, a brief passage or a list of sentences. Occasionally and unpredictably the subject is presented a memory probe. A memory probe is any word that occurred earlier, but recently in the discourse. The subject will be instructed to produce the word (the target word) that had followed the probe word in the discourse. In these tasks, two types of variations have usually been manipulated. One was the number of words that had intervened between the target and the probe and the other was the structure of the discourse intervening between the target and the probe.

Auditory Sequencing

Hirsh (1959) emphasized the importance of temporal sequencing ability for making sense of auditory input and language. The author found that a longer separation time of between 15 and 20 msec is required for the listener to report correctly which of the two sounds preceded the other. The minimum temporal interval appeared to be independent of the kinds of sounds used: whether short or long, of high or low frequency, of narrow or wide band width (Hirsh, 1959).

Techniques used to assess auditory sequencing in adults

Studies reported in literature have used varied techniques to assess auditory sequencing. Conditioned recall and story repetition are two such techniques that have been used.

Conditioned recall task: According to Brookshire (1972), during this task the participant is instructed to listen to a string of items and then recall or write down the items in the correct temporal order. The listener may be instructed to recall the items in the order of presentation or in a reverse order. The task can be carried out using numbers (single-digit or multi-digit), alphabets, words (monosyllabic, bisyllabic or polysyllabic) sentences or non-verbal stimuli (tones varying in frequency, intensity or duration).

***Story repetition task*:** Stark (1969) described this task to involve the listener narrating an unfamiliar story or sequence of events and the listener is asked to repeat the story/event in the correct order. Stark reported that this technique is specifically useful in assessing auditory sequencing abilities in children.

Multistep related/unrelated commands: Auditory sequencing abilities have also been assessed by making the participant follow multistep related/unrelated commands. This method has been used by Sigman and Ungerer (1983) to study the auditory sequencing abilities in children with autism.

Factors affecting auditory memory and sequencing

A multitude of factors have been reported to affect auditory memory and sequencing. These factors have been found to be related to the subject or the stimuli.

Some of the ***stimuli related factors*** are inter-stimuli interval, rate of presentation, length/ duration of the stimuli, signal to noise ratio and target stimulus position in the token (Aaronson, 1966, 1967; Baddeley, 1975; Yathiraj & Vijayalakshmi, 2006)

Inter-stimuli interval: In a study by Yathiraj and Vijayalakshmi (2006), it was found that normal hearing individuals performed better for tokens having an inter-stimulus interval of 250 msec and 500 msec when compared to 750 msec and 1 sec. Similar findings was seen for both auditory memory and auditory sequencing subtests. Stockard Pope, Werner and Backfired (1992, cited in Ceponiene, 2001) found that with increase in inter-stimulus interval the amplitude of MMN diminished in normal hearing subjects.

Rate of presentation: Studies aimed to investigate the relationship between auditory memory span and rate of presentation have found controversial results. Mackworth (1962) and Norman (1966) found that a slow presentation rate may permit greater accuracy since the subject has more time for rehearsal, recoding, or organization. On the other hand, it was reported by Conrad and Hille (1958) and Posner (1964) that with a slow rate, there is a longer interval between presentation of early items and their recall which increases the likelihood of decay or interference. It was found by Aaronson (1966, 1968) that both item and order errors increase with more rapid presentation rates for those subjects who had to recall the entire sequence. Aaronson (1974) reported that with the slow rate which produced longer inter-stimulus intervals, subjects reported that they identified each item in turn. With the fast rate, there was insufficient time for immediate identification of each item and the subjects tended to listen passively and postponed identification of early items until later ones had been 'sensed'. A similar finding has been reported for nonverbal sounds by Massaro (1970) and for vowels by Thomas, Cetti and Chase (1971).

Length/duration of the stimuli: A number of experiments (Baddeley, 1975; Yathiraj & Vijayalakshmi, 2006) explored that the immediate memory span is not constant, but varies with the length of the words to be recalled. Baddeley, Thomson and Buchanan (1975) drew three important conclusions, first that memory span was inversely related to word length across a wide range of materials; second, when number of syllables and number of phonemes were held constant, words of short temporal duration were better recalled than words of long duration; and third that span could be predicted on the basis of the number of words which the subject could read in approximately 2 sec.

Signal to noise ratio: Aaronson (1974) evaluated the ability to recall when digits were embedded in varying levels of noise and found that the signal-to-noise ratio affected perceptual processing time and hence results in deterioration of memory span. The effect of noise was significantly more at higher rates of presentation.

Target stimuli position in the token: During the memory tasks earlier presented items are reported to be affected by retroactive interference (RI), which meant that the longer the list, the greater the interference, and the less likelihood that they were recalled. On the other hand, items that have been presented lastly were reported to suffer little RI, but suffer a great deal from proactive interference (PI), which means that the longer the delay in recall, the more likely that the items would be lost. Using a paired association paradigm, Madigan and McCabe (1971) found that younger adults demonstrated a very typical serial position curve such that words from the first pair of the list and words from the final two pairs were remembered more accurately than words from intermediate pairs. They attributed this recency effect to the fact that words from the last two serial positions were most likely to still be held in a short-term or primary memory store where they could be quickly accessed in recall.

Some of the ***subject related factors*** influencing auditory memory and sequencing are listening strategies, attention, associated problems and age

Listening strategies: Aaronson (1974) reported that listening strategies influence the shape of the serial position curve significantly. Strategy utilized in a recall task is reported to vary with the age of the individual (Stine & Wingfield, 1987). Use of strategies such as chunking and association are known to improve memory and sequencing span (Moshe, Keshet & Oded, 2007).

Attention: Cowan, Lichty, and Grove (1990) investigated the relation between selective attention and auditory memory retention in a task in which subjects had to read a novel, silently or by whispering, and were instructed to ignore syllables of speech presented through headphones. Occasionally, the subjects received a visual cue to stop reading and to identify the last syllable presented through headphones. In the practice session in which subjects listened to the syllables and did not read, identification was over 90% correct for both consonants and vowels. However, memory for syllables that were to be ignored at the time of presentation dropped off dramatically as the post-syllabic delay increased from 1 to 10 sec.

Associated problems: Various physical and psychological conditions are reported to be influence an individual's memory and sequencing abilities. Memory deficits have been reported in individual with learning disability (Gathercole, Alloway, Willis & Adams, 2005), dementia (Grober & Buschke, 1987), parkinson's disease (Sagar, Sullivan, Gabrieli, Corkin & Growdon, 1987), alzheimer's disease **(**Grady, Furey, Pietrini, Horwitz & Rapoport, 2000) and aphasia (Shallice & Warrington, 1977).

Age: Studies have found a significant decline in the auditory memory and sequencing abilities with aging. Cerella (1990), Lindenberger and Baltes (1994), and Salthouse (1996) opined that a generalized slowing in brain function with age is responsible for most of the age-related declines in problem solving, reasoning, memory and language. A detailed review of studies on age related changes in auditory memory and sequencing abilities is presented in the next section.

Age related changes in auditory memory and sequencing

Many investigators in the area of memory feel that certain aspects of memory such as secondary memory or long-term memory are relatively resistant to change with age. However, other domains like primary memory or short-term memory undergo significant alterations (Karlin, 1942; Craik, 1977; Craik, 1984; Poon, 1985 & Huppert, 1991). Petersen and Weingartner (1991) commented that a part of the problem revolves around the terminology used to describe various components of memory and concluded that different aspects of memory are variably sensitive to the aging process.

With the aim to provide a direct assessment of possible age differences in the retrieval of information from short-term memory, Anders, Fozard and Lillyquist (1972) employed a recognition task. A subject was presented with a sequence of 1 to 7 digits to memorize and after each list he was to decide whether a test item had appeared in the list. The list was composed of a randomly selected subset of the single digits 1 through 9. The measure of interest was the time required to make the decision for different length lists. They employed 10 young subjects from 19 to 21 years of age, 10 middle-aged subjects from 33 to 43 years of age and 10 old-aged subjects ranging from 58 to 85 years. They found that the speed of the search varied with age. The young subjects searched through the contents of short-term memory at about twice the speed of either the middle- or old-aged subjects. In addition, there was an increase with age in response time unrelated to the number of items in the list. The authors concluded that this effect could reflect a slowing of one or some combination of operations necessary to initiate the search (formulating the internal representation of the test item or gaining access to the stored list) or to express the results of the search (to make the decision yes or no, to initiate and carry out the motor response).

Neils, et al., (1991) evaluated auditory sequencing and memory in three age groups using the 'Repetition Test' developed by Tallal and Piercy (1973). The test involved a series of subtests that required the identification of tones. The older elderly group (mean age 80 years) unlike the younger elderly (mean age 70 years), performed poorer than the young adult group (mean age 25 years). This was observed when the task required auditory memory of 4 and 5 tones with the inter-stimulus interval decreased. Performance was not related to hearing sensitivity, thus suggesting that changes in the auditory mechanism that occurred with age encompassed more than a loss of hearing sensitivity. Further, the performance on the 'Repetition Test' was found to correlate with memory for digits, which was evaluated using the Wechsler's Digits Forward test. This indicated a relationship between auditory processing and higher cortical functions.

The memory function in a group of 161 community-dwelling, cognitively normal individuals aged 62 to 100 years was evaluated by Petersen, Smith, Kokmen, Ivnik and Tangalos (1992). They used the 'Free and Cued Selective Reminding Test' and the 'Rey Auditory Verbal Learning Test' to evaluate two aspects of memory function thought to be sensitive to the effects of aging such as learning and delayed recall. The results demonstrated that learning or acquisition performance declines uniformly with increasing age, but was not related to education. The Wechsler Memory Scale-Revised was administered on 61 of the 161 individuals, and the non-age-corrected raw score totals for verbal memory, nonverbal memory, and attention and concentration were evaluated with respect to age and education. The verbal raw score total declined significantly with age, but no relation with education was found.

The nonverbal raw score total also declined significantly with age, but again was not significantly related to education. Finally, the attention and concentration raw score was similarly related to age but not education.

The effect of age on a digit forward task and digit backward task was studied by Gregoire and Linden (1997). From a sample of 1,000 subjects aged between 16 years to 79 years, they found that most of the adult lifespan was characterized by slight decline in memory abilities. A sharper decline was observed after the age of 70. The results of the study also showed that there was no significant effect of age on the difference between digit span forward and backward.

Murphy, et al., (2000) determined the age related memory changes in quiet and in noise using a paired associate memory task. In a trial, five word-pairs were presented aurally to the subjects. Following a warning tone, the first word of one of the pairs was presented again and the participant was asked to retrieve the second word of the pair. Murphy et al. manipulated perception by presenting the word pairs either in quiet or in background babble. The babble was presented at two different levels, -5 dB and -10 dB SNR. The study employed twenty-six younger adults, ranging in age from 20 to 24 years and fifteen older adults in the age range of 65 to 75 years. The results of the study showed that in quiet, older adults recalled significantly fewer words for paired associates early in the list. When perceptual stress in the form of a twelve speaker multi-talker babble was added to the task, memory performance of young adults declined to look very similar to that to old adults in quiet. However, when the equivalent background babble was added to the word presentation to the older adults, their memory performance further declined to an even lower levels of retention. For older listeners and for younger listeners in noisy situations, the most recent words were stored, but the storage of earlier words was disrupted as more word pairs continue to be heard.

The effect of age and presentation level on 50 young (19 to 25 years) and 50 older (65 years and above) individuals with normal hearing sensitivity was studied by Heinrich and Schneider (2000). A paired-associate memory task was employed. Both age groups were equated for perceptual stress by determining the amount of temporal distortion for each group that led to the same percentage of correctly perceived words. The extent of temporal distortion that equated perceptual performance for both age groups was higher for the young participants on the two presentation levels used (40 dB SPL and 50 dB SPL). The results of the study confirmed a pronounced serial position effect such that the fourth and fifth word pairs were remembered more easily than the first three pairs. They found a significant age effect confirming the observation that young adults remembered the word pairs better than the older adults. The presentation level did not show any significant effect. Further, they noted a drop in memory performance for temporally-distorted words in older adults when the words were presented at a higher sound pressure level. The authors attribute the findings to the rollover effect, a phenomenon that is sometimes observed in individuals with central auditory disorders. In such individuals it has been reported by Heinrich and Schneider (2000) that the word identification is normal for intermediate sound pressure levels but decreased at higher levels. The authors report that the rollover effects were expected in individuals with temporal processing disorders.

To evaluate the scores obtained in the daily memory function, Moral, Tomas, Bataller, Oliver and Navarro (2010) compared Spanish young with elderly people. This was done by comparing the scores obtained on the Rivermead Behavioural

Memory Test by the two groups. The results of the comparison between the 60 young and 120 elderly individuals showed a statistically significant difference. Those between 18 and 30 years obtained a higher average than those over 65, indicating a decline in daily memory function with age.

Several reasons have been speculated by Light and Leah (1999) to explain why older adults use less effective encoding and retrieval strategies as they age. The first was the ‘disuse’ view, which implied that memory strategies were used less by older adults as they moved further away from the educational system. Second was the ‘diminished attentional capacity’ hypothesis, which meant that older people engaged less in self-initiated encoding due to reduced attentional capacity. The third reason was the ‘memory self-efficacy’, which indicated that older people did not have confidence in their own memory performances, leading to poor consequences.

From the review of literature it is clear that aging results in deterioration of memory and sequencing abilities. However, the tests of auditory memory and sequencing developed in India (Yathiraj & Mascarenhas, 2003; Yathiraj & Vijayalakshmi, 2006) have paid attention only to children and not to the elderly. It is important to see if similar trend exists in Indian context owing to the lower literacy percentage. Hence, it is essential to investigate the effect of age on the auditory memory and sequencing abilities of elderly individuals with normal peripheral hearing sensitivity in Indian context.

METHOD

The present study was conducted with the aim of investigating the effect of age and gender on auditory memory and sequencing in older adults with normal hearing sensitivity and to compare their responses with that of young adults. The study also aimed to examine the relation between the perceived degree of memory impairment and the actual degree of impairment.

Participants

The participants were divided into 3 groups based on their age (Group I, Group II and Group III). Each group included 20 participants with 10 males and 10 females. Group-I and Group-II included older adults in the age ranges of 50 to 64;11 years and 65 to 80 years respectively. Group-III included normal hearing individuals in the age range of 20 to 30 years. The educational levels of all the participants were noted and are presented in the Table 1.

Table 1: *Educational levels of the participants.*

Educational level	Group I (50-64.11 years)		Group II (65-80 years)		Group III (20-30 years)		TOTAL
	Males	**Females**	**Males**	**Females**	**Males**	**Females**	
Primary	1	0	1	2	0	0	4
Secondary	1	4	2	5	0	0	12
High school	1	2	2	3	0	0	8
Pre-university	2	4	0	0	0	0	6
Graduation	4	0	5	0	6	5	20
Post-graduation	1	0	0	0	4	5	10
TOTAL	10	10	10	10	10	10	60

The participants were native speakers of Kannada. They had normal AC and BC pure-tone thresholds after applying a correction factor for age as recommended by Indrani (1981), whenever required. Their speech identification score was 80% or more on the 'Phonemically balanced Kannada word test' developed by Yathiraj and Vijayalakshmi (2005).None of the participants reported of any history of middle ear pathology or any major neurological problem. An informed consent was taken from all the participants prior to carrying out the evaluations.

Material

To obtain information about early signs of dementia, a checklist was developed based on the information reported in literature and the opinion of experienced Speech and Hearing professionals. The initial checklist contained 12 questions which required responses on a 3-point scale ('never', 'sometimes' and 'always'). A symptom that occurred less than 25% of the time was required to be scored 'never', while those that occurred 25% to 75% and more than 75% of the time were scored 'sometimes' and 'always' respectively. Item validity was checked by obtaining the opinion of five speech and hearing professionals who had at least 10 years of experience in the area of cognition. After incorporating the modifications and suggestions of the speech and hearing professionals, the checklist had nine questions. As no changes were recommended for the procedure to obtain the responses, the 3-point rating scale was retained. Further, the checklist was scored by awarding a response 'never' a score of 0, while 'sometimes' was scored 1 and 'always' was scored 2. Thus, the total possible score ranged between 0 and 18 on the developed 'Memory ability checklist'.

To test the auditory memory and sequencing abilities of the participants, they were tested using the 'Auditory Memory and Sequencing Test in Kannada' developed by Yathiraj and Vijayalakshmi (2006). The test contained four lists of words with different inter-stimulus intervals (250 msec, 500 msec, 750 msec and 1 sec). Each list commences with a three-word token and gradually increased to an eight-word token with a total of twenty tokens. The list with an inter-stimulus interval of 500 msec was used for the present study.

Instrumentation

Madsen Orbiter-922 type I diagnostic audiometer with calibrated Telephonics TDH-39 headphones was used to estimate the air conduction thresholds and to carry out speech audiometry (ANSI S3.6, 1996). Calibrated Radio Ear B-71 bone vibrator was used to estimate bone conduction thresholds. The same audiometer was also used to route the stimuli for the auditory memory and sequencing test in Kannada from a laptop to loud speakers. A calibrated Grason StadlerInc-Tympstar, clinical immittance meter used to rule out any middle ear pathology.

Test environment

All tests were administered in an acoustically treated suite. It was ensured that the noise levels were within the permissible limits as recommended by ANSI S3.1 (1991).

Procedure

Procedure for participant selection:

Pure-tone thresholds were obtained in octave intervals between 250 Hz to 8000 Hz for air conduction and between 250 Hz and 4000 Hz for bone conduction using the modified Hughson-Westlake procedure (Carhart & Jerger, 1959). Speech identification scores (SIS) were obtained under headphones using the phonemically balanced word list (Yathiraj & Vijayalakshmi, 2005) at 40 dB SL. Participants with a pure-tone threshold of less than 25 dB HL, after applying a correction factor for age as recommended by Indrani (1981) and a SIS of greater than 80% were selected.

Tympanometry and reflexometry were carried out to rule out any possibility of middle ear pathology using a 226 Hz probe tone. Ipsilateral and contralateral reflexes at 500 Hz, 1000 Hz, 2000 Hz and 4000 Hz were obtained. Participants with type-A tympanogram with bilateral reflexes present were considered for further assessment.

The developed 'Memory ability checklist' was administered to obtain their demographic details and to rule out signs of memory problems in the participant. Each participant was required to respond on the three point scale. Only those participants with a total score of less than 9 were selected.

Procedure for administering the Kannada Auditory Memory and Sequencing Test:

The Kannada Auditory Memory and Sequencing Test (Yathiraj & Vijayalakshmi, 2006) was administered on participants who met the participant selection criteria. ACD containing the test stimuli were played on a laptop. The signal from the laptop was fed to the CD input of the Madsen Orbiter-922 type-I diagnostic audiometer. The output of the audiometer was given to a loud speaker which was placed 1 meter from the head of the participants at 0º azimuth. The signal was presented at 40 dB HL.

The participants were instructed to listen to the group of words present in each token and repeat them in the same order. A score of one was awarded for every correct word that was recalled. An additional score of one was awarded if the words recalled were in the correct sequence. The responses were recorded on a scoring sheet and the total score for the memory subtest and the sequencing subtest was calculated.

Analyses

The raw scores obtained from the 60 participants on the ‘Kannada auditory memory and sequencing test’ and the ‘Memory ability checklist’ were tabulated. The data thus obtained was subjected to statistical analyses, using SPSS (Version 18). MANOVA was done to see the effect of age and gender on the scores of the auditory memory and sequencing subtests. To study the effect of age and gender on the total score of the ‘Kannada auditory memory and sequencing test’, ANOVA was carried out. Non parametric Kruskal-Wallis test was used to see the impact of age on the scores obtained on the ‘Memory ability checklis’.

RESULTS

Based on the statistical analyses, a comparison was made between the scores obtained across the three age groups (50 to 64;11 years, 65 to 80 years & 20 to 30 years) for four different scores. This included the auditory memory subtest score; auditory sequencing subtest score; total auditory memory and sequencing score; and the 'Memory ability checklist' score. A comparison was also made between the genders on the same parameters.

The results are discussed under the following headings:

1. Effect of age

    1.1 Effect of age on the auditory memory subtest score

    1.2 Effect of age on the auditory sequencing subtest score

    1.3 Effect of age on the total auditory memory and sequencing score

    1.4 Effect of age on the 'Memory ability checklist' score

2. Effect of gender

    2.1 Effect of gender on the auditory memory subtest score

    2.2 Effect of gender on the auditory sequencing subtest score

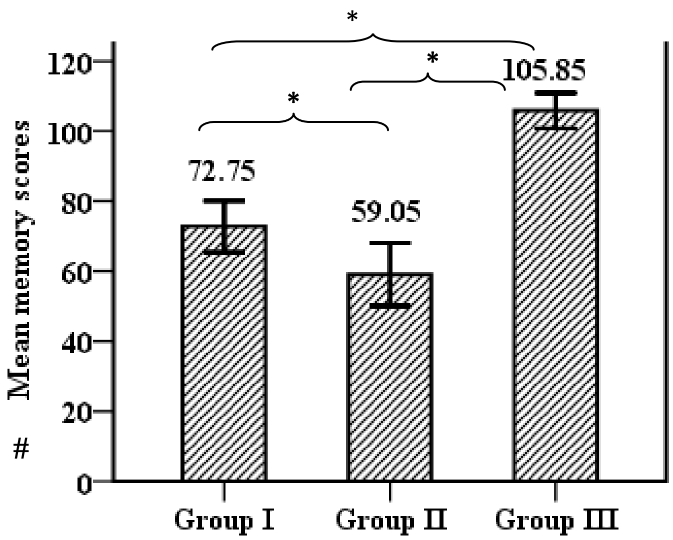
    2.3 Effect of gender on the total auditory memory and sequencing score

    2.4 Effect of gender on the 'Memory ability checklist' score

1. Effect of age

1.1 Effect of age on the auditory memory subtest score

The mean and standard deviation of the auditory memory subtest score was determined for each age group (Figure 1). From the figure it is evident that the mean memory score of the two groups of older adults (Groups I & II) was lesser than that of the younger adults (Group III). To check if this difference was statistically significant, MANOVA was carried out. The results indicated that there was a significant main effect [$F(2, 54) = 216.113$, $p < 0.05$]. Further, Duncan post-hoc test was used to see whether each age group differed significantly from the other on the memory subtest scores. The results indicated that the scores of Group-I and Group-II differed significantly from the Group-III ($p < 0.05$) and also differed significantly from each other ($p < 0.05$).

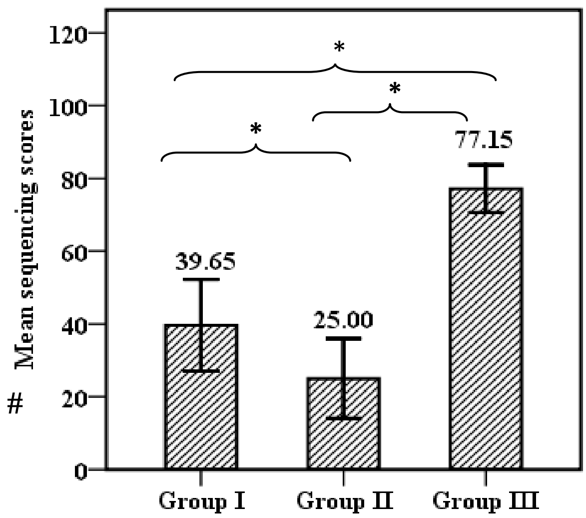


Note: # *Maximum score is 118*
* *p < 0.05*

Figure 1: Mean and standard deviation of the memory subtest scores for the three age groups.

__1.2 Effect of age on the auditory sequencing subtest score__

From the descriptive statistics (Figure 2) it is apparent that the mean sequencing score of the younger adults (Group III) was higher than that of the two older groups (Group I & Group II). Also, the variability for the older adults was more compared to the younger adults. The results of MANOVA also indicated a significant main effect of group [F (2, 54) =154.082, $p < 0.05$]. The findings of the Duncan post-hoc test showed that the mean sequencing scores of Group-I and Group-II differed significantly ($p < 0.05$) from the Group-III. Additionally, the two older groups also differed significantly from each other ($p < 0.05$).

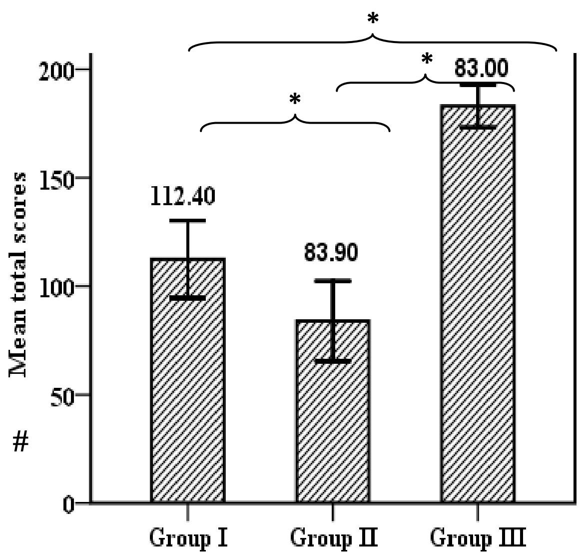


Note: *# Maximum score is 118*
** p < 0.05*

Figure 2: Mean and standard deviation of the sequencing subtest scores for the three age groups.

1.3 Effect of age on the total auditory memory and sequencing score

The findings of the descriptive statistics (mean and SD) for the total memory and sequencing score across age groups are presented in the Figure 3. It can be observed that the scores decreased with increase in age. To determine the effect of age on these total scores of the 'Kannada auditory memory and sequencing test' ANOVA was carried out. A statistically significant main effect for groups [$F (2, 54) = 224.600$, $p < 0.05$] was seen. Duncan post-hoc test indicated a significant difference in the mean total auditory memory and sequencing scores of Groups I and II ($p < 0.05$), Groups I and III ($p < 0.05$) as well as between Groups II and III ($p < 0.05$).

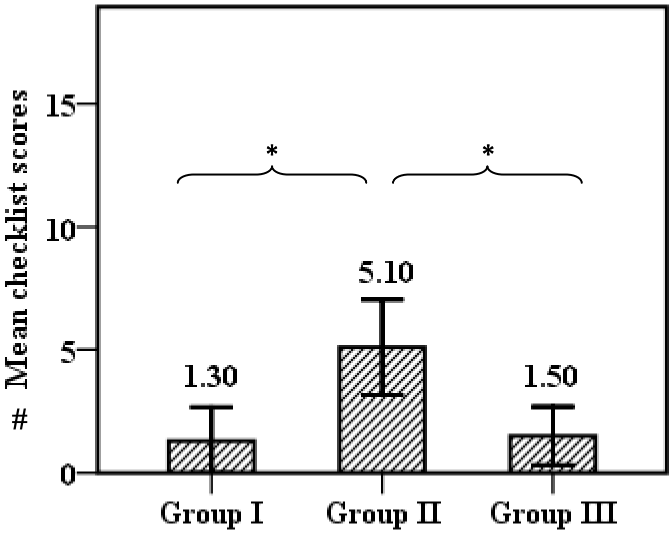


Note: *# Maximum score is 236*
** p < 0.05*

Figure 3: Mean and standard deviations of the total memory and sequencing scores across the three age groups.

1.4 Effect of age on the 'Memory ability checklist' score

Mean and SD of the 'Memory ability checklist' scores were obtained for the three age groups (Figure 4). To compare the age effect on the 'Memory ability checklist' score non-parametric Kruskal-Wallis test was carried out. . The results showed a significant age effect [χ^2 (2) = 31.344, $p < 0.05$]. The findings of the post-hoc analysis carried out using the non-parametric Mann-Witney test showed a significant difference between Group-I and -II ($p < 0.05$) and Group-II and -III ($p < 0.05$) but not between Group-I and -III ($p > 0.05$).



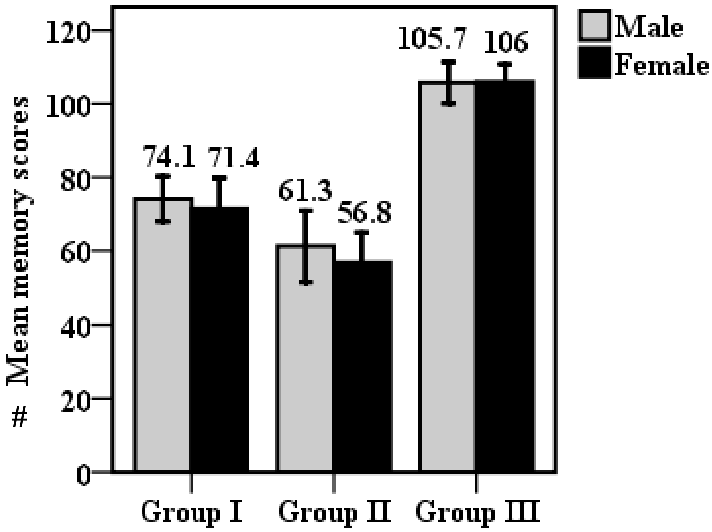
Note: # *Maximum score is 18*
* *p < 0.05*

Figure 4: Mean and standard deviations of the scores on the 'Memory ability checklist' for the three age groups.

2. Effect of gender

2.1 Effect of gender on the auditory memory subtest score

The mean and standard deviation of the auditory memory subtest score was determined across genders for each of the three age groups (Figure 5). The MANOVA results indicated that there was no significant gender effect [F (1, 54) =1.481, p > 0.05] when the three age groups were combined. To determine if this lack of gender difference was maintained for each of the three age groups, group wise comparison using MANOVA was done. It was seen that in each of the age groups, both males and females performed equally (p > 0.05) on the memory subtest.

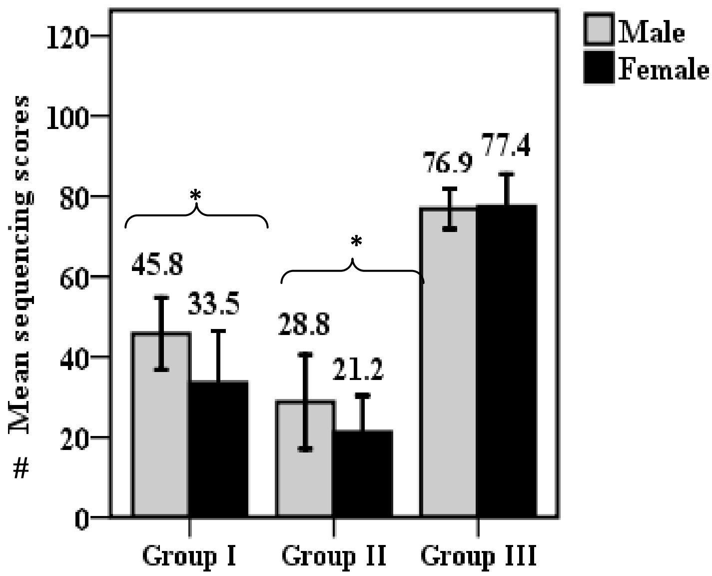


Note: # *Maximum score is 118*

Figure 5: Mean memory subtest scores for males and females across the three age groups.

2.2 Effect of gender on the auditory sequencing subtest score

The descriptive statistics of the sequencing subtest (Figure 6) indicated that the females in the older two groups performed poorer than the males. Such a difference was not observed in the younger age group. The results of MANOVA indicated a significant difference [$F (1, 54) = 6.680$, $p < 0.05$] between the genders, when the age groups were combined. However, the group wise comparison revealed that the significant difference between genders was present in Group-I ($p < 0.05$) and Group-II ($p < 0.05$) and not in Group-III ($p > 0.05$).

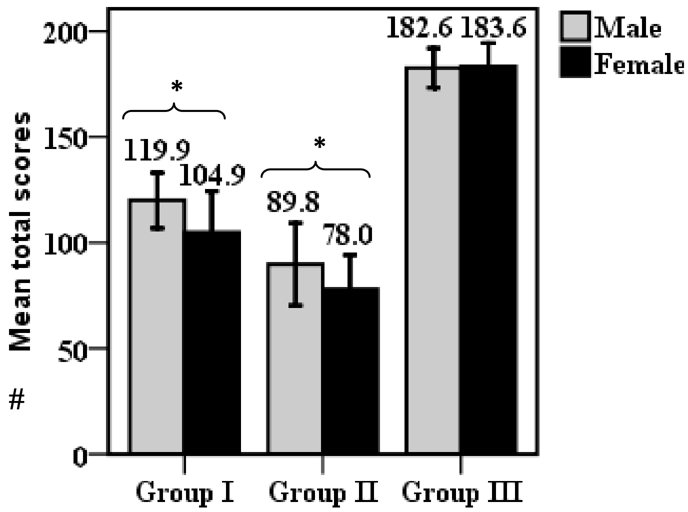


Note: *# Maximum score is 118*
** p < 0.05*

Figure 6: Mean sequencing subtest scores for males and females for the three age groups.

2.3 Effect of gender on the total score

ANOVA was carried out to see the effect of gender on the total score of the 'Kannada auditory memory and sequencing test'. The overall results indicated significant difference [F (1, 54) = 4.861, p < 0.05] between genders. However, a significant difference was present only in the older two adult groups (p < 0.05) and not in younger adults group (p > 0.05) on the Duncan post-hoc test (Figure 7).

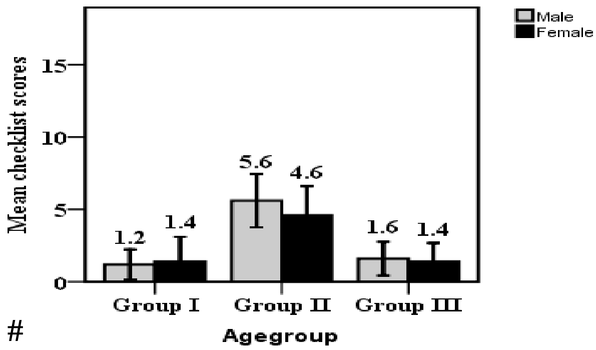


Note: *# Maximum score is 236*
**=p<0.05*

Figure 7: Mean total memory and sequencing scores for males and females across the three age groups.

2.4 Effect of gender on the 'Memory ability checklist' score

Figure 8 shows the mean 'Memory ability checklist' scores across genders for all the three age groups. To study the gender effect on the 'Memory ability checklist' score, non-parametric Kruskal-Wallis test was carried out. The results showed no significant difference [χ^2 (2) = -0.158, p>0.05] between genders across all the three age groups.



Note: # *Maximum score = 18*

Figure 8: Mean scores on the 'Memory ability checklist' for males and females across the three age groups.

Thus, from the findings of the study it can be seen that the younger adults (20 to 30 years) performed better than the two groups of older adults (50 to 64;11 years & 65 to 80 years) on both memory and sequencing sub-tests. On comparison of the two older groups of adults (Groups I & II), younger of these two groups (Group I) got significantly higher scores than the older of these groups (Group II) on both memory and sequencing sub-tests. In all three groups, higher scores were obtained on the memory subtest compared to the sequencing subtest. When a comparison was made between the genders, both the genders performed equally on the memory subtest in all the age groups. However, the performed of the males was superior to that of the females on the sequencing subtest in both the older adult groups. Such a difference was not seen in the younger group. When the checklist scores were compared across the groups, the 20 to 30 years old and the 50 to 64;11 years old got similar scores. The 65 to 80 years old got the highest scores on the 'Memory ability checklist' indicating a greater degree of perceived memory problems than the other two groups.

The findings of the study are discussed in the light of the available literature. This is done to see if the findings support or refute the findings of studies reported in literature.

DISCUSSION

The outcomes of the study are discussed in relation to the results obtained. The comparison of the scores obtained on the auditory memory and sequencing test and the 'Memory ability checklist' are discussed for three age groups as well as across the genders. The comparison of the 'Memory ability checklist' scores with the total auditory memory and sequencing scores for each age group are also discussed.

Comparisons of memory and sequencing abilities across age groups

The results of the present study showed that the younger adults aged 20-30 years (Group-III) performed better than the two groups of older adults aged 50 to 64;11 and 65 to 80 years respectively (Group-I & -II). This was observed on auditory memory subtest as well as the sequencing subtest. Similar results are also seen on the total auditory memory and sequencing scores.

These results are in agreement with those of Anders, Fozard and Lillyquist (1972) and Neils, et al., (1991). They reported of considerable decrement in the memory and sequencing scores of the elderly compared when compared younger adults on a recognition task and free recall task respectively. Kester, Benjamin, Castel and Craik (2002) also opined that the elderly experience trouble retrieving information from memory, particularly when retrieval required effortful processing, as in un-cued recall.

In the current study, a comparison of the two older groups of adults (Groups I & II) revealed that the younger of these two groups (50 to 64;11) got significantly higher scores than the older of these groups (and 65 to 80 years). This was observed on the memory as well as sequencing subtests.

Similar findings have been reported by Park (1996) in a longitudinal comparison study. The study revealed that age-related changes from age 20 to 60 tended to be small. Whereas changes after the age of 60 had a steeper slope. Park (2002) too found that memory scores showed a linear life-long decline with an accelerated decline in the later decades. Several other studies have also reported of a generalized slowing in brain function which resulted in a decline in problem solving, reasoning, memory, and language (Cerella, 1990; Lindenberger & Baltes, 1994; Salthouse, 1985, 1993, 1996). Additionally, a slowing of behaviour in old age has also been documented (Birren, 1965; Salthouse, 1991, 1996).

Age related decline in memory and sequencing has been ascribed to several reasons in literature. Salthouse (1996) suggested that age-related impairments on tasks that do not have an obvious speed component, such as free recall tasks, could be explained via the simultaneity mechanism where the products of earlier processes were lost before later processes were carried out. The reduction in the memory and sequencing scores with aging has also been attributed to inadequate signal processing due to aging of the sensory systems by Murphy, et al., 2000). Yet another reason for a reduction in performance with aging, according to Craik and Byrd (1982), had been the depletion of attentional resources available for cognitive processing. Further, Kester, Benjamin, Castel and Craik (2002) noted that age-related decrement in executive control over cognitive processes has lead to a decline in memory ability in the elderly.

Thus, the findings of the present study are in consonance with that reported in literature. These results add to the corpus of findings regarding age related decline in auditory memory and sequencing. The current study highlights that such age related changes are universal and not restricted to certain regions or communities. Further, it can be construed that the age related changes seen in memory and sequencing performance in the present study could be due to a combination of inadequate signal processing, attention reduction and cognitive decrement. Additionally, in agreement with Park (2002), these changes continue to decline with advancement in age.

Comparisons between memory and sequencing scores across age groups

Overall, in the present study, all three groups obtained higher scores on the memory sub-test compared to the sequencing sub-test, indicating that the latter task was a more challenging one. The drop in score was similar for the two older groups (33.1 & 34.05 for Groups I & II respectively). However, their drop in score was more than that of seen in the younger group (28.7). This indicates that the older two groups found the sequencing task more difficult than the younger group.

Similar findings have been reported by Yathiraj and Vijaylakshmi (2006) in children aged 11 to 12 years. The authors found that the memory subtest scores ranged between 101 to 105, with the maximum attainable score being 118. However, the scores for the sequencing subtest dropped to 69 to 78 for the same maximum attainable score of 118.

Comparison across gender in each age group

It was found in the present study that both males and females performed equally on the memory subtest. Similar findings were seen across all three age groups. This finding is consistent with that of Susan, Susan, Benjamin and Hannah (2004) who found no significant between genders on a working memory task.

However, on the sequencing subtest, the present study revealed that the performance of the female participants was poorer than that of the male participants.

This was observed in the two older adult groups (Group-I & -II) but was absent in the younger adult group (Group-III) where both genders performed equally. A possible reason for the presence of a gender difference in the older two groups could be due to the educational differences in the males and females. From the Table 1 presented in the method section, it is evident the males in both the elderly groups had higher educational levels when compared to the females of the same age group. Such a difference in educational level was not present between the genders in the younger adult group.

The effect of education on the performance of males and females has been reported by Coffey, Saxton, Ratcliff, Bryan, and Lucke (1999). The authors found that each year of education was associated with an increase in peripheral CSF volume (a marker of cortical atrophy) of 1.77 mL ($p<0.03$) in a nonclinical population. In the present study, since the females had comparatively less education than the males, they were likely to have a greater degree of cortical atrophy which in turn could have resulted in poor performance on the sequencing subtest.

In contrast to the findings of the present study, Alexander, Packard and Peterson (2002) and Lowe, Mayfield and Reynolds (2003) documented better scores in young and older females on various memory and sequencing tasks. Subject variability, material used for the task and education level of the subjects may have accounted for the difference in the findings between their study and that of the present one.

Craik and Byrd (1982) reported that difficult tasks required more attentional capacity than simpler tasks. In the current study, the sequencing task was more taxing. This is evident from the lower scores on this task compared to the memory subtest.

Since the sequencing subtask was relatively more complex than the memory subtask, the differences in the gender could probably be picked-up with the former and not with the latter subtest.

Comparisons of 'Memory ability checklist' score and the total auditory memory and sequencing test scores

The results of the study revealed that all the three age groups differed significantly from each other on the total auditory memory and sequencing test score. The younger adults (20 to 30 years) performed better than the two groups of older adults. Among the two groups of older adults, Group-I (50 to 64;11 years) performed superior to the Group-II (65 to 80 years).

The younger adults (Group-III) had lowest scores on the 'Memory ability checklist' which indicated that they did not perceive themselves as having any memory problems. This was in agreement with their scores obtained on the memory and sequencing test. The 65 to 80 years old participants (Group-II) had the highest scores on the 'Memory ability checklist' which also evident from their poor scores on the Kannada auditory memory and sequencing test. On the other hand, the participants aged 50 to 64;11 years, did not report of any decline in their memory ability. However, their test scores were significantly low when compared to the younger adults.

The above findings are in accordance with that of Taylor, Miller and Tinlenberg (1992). The authors found that among the older adults (< 60 years), the decline in memory ability is not significant enough to cause an increase in the scores of self-report questionnaires. Hertzog, Dixon and Hultsch (1990) reported that the self-reports of the older individuals do not necessarily correspond with their actual memory ability unless the memory problem start occurring frequently. Hence, it can be concluded that a memory test is able to detect a decline in memory and sequencing abilities before the individual starts perceiving the deficit.

Thus, the hypothesis of the present study, which stated that there is no significant difference in the auditory memory and sequencing abilities between the young adults and older adults with normal hearing sensitivity as well as there is no significant difference in the auditory memory and sequencing abilities between two groups of older adults, is rejected. The other hypothesis which stated that there is no significant difference between genders in the auditory memory and sequencing abilities in all the three age groups is accepted in the younger adult group and rejected in both the older adult groups. Further, individuals are able to perceive their memory problems only when the condition becomes more pronounced. This was evident from the findings of the 'Memory ability checklist'.

SUMMARY AND CONCLUSION

As adults grow older, physical, sensory, emotional, psychological, and social changes are reported to occur (Dugan & Kivett, 1994). A large number of elderly individuals have been reported to live with mild memory problems that are a part of a normal aging process (Schroder et al., 1998). In addition to aging, educational level of the individual is also known to have a high correlation with the memory abilities (Gathercole, et al., 2004). The National Sample Survey (2004-2005) report shows that the overall literacy of India is only 67.3% which is lower than that seen in other countries. Thus, there is a possibility that the memory abilities of Indians could be differently affected compared to that seen in populations in other parts of the world. On account of this, it is essential to see if similar age related changes are seen in Indians as in the other parts of the world where the literacy level is noted to be higher.

The present study aimed at investigating the changes in auditory memory and sequencing abilities with age in subjects with normal peripheral hearing sensitivity. A total of 60 participants, divided into three groups (Group I, Group II and Group III) based on their age were recruited. Each group included 20 participants with 10 males and 10 females. Group-I and Group-II included older adults in the age ranges of 50 to 64;11 years and 65 to 80 years respectively. Group-III included individuals in the age range of 20 to 30 years. All the participants were tested using the 'Auditory Memory and Sequencing Test in Kannada' developed by Yathiraj and Vijayalakshmi (2006) to assess their auditory memory and sequencing abilities. Additionally, the 'Memory ability checklist' was administered on all the participants to check for the early signs of dementia. This checklist was also used to see if there was an agreement between the perceived degree of memory impairment, as indicated by the checklist scores and the actual degree of memory impairment, as indicated by the auditory memory and sequencing test results.

MANOVA was carries out to see the effect of age and gender on the auditory memory and sequencing subtests. ANOVA and Kruskal Wallis tests were used to study the effect of age and gender on the total auditory memory and sequencing score and 'Memory ability checklist' score, respectively.

The results of the present study revealed that,

- The younger adults (20 to 30 years) performed better than the two groups of older adults (50 to 64;11 years & 65 to 80 years) on both the memory and sequencing subtests. This difference in performance could be attributed to a generalized slowing in brain function which has been noted to result in a decline in problem solving, reasoning, memory and language (Cerella, 1990), inadequate signal processing due to aging of the sensory systems (Murphy et al., 2000) and depletion of attentional resources due to aging (Craik & Byrd, 1982).
- On comparison of the two older groups of adults (Groups I & II), the 65 to 80 years old participants (Group II) got significantly lower scores than those aged 50 to 64.11 years (Group I) on both memory and sequencing subtests. This finding is in agreement with Park (1996) who also reported that after 60 years of age, memory abilities decline more steeply.
- In all three groups, higher scores were obtained on the memory subtest compared to the sequencing subtest, as the latter task is relatively more taxing (Craik & Byrd, 1982).

- In the younger age group (20 to 30 years), both males and females performed equally on the memory subtest as well as the sequencing subtest.
- In both the older adult groups, males performed superior to the females on the sequencing subtest. However, their performance was equal on the memory subtest. This difference in performance could be attributed to the difference in educational level between the two genders. Such findings have also been observed by Coffey, et al. (1999).
- The 20 to 30 years old and the 50 to 64;11 years olds got similar scores on the 'Memory ability checklist'. The memory problem in the latter group (50 to 64;11 years) may not have been large enough for them to perceive their problem. Thus, subtle memory and sequencing problems that are evident on tests may not be perceived by individuals.
- The oldest age group (65 to 80 years) got the highest scores on the 'Memory ability checklist' indicating a greater degree of perceived memory problems than the other two groups. They also obtained the poorest scores on the memory and sequencing test. Thus, when the memory problem is fairly large, individuals are able to perceive them.

From the results of the present study it can be inferred that,

- Memory and sequencing abilities show a linear life-long decline with an accelerated decline in the later decades.
- Age related changes are universal and not restricted to certain regions or communities.
- Educational level of the participant plays an important role on the performance of complex tasks such as sequencing.

- In elderly individuals aged less than 65 years, self-report scores of the memory abilities may not necessarily correspond with their actual memory abilities.

Implications

- From the present study it is clear that memory abilities deteriorate with age. This must be kept in mind while counselling older adults about the hearing aid/assistive listening use. Written/ printed material should be provided to them.
- The elderly individuals should be trained to use different listening strategies to help remember better.
- Due to the role of education in the performance of sequencing tasks, emphasis needs to be given to encourage higher levels of educations in all individuals.

REFERENCES

Aaronson, D. (1966). *Perception and Immediate Recall of Auditory Sequences*. Unpublished doctoral thesis, University of Pennsylvania.

Aaronson, D. (1967). Temporal factors in perception and short-term memory. *Psychological Bulletin*, *67,* 130-144.

Aaronson, D. (1968). Temporal course of perception in an immediate recall task. *Journal of Experimental Psychology, 76*(1), 129-140.

Aaronson, D. (1974). Stimulus factors and listening strategies in auditory memory: An experimental demonstration. *Cognitive Psychology, 6*(1), 133-158.

Alexander, G. M., Packard, M. G., & Peterson, B. S. (2002). Sex and spatial position effects on object location memory following intentional learning on object identification. *Neuropsychologia*, *40*, 1516-1522.

American National Standards Institute. *American National Standard: Specification for Audiometers*. New York: American National Standards Institute, Inc. 1996, ANSI S3.6-1996.

American National Standards Institute (1991). *American National Standard Maximum Permissible Ambient Noise Levels for Audiometric Test Rooms*. ANSI S3.1 (1991). New York: American National Standards Institute.

Anders, T., Fozard, J., & Lillyquist, T. (1972). Effects of age upon retrieval from short-term memory. *Developmental Psychology*, *6,* 214-217.

Arking, R. (1991). *Biology of aging: Observations and principles.* Englewood Cliffs, NJ: Prentice-Hall.

Baddeley, A. D. (1966). *The psychology of memory (pp. 131-132).* New York, Basic Books Inc., Publishers.

Baddeley, A. D., Thomson, N., & Buchanan, M. (1975). Word length and the structure of short-term memory. *Journal of Verbal Learning and Verbal Behavior, 14*(6), 575–589.

Berry, J. W. (1969). On cross-cultural comparability. *International Journal of Psychology, 4*, 119-128.

Birren, J. E. (1965). Age changes in speed of behavior: its central and neurophysiological correlates. In Welford, A.T. & Birren, J. E. (Eds), *Behaviol; Aging and the Nervous System*, (pp.191-216). Springfield, IL: Charles C. Thomas.

Braver, T. S., & Barch, D. M. (2002). A theory of cognitive control, aging cognition, and neuromodulation. *Neuroscience and Biological behaviors*, *26*, 809–817.

Brookshire, R. H. (1972). Visual and auditory sequencing by aphasic subjects. *Journal of communication disorders, 5* (3), 259-269.

Carhart, R., & Jerger, J. F. (1959). Preferred method for clinical determination of puretone thresholds. *Journal of Speech and Hearing Disorders, 24*, 330-345.

Cerella, J. (1990). Aging and information-processing rate. In Birren, J. E. & Schaie, K. W. (Eds), *Handbook of the psychology of aging*, (pp.201-221). San Diego, CA: Academic Press.

Chisolm, T. H., Willot, J. F., & Lister, J. J. (2003). The aging auditory system: Anatomic and physiologic changes and their implication for rehabilitation. *International Journal of Audiology*, *42*, 2S3-2S11.

Coffey, C. E., Saxton, J. A., Ratcliff, G., Bryan, R. N., & Lucke, J. F. (1999). Relation of education to brain size in normal aging: implications for the reserve hypothesis. *Neurology*, *53* (1), 189-96.

Conrad, R., & Hille, B. A. (1958).The decay theory of immediate memory and paced recall. *Canadian Journal of Psychology*, *12*, 1-6.

Conrad, R. (1964). Acoustic Confusions in Immediate Memory. *British Journal of Psycho1ogy, 55*, 75-84.

Cowan, N. (1984). On short and long auditory stores. *Psychological Bulletin, 96*(2), 341-370.

Cowan, N. (1988). Evolving conceptions of memory storage, selective attention, and their mutual constraints within the human information processing system. *Psychological Bulletin, 104*, 163-191.

Cowan, N., Lichty, W., & Grove, T. (1988). Memory for unuttered speech during silent reading. In Gruneberg, M. M., Morris, P. E., & R. N. Sykes (Eds.). *Practical aspects of memory: Current research and issues* (pp. 327-223). New York: Wiley.

Craik, F. I. M. (1977). Age differences in human memory. In: Birren, J. E, Schaie, K. W, (Eds), *Handbook of the psychology of aging* (pp.384-420). New York: Van Nostrand Reinhold.

Craik, F. I. M. (1984). Age differences in remembering. In: Squire LR, Butters N, (Eds.), *Neuropsychology of memory* (pp.3-12). New York: Guilford Press.

Craik, F. I. M., & Byrd, M. (1982). Aging and cognitive deficits: the role of attentional resources. In F. I. M. Craik & S. Trehub (Eds) *Aging and Cognitive Processes*, Hillsdale, NJ: Erlbaum, 191-211.

Dugan, E., & Kivett, V. R. (1994). The importance of emotional and social isolation to loneliness among very old rural adults. *The Gerontologist, 34*(3), 340-346.

Gathercole, S. E., Alloway, T. P, Willis, C., & Adams, A. M. (2006). Working memory in children with reading disabilities. *Journal of Experimental Child Psychology, 93*, 265-281.

Gathercole, S. E., Pickering, S. J., Knight, C., & Stegmann, Z. (2004). Working memory skills and educational attainment: Evidence from national curriculum assessments at 7 and 14 years of age. *Applied Cognitive Psychology, 18,* 1-16.

Grady, C. L., Furey, M. L., Pietrini, P, Horwitz, B., & Rapoport, S. I. (2000). Altered brain function connectivity and impaired short term memory in Alzheimer's disease, *Brain, 124,* 739-756.

Gregoire, J., & Linden, M. V. (1997). Effects of age on forward and backward digit spans. *Aging, Neuropsychology, and Cognition, 4*(2), 140-149.

Grober, E., & Buschke, H. (1987). Genuine memory deficits in dementia. *Developmental Neuropsychology, 3,* 13-36.

Hamilton, S. I. (2006). *The Psychology of Ageing: An Introduction*. London: Jessica Kingsley Publishers.

Hanninen, T., Koivisto, K., Reinikainen, K. J., Helkala, E. L., Soininen, H., Mykkanen, L., Laakso, M., & Riekkinen, P. J. (1996). Prevalence of ageing-associated cognitive decline in an elderly population. *Age and Ageing*, *25,* 201-205

Hedden, T., & Gabrieli, J. D. (2004). "Insights into the ageing mind: a view from cognitive neuroscience". *Nature Reviews Neuroscience, 5*(2), 87–96.

Heinrich, A. & Schneider, B. (2000). Effects of age and auditory degradation on memory. *Journal of Speech and Hearing Research, 20,* 108-115.

Hertzog, C., & Dixon, R. A. (1994). Metacognitive development in adulthood and old age. InJ. Metcalfe & Shimamura (Eds), *Metacognition: Knowing about Knowing* (pp. 227-251). Cambridge, MA: MIT Press.

Hirsh, I. J. (1959). Auditory perception of temporal order. *Journal of Acoustic Society of America, 31*, 759-767.

Huppert, F. A. (1991). Age-related changes in memory: Learning and remembering new information. In: Boller, F., & Grafman, J. (Eds). *Handbook of Neuropsychology* (pp. 123-148). Amsterdam: Elsevier Science Publishing.

Indrani, (1981). *Hearing by air conduction as a function of age and sex in Indians*. Unpublished Master's Dissertation, University of Mysore. India.

Jerger, J., & Hayes, D. (1977). Diagnostic speech audiometry. *Archives of Otolaryngology, 103,* 216-222.

Karlin, J. E. (1942). A factorial study of auditory function. *Psychometrika, 7,* 251-279.

Kester, J. D., Benjamin, A. S., Castel, A. D. & Craik, F. I. M. (2002). Memory in elderly population. In Baddeley, A., Wilson, B. & Kopelman, M. (eds.), *Handbook of hearing disorders (2nd Ed.)* (pp. 543-568). London: Wiley.

Konkle, D. F., Beasley, D. S. & Bess, F. H. (1977). Intelligibility of time-altered speech in relation to chronological aging. *Journal of Speech and Hearing Research, 20,* 108-115.

Light and Leah (1999). Memory and Aging: Four Hypotheses in Search of Data. *Annual Reviews of Psychology.* Annual Reviews Inc. Retrieved from http://www.annualreviews.org/doi/pdf/10.1146/annurev.ps.42.020191.002001. on 9 May 2011.

Lindenberger, U., & Baltes, P. B. (1994). Sensory functioning and intelligence in old age: A strong connection. *Psychology and Aging, 9*, 339-355.

Ling, D. (1972). Rehabilitation of cases with deafness secondary to otitis media. In A. Glorig and K. E. Gerwin (Eds.), Otitis media. Springfield, Ill.; Charles C. Thomas, 249-253.

Lowe, P. A., Mayfield, J. W., & Reynolds, C. R. (2003). Gender differences in memory test performance among children and adolescents. *Archives of clinical neuropsychology*, *18* (8), 865-878.

Mackworth, J. F. (1962). The visual image and the memory trace. *Canadian Journal of Psychology*, *16*, 55-59.

Madigan, S. A., & McCabe, L. (1971). Perfect recall and total forgetting: A problem for models of short-term memory. *Journal of Verbal Learning and Behavior, 10,* 101-106.

Massaro, D.W. (1970). Perceptual Processes and Forgetting in Memory Tasks. *Psychological Review, 77*, 557-567.

Massaro, D. W. (1975). *Experimental psychology and information processing*. Chicago: Rand McNally.

McCroskey, R. L., & Kasten, R. N. (1982).Temporal factors and the aging auditory system. *Ear and Hearing, 3*, 124-127.

Mechan, A. O., Wyss, A., Rieger, H., & Mohajeri, M. H. (2009). A comparison of learning and memory characteristics of young and middle-aged wild-type mice in the IntelliCage. *Journal of Neuroscience Methods, 180*(1), 43-51.

Miller, G. A. (1956). The magical number seven, plus or minus two. *Psychological Review*, *63*, 81-97.

Mitrushina, M., & Satz, P. (1991). Changes in cognitive functioning associated with normal aging. *Archives of Clincal Neuropsychoylogy, 6*, 49-60.

Moral, J. C., Tomas, J. M., Bataller, S., Oliver, A., & Navarro, E. (2010). Comparison between Spanish young and elderly people evaluated using Rivermead Behavioural Memory Test. *Aging Neuropsychology and Cognition*, *17*(5), 545-55.

Moshe, N. B., Keshet, B. T., & Oded, L. (2007). The associative memory deficit of older adults: the role of strategy utilization. *Psychology and Aging*, *22*(1), 202-208.

Murphy, D. R., Craik, F. I. M., Li, K. Z. H., & Schneider, B. A. (2000). Comparing the effects of aging and background noise on short-term memory performance. *Psychology and Aging, 15,* 323–334.

National Sample Survey, (2004-2005). *61st Round Survey Report.* Ministry of Human Resource Development. Government of India.

Neils, J., Newman, C. W., Hill, M., & Weiler, E. (1991). The Effects of Rate, Sequencing, and Memory on Auditory Processing in the Elderly. *Journal of Gerontology: Psychological Sciences, 46*(2), 71-75.

Newman, C. W., & Spitzer, J. B. (1983). Prolonged auditory processing in the elderly: Evidence from the backward recognition-masking paradigm. *Audiology, 22,* 241-252.

Norman, D. A. (1966). Acquisition and retention in short-terrn memory. *Journal of Experimental Psycho1ogy, 72,* 369-381.

Oberauer, K., Wendland, M., & Kliegl, R. (2003). Age difference age differences in working memory-The roles of storage and selective access. *Memory & Cognition, 31*(4), 563-569.

Parente, R., & Stapleton, M. (1993). An empowerment model of memory training. *Applied Cognitive Psychology, 7,* 585-602.

Park, D. C. (1996). Mediators of long-term memory performance across the life span. *Psychology and Aging, 11,* 621–637.

Park, D. C. (2002). Models of visuospatial and verbal memory across the adult life span*. Psychology and Aging, 17,* 299–320.

Parkin, A., Walter, B., & Hunkin, N. (1995). Relationships between normal aging, frontal lobe function, and memory for temporal and spatial information. *Neuropsychology, 9,* 304-312.

Petersen, R. C., Smith, G., Kokmen, E., Ivnik, R. J., & Tangalos, E. G. (1992). Memory functions in normal aging. *Neurology, 42,* 396-401.

Petersen, R. C. & Weingartner, H. (1991). Memory nomenclature. In: Yanagihara. T., & Petersen, R. C. (Eds). *Memory disorders: research and clinical practice* (pp. 9-20). New York: Dekker.

Pichora-Fuller, M. K., & Souza, P. E. (2003). Effect of aging on auditory processing of speech. *International Journal of Audiology, 42* (2), 2S11-2S16.

Pisoni, D. B., & Geers, A. (1998).Working memory in deaf children with cochlear impants: correlations between digit span and measures of spoken language processing. *Research on Spoken Language Processing, 22,* 335-343.

Poon, L. W. (1985). Differences in human memory with aging: nature, causes, and clinical implications. In: Birren, J. E., & Schaie, K. W. (Eds). *Handbook of the psychology of aging, 2nd ed*. (pp. 427-462). New York: Van Nostr and Reinhold.

Posner, M. I. (1964). Rate of Presentation and Order of Recall in Immediate Memory. *British Journal of Psychology, 55,* 303-306.

Rastatter, M. P., & Hood, S. B. (1986). Simple motor and phonemic processing reaction times of elderly subjects. *The Journal of Auditory Research, 26,* 157-166.

Sagar, H. J., Sullivan, E. V., Gabrieli, J. D. E., Corkin, S., & Growdon, J. H. (1988). Temporal ordering and short-term memory deficits in Parkinson's disease. *Brain, 111*, 525-539.

Salthouse, T. A. (1991). *Theoretical Perspectives on Cognitive Aging.* Hillsdale, NJ: Erlbaum.

Salthouse, T. A. (1996). General and specific speed mediation of adult age differences in memory. *Journals of Gerontology: Series B: Psychological Sciences and Social Sciences, SIB,* 30-42.

Schneider, B. A., & Pichora-Fuller, M. K. (2001). Age-related changes in temporal processing: Implications for listening comprehension. *Seminars in Hearing, 22*, 227–239.

Schacter, D.L., & Tulving, E. (1994). *Memory systems.* Cambridge, MA: MIT Press.

Schroder, J., Kratz, B., Pantel, J., Minnemann, E., Lehr, U., & Sauer, H. (1998). Prevalence of mild cognitive impairment in an elderly community sample. *Journal of Neural Transmission, 4,* 51-59.

Shallice, T., & Warrington, E. K. (1977). Auditory-verbal short-term memory impairment and conduction aphasia. *Brain and Language, 4*(4), 479-491.

Sigman, M., & Ungerer, J. (1983). Sensorimotor skills and language comprehension skills in autism children. *Journal of Abnormal Child Psychology, 9,* 149-166.

Small, S. A., Stern.Y., Tang, M., & Mayeux, R. (1999). Selective decline in memory function among healthy elderly. *Neurology,* 52, 1392-1396.

Stark, J., (1967). A comparison of the performance of aphasic children on three sequencing tests. *Journal of communication disorders. 1*(1), 331-34.

Stine, E. L., & Wingfield, A. (1987). Process and strategy in memory for speech among young and older adults. *Psychology and Aging. 2*(3), 272-279.

Sternberg, S. (1966). High speed scanning in human memory. *Science, 153*, 652-654.

Susan, G. E., Susan, P. J., Benjamin, A., & Hannah, W. (2004). The structure of working memory from 4 to 15 years of age. *Developmental Psychology, 40* (2), 177-190.

Tallal, P., & Piercy, M. (1973). Defects of non-verbal auditory perception in children with developmental aphasia. *Nature, 241,* 468-469.

Taylor, J. L., Miller, T. P. & Tinklenberg, J. R. (1992). Correlates of memory decline: a 4-year longitudinal study of older adults with memory complaints. *Psychology* & *Aging, 7,* 185-193.

Thomas, I. B., Cetti, R. P., & Chase, P. W. (1971). Effect of silent intervals on the perception of temporal order for vowels, Journal of Acoustical Society of America, 49, 85 (A).

Timothy, S. A. (2009). "When does age-related cognitive decline begin?". *Neurobiology of Aging, 30* (4), 507–514.

Turkington, C. & Harris, J. R. (2002).*The encyclopedia of learning disability*, Edn. II, American Bookworks Corporation, USA.

Winer, J. A., & Schreiner, C. E. (2010). *The auditory cortex: a functional analysis*. New York : Springer.

Wingfield, A., & Tun, P. (2001). Spoken language comprehension in older adults: Interactions between sensory and cognitive change in normal aging. *Seminars in Hearing, 22*, 287–301.

Yathiraj, A., & Mascarenhas, K. E. (2003). '*Auditory Sequencing Test'.* Material developed in the Department of Audiology, AIISH, Mysore

Yathiraj, A., & Vijayalakshmi, C. S. (2005). '*Phonemically balanced word list in Kannada'.* Material developed in the Department of Audiology, AIISH, Mysore.

Yathiraj, A., & Vijayalakshmi, C. S. (2006). *'Kannada Auditory Memory and Sequencing Test'.* AIISH Research Fund Project, Mysore.

Youngjohn, J. R., & Crook, T. H. (1993). Learning, forgetting, and retrieval of everyday material across the adult life span. *Journal of Clinical and Experimental Neuropsychology, 15,* 447-460.

APPENDIX I

MEMORY ABILITY CHECKLIST

Name: Age:

Gender: Date of birth:

Education: Occupation:

Home address & telephone no:

Sl. no.	Questions	Yes	No
1.	Do you have any relatives suffering from memory problems?		
2.	Were you brought up in a rural area?		

		Usually (Greater than 75% of times)	**Sometimes** (Greater than 25% but less than 75%)	**Never** (Less than 25% of the time)
1.	While talking to people, do you have difficulty finding the right word?			
2.	Do you have difficulty in remembering important dates?			
3.	Do you have difficulty in remembering names of familiar objects?			
4.	Do you often forget why you visited a particular place?			
5.	Do you have difficulty in recalling digits, especially your phone/ vehicle/ door number?			
6.	Do you misplace things very often?			
7.	Do you lose your way while going for a walk or driving in your neighborhoods?			
8.	Have your family members or friends told you that you are repeating the same things over and over again?			
9.	Do you have difficulty recalling the correct order of information you just			

	heard?			