AUDITORY AND VISUAL RECALL ABILITIES IN NEUROTYPICAL ADULTS

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CERTIFICATE

This is to certify that this dissertation entitled ***Auditory and Visual Recall Abilities In Neurotypical Adults*** is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech-Language Pathology) of the student Registration Number: 16SLP005. 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.

Mysore
April, 2018

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CERTIFICATE

This is to certify that this dissertation entitled ***Auditory and Visual Recall Abilities In Neurotypical Adults*** has been prepared under my supervision and guidance. It is also been 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 ***Auditory and Visual Recall Abilities In Neurotypical Adults*** is the result of my own study under the guidance of Dr. Shyamala K. C., Professor in Language Pathology, Department of Speech language pathology, 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,
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Don't make people feel important; make people feel their importance
-Bryant McGill

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INTRODUCTION

Cognition is an umbrella term where it is defined as “coordinated operation of active mental process within a multi-component memory system” (Ashcraft, 1989). Cognition refers to a range of mental processes relating to the acquisition, storage, manipulation, and retrieval of information. Cognition involves all conscious and unconscious processes by which knowledge is aggregated, like perceiving, recognizing, conceiving and reasoning. It includes processes such as the ability to perceive and react, process and understand, store and retrieve information, make decisions and produce appropriate responses. Cognition has various cognitive domains which are responsible for regulating specific actions or behaviors. One of the cognitive domain is memory.

Cognitive psychologist Margaret W. Matlin has described memory as the “process of retaining information over time” (Matlin, 2005). Sternberg (1999) stated, “Memory is the means by which we draw on our past experiences in order to use this information in the present”. Functionally, memory is defined as the capability to encode, hold, and subsequently remember material in the brain. From a psychological and neurological viewpoint, memory is the collection of encoded neural connections in the brain. It is the rebuilding of previous happenings and practices by a synchronous firing of neurons that were fired at the time of learning. The encoding process of memory starts when we are born and occurs continuously. For forming a memory first it needs to be picked up by one or more of our senses. A memory starts off in short term memory. Then the important memories move from short term to long term memory. Transition to long term memory for

more permanent storage happens in several steps. It can become permanent through repetition or associating it with other previously acquired knowledge. Memory storage is believed to involve very widespread synaptic alternations in many parts of cortex. This process involves the concept of Hebbian learning (Neurons that fire together, wire together). Thus, correlated activity between neurons leads to strengthened connections between them, both excitatory and inhibitory. Until recently, the hippocampus was believed to be mainly responsible for transferring experiences into memory, but new methods implicate the entire hippocampal neighborhood, the medial temporal lobes. The Hippocampus helps in combining information from cognitive and emotional areas, and binds that information into a memory trace that codes for all aspects of a consciously experienced event (Moscovitch, 1995).

Memory retention and recalling are key memory processes. Retention is the capability to hold information, and retrieval is the recollection of held information in the mind in response to external stimuli. Recall refers to the retrieval of events or information from the past. Retrieval can be an active process of reimagining the perceptions, feelings, and possibly thoughts about the event and its context. Along with encoding and storage, it is one of the three core processes of memory. It involves remembering a fact, event or object that is not currently physically present (in the sense of retrieving a representation, mental image or concept), and requires the direct uncovering of information from memory. Hence, Recall can also be defined as a process where information can be recollected or retrieved from storage at will. Recall is typically the more difficult task, because it requires a person to supply an appropriate answer, with no hints given. In contrast in recognition simply requires a person to identify whether or not an item has been seen before. It is easier

to recognize things than recall them because recognition tasks provide memory cues that facilitate searching through memory. Recall memory is attained through learning usually involving some combination of memorizing, practice and application.

Language and cognition are highly interdependent. Language influences the cognitive processes, the way inputs are interpreted, and how information is stored and used. Cognitive research literature has highlighted that these processes are related to one another and also to factors such as learning, testing, and capacity limit of memory, attention demand, and complexity of material. The conventional concept of learning and retrieval is that learning takes place during events of studying, while retrieval helps to assess the learned contents. The task like recalling the password number to complex tasks as language comprehension, formulation and production requires to store and retrieve information in the correct order (Lewandowsky, Brown, Wright & Nimmo, 2006). Memory processes and language functions are intricately connected where language involves use of an arbitrary set of symbols (code) arranged in a prescribed manner to convey meaning. However verbal memory and language are interdependent on each other. Before an item can be stored in long-term verbal memory, it must be decoded and recognized as a linguistic item with phonological and/or semantic characteristics. The ability to retrieve an item from verbal memory depends upon the access to the verbal representation of the item. Thus, language is the medium through which these lasting impressions are conveyed at a later time. On the other hand, one way in which language is dependent upon verbal memory is that vocabulary is learned via verbal-memory functions. The acquisition of a new word and its meaning requires the use of verbal memory to enter the item into more permanent semantic storage.

Studies show that with aging there is deterioration in language and cognitive abilities in older adults. The major concerns of older adults is that they experience memory loss, which is one of the key symptoms of cognitive impairment. However, memory loss in normal aging is qualitatively different from the kind of memory loss associated with Alzheimer's disease (Budson & Price, 2005). Research has revealed that individuals' performance declines with age on memory tasks that executed by frontal regions. Older adults tend to exhibit deficits on tasks that involve remembering the learnt information/ items in sequence (Parkin, Walter & Hunkin, 1995) memory tasks that require them to remember the specific context in which they learned information (Craik, 1987) and prospective memory tasks that involve remembering to perform future acts. Complaints also often include difficulty in remembering what has been read, the key content of the conversation and location of certain objects used every day.

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 (Schorder, Kartz, 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 function.

Recall abilities are one of the predictive memory function for checking the cognitive abilities. Many studies have proven that recall ability heavily influences complex cognitive acts such as language comprehension and formulation (Jones, 2015). Also, many studies have

incorporated recall as a measure to determine the presence and severity of cognitive impairment (Visser, Verhey, Hofman, Schentels & Jolles, 2002; Achiron, Polliack, Rao, Barak, Lavie, Appleboim & Harel, 2005).

The recall of target item produced through a two-stage generation and recollection process. For the generation stage the stimuli or cue can be presented through different modalities i.e. auditory and visual modality. Also the type of modality affects the recall ability. Though through which modality the individual can recall better is still not proved. There are many controversies reported between the modality of the stimuli. Few studies have been focused on the comparison of the different modalities of recall abilities. As there is great significance of the recall test in identifying if there is any memory disturbances in neurotypical older adults and to compare which modality is better to help recall better, the present study was taken up.

Need for the study:

Rate of cognitive impairment is increasing and these rates are more with the aging. With increasing age, memory is one of the faculty which is reported to be deteriorating with other cognitive skills. Therefore it is important to study and understand the memory changes and their impact on communication in aging population. Also this will help in differentiating between senile and senescent changes in older individuals. Presenting two types of stimuli i.e. auditory and visual will help in determining which stimuli is better recalled by older adults. Also comparing the two modalities will help in better assessment and better treatment methods to address recall and language. The modality specific decline with aging in the task performance of recall needs more research and evidence. None of the previous Indian studies have

specifically performed on assessing auditory and visual recall abilities in the individuals. This necessitates carrying out this study.

Aim of the study:

The purpose of the study is to see age related changes in free and serial recall when stimuli is presented auditorily and visually. Findings will assist in understanding age related changes and will help in appropriate assessment of communicative function of older individuals and also will help in their intervention.

Objectives of the study:

1. To compare visual and auditory recall in neurotypical older adults individuals across the age groups
2. To study visual and auditory recall abilities for free and serial recall
3. To compare the visual and auditory recall pattern for different linguistic complexity level and serial position effects associated with recall task i.e. primacy and recency effect.

Chapter 2

REVIEW OF LITERATURE

2.1 Cognition

Cognition is not just a process it's a mental process and through which the internal and external input is transformed, reduced, elaborated, stored and used (Neisser, 1967). Variety of functions like perception, attention, memory coding, retention and recall, decision making, reasoning, problem solving, imaging, planning and executive actions are involved in cognition. Cognition is the activity of knowing the acquisition, organization, and use of knowledge.

Cognition is not merely a process, but a 'mental' process. In what is perhaps the most influential definition (Neisser, 1967), cognition indeed refers to the mental process by which external or internal input is transformed, reduced, elaborated, stored, recovered, and used. As such, it involves a variety of functions such as perception, attention, memory coding, retention, and recall, decision making, and reasoning, problem-solving, imaging, planning and executing actions. Such mental processes involve the generation and use of internal representations to varying degrees, and may operate independently (or not) at different stages of processing. Furthermore, these processes can to some extent be observed or at least empirically probed, leading to scientific investigation by means of methods akin to those of the natural sciences

2.2 Memory

Memory is one of the important aspects of cognition. Memory can be defined as a lasting representation that is reflected in thought, experience, or behavior (Baars & Gage, 2010). Memory, broadly defined, is the ability to use the past in the service of the present (Kolb & Whishaw, 1996). It is a process where what is experienced or learned is recorded in the CNS (registration), where it persists with a variable degree of permanence (retention) and can be recollected or retrieved from storage at will (recall). In simple words memory is the ability to recall or recognize previous experience.

Atkinson and Shiffrin (1968) developed the basic architecture of the memory system i.e. Multi store model. Three types of memory store were proposed:

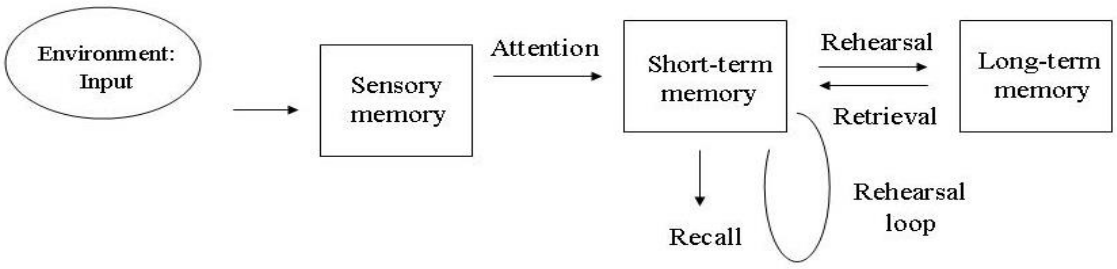


Figure 2.1. The Multi Store Memory Model of Attkinson-Shifirin (1986), http://www.simplepsychology.org/memory.html.

Sensory stores receives the environmental stimuli through different modalities (e.g. vision, hearing), which is held for very brief time. Iconic memory is stored for 1.6 seconds (Landman, Spekreijse and Lamme, 2003). Echoic memory is stored for 2-4 seconds (Treisman, 1964). Short term memory is of very limited capacity and for limited duration for simple maintenance of information. Working memory is a limited capacity system that

involves the active manipulation of the information that is currently being manipulated and it also uses the long term memory to retrieve the information. Long term memory is of unlimited capacity and holds information over very long periods of time. Retrieving/ recalling this information is challenging. Due to these factors recent research has been focusing considerably into recall abilities, which is the final stage of memory.

2.2.1 Recall & Recognition

Recognition and recall/retrieval is used for measuring the memory. Recognition is the ability to recognize previously encountered events, objects or people. When the previously experienced event is re-experienced, this environmental content is matched to stored memory representations, eliciting matching signals. Recognition requires judging and identification of the context.

Recall refers to the retrieval of information or event from the past. It is also defined as the process of retrieving or recollecting the information from the storage at will. Tulving and Thomoson (1973) developed the Encoding Specificity principle, where they state that the probability of successfully recalling the information depends on the information overlap between the information presented and the information which is stored in the memory. Encoding specificity takes into account the effect of contextual cues.

2.2.1.1 Types of recall:

There are 5 types of recall

i. Free recall: Without any cues or hints the information is recalled

ii. Serial recall: Recalling the objects or events in the order in which they occurred

iii. Cued recall: With the cues or hints of the related target the information is recalled

iv. Immediate recall: Recalling the information immediately after it was presented or learnt

v. Delayed recall: Recalling the information after given period of time after it was presented or learnt

2.2.1.2 Factors affecting recall abilities-

There are several factors which can affect the recall abilities-

Cognition and behavior:-

Attention and motivation: Attention largely affects the memory during the encoding phase and motivation generally leads to better recall.

Age and gender:-

Age: Younger adults can recall more items than children or older adults (Light, 2011)

Gender: there are less research associated with the gender difference in recall abilities and with the present research it shows mixed results. Some authors like Siegler and Logue,

1982; Freides and Avery, 1991 reports that there is no gender difference in recall abilities, whereas authors like Resnick, Goldszal, Davatzikos, Golski, Kraut, Metter and Zonderman (2000) reported that there was a significant difference between recall abilities of males and females, attributing this differences to age related changes in brain volume. They states that the males had larger cerebral volume than females. Whereas study done by Xu, Kobayashi, Yamaguchi, Iijima, Okada and Yamashita (2000) reported that the atrophy was more in males as to females.

Language:-

Word length effect: As the word length increase recall abilities decreases. This is because more short words can be rehearsed than long words in the phonological store of working memory (Baddeley, 2000).

Serial position effect: Primacy effect- in a list first few items may be recalled better

Recency effect- in a list last few items are recalled better.

Similarity effect: Words which are semantically related are recalled better compared to semantically unrelated words.

Word frequency: Words which are used frequently are easier to recall.

Imageability: Words which can be visualized are easier to recall (concrete vs. abstract words).

Stimulus factors and Physiological state:-

Context: Recalling is better when the environment is similar in both the learning and recalling phase.

Presentation rate: Items which are presented at slower rate enhances the recall ability.

Physiological state: Drugs can impair the ability to recall.

Modality: The modality of the stimuli that can be auditory or visual (written words or images) affects the recall ability (Rossi & Rossi, 1965).

2.2.1.3 Neurological substrates of recall

Different brain structures are involved in the process of recall. During the process of recall, the right prefrontal cortex, the anterior cingulate cortices, the right inferior parietal cortex and the cerebellum is activated (Cabeza, Kapur, Craik, McIntosh, Houle & Tulving, 1997). The right prefrontal area is attributed to the process of recall attempt (Tulving, 1983). It is not related to the actual recovery of the information that is stored but rather to the attempt or the effort that is put for such recovery. Studies using the PET paradigm have found that anterior cingulate cortex activations are seen during initiation tasks than control tasks, including generation tasks (Petersen, Fox, Posner, Mintun & Raichle, 1988) willed action tasks (Frith, Friston, Liddle & Frackowiak, 1991). Recall involves more of self-initiated processing (Craik, 1983) which supports the hypothesis associated with the functioning of anterior cingulate cortex. The right inferior parietal cortex is involved in perceptual tasks. It depends upon the amount of perceptual information that is available for processing (Schacter, Alpert, Savage, Rauch & Albert,

1996). Hence, it is more active in tasks where a part of the information is given i.e. like in cued recall. Cerebellum was earlier thought to be only associated with motor learning. More recently it has been found that it is also involved in cognitive processes (Leiner, Leiner & Dow, 1991). As previously mentioned recall involves a self-initiated processing, which is also a function of the cerebellum particularly it is involved in generating the response candidates. The left inferior frontal gyrus has also been attributed to recall of recent items especially in memory interference resolution (Oztekin, McElree, Staresina & Davachi, 2008).

2.2.1.4 Language and recall

Cognition is important and is closely related to the language and communication. Language comprehension and formulation are the complex part of the cognitive system. Difficulty recalling is one of the major problems human beings face. Lewis, Vasishth and Van Dyke (2006) stated that for accurate sentence processing the recall is necessary, they described a computational model of sentence processing. Martin and Saffran (1997) states that memory and language are closely linked and recall is one of the primary support for activation of phonological representation. Arian and Neisser (2000) reported that memories are more accessible when the language at retrieval matches the language at encoding. They also reported that retrieval language influences the recall in two ways, one is by association between specific words and second is by an overall effect of linguistic ambience influence the recall ability. Also the language in which one carries out mental activity creates an internal context, analogous to the mental states that produce the phenomenon of mood state dependent recall (Bower, 1981). Geiselman (1988) reported that mental reinstatement of the language used in an earlier occasion may serve to produce increased recall just as the

mental reinstatement of context does. Also recall ability influences the naming and verbal fluency skill as reported by Jones (2015). These findings suggest that recall is uniquely linked with language abilities. Also age related language decline has been observed which in turn affects recall abilities.

2.2.1.5 Neurotypical aging

Neurotypical aging cause neuroanatomical changes which declines cognition and linguistic abilities of the person and it is a part of the natural maturation process. The basic cognitive functions most affected by age are attention and memory. Older adults show short term or immediate memory tasks a deficit, used to examine working memory although the size of the deficit depends on the task used (Kausler & Puckett, 1979; Wingfield, Stine, Lahar & Aberdeen, 1988; Salthouse & Bobcock, 1991). With aging it has been reported that there is limited storage capacity (Miller, 1956; Halford, Maybery, & Bain, 1988; Case, 1995), time limitations in the speed and efficiency of mnemonic strategies such as rehearsal (Baddeley, 1986) or short term memory search (Cowan et al., 1998), and also limitation in the attention control and irrelevant information inhibition (Engle, Conway, Tuholski, & Shisler, 1995). Salthouse reported that processing speed declines in older age and he stated that this general slowing is the result of the primary cause of age related declines in cognitive performance.

Cohen, G. and Burke, D.M. (1993) reported that older adult's most common complaint about memory is difficulty in recalling the names and words with the specific labels. Also some research shows that there is temporal-order memory deterioration with advancing age. Aging effects have been observed in recency judgment tasks (Parkin et al.,

1995; Fabiani & Friedman, 1997), quarter of the list judgments tasks (Vakil & Tweedy, 1994), list learning tasks (Naveh-Benjamin, 1990; Vakil et al., 1997), as well as serial (Kessels et al., 2007; Golomb, Peelle, Addis, Kahana, & Wingfield, 2008; Li et al., 2010) and free (Kahana, Howard, Zaromb & Wingfield, 2002; Golomb et al., 2008) recall tasks.

Miller (1956) pointed out that young adults have better recall abilities than older adults. Kynette, Kemper, Norman & Cheung (1990) stated that recitation rate is slowed with aging. Certain authors like Broadbent (1975) argued that slowed recitation is because of the limited capacity to hold the information and others like Cowan (2001) hypothesized that it could be because of the difficulty in processing the chunking information. He also states that compared to younger adults, older adults tend to form weaker item to item association and this in turn results in weaker association to form multiple chunks in serial recall. Serial position functions in younger adults are also different from those produced by older adults (Maylor, Vousden & Brown, 1999; Murphy, Craik, Li & Schneider, 2000). Chalfonte and Johnson (1996) and Mitchell, Johnson, Raye, Mather and D'Esposito (2000) reported that older adults have deficiency in memory that needs the binding of the information to contextual elements. Raz (2000) reported that the frontal lobes are among the first to be impaired in aging. The frontal lobes of the brain play a major role in planning, decision-making, conflict resolution, and executive functions.

In older adults the word length effect has been found which showed that there is decrease in serial recall of long words compared to short words (Baddeley, Thomson & Buchanan, 1975) when presented visually and aurally (Morris. 1984) because of the limited phonological store for long words. Also the word frequency effect has been found which showed that there is increased performance for high frequency words on recall task

(Roodenrys & Quinlan, 2000) this was because high frequency words are processed faster and have association between the items and increased performance for low frequency word on recognition task (Kinsbourne & George, 1974) this is because low frequency words are processed for longer time and are more item-context associations which help in confirmation that an item was presented (Neath & Surprenant, 2003). Worden and Sherman-Brown (1983) reported that high frequency words are better recalled than low frequency words. Also easy words (high frequency with few phonological neighbors) were recalled well than difficult words (low frequency with many phonological neighbors; Humes et al., 1993).

The most extant theories of cognitive aging has been shown the differences in memory span measures with aging. Age related deficits have been seen in short term memory or working memory and its more notable in attentional-executive working memory control (Baddeley, 1986; Engle, Kane & Tuholski, 1999; Miyake et al., 2000; Kane et al., 2001), it has been cites as a mechanism to explain the age related declines in the fluid cognition in wide variety of tasks, in casual mechanism (Hasher & Zacks, 1988; Mayr & Kliegl, 1993) or as a mediator between a rather general decrease in processing resources and higher-order cognition (Salthouse, 1996).

A study was conducted to analyze verbal recall abilities in younger and older adults. Where 30 neurotypical adults of age range 18-25 years and 30 neurotypical older adults of age range 55-65 years where taken with equal number of male and female participants and all of them where Kannada speakers. The tasks were 3 syllable, 4 syllable and 5 syllable word recall, semantically related word recall, semantically unrelated word recall, digit recall and non-word recall. This stimuli was presented through auditory mode only. The

result showed that as age increased the verbal recall abilities decrease with no significant effect was seen in gender in younger adult group and there was a gender difference in older adult group where males performed better than females. Also the recall ability was better for digits than words. Also semantically related words were recalled well than unrelated words & recall for words were better than recall for non-words (Veena & Abhishek, 2016). With increasing age the modality through which the stimuli presented also will affect the recall abilities.

Pathological aging is due to abnormal change in human body and it is also referred as senility. It causes the reduced function of mind and body with advancing age, which includes inability to remember simple, recent events, general confusion and bewilderment and increasing debility. Disease can be of degenerative/ non-degenerative type (Kempler, 2005). In pathological aging cerebral atrophy, ventricular enlargement and hippocampal atrophy are of rapid in progression and are more evident (Reese, 2000). Because of this, pathological aging individuals have more severe impairment in cognitive aspects such as memory than compared to normal aging (Elias, 1995). Pathological aging shows mild to profound disturbances in memory which also affects their communication skills. Many studies stated that language deficits such as naming disorders, verbal disfluencies and perseveratory efforts are because of the impaired cognitive skills (Jones, 2015). A variety of conditions such as Parkinson's diseases, Huntington's diseases, brain stroke, head trauma, Alzheimer's diseases, and Multiple sclerosis may cause senility.

2.2.1.6 Auditory and visual recall modality

Recall requires the individual to reproduce the material which has been presented. The presentation of the stimuli can be in two modalities i.e. Auditory or Visual. In few studies it has been found that there is wide variety in recall and recognition task, when the stimuli is presented auditory and visually. Modality of presentation of the stimuli affects the recall ability (Rossi & Rossi, 1965). Where the auditory presentation of verbal items results in better performance to visual presentation (Murdock, 1972). Recent research has shown that there is similar effect of auditory and visual information presentation on mnemonic properties. In one of the studies the influence of auditory, verbal and visual stimulus material on primacy effect in free recall was studied. Primacy effect was seen significantly in verbal or auditory stimuli presentation. And it was suppressed when pictorial materials were presented because of the elevation of recall at midlist and later items (Sharps, Price & Bence, 1996). It has been know that for immediate recall when the verbal material is better when it is presented through auditory modality than visual modality. The auditory modality advantage was seen more to the last one or two items of the list of digits, characters, pseudo-words, or words (Crowder, 1967; Conrad & Hull, 1968; Crowder & Morton, 1969). This modality effect is also sometimes called as auditory recency effect (Neath, 1998). Rummer (2001) and Engelkamp (2003) demonstrated that the advantage of auditory presentation over visual can be seen with respect to the most recent words of sentences

Recall performance on a paired associate learning task was studies as a function of word imagery modality i.e. visual or auditory, presentation mode i.e. visual or auditory. The results showed that the recall ability was greater for visual imagery words and results

were similar with Paivio (1971) conceptual-peg hypothesis. Visual presentation of the stimuli had greater recall than auditory presentation, and females showed greater recall abilities than males. Though the predicted interaction between these modalities did not show statistical significance (Papineau & Lohr, 1981). Also the rate of the stimuli will affect the modality. The faster the rate of presentation of stimuli, greater the superiority of auditory over visual modality (Murdock & Walker, 1969). This is because coding of visual stimuli takes more time but if adequate time is given for the stimuli presentation then the auditory superiority will decrease. Also visually presented stimuli take longer because of more transformations are required. The reason for auditory superiority is also that auditory store has more capacity than visual store (Murdock, 1967).

Generating the abstract code from visual or auditory presentation may differ. The coding of a visual presentation may involve a gradual loss of visual details while auditory presentation will be directly into the abstract schema. This concludes that visual presentation lead to better physical identity matching only when inter stimulus interval is zero. Whereas if inter stimulus interval is lengthened then this superiority decreases (Harriot, 1974). Pictorial stimuli of presentation may be rapidly processed to a deep level and thus may show more persistent memory trace than auditory or printed word stimuli (Craik, 1973). The comparison between the presentation of stimulus through pictures or spoken words generally showed higher recall ability for picture presentation for children between kindergarten and eighth grade levels (Horowitz, 1969; Cole, Frankel, & Sharp, 1971). There are controversies in the modality of stimulus presentation. Some researchers have found that auditory memory is superior to visual (Minsterberg & Bingham, 1894; Binet, 1894; Koch, 1930; Jasen, 1971). Others have investigated that visual is superior to

auditory (Kirkpatrick, 1894; Hawkins, 1897; Henmon, 1912; O'Brien, 1921; Worchester, 1925). Simultaneous presentation of the items i.e. visually and aurally always shows greater recall ability (Binet, 1894; Mimsterberg & Bingham, 1894; Koch, 1930). Most of the studies shows that adults perform better in visual memory task than auditory but this is reverse with children (Hawkins, 1897; MacDougall, 1904; Abbot, 1909). But as age increases there is decline in visual short term memory (over 40 years) than auditory memory (McGhie, Chapman, & Lawson, 1965). In short which modality is superior is cannot be given a general answer. Therefore the further experiments are needed.

From all the above findings we can infer that the recall pattern declines with normal ageing as well as in clinical conditions such as MCI and Dementia. Very few studies have been focused on comparing the different recall modalities and the ability to recall using language specific stimuli. And how the decline in recall abilities is seen in normal aging typical individuals is studied.

Chapter 3

METHODS

The purpose of the study is to see the age related changes in free and serial recall when stimuli is presented auditorily and visually. To meet the aim of the study the following conditions were considered i.e. auditory free recall, auditory serial recall, visual free recall & visual serial recall. Each of the conditions included the further tasks such as 3 syllable, 4 syllable word recall, semantically related word recall, semantically unrelated word recall and non-word recall.

3.1 Participants

Sixty neurotypical healthy adults in the age range of 40 years to 70 years in three age groups i.e. 41-50, 51-60 and 61-70 years were taken up for the study. In each group 20 participants were taken. All participants were native speakers of Hindi. A written consent was taken from all the participants.

3.1.1 Inclusive criteria

Participants were screened with Mini Mental State Examination, MMSE (Folstein, Folstein & McHugh, 1975) to rule out pre-existing memory disturbances if any. Participant scoring greater than or equal to 25 on the MMSE were taken up for the study. All participants had a minimum primary school education and were able to read and write in Hindi. All participants were physically fit during the testing period. Also the demographic

details of the participants were taken (hypertension, diabetes, etc.). Informal hearing screening was carried out for the participants to rule out hearing.

3.2 Stimulus preparation and presentation:

3.2.1 Test conditions

The stimulus is presented through auditory and visual mode. All stimuli were presented in Hindi. The auditory stimuli was recorded using PRAAT software (version 6.0.20) in quiet environment and was presented through headphones. Visual stimuli was presented through PowerPoint with white background in Devanagari script in bold font with ninety six font size. A string of seven units were presented one after the other with each having inter stimulus duration of 1000 msec except the 4 syllable words and non-words having the inter stimulus interval of 2000 msec. In auditory stimuli before first and after last word in the series the beep sound was presented to indicate the starting and ending of the string respectively. Also in visual stimuli the red slide was used to indicate the same. The test was carried out in 4 conditions which include;

i. Auditory free recall
ii. Auditory serial recall
iii. Visual free recall
iv. Visual serial recall

3.3 Materials

1. **Word recall:** It has 2 subtasks with varying syllable length. These words were taken from Lingustic profile test (LPT) Hindi Normative Data For Children in

grades I to X (Monika & Karnath, 1995), An adaptation of early reading skills (ERS) in Hindi (Brajesh & Goswami, 2011-2012) & Sandarbh-Mulak Shabd-Kosh Hindi-English, (Gaba, 1986) (materials used for the different tasks and their source are describes below in figure 3.2)

Three word syllable recall: eg., /ʈʌmɑʈʌr/, /kʌbʊtʌr/.

Four word syllable recall: eg., /mʌhɑsɑgʌr/, /ʌpʌrɑdʒit/ (these words were taken from different literature books and various existing test materials from Hindi language; Linguistic profile test (LPT) Hindi Normative Data For Children in grades I to X (Monika & Karnath, 1995); An adaptation of early reading skills (ERS) in Hindi (Brajesh & Goswami, 2011-2012); Sandarbh-Mulak Shabd-Kosh Hindi-English (Gaba, 1986)).

2. Semantically related words: Here words were presented from the semantically same category (these words were taken from Manual for Adult Non Fluent Aphasic Therapy in Hindi (Richa & Goswami, 2004)). Eg., /seb/, /ʌnar/.
3. Sematically unrelated words: In this set of the words, semantically different category (these words were taken from Manual for Adult Non Fluent Aphasic Therapy in Hindi (Richa & Goswami, 2004)). Eg., /nani/, /pʌsinɑ/.
4. Non words: In this the participants were asked to recall the non-words of 3-5 syllable length words. In this the non-words were constructed by selecting the meaningful words from Sandarbh-Mulak Shabd-Kosh Hindi-English (Gaba, 1986). Also the guidelines were taken from the dissertation on Non-word Repetition in Children with Language Impairment (Shylaja & Swapna, 2010). Eg., /kadʒarin/, /ɖimokuni/.

Total of 36 words were taken in each of the subtask and those words were validated by 5 speech and language pathologist whose native language was Hindi and the list is appended (Appendix II).

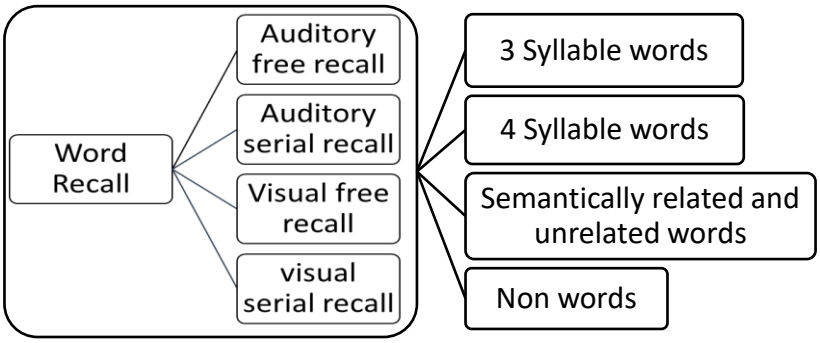


Figure 3.1. Depiction of test conditions and tasks.

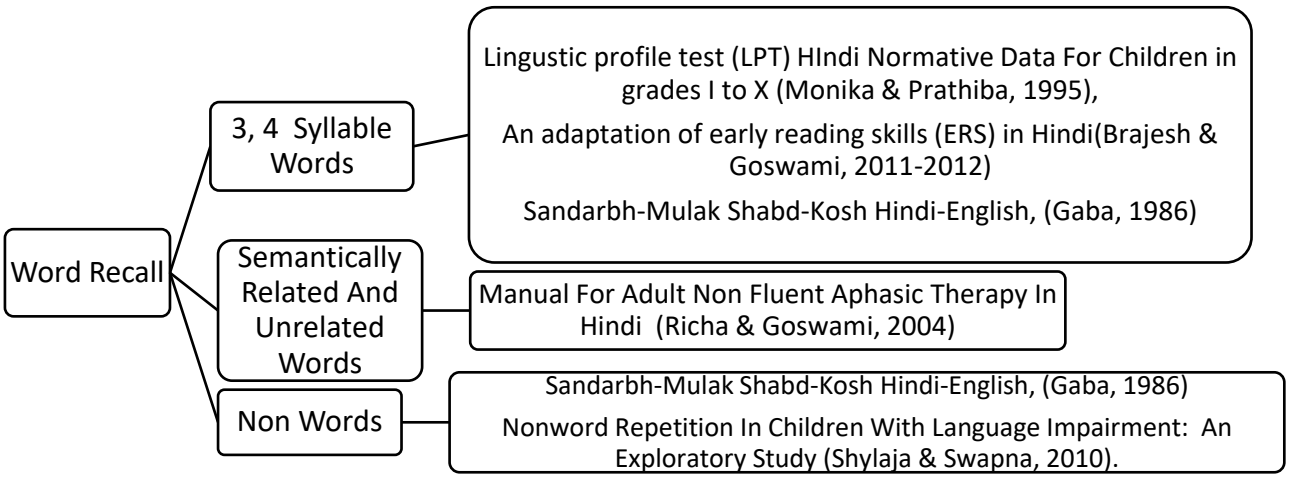


Figure 3.2. Summary of material adopted for the study.

3.4 Procedure

The testing was done in a quiet and non-distracting environment. This was carried out in two phases:

Training phase: In this phase two practice trials were given to the participants before presenting the test items in auditory and visual modality under each of the condition i.e. free and serial order recall. After this training phase, participants were presented with the test items. Materials that were used for the practice trials were not included in the test trials. However, they were constructed in similar ways to the stimulus used in testing phase.

Testing phase: Participants were tested individually within one session lasting for about 20 minutes. They were made to sit in front of computer about 50 cm away from the screen in a comfortable posture. The stimuli was presented in the auditory mode through headphones and visual mode through the PowerPoint presentation. A string of 7 units were presented one after the other, with each having inter stimulus duration of 1000 msec except the 4 syllable words and non-words having the inter stimulus interval of 2000 msec. The test was carried out in order of auditory serial recall, auditory free recall, visual serial recall and visual free recall across 5 tasks (3 syllable & 4 syllable word recall, semantically related word recall, semantically unrelated word recall & non-word recall).

The study included the following conditions and the summary of the test conditions and tasks are depicted in the figure 3.3 below;

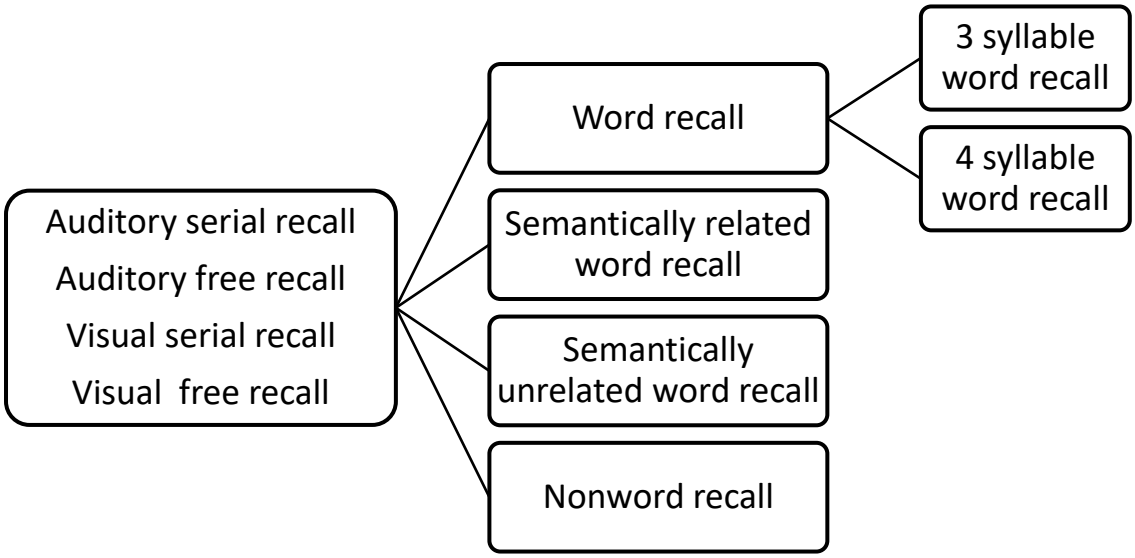


Figure 3.3. Summary of test conditions.

3.5 Analysis and scoring

Quantitative and Qualitative analysis of the data was carried out.

Quantitative Analysis: A maximum score of '1' was given for each set that is recalled appropriately and a score of '0' was given if the participants recall is not appropriate at any level. Scoring was done separately for immediate recall and delayed recall. Codes for scoring was used as V for visual recall, A for auditory recall, S for serial recall and F for free recall.

Qualitative Analysis: The responses were audio recorded for each of the task. The error responses were analyzed in terms of the type of error exhibited by the participants and also for the serial position effects.

The data was coded, tabulated and subjected to Statistical Analysis Using Statistical Package for Social Sciences SPSS version 17.0.

Chapter 4

RESULTS AND DISCUSSION

The main aim of the study is to analyze age related changes in free and serial recall when stimuli is presented auditorily and visually. In this for different conditions were considered i.e. auditory serial recall, auditory free recall, visual serial recall & visual free recall across the 5 different sets of tasks i.e. 3 syllable words, 4 syllable words, semantically related words, semantically unrelated words & non-words as stimuli. Total of 60 participants were taken up for the study and were divided into 3 groups i.e. age group 1 from 41-50, age group 2 from 51-60 & age group 3 from 61-70 years with each group consists of 20 participants in it. Qualitative and quantitative analysis were carried out in which quantitative analysis was done using Statistical Package for Social Sciences (SPSS) software version 17.0. The *p* value obtained was <0.05 depicting that the data was non-normally distributed or skewed. As the data was not-normally distributed and was not meeting the assumptions of parametric tests, non-parametric test statistics was applied. It was used to compare the performance of participants on visual and auditory recall tasks.

The objectives of the study are as follows:

1. To compare visual and auditory recall in neurotypical older adults individuals across the age groups
2. To study visual and auditory recall abilities for free and serial recall

3. To compare the visual and auditory recall pattern for different linguistic complexity level and serial position effects associated with recall task i.e. primacy and recency effect.

The results of the study are discussed under the following headings;

A) Quantitative analysis

For objective 1; a) Comparison of visual and auditory recall abilities across the different age groups of neurotypical adults.

b) Comparison of visual and auditory recall abilities across the gender within age groups

For objective 2; Comparison of visual and auditory recall abilities for free and serial recall across the age groups of neurotypical older adults.

For objective 3(a); Comparison of visual and auditory recall abilities for free and serial recall across the different linguistic complexity levels (semantically related, semantically unrelated, 3 syllable, 4 syllable and non-words)

B) Qualitative analysis

For objective 3(b); Recency and primacy effect during recall and errors analysis during recall across the age groups were qualitatively analyzed.

A) Quantitative analysis

Objective 1

a) Comparison of visual and auditory recall abilities across the different age groups of neurotypical older adults

The mean, SD and median values have been extracted and shown in the table 4.10. Check of normality was done using Shapiro-Wilks test on the data obtained and it was found that the data does not follow the normality. Statistical analysis was done to find out the difference in age group using non-parametric test.

To compare between the age group which task is better, initially Kruskal-Wallis test was administered to check if there was any significant difference between the age groups for each tasks (table 4.1). The decreasing trend in mean ranks was observed between the age groups for each tasks. The significant difference was found only for the following tasks (Chi-square values) i.e. Visual free semantically related, Visual free semantically unrelated, Visual free 3 syllable, Visual free 4 syllable, Visual serial semantically related, Auditory free semantically unrelated, Auditory free 3 syllable, Auditory free 4 syllable and Auditory serial semantically related ($p<0.05$).

Table 4.1

Chi-Square scores and p value (Kruskal-Wallis test) for overall age group

	Chi-Square	***p* value**
Visual free semantically related	22.03*	0.000
Visual free semantically unrelated	7.84*	0.020
Visual free 3 syllable	10.13*	0.006
Visual free 4 syllable	7.90*	0.019
Visual free non-words	4.75	0.093
Visual serial semantically related	11.02*	0.004
Visual serial semantically unrelated	0.97	0.613
Visual serial 3 syllable	2.18	0.336
Visual serial 4 syllable	1.95	0.377
Visual serial non-words	3.73	0.154
Auditory free semantically related	4.96	0.084
Auditory free semantically unrelated	13.41*	0.001
Auditory free 3 syllable	8.16*	0.017

Auditory free 4 syllable	6.04*	0.049
Auditory free non-words	1.26	0.532
Auditory serial semantically related	6.23*	0.044
Auditory serial semantically unrelated	5.68	0.058
Auditory serial 3 syllable	1.36	0.506
Auditory serial 4 syllable	0.71	0.699
Auditory serial non-words	0.61	0.735

*Chi-square values shows significant difference ($p<0.05$)

Further statistical analysis was carried out to see the significant difference by comparing each of the groups with respect to the task.

Comparing age group 1 and 2: Non-parametric Man Whitney U test was done for age 1 and age 2 as the data did not follow the normal distribution. Only the task which showed significant difference on Kruskal-Wallis test was taken up in Mann-Whitney U test. /Z/ values are shown in the table 4.2. It revealed that there is significant difference between visual free semantically related, visual free semantically unrelated, and auditory serial semantically related tasks ($p<0.05$). The results revealed that age group 1 performed better than age group 2 on the above tasks as seen in mean ranks.

Table 4.2

/Z/ scores and p value (Mann-Whitney U Test) for age group 1 and 2

	/Z/	***p* value**
Visual free semantically related	1.99*	0.046
Visual free semantically unrelated	2.35*	0.018
Visual free 3 syllable	0.21	0.833
Visual free 4 syllable	1.35	0.175
Visual serial semantically related	0.92	0.356
Auditory free semantically unrelated	0.11	0.907
Auditory free 3 syllable	0.23	0.811
Auditory free 4 syllable	0.12	0.899
Auditory serial semantically related	1.99*	0.046

*/Z/ values shows significant difference ($p<0.05$)

Comparing age 1 and age 3: Non-parametric Man Whitney U test was done for age 1 and age 3 as the data did not follow the normal distribution. Only the task which showed significant difference on Kruskal-Wallis test was taken up in Mann-Whitney U test. /Z/ values are shown in the table 4.3. It revealed that there is significant difference between all

task (p<0.05) except visual free 4 syllable. The results revealed that age group 1 performed better than age group 3 on the above tasks.

Table 4.3

/Z/ scores and p value (Mann-Whitney U Test) for age group 1 and 3

	/Z/	***p* value**
Visual free semantically related	4.07*	0.000
Visual free semantically unrelated	2.46*	0.014
Visual free 3 syllable	2.67*	0.008
Visual free 4 syllable	1.41	0.157
Visual serial semantically related	2.86*	0.004
Auditory free semantically unrelated	3.08*	0.002
Auditory free 3 syllable	2.16*	0.030
Auditory free 4 syllable	2.22*	0.026
Auditory serial semantically related	2.24*	0.024

*/Z/ values shows significant difference (p<0.05)

Comparing age 2 and age 3: Non-parametric Man Whitney U test was done for age 2 and age 3 as the data did not follow the normal distribution. Only the task which showed significant difference on Kruskal-Wallis test was taken up in Mann-Whitney U test. /Z/ values are shown in the table 4.4. It revealed that except visual free semantically unrelated

task all showed significant difference (p<0.05). The result revealed that age group 2 performed better than age group 3 on the above tasks.

Table 4.4

/Z/ scores and p value (Mann-Whitney U Test) for age group 2 and 3

	/Z/	***p* value**
Visual free semantically related	3.69*	0.000
Visual free semantically unrelated	0.22	0.820
Visual free 3 syllable	2.81*	0.005
Visual free 4 syllable	2.82*	0.005
Visual serial semantically related	2.76*	0.006
Auditory free semantically unrelated	3.24*	0.001
Auditory free 3 syllable	2.75*	0.006
Auditory free 4 syllable	2.06*	0.039
Auditory serial semantically related	1.96*	0.049

*/Z/ values shows significant difference (p<0.05)

So overall it was observed that, age group 1-3 showed more difference than age group 2-3 following age group 1-2. The overall performance of age group 1 was superior following group 2 and the age group 3. Which shows the gradual decline in the performance from age group 1 to age group 3.

The decline is the scores are observed in recall abilities with respect to the age. Where age group 1 performed better than other age groups. This can be interpreted based on the neurological and morphological changes associated with normal aging which decline overall brain volume, cortical thinning and grayal atrophy (Raz et al., 1997). Also the decline in cognitive processing or functions like speed of information processing (Sathouse, 1996), lack of inhibition or poor memory capacity (Craik, Morris & Gick, 1990). According to Raz et al., 1997 the prominent changes due to aging are seen in the prefrontal cortex (PFC), an area often attributed to the process of recall attempt (Tulving, 1983), it can be implied that decline in recall abilities with aging can be due to this atrophy in PFC. With increasing age, there can be difficulties in the representation, retention, and/or revising of context in the working memory, which are important for recalling. Another support is derived from Kyanette et al., (1990) study which indicated that with aging the recitation rate slows down. So it can be assumed that the older adults will have difficulty to rehearse more items in the short time span because of slow recitation rate.

b) Comparison of females and males across age groups:

The mean, SD and median values have been extracted and shown in the appendix 1. Total mean, SD and median values for task is given in table 4.5. Shapiro-Wilks test was done and was found that data does not follow normality. Statistical analysis was done to find the overall gender difference using non-parametric Mann-Whitney U test which revealed that there is no significant difference between the genders. Further statistical analysis was done the find the gender difference within each age group using Mann-Whitney U test. It revealed no gender difference in all the three age groups, so the gender was compiled for further analysis.

Table 4.5

Total mean, SD and Median for age group 1, 2 and 3 (n=60) across the tasks

	Mean	**SD**	**Median**
Visual free semantically related	5.38	1.02	5.00
Visual free semantically unrelated	3.78	1.12	4.00
Visual free 3 syllable	3.11	1.26	3.00
Visual free 4 syllable	2.80	1.03	3.00
Visual free non-words	0.48	0.65	0.00
Visual serial semantically related	2.38	1.13	2.00
Visual serial semantically unrelated	1.78	1.00	2.00
Visual serial 3 syllable	1.71	0.92	2.00
Visual serial 4 syllable	0.81	0.81	1.00
Visual serial non-words	0.08	0.33	0.00
Auditory free semantically related	5.66	1.203	6.00
Auditory free semantically unrelated	4.60	0.88	5.00
Auditory free 3 syllable	3.78	1.15	4.00

Auditory free 4 syllable	3.11	1.05	3.00
Auditory free non-words	0.75	0.81	1.00
Auditory serial semantically related	3.45	1.48	3.00
Auditory serial semantically unrelated	1.86	1.04	2.00
Auditory serial 3 syllable	1.66	1.18	2.00
Auditory serial 4 syllable	1.53	1.14	1.00
Auditory serial non-words	0.20	0.40	0.00

With respect to the gender, there was no difference observed. In literature there are mixed results for gender effect in recall. Resnick et al., (2000) suggested that this may be due to equal changes in cerebral volume in males and females associated with the normal aging process.

Objective 2

Comparison of visual and auditory recall abilities for free and serial recall across the age groups of neurotypical older adults

To see out of four conditions i.e. visual free recall, visual serial recall, auditory free recall and auditory serial recall which one is better within each age group separately, the totals are taken out of 35 (as there are 5 tasks in each conditions with highest scoring of 7 for each task) and normality was tested. Check of normality was done using Shapiro-Wilks test on the data obtained and it was found that there was normality (p>0.05) for four conditions (visual free recall, visual serial recall, auditory free recall and auditory serial recall). As a result parametric test was done followed by Bonferroni multiple comparison to analyze the significant difference, if any. The mean percent values, standard deviation and median values were derived and is indicated in the table 4.6 and also the graph is given in the figure 4.1.

Now, considering four conditions visual free recall, visual serial recall, auditory free recall and auditory serial recall the interest is in knowing which out of the four is giving better results. Hence, one way repeated measure ANOVA is done to compare four conditions within each age group separately.

Table 4.6

Mean, SD and Median for age group 1, 2 and 3 (n=60) across the age groups and four conditions

	Age range	Mean	SD	Median
Visual free recall	41-50	17.65	3.31	18.00
	51-60	16.10	2.57	16.50
	61-70	12.95	2.94	13.00
Visual serial recall	41-50	8.15	2.70	8.00
	51-60	6.70	2.47	7.00
	61-70	5.50	2.18	5.00
Auditory free recall	41-50	19.30	3.07	20.00
	51-60	18.50	3.56	18.50
	61-70	15.95	2.72	16.00
Auditory serial recall	41-50	10.30	3.82	10.00
	51-60	8.45	2.68	9.00
	61-70	7.40	3.21	6.50

Figure 4.1 Mean scores of visual free recall, visual serial recall, auditory free recall and auditory serial recall

One way repeated measure ANOVA was done within the age group to see which condition is better.

Age group 1: The analysis of results shows that the mean percent score of auditory free recall and visual free recall were higher than other two conditions i.e. visual serial recall and auditory free recall. There was a significant difference between the 4 conditions within the age group 1 at F (3, 57) = 67.575, $p<0.01$. Estimated marginal means was calculated for pairwise comparison (table 4.7). Which shows that there was no statistically significant difference between condition 1 and 3 and condition 2 and 4. Which reveals that visual free recall scores are better than other two conditions except condition 3 and auditory free recall is better than other two conditions except condition 1.

Table 4.7

F score and p values (one way repeated measure ANOVA) for age group 1

Age 1		Mean difference	*p* value
	Condition 2	9.50*	0.00
Condition 1	Condition 3	1.65	0.64
	Condition 4	7.35*	0.00
	Condition 1	9.50*	0.00
Condition 2	Condition 3	11.15*	0.00
	Condition 4	2.15	0.23
	Condition 1	1.65	0.64
Condition 3	Condition 2	11.15*	0.00
	Condition 4	9.00*	0.00
	Condition 1	7.35*	0.00
Condition 4	Condition 2	2.15	0.23
	Condition 3	9.00*	0.00

*shows significant difference ($p<0.05$)
Note: Condition 1-visual free serial recall, Condition 2- visual serial recall, Condition 3- auditory free recall, Condition 4- auditory serial recall

Age group 2: The analysis of results shows that the mean score of auditory free recall ad visual free recall were higher than other two conditions. There was a significant difference between the 4 conditions within the age group 2 at F (3, 57) = 170.580, $p<0.01$. Estimated marginal means was calculated for pairwise comparison (table 4.8). Which shows that there was statistically significant difference between all the conditions. Overall scores reveals that auditory free recall is better than other conditions.

Table 4.8

F score and p values (one way repeated measure ANOVA) for age group 2

Age 2		Mean difference	*p* value
	Condition 2	9.40*	0.00
Condition 1	Condition 3	2.40*	0.01
	Condition 4	7.65*	0.00
	Condition 1	9.40*	0.00
Condition 2	Condition 3	11.8*	0.00
	Condition 4	1.75*	0.03
	Condition 1	2.40*	0.01
Condition 3	Condition 2	11.8*	0.00
	Condition 4	10.05*	0.00
	Condition 1	7.65*	0.00
Condition 4	Condition 2	1.75*	0.03
	Condition 3	10.05*	0.00

*shows significant difference ($p<0.05$)
Note: Condition 1-visual free serial recall, Condition 2- visual serial recall, Condition 3- auditory free recall, Condition 4- auditory serial recall

Age group 3: The analysis of results shows that the mean score of auditory free recall ad visual free recall were higher than other two conditions. There was a significant difference between the 4 conditions within the age group 1 at F (3, 57) = 89.083, $p<0.01$. Estimated marginal means was calculated for pairwise comparison (table 4.9). Which shows that there was statistically significant difference between all conditions except between the condition 2 and 4. Overall scores reveals that auditory free recall is better than all other conditions.

Table 4.9

F score and p values (one way repeated measure ANOVA) for age group 3

Age 3		Mean difference	*p* value
	Condition 2	7.45*	0.00
Condition 1	Condition 3	3.00*	0.00
	Condition 4	5.55*	0.00
	Condition 1	7.45*	0.00
Condition 2	Condition 3	10.45*	0.00
	Condition 4	1.90	0.18
	Condition 1	3.00*	0.00
Condition 3	Condition 2	10.45*	0.00
	Condition 4	8.55*	0.00
	Condition 1	5.55*	0.00
Condition 4	Condition 2	1.90	0.18
	Condition 3	8.55*	0.00

*shows significant difference ($p<0.05$)

Note: Condition 1-visual free serial recall, Condition 2- visual serial recall, Condition 3- auditory free recall, Condition 4- auditory serial recall

From the results obtained, it can be inferred that auditory free recall abilities were significantly higher in all the neurotypical individuals in all the age groups as compared to other conditions i.e. visual free recall, visual serial recall and auditory serial recall. This finding is consistent with the other studies that reported as auditory recall being superior to visual presentation. As hypothesized by Sperling (1963) a primary function of a verbal rehearsal in visual memory task is to convert the information from visual memory to auditory storage. This means the memory traces are transformed and encoded in an auditory form, regardless of the sensory channel of perception. Therefore the rehearsal is less necessary in auditory than for visual presentation as no efforts are need to get the auditory input into the auditory storage (Jensen, 1971). Also the performance was better on free recall than serial recall irrespective of age. Because on serial recall the individual has to actively maintain and monitor the previous responses but in free recall individual has to do only an on-line storage and manipulation of the information, which is easy (Craik, Morris and Grick, 1990). The results are in consonance with Golomb et al., (2008) study which reported that temporal context information is necessary for serial recall.

Objective 3 (a)

Comparison of visual and auditory recall abilities for free and serial recall across the different complexity level

The mean, median and standard deviation score are given for all the age group with respect to different task in the following table 4.10.

Table 4.10

Mean, SD and Median values for all the age groups and tasks

		Age group 1			Age group 2			Age group 3		
		Mean	**SD**	**Median**	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**
Visual serial	**SR**	2.95	3.00	1.47	2.45	0.69	3.00	1.75	2.00	0.79
	SUR	2.00	1.17	2.00	1.75	0.97	2.00	1.60	0.88	2.00
	3sylb	2.00	1.08	2.00	1.60	0.94	2.00	1.55	0.69	2.00
	4sylb	1.00	0.97	1.00	0.85	0.75	1	0.60	0.68	0.50
	NW	0.20	0.52	0	0.05	0.22	0	0	0	0
Visual free	**SR**	6.05	0.99	6.00	5.55	0.69	5.00	4.55	0.76	4.00
	SUR	4.40	1.23	4.00	3.45	1.05	3.00	3.50	0.83	3.5
	3sylb	3.60	1.39	3.5	3.40	0.88	3.00	2.35	1.14	2.50

	4sylb	2.85	1.04	3.00	3.25	0.85	3.50	2.30	1.03	2
	NW	0.75	0.85	1.00	0.45	0.51	0.00	0.25	0.44	0
Auditory serial	**SR**	4.15	1.59	4.5	3.15	1.27	3	3.05	1.39	3
	SUR	2.2	1.11	2	2	0.92	2	1.4	0.99	2
	3sylb	1.95	1.69	2	1.65	0.93	2	1.4	0.75	1
	4sylb	1.85	1.66	1.5	1.45	0.69	1	1.3	0.80	1
	NW	0.15	0.37	0	0.2	0.41	0	0.25	0.44	0
Auditory free	**SR**	6.1	0.79	5	5.60	1.5	6	5.30	1.13	5
	SUR	4.9	0.85	5.0	4.9	0.72	5	4.0	0.79	4
	3sylb	4.1	1.21	4	4.1	0.97	4	3.15	1.04	3
	4sylb	3.3	1.3	3	3.35	1.04	3	2.7	0.66	3
	NW	0.9	1.16	0.5	0.55	0.51	1	0.8	0.62	1

Note: SR- semantically related, SUR- semantically unrelated, 3sylb- 3 syllable, 4sylb- 4 syllable, NW- non words

i) Comparison between Semantically related and Semantically unrelated words:

The mean median and standard deviation scores of recall of semantically related and unrelated words for each age group were computed in the table 4.10. The mean values were lowered for semantically unrelated words than semantically related words for all the age groups in visual serial, visual free, auditory serial and auditory free recall tasks. Median scores also were in the same directions as mean scores.

Wilcoxon singed rank test was used for further statistical analysis to test the significance between the semantically related and unrelated words scores across the age groups with the different tasks. The /Z/ scores and *p* values are as shown in the table 4.11.

It is evident from the table that recall abilities for semantically related words are superior to the recall abilities of semantically unrelated words in all the age groups in visual free , auditory serial and auditory free recall tasks except visual serial semantically related and unrelated task for age group 1 and 3.

Table 4.11

/Z/ score and p value (Wilcoxon Signed Rank Test) for comparison between semantically related and unrelated words

	Age 1		**Age 2**		**Age 3**	
	/Z/	***p* value**	***/Z/***	***p* value**	***/Z/***	***p* value**
Visual free semantically unrelated - Visual free semantically related	3.57*	0.00	3.67*	0.00	3.23*	0.001
Visual serial semantically unrelated - Visual serial semantically related	1.92	0.055	2.33*	0.019	0.57	0.56
Auditory free semantically unrelated - Auditory free semantically related	3.75*	0.00	2.24*	0.025	3.22*	0.001
Auditory serial semantically unrelated - Auditory serial semantically related	3.25*	0.001	3.08*	0.002	3.44*	0.001

*shows significant difference ($p<0.05$)

(Note: VSSR-Visual Serial Semantically Related, VSSUR- Visual Serial Semantically Unrelated, VFSR-Visual Free Semantically Related, VFSUR- Visual Free Semantically Unrelated, ASSR- Auditory Serial Semantically Related, ASSUR- Auditory Serial Semantically Unrelated, AFSR- Auditory Free Semantically Related, AFSUR- Auditory Free Semantically Unrelated)

*Figure 4.*2 Mean scores of semantically unrelated and related words in visual serial, visual free, auditory serial and auditory free recall tasks

The results shows that the recall ability was better for semantically related words compared to unrelated words in all the age groups. Items from the related category can be recalled well as it contributes to the increased probability of recalling the long term representation from lexical category. This is because of the category gives the retrieval cue (Crowder, 1979; Poirier & saint-Aubin, 1995; Saint-Aubin & Poirier, 1999). Reaction time studies have also yielded similar results, wherein the reaction time for semantically related words were better compared to unrelated words, which attributed to the semantic priming effects (Krishnan & Tiwari, 2010).

ii) Comparison between 3 and 4 syllable words:

The mean, SD and median score for the stimuli of different syllable length are specified in the table 4.10. It can be inferred from the table that mean scores of the 3 syllable words is superior than that of the 4 syllable words in all the age groups for all the conditions.

Further statistical analysis i.e. Wilcoxon Signed rank test was done to see the significant difference between the 3 syllable and 4 syllable words for each of the age groups for all the 4 conditions. The /Z/ scores and p values are shown in the table 4.12.

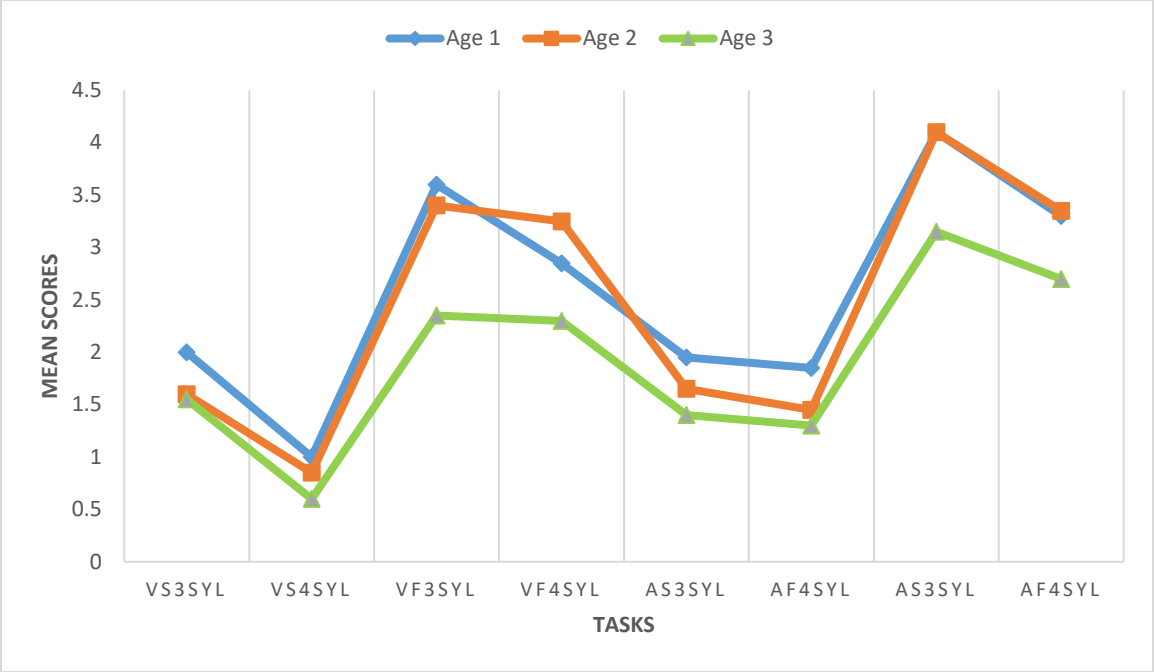
It is evident from the table that the 3 syllable words are superior to the 4 syllable words for all the conditions in all the age groups except visual free for age group 2 and 3 & auditory serial for all the age group showed no significant difference.

Table 4.12

/Z/ score and p value (Wilcoxon Signed Rank Test) for comparison between 3 and 4 syllable words

	Age 1		**Age 2**		**Age 3**	
	/Z/	***p* value**	**/Z/**	***p* value**	**/Z/**	***p* value**
Visual free 4 syllable - Visual free 3 syllable	1.99*	0.047	0.66	0.50	0.08	0.93
Visual serial 4 syllable - Visual serial 3 syllable	2.61*	0.009	2.83*	0.005	3.21*	0.001
Auditory free 4 syllable - Auditory free 3 syllable	2.00*	0.046	2.91*	0.004	2.13*	0.033
Auditory serial 4 syllable - Auditory serial 3 syllable	0.35*	0.72	1.08	0.27	0.57	0 .56

*shows significant difference ($p<0.05$)



(*Note: VS3SYL-Visual Serial 3 Syllable, VS4SYL- Visual Serial 4 Syllable, VF3SYL- Visual free 3 Syllable, VF4SYL- Visual Free 4 Syllable, AS3SYL- Auditory Serial 3 Syllable, AF4SYL- Auditory Free 4 Syllable, AS3SYL- Auditory Serial 3 Syllable, AF4SYL- Auditory Free 4 Syllable)*

Figure 4.3 Mean scores of 3 and 4 syllable words in visual serial, visual free, auditory serial and auditory free recall tasks.

The findings of the study highlight that the recall of 3 syllable words were recalled well than 4 syllable words in all the age groups. 3 syllable words require less pronunciation time and so can be held up in the phonological store of the phonological loop and can be rehearsed more times. Miller (1979) hypothesized that the working memory has a limited capacity and that it depends upon the number of items, which was contradicted by Baddeley (1975) with the pronunciation-time hypothesis. Baddeley (1975) opined that the capacity is not determined by the number of items but determined by the limited time for which the verbal trace of the item endures and in the amount of rehearsal. In case of 4 syllable words only 1-3 items can be rehearsed whereas for 3 syllable words more items can be rehearsed

in a given time and hence better recall abilities. The results obtained for this objective study favors Baddeley (1975) findings.

iii) Comparison between serial and free Semantically related and Semantically unrelated words:

The mean, SD and median score were extracted for all the age group for all the conditions. The scores are shown in table 4.13. As shown in the table the mean scores values for free recall is better in all the age groups for visual and auditory task for semantically related and unrelated tasks.

Wilcoxon signed rank test was carried out to test the significance between the pairs. The /Z/ score and *p* values are shown in the table 4.13.

Overall the performance of free recall is superior in all the age groups compared to serial recall

Table 4.13

/Z/ score and p value (Wilcoxon Signed Rank Test) for serial and free semantically related and unrelated words

	Age 1		**Age 2**		**Age 3**	
	/Z/	***p* value**	**/Z/**	***p* value**	**/Z/**	***p* value**
Visual serial semantically related - Visual free semantically related	3.74*	0.000	3.98*	0.000	3.96*	0.000
Visual serial semantically unrelated - Visual free semantically unrelated	3.75*	0.000	3.88*	0.000	3.78*	0.000
Auditory serial semantically related - Auditory free semantically related	3.52*	0.000	3.84*	0.000	3.63*	0.000
Auditory serial semantically unrelated - Auditory free semantically unrelated	3.75*	0.000	3.98*	0.000	3.98*	0.000

*shows significant difference ($p<0.05$)

iv) Comparison between 3 and 4 syllable words for serial and free recall:

The mean, SD and median score were extracted for all the age group for all the conditions. The scores are shown in table 4.10. As seen, the mean scores values for free recall is better in all the age groups for visual and auditory task for 3 syllable word and 4 syllable word tasks.

Wilcoxon signed rank test was carried out to test the significance between the pairs. The /Z/ scores and *p* values are shown in the table 4.14.

Overall the performance of free recall is superior in all the age groups compared to serial recall

Table 4.14

/Z/ score and p value (Wilcoxon Signed Rank Test) for free and serial recall of 3 and 4 syllable

	Age 1		**Age 2**		**Age 3**	
	/Z/	***p* value**	***/Z/***	***p* value**	***/Z/***	***p* value**
Visual serial 3 syllable - Visual free 3 syllable	2.99*	0.003	3.76*	0.000	2.38*	0.017
Visual serial 4 syllable - Visual free 4 syllable	3.54*	0.000	3.89*	0.000	3.89*	0.000
Auditory serial 3 syllable - Auditory free 3 syllable	3.69*	0.000	3.98*	0.000	3.46*	0.001
Auditory serial 4 syllable - Auditory free 4 syllable	2.93*	0.003	3.86*	0.000	3.83*	0.000

*shows significant difference ($p<0.05$)

v) Comparison between auditory or visual serial and free with semantically related and unrelated words:

The mean, SD and median score were extracted for all the age group for all the conditions. The scores are shown in table 4.10. As shown in the table the mean scores for auditory recall is better than visual recall for all the age groups, expect age group 3 for ASSUR and VSSUR.

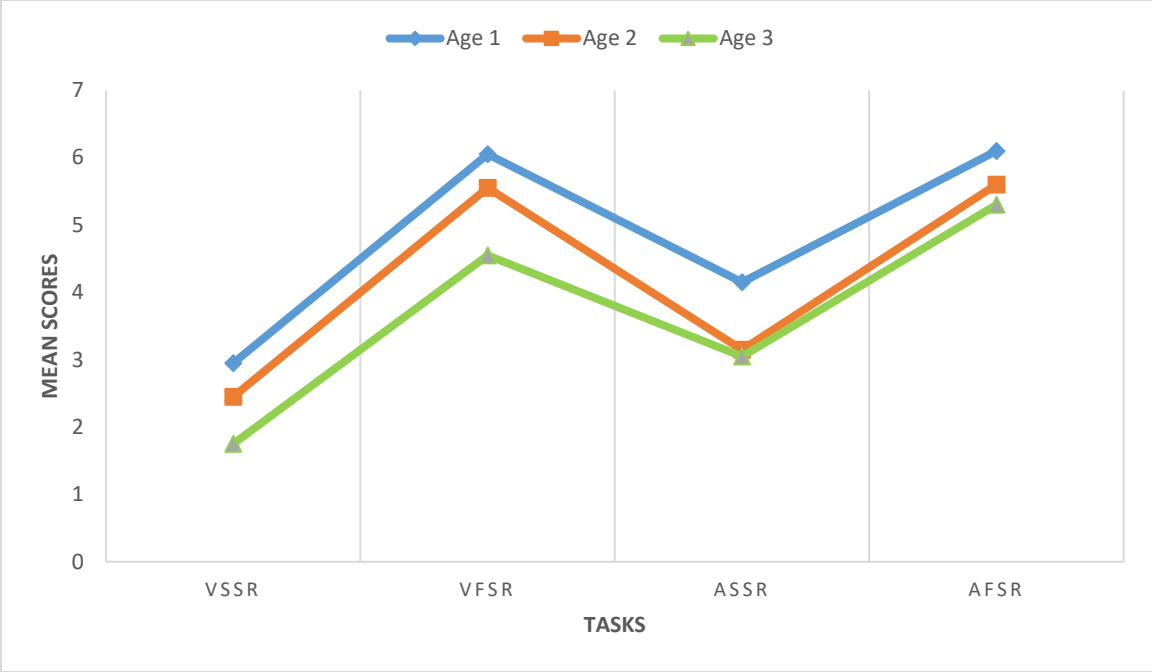
Wilcoxon signed rank test was carried out to test the significance between the pairs. The /Z/ scores and *p* values are shown in the table 4.15. The significant difference was found in ASSR-VSSR for all the age groups; AFSR-VFSR for only age group 3 and AFSUR-VFSUR for only age group 2 and 3.

Table 4.15

/Z/ score and p value (Wilcoxon Signed Rank Test) for comparison between auditory or visual serial and free with semantically related and unrelated words

	Age 1		**Age 2**		**Age 3**	
	/Z/	***p* value**	***/Z/***	***p* value**	***/Z/***	***p* value**
Auditory serial semantically related - Visual serial semantically related	2.31*	0.021	2.16*	0.030	2.97*	0.003
Auditory serial semantically unrelated - Visual serial semantically unrelated	0.69	0.490	1.07	0.281	0.82	0.411
Auditory free semantically related - Visual free semantically related	0.05	0.953	0.15	0.874	2.98*	0.003
Auditory free semantically unrelated - Visual free semantically unrelated	1.48	0.139	3.81*	0.000	2.06*	0.039

*shows significant difference ($p<0.05$)



(Note: VSSR-Visual Serial Semantically Related, VFSR- Visual Free Semantically Related, ASSR- Auditory Serial Semantically Related, AFSR- Auditory Free Semantically Related)

Figure 4.4 Mean scores of semantically related words in visual serial, visual free, auditory serial and auditory free recall tasks

The overall findings shows that auditory free semantically related recall is better than any other conditions as specified above. The results show that the recall ability was better for semantically related words compared to unrelated words in all the age groups. Items from the related category can be recalled well as it contributes to the increased probability of recalling the long term representation from lexical category. This is because of the category gives the retrieval cue (Crowder, 1979; Poirier & Saint-Aubin, 1995; Saint-Aubin & Poirier, 1999). Reaction time studies have also yielded similar results, wherein the reaction time for semantically related words were better compared to unrelated words, the fact attributed to the semantic priming effects (Krishnan & Tiwari, 2010).

vi) Comparison between auditory or visual serial and free with 3 syllable and 4 syllable words

The mean, SD and median score were extracted for all the age group for all the conditions given in table 4.10. The scores are shown in table. Wilcoxon signed rank test was carried out to test the significance between the pairs. The /Z/ scores and *p* values are shown in the table 4.16. There is significant difference between the AF3sy-VF3sy and AS4sy-VS4sy for age group 2 and 3. The overall score shows that the auditory free recall is superior to any other conditions.

Table 4.16

/Z/ score and p value (Wilcoxon Signed Rank Test) for comparison between auditory or visual serial and free with 3 and 4 syllable words

	Age 1		**Age 2**		**Age 3**	
	/Z/	***p* value**	***/Z/***	***p* value**	***/Z/***	***p* value**
Auditory free 3 syllable - Visual free 3 syllable	1.33	0.183	2.82*	0.005	2.38*	0.017
Auditory free 4 syllable - Visual free 4 syllable	1.06	0.286	0.48	0.627	1.79	0.073
Auditory serial 3 syllable - Visual serial 3 syllable	0.09	0.924	0.40	0.684	0.72	0.470
Auditory serial 4 syllable - Visual serial 4 syllable	1.72	0.084	2.82*	0.005	2.56*	0.010

*shows significant difference ($p<0.05$)

vii) Comparison between words and non-words:

The total words i.e. 3 syllable and 4 syllable words were added together and converted to the percentage and also the non-words were converted to the percentage to see the difference. The mean percentage value, SD and median were extracted and are shown in the following table 4.17.

Table 4.17

Mean, SD and Median values for words and non-words

	Age	Mean	SD	Median
	41-50	46.07	13.20	42.85
VFWPER	51-60	47.50	10.43	46.42
	61-70	33.21	13.56	32.14
	41-50	21.42	10.61	21.42
VSWPER	51-60	17.50	10.22	14.28
	61-70	15.35	7.05	14.28
	41-50	52.85	13.59	57.14
AFWPER	51-60	53.21	12.58	53.57
	61-70	41.78	10.93	42.85
	41-50	27.14	21.44	21.42
ASWPER	51-60	22.14	10.33	21.42
	61-70	19.28	9.58	17.85
VFNWPER	41-50	10.71	12.15	14.28

	51-60	6.42	7.29	0.00
	61-70	3.57	6.34	0.00
	41-50	2.85	7.47	0.00
VSNWPER	51-60	0.71	3.19	0.00
	61-70	0.00	0.00	0.00
	41-50	12.85	16.64	7.14
AFNWPER	51-60	7.85	7.29	14.28
	61-70	11.42	8.79	14.28
	41-50	2.14	5.23	0.00
ASNWPER	51-60	2.85	5.86	0.00
	61-70	3.57	6.34	0.00

Note: VFWPER- Visual Free Word Percentage, VSWPER- Visual Serial Word Percentage, AFWPER- Auditory Free Word Percentage, ASWPER- Auditory serial Word Percentage, VFNWPER- Visual Free Non-Word Percentage, VSNWPER- Visual Serial Non-Word Percentage, AFNWPER- Auditory Free Non-Word Percentage, ASNWPER- Auditory Serial Non-Word Percentage.

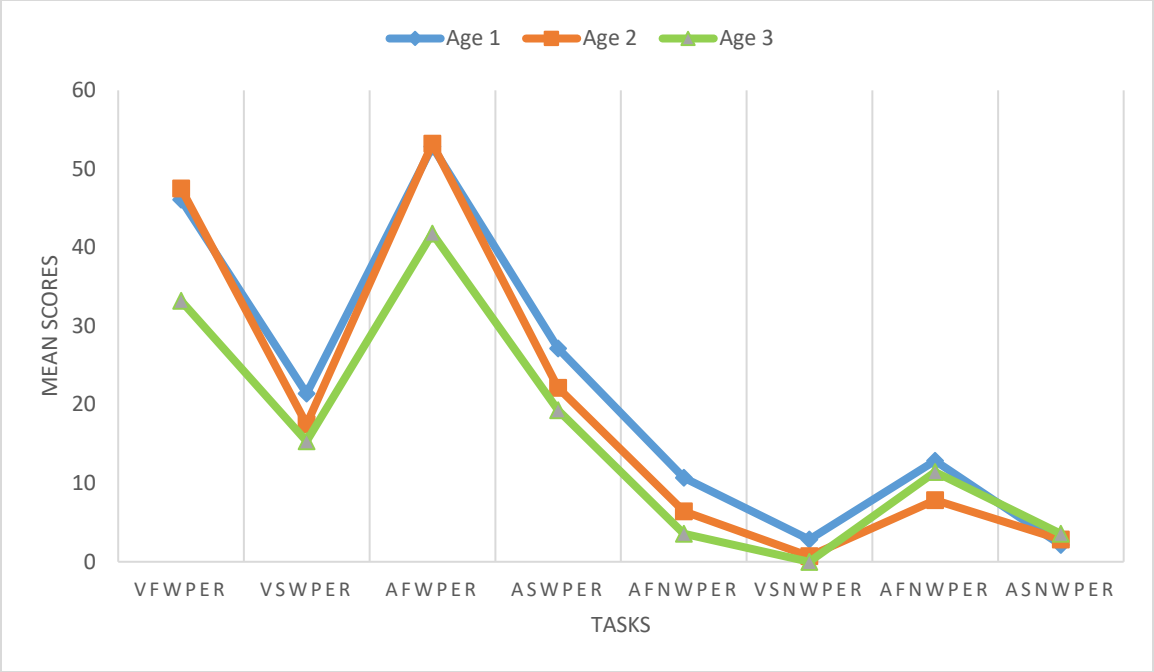


Figure 4.5 Mean percent scores of words and non-words

Age wise Wilcoxon signed rank test was done to see the significant difference between the words and non-words for free and serial visual and auditory recall. The values are shown in table 4.18 and the mean values are shown in figure 4.5. The significant difference was found between all the variables for all the age groups, in which words are superior to non-words.

Table 4.18

/Z/ score and p value (Wilcoxon Signed Rank Test) for comparison between words and non-words.

	Age 1		**Age 2**		**Age 3**	
	/Z/	***p* value**	***/Z/***	***p* value**	***/Z/***	***p* value**
vfnwper - vfwper	3.93*	0.000	3.93*	0.000	3.86*	0.000
vsnwper - vswper	3.74*	0.000	3.75*	0.000	3.87*	0.000
afnwper - afwper	3.85*	0.000	3.93*	0.000	3.94*	0.000
asnwper - aswper	3.53*	0.000	3.89*	0.000	3.97*	0.000

*shows significant difference ($p<0.05$)

The recall score was greater for words than for non-words in all the age groups. This can be because during word recall the long term semantic representation of the words also get activated and facilitated in recall. In non-word recall this semantic representation is not available (Schweikert, 1993). In recall of words the existing long term representations helps to reconstruct to be remembered items, which is not available in case of non-words. This supports the findings of study by Saint-Aubin and Poirier (2000) who reported that minimal long term representation for non-words is considered to be responsible for their lower item recall.

B) Qualitative analysis

Objective 3 (b)

Recency and Primacy effect during recall and error analysis during recall in individuals

Recency effect is where items presented at the end of the list may be recalled well at the beginning of recall. Primacy effect is where the first few items may be recalled better. It revealed that all age group individuals had more of recency effect for both the modalities.

The results for serial position effect for both the serial and free modality was checked. It was observed that in free recall the recency effect was more for all the age groups in both the modalities. Whereas in serial recall, the primacy effect was more for group 1 and 2 and in group 3 more of recency effect was observed. While during serial recall task the recency effect was less in age group 1 and 2 and it was more in age group 3. In all the age groups the recall of the middle items was comparatively poor.

In free recall, it was observed that all age group individuals initiated recall with the end of the list items, i.e. more of recency effect was seen (Murdock, 1976). Recency effect is related to the temporal context; if tested immediately, the current temporal context would serve as a retrieval cue, which in turn would predict more recent items to have an increased likelihood of recall, in contrast to items earlier in the list as these were studied in a different temporal context (Howard & Kahana, 2002).

In serial recall more of primacy effect was seen in all the age groups (Murdock, 1976). Primacy effect may be due to the fact that initial items in the list are effectively

stored in the long term memory because a greater amount of processing devoted to them. The lack of temporal organization indicated that older adults have deficits in maintaining order information (Howard & Kahana, 1999; Naveh-Benjamin, 2000; Howard, Naveh-Benjamin, Guez & Shulman, 2004; Kahana & Wingfield, 2006).

Further qualitative analysis was done which indicated that all the participants had omission, transposition and repetition errors during both auditory and visual recall abilities. Where more repetition error were found in group 3 as compared to group 1 and 2 in both the modalities. The phonological error were observed only in group 1. It may be because of the reconstruction process attempted by the lower age group individuals. As the information available in the trace starts to decay, they try to reconstruct it using the available phonological information. These will result in accurate recall only if the initial phoneme is available or if other cues are available with respect to the lexical nature of the target word. In the absence of these effects, phonological error occurs (Schiwicket, 1993). The transposition error were more found for visual recall than auditory modality. Transposition errors were seen can be because of the inability to maintain the correct order of the information (Cabeza et al., 2000). Also more repetition errors were found in higher age group as they had difficulty recalling the other items in a list. They are not able to bind contextual information available and hence try to recall the items from the list which was given earlier. Repetition errors can be due to the atrophy of pre frontal cortex (Raz et al., 1998).

In summary, the results of the present study revealed that there were differences in the recall abilities between the age groups and different type of modalities. Also, the aging effect was seen in the study were overall performance of age group 1 was better than age

group 2 following age group 3. Also between the modalities auditory modality was found to be superior to visual modality. Also the study was explored to see the relationship between the stimuli of different linguistic load and recall abilities. It was seen that the recall abilities were better for shorter syllable length words compared to longer syllable length words, semantically related words compared to semantically unrelated words, words were recalled better than non-words. Recall abilities were also compared across the types i.e. free and serial recall, which showed that recall was better for free than serial recall. Qualitative analysis revealed that primacy effect for serial recall was more in age group 1 and 2 than age group 3 & recency effect was more in group 3. Whereas in free recall, the recency effect was more in all the age groups. Participants had omission, transposition and repetition errors during both auditory and visual recall abilities. But the repetition errors were more for age group 3 and phonological error were only observed in group 1.

Chapter 5

SUMMARY AND CONCLUSION

Cognition refers to a set of mental activities that are involved in processing of memory, language, learning and speech. Learning about different cognitive processes helps us to understand how we acquire, store, retrieve and utilize knowledge (Matlin, 1983). Memory is a pivotal aspect of cognition. Until recently, memory has been studied only as a whole, hardly any attention has been lavished upon a substrate of memory process i.e. Recall.

Long term memory has a lot of information traces for many things and retrieving or recalling this information is challenging. The major factor which would influence the recall abilities is aging. Recall abilities is one the important method in early diagnosis of Mild Cognitive Impairment and other neurodegenerative disease like Dementia, Frontal lobe degeneration and Alzheimer's disease. The major trouble in older adult is the experience of memory loss and attention disturbances. The other difficulties like remembering activities of daily living, location of certain important objects also are seen. Hence, the nature of memory loss is different in normal aging than from the pathological aging which is due to the cognitive impairment. Also in the Indian context there are very less studies which focuses on the recall abilities.

The primary aim of the study was to analyze auditory and visual recall abilities in neurotypical older adults. The study included 60 normal adults, from age range 41 to 70 tears which were divided into three age groups i.e. age group 1 from 41-50; age group 2

from 51-60 and age group 3 from 61-70 years. All the participants were Hindi native speakers and were screened using Mini Mental State Examination (MMSE) by Flostein and Mc Hugh (1975) with a criteria to obtain a score of 25 or above. Another criteria was to have minimum education of tenth grade. The stimulus consisted of 4 lists with different linguistic complexity i.e. 3 syllable words, 4 syllable words, semantically related and unrelated words and a set of non-words. Each list had 7 items, which was randomized and presented across the 4 conditions i.e. visual serial, visual free, auditory serial and auditory free recall. The stimulus was recorded using PRAAT software (version 6.0.20) in quiet environment and was presented through headphones. Visual stimuli was presented through PowerPoint with white background in Devanagari script in bold font having ninety six font size. A string of seven units were presented one after the other with each having inter stimulus duration of 1000 msec except the 4 syllable words and non-words having the inter stimulus interval of 2000 msec. In auditory stimuli before first and after last word in the series the beep sound was presented to indicate the starting and ending of the string respectively. Also in visual stimuli the red slide was used to indicate the same. The obtained data was analyzed both quantitatively and qualitatively.

The primary objective of the study was to investigate the auditory and visual recall abilities in older neurotypical adults. Mean and median values were more for age group 1 compared to age group 2 and 3. Statistically significant difference was seen on Man Whitney U test (as data did not follow the property of normal distribution). It can be inferred from the results that as age increase the verbal recall abilities decrease. There was no significant gender effect found.

The second objective was to compare between the modalities with type of recall abilities in different age groups. The results showed that the overall auditory free recall abilities were significantly higher in all the age groups as compared to other conditions. This finding is consistent with the other studies that reported auditory recall being superior to visual presentation. As hypothesized by Sperling (1963) a primary function of a verbal rehearsal in visual memory task is to convert the information from visual memory to auditory storage. Which means the memory traces are transformed and encoded in an auditory form, regardless of the sensory channel of perception. Therefore the rehearsal is less necessary in auditory than for visual presentation as no efforts are need to get the auditory input into the auditory storage.

The third objective was to compare the different linguistic complexity levels. Which showed that the number of words recall in semantically related words were superior to the unrelated words. Which illustrates that items within the same semantic category are recalled better as it helps in activating long term memory. Also the recall abilities were better for 3 syllable word than 4 syllable word. As the word length increases, recall abilities are known to decrease. Comparison of words and non-words were also carried out which revealed the recall of words were superior to recall of non-words.

The study helps us to infer that along with other cognitive process recall abilities also declines with increasing age. These recall abilities also vary with respect to the nature of linguistic stimuli and the modality of the presentation of the stimuli. This again supports the notion that language and memory are intricately connected.

Implications of the study:

- The current study enables us to understand age related cognitive changes with reference to the auditory and visual recall abilities. The results of the study reveals age related decline in auditory and visual recall abilities, hence this needs to be kept in mind while evaluating geriatric population, typical or atypical.
- The study also explores the different linguistic complexity level which shows that there is relation between cognition and language as it was seen in recall abilities. This is turn may have significant effects in planning appropriate assessment and treatment strategies in persons with cognitive linguistic deficits.
- The test protocol used (see appendix) may serve as a comprehensive assessment battery for evaluating/ screening recall in older Hindi speaker adults.

Limitation of the study:

- The study was restricted to Hindi language and would have been better carried out in bilingual context (Hindi-English) as bilingualism is a common phenomenon in the present society.
- Equal number of female and male participants have not taken into the study to see a significant gender effect.

Future directions:

- The same study can be carried out in clinical population to assist in the early diagnosis, assessment and intervention of neurodegenerative diseases.
- The study can be extended into bilingual population to study the effect of bilingualism on recall abilities.
- In visual modality pictorial and textual representation of the stimuli should be compared to see the superiority.

REFERENCES

Abhishek, B. P., & Prema, K. S. (2015). Lexical semantic processing in persons with Bilingual aphasia. *Doctoral Thesis submitted to the University of Mysore.* All India Institute of Speech and Hearing, Mysuru, Karnataka.

Albert, M. L. (1976). Short term memory and aphasia. *Brain and Language, 3,* 28-33.

Ashcraft, M. H. (1989). *Human Memory and Cognition*. Glenview, IL: Scott, Foresman & Co.

Atkinson, R. C., & Shiffrin, R. M. (1968). Chapter: Human memory: A proposed system and its control processes. *The psychology of learning and motivation, 2, 89-195.*

Baars, B. J., & Gage, N. M. (2010). *Cognition, brain, and consciousness: Introduction to cognitive neuroscience*. Academic Press.

Bäckman, L., & Forsell, Y. (1994). Episodic memory functioning in a community-based sample of old adults with major depression: Utilization of cognitive support. *Journal of abnormal psychology*, *103*(2), 361.

Baddeley, A. (1986). Oxford psychology series, No. 11. Working memory.

Baddeley, A. (2000). The episodic buffer: a new component of working memory. Trends in cognitive sciences, 4(11), 417- 423.

Baddeley, A. D., & Hitch, G. (1974). Working memory. *The psychology of learning and motivation, 8,* 47-89.

Bartlett, F. C. & Burt, C. (1933). Remembering: A study in experimental and social psychology. British Journal of Educational Psychology, 3(2), 187-192.

Bayles, K. A., Kaszniak, A. W., & Tomoeda, C. K. (1987). *Communication and cognition in normal aging and dementia*. College-Hill Press/Little, Brown & Co.

Bly B M. (2003). *Cognitive Science* (2nd Edition).

Brajesh, P., & Goswami, S.P. (2011-12). *An adaptation of early reading skills (ERS) Hindi (ERS-H)*. Departmental of Speech and Language Pathology. All India Institute of Speech and Hearing. Mysore.

Cabeza, R., Anderson, N. D., Houle, S., Mangels, J. A., & Nyberg, L. (2000). Age-related differences in neural activity during item and temporal-order memory retrieval: a positron emission tomography study. *Journal of Cognitive Neuroscience*, *12*(1), 97 206.

Cabeza, R., Kapur, S., Craik, F. I. M., McIntosh, A. R., Houle, S., & Tulving, E. (1997). Functional neuroanatomy of recall and recognition: a PET study of episodic memory. *Journal of Cognitive Neuroscience*, *92*, 254-265.

Catani, M., Allin, M. P., Husain, M., Pugliese, L., Mesulam, M. M., Murray, R. M., & Jones, D. K. (2007). Symmetries in human brain language pathways correlate with verbal recall. *Proceedings of the National Academy of Sciences*, *104*(43), 17163- .

Chassé, V., Belleville, S., & Caza, N. (2005). Effects of presentation and recall format on immediate serial recall: A linguistic account. *Brain and Language*, *95*(1), 185-186.

Cloutier, S., Chertkow, H., Kergoat, M. J., Gauthier, S., & Belleville, S. (2015). Patterns of cognitive decline prior to dementia in persons with mild cognitive impairment. *Journal of Alzheimer's disease*, *47*(4), 901-913.

Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences, 24*, 87–185.

Cowan, N., Nugent, L. D., Elliott, E. M., Ponomarev, I., & Saults, J. S. (1999). The role of attention in the development of short-term memory: Age differences in the verbal span of apprehension. *Child Development*, *70*(5), 1082-1097.

Craik, F. I. M. (1983). On the transfer of information from temporary to permanent memory. *Philosophical Transactions of the Royal Society, London, Series B, 302*, 341-359.

Craik, F. I., & Bialystok, E. (2006). Cognition through the lifespan: mechanisms of change. *Trends in cognitive sciences*, *10*(3), 131-138.

Craik, F. I., & McDowd, J. M. (1987). Age differences in recall and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *13*(3), 474.

Craik, F. I., Morris, R. G., & Gick, M. L. (1990). Adult age differences in working memory. *Neuropsychological impairments of short-term memory*, 247.

Craik, F. I., Naveh-Benjamin, M., Ishaik, G., & Anderson, N. D. (2000). Divided attention during encoding and retrieval: Differential control effects? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*(6), 1744.

Crook, T., Bartus, R. T., Ferris, S. H., Whitehouse, P., Cohen, G. D., & Gershon, S. (1986). Age-associated memory impairment: Proposed diagnostic criteria and measures of clinical change—report of a national institute of mental health work group.

Crook, T., Ferris, S., McCarthy, M., & Rae, D. (1980). Utility of digit recall tasks for assessing memory in the aged. *Journal of Consulting and Clinical Psychology*, *48*(2), 228.

Crowder, R. G. (1979). Similarity and order in memory. *Psychology of learning and motivation*, *13*, 319-353.

Crowder, R. G. (1993). Systems and principles in memory theory: Another critique of pure memory. *Theories of memory*, *5*.

Davachi, L., & Wagner, A. D. (2002). Hippocampal contributions to episodic encoding: insights from relational and item-based learning. *Journal of neurophysiology*, *88*(2), 82-990.

Elias, J.W. (1995). Introduction: Normal versus pathological aging: are we screening adequately for dementia? *Experimental Aging Research, 21, 97-100.*

Eysenck M W., Keane M T. (2010). *Cognitive Psychology* (6th Edition) Psychology press.

Eysenck, M. W. (2012). *Simply psychology*. Psychology Press.

Folstein, M. F., Folstein, S., & McHugh, P. R. (1975). "Mini Mental State": A practical methods of grading cognitive status of patients for the clinician. *Journal of Psychiatric Research, 12,* 189-198.

Frith, C. D., Friston, K., Liddle, P. F., & Frackowiak, R. S. J. (1991).Willed action and the prefrontal cortex in man: A study with PET. *Proceedings of the Royal Society of London, 244,* 241-246.

Glanzer, M., & Cunitz, A. R. (1966). Two storage mechanisms in free recall. *Journal of verbal learning and verbal behavior, 5*(4), 351-360.

Glisky, E.L., Rubin, S.R., & Davidson, P.S. (2001). Source memory in older adults: an encoding or retrieval problem? *Journal of Experimental Psychology: Learning Memory and Cognition, 27(5), 1131-1146.*

Gunter, T.C., Jackson, J. L., & Mulder, G. (1998). Priming and aging: an electrophysiological investigation of N400 and recall. *Brain and Language, 65(2), 333-355.*

Henneges, C., Reed, C., Chen, Y. F., Dell'Agnello, G., & Lebrec, J. (2016). Describing the Sequence of Cognitive Decline in Alzheimer's disease Patients: Results from an Observational Study. *Journal of Alzheimer's disease*, *52*(3), 1065-1080.

Howard, M. W., & Kahana, M. J. (2002). A distributed representation of temporal context. *Journal of Mathematical Psychology*, *46*(3), 269-299.

Howes, M. B. (2006). Human memory: Structures and images. Sage Publications.

Ingersoll, G. M., & Di Vesta, F. J. (1974). Effects of modality preferences on learning and recall of bisensory stimuli. *Perception & Psychophysics,* 15(1), 73-78

Jensen, A. R. (1971). Individual differences in visual and auditory memory. *Journal of Educational Psychology, 62*(2), 123.

Kail, R. V., & Hagen, J. W. (1977). *Perspectives on the development of memory and cognition*. Lawrence Erlbaum Associates.

Kamath, A., & Prema, K. S. (2001). Cognitive Linguistic Assessment Protocol for adults. *Unpublished Masters Dissertation, Mysore, India.*

Kapur, S., Craik, F. I., Jones, C., Brown, G. M., Houle, S., & Tulving, E. (1995). Functional role of the prefrontal cortex in retrieval of memories: a PET study. *Neuroreport*, *6*(14), 1880-1884.

Kempler, D. (2005). *Neurocognitive disorders in aging*. Sage.

Kintsch, W. (1970). Models for free recall and recognition. In D. A. Norman (Ed.), *Models of Human Memory* (pp. 333-370). New York: Academic Press.

Kolb, B., & Whishaw, I. Q. (1998). Brain plasticity and behavior. *Annual review of psychology*, *49*(1), 43-64.

Kolb, B., & Whishaw, I.Q. (1996). Fundamentals of Neuropsychology. Publisher: Macmillan.

Kral, V. A. (1962). Senescent forgetfulness: benign and malignant. *Canadian Medical Association Journal*, *86*(6), 257.

Kynette, D., Kemper, S., Norman, S., & Cheung, H. (1990). Adults' word recall and word repetition. *Experimental Aging Research, 16,* 117–121.

LaBar, K. S., & Cabeza, R. (2006). Cognitive neuroscience of emotional memory. *Nature Reviews Neuroscience*, *7*(1), 54-64.

Leahey T H., Harris R J. (1993). *Learning and Cognition* (3rd Edition). Library of Congress Cataloging-in-Publication Data.

Leiner, H. C., Leiner, A. L., & Dow, R. S. (1991). The human cerebro-cerebellar system: Its computing, cognitive and language skills. *Behavioral Brain Research, 441,* 113 128.

Lemos, R., Duro, D., Simões, M. R., & Santana, I. (2014). The free and cued selective reminding test distinguishes front temporal dementia from Alzheimer's disease. *Archives of Clinical Neuropsychology*, *29*(7), 670-679.

Lewis, R. L., Vasishth, S., & Van Dyke, J. A. (2006). Computational principles of working memory in sentence comprehension. *Trends in Cognitive Science, 10(10),* 447-454.

Marian, V., & Neisser, U. (2000). Language-dependent recall of autobiographical memories. *Journal of Experimental Psychology: General*, *129*(3), 361.

Matlin, M. W. (2005). *Cognition*. Crawfordsville: John Wiley & Sons, Inc.

McConkey, R., & Green, J. M. (1973). Presentation method and the free recall performance of retarded adults. *American journal of mental deficiency*, *78*(1), 95.

Miller, G. A. (1956). The magical number seven, plus or minus two: Some limits on our capacity for processing information. *Psychological Review, 63,* 81–97.

Moniks, S. & Prathiba, K. (1995). Linguistic profile test (LPT) Hindi normative data for children in grades I to X. *An unpublished Masters Dissertation. University of Mysore.*

Morris, R. G., & Kopelman, M. D. (1986). The memory deficits in Alzheimer-type dementia: A review. *The Quarterly Journal of Experimental Psychology*, *38*(4), 575-602.

Naveh-Benjamin, M., Cowan, N., Kilb, A., & Chen, Z. (2007). Age-related differences in immediate serial recall: Dissociating chunk formation and capacity. *Memory & cognition*, *35*(4), 724-737.

Neisser, U. (1967). Cognitive Psychology. New York: Appleton-Century-Crofts.

Noack, H., Lövdén, M., Schmiedek, F., & Lindenberger, U. (2013). Age-related differences in temporal and spatial dimensions of episodic memory performance before and after hundred days of practice. *Psychology and aging*, *28*(2), 467.

Oztekin, I., McElree, B., Staresina, B. P., & Davachi, L. (2008). Working memory retrieval: Contributions of left prefrontal cortex, left posterior parietal cortex and hippocampus. *Journal of Cognitive Neuroscience, 21,* 581-593.

Papineau, W., & Lohr, J. M. (1981). Effect of sensory modality for presentation and word imagery on paired-associate learning. *Perceptual and Motor Skills*, *52*(3), 747-750.

Parkin, A. J., Walter, B. M., & Hunkin, N. M. (1995). Relationships between normal aging, frontal lobe function, and memory for temporal and spatial information. *Neuropsychology*, *9*(3), 304.

Poirier, M., & Saint-Aubin, J. (1995). Memory for related and unrelated words: Further evidence on the influence of semantic factors in immediate serial recall. *The Quarterly Journal of Experimental Psychology*, *48*(2), 384-404.

Racine, A.M., Koscik, R.L., Berman, S.E., Nicholas, C.R., Clark, L.R., Okonkwo, O.C., Rowley, H.A., Asthana, S., Bendlin, B., Blennow, K., Zetterberg, H., Gleason, C., Carlsson, C., & Johnson, S. (2016). Biomarker clusters are differentially associated with longitudinal cognitive decline in late midlife. *Brain, 139, 2261-2274.*

Ranjitha, K. B. N., & Abhishek, B. P., (2016). Verbal recall abilities in individuals with and without cognitive impairment. *An unpublished Masters Dissertation. University of Mysore.*

Raz, N., Gunning-Dixon, F. M., Head, D., Dupuis, J. H., & Acker, J. D. (1998). Neuroanatomical correlates of cognitive aging: evidence from structural magnetic resonance imaging. *Neuropsychology*, *12*(1), 95.

Reese, C. M., Cherry, K. E., & Copeland, A. L. (2000). Knowledge of normal versus pathological memory aging in younger and older adults. *Aging, Neuropsychology, and Cognition*, *7*(1), 1-8.

Reilly, J., Troche, J., Paris, A., Park, H., Kalinyak-Fliszar, M., Antonucci, S. M., & Martin, N. (2012). Lexicality effects in word and non-word recall of semantic dementia and progressive nonfluent aphasia. *Aphasiology*, *26*(3-4), 404-427.

Reilly, J., Troche, J., Paris, A., Park, H., Kalinyak-Fliszar, M., Antonucci, S. M., & Martin, N. (2012). Lexicality effects in word and nonword recall of semantic dementia and progressive nonfluent aphasia. *Aphasiology*, *26*(3-4), 404-427.

Richa, N. D. & Goswami, S. P., (2004). Manual for Adult Non Fluent Aphasic Therapy in Hindi. *An unpublished Masters Dissertation. University of Mysore.*

Rummer, R., Schweppe, J., & Martin, R. C. (2013). Two modality effects in verbal short-term memory: Evidence from sentence recall. *Journal of Cognitive Psychology*, 25(3), 231-247.

Saffran, E. M., & Martin, N. (1990).Neuropsychological evidence for lexical involvement in short-term memory. In G. Vallar & T. Shallice (Eds.), *Neuropsychological impairments of short-term memory.* Cambridge, UK; Cambridge University Press.

Saffran, N. M. E. M. (1997). Language and auditory-verbal short-term memory impairments: Evidence for common underlying processes. *Cognitive Neuropsychology*, *14*(5), 641 682.

Saint-Aubin, J., & Poirier, M. (2000). Immediate serial recall of words and non-words: Tests of the retrieval-based hypothesis. *Psychonomic Bulletin & Review*, *7*(2), 332-340.

Salthouse, T. A. (1985). Speed of behavior and its implications for cognition.

Salthouse, T. A. (2009). When does age-related cognitive decline begin? *Neurobiology of aging*, *30*(4), 507-514.

Schweickert, R. (1993). A multinomial processing tree model for degradation and redintegration in immediate recall. *Memory & Cognition*, *21*(2), 168-175.

Sharps, M. J., Price, J. L., & Bence, V. M. (1996). Visual and auditory information as determinants of primacy effects. *The Journal of general psychology*, *123*(2), 123-136.

Shylaja, K., Abraham, A., Leela Thomas, G., & Swapna, N. (2001). Non-word repetition in simultaneous and sequential bilinguals. *Journal of All India Institute of Speech & hearing*, *30*.

Stuart, G., & Hulme, C. (2000). The effects of word co-occurrence on short-term memory: Associative links in long-term memory affect short-term memory performance. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*(3), 796.

TuIving, E. (1983). *Elements of episodic memory.* New York: Oxford University Press.

Tulving, E., & Thomson, D. M. (1973). Encoding specificity and retrieval processes in episodic memory. *Psychological Review,* 80, 352-373.

Unsworth, N. (2009). Variation in working memory capacity, fluid intelligence, and episodic recall: A latent variable examination of differences in the dynamics of free recall. *Memory & Cognition, 37*(6), 837-849.

Veena, S. R., & Abhishek, B. P., (2016). Verbal recall abilities in younger and older adults. *An unpublished Masters Dissertation. University of Mysore.*

Wetzel, C. D., & Squire, L. R. (1982). Cued recall in anterograde amnesia. *Brain and language*, *15*(1), 70-81.

Appendix-I
Mean, SD and Median values of male and female

			Age 1			Age 2			Age 3		
			Mean	**SD**	**Med**	**Mean**	**SD**	**Med**	**Mean**	**SD**	**Med**
Visual serial	**SR**	**F**	3.07	1.49	3.00	2.66	0.50	3.00	2.00	0.70	2.00
		M	2.71	1.49	3.00	2.27	0.78	2.00	1.66	0.81	2.00
	SUR	**F**	1.76	1.23	1.00	1.66	1.11	2.00	2.00	0.70	2.00
		M	2.42	0.97	2.00	1.81	.87	2.00	1.46	0.91	1.00
	3sylb	**F**	1.84	0.98	2.00	1.88	1.16	2.00	1.80	0.83	2.00
		M	2.28	1.25	2.00	1.36	.67	1.00	1.46	0.63	2.00
	4sylb	**F**	0.76	0.72	1.00	0.88	0.92	1.00	0.80	0.83	1.00
		M	1.42	1.27	1.00	0.81	0.60	1.00	0.53	0.63	0.00
	NW	**F**	.076	0.27	0.00	0.00	0.00	0.00	0.00	0.00	0.00
		M	0.42	0.78	0.00	0.09	0.30	0.00	0.00	0.00	0.00
Visual free	**SR**	**F**	6.30	0.94	7.00	5.55	0.72	5.00	4.60	0.89	4.00
		M	5.57	0.97	6.00	5.54	0.68	5.00	4.53	0.74	4.00

	SUR	**F**	4.46	1.45	4.00	3.44	1.13	3.00	4.00	0.00	4.00
		M	4.28	0.75	4.00	3.45	1.03	3.00	3.33	0.89	3.00
	3sylb	**F**	3.92	1.49	4.00	3.44	0.88	3.00	2.40	1.14	2.00
		M	3.00	1.00	3.00	3.36	0.92	3.00	2.33	1.17	3.00
	4sylb	**F**	3.00	1.15	3.00	3.11	1.05	4.00	2.00	0.70	2.00
		M	2.57	0.78	2.00	3.36	0.67	3.00	2.40	1.12	3.00
	NW	**F**	0.84	0.98	1.0	0.11	0.33	0.00	.20	0.44	0.00
		M	0.57	0.53	1.00	0.72	0.46	1.00	.26	0.45	0.00
Auditory serial	**SR**	**F**	6.15	0.80	6.00	5.00	1.93	5.00	5.60	0.89	5.00
		M	6.00	0.81	6.00	6.09	0.83	6.00	5.20	1.20	6.00
	SUR	**F**	4.92	0.95	5.00	5.00	0.86	5.00	4.80	0.44	5.00
		M	4.85	0.69	5.00	4.81	0.60	5.00	3.73	0.70	4.00
	3sylb	**F**	4.15	1.34	4.00	3.88	1.05	4.00	3.40	0.89	4.00
		M	4.00	1.00	4.00	4.27	0.90	4.00	3.06	1.09	3.00
	4sylb	**F**	3.69	0.94	4.00	3.33	1.11	4.00	2.40	0.54	2.00
		M	2.57	1.61	3.00	3.36	1.02	3.00	2.80	0.67	3.00

	NW	**F**	1.07	1.32	1.00	0.55	0.52	1.00	0.60	0.54	1.00
		M	0.57	0.78	0.00	0.54	0.52	1.00	0.86	0.63	1.00
Auditory free	**SR**	**F**	4.07	1.70	5.00	2.77	1.48	2.00	2.40	0.89	2.00
		M	4.28	1.49	4.00	3.45	1.03	4.00	3.26	1.45	3.00
	SUR	**F**	2.07	1.35	2.00	1.55	1.13	2.00	1.80	1.09	2.00
		M	2.42	0.53	2.00	2.36	0.50	2.00	1.26	0.96	1.00
	3sylb	**F**	2.07	1.97	2.00	1.56	1.01	1.00	1.40	0.54	1.00
		M	1.71	0.95	2.00	1.72	0.90	2.00	1.40	0.82	1.00
	4sylb	**F**	2.00	1.77	2.00	1.33	0.86	1.00	1.20	0.83	1.00
		M	1.57	1.51	1.00	1.54	.52	2.00	1.33	0.81	1.00
	NW	**F**	0.07	0.27	0.00	0.11	0.33	0.00	.40	0.54	0.00
		M	0.28	0.48	0.00	0.27	0.46	0.00	.20	0.41	0.00

Note: M-male; F-female; Med-median

Appendix II
Stimulus Materials used for tasks

Test Items-List:

List 1: Visual serial recall stimuli

Semantically related	Semantically unrelated	3 syllable	4 syllable	Non-words
/kʌmʌr/	/siti/	/pʌraʎa/	/tʃʌmʌt͡kari/	/kadʒarin/
/ank^{h}/	/tʃ^{h}ilka/	/nib^{h}ana/	/kʌlapini/	/d̪imokuni/
/edi/	/ansũ/	/kamini/	/pʌrisima/	/sʌliḍaka/
/kan/	/kagʌdʒ/	/g^{h}otala/	/sukumari/	/kindʒaḍi/
/dʒib^{h}/	/tʃudi/	/dʒʌvani/	/d͡ʒvalamuk^{h}i/	/rakina/
/pet/	/k^{h}ʌtmʌl/	/d̪ʌʎalu/	/b^{h}agiḍari/	/suṯuḍasil/
/ʌngũt^{h}a/	/gulab/	/b^{h}ʌrosa/	/ad^{h}ivasi/	/d^{h}iroʃi͡rʎʌ/

List 2: Visual free recall stimuli

Semantically related	Semantically unrelated	3 syllable	4 syllable	Non-words
/seb/	/tʃʌkʌr/	/pʌkoda/	/d̪ʌgabadʒi/	/rinaʎas/
/ʌnar/	/dʒaḍugʌr/	/gulabi/	/d^{h}ʌr͡mʌʃast̪r͡ʌ/	/ʎɛrʌḍakira/
/pʌpiṯa/	/ʌtʃari/	/dʒʌṯana/	/naraʎʌɲi/	/ḍ^{h}alarʌk/
/dʒamun/	/nani/	/nivala/	/lʌg^{h}upɛʃi/	/ṯid͡ʒʌkʃ͡i/
/kela/	/pʌsina/	/tʃʌpaṯi/	/sʌntʃarika/	/gʌkʌnalo/
/ãm/	/ṯulsi/	/ṯʌnadʒa/	/gʌliʎara/	/katʃ^{h}urat/
/ṯʌrbudʒa/	/pɐ̃nk^{h}a/	/bʌngali/	/k^{h}ʌriḍari/	/niboḍ^{h}ip͡rʌ/

List 3: Auditory serial recall stimuli

Semantically related	Semantically unrelated	3 syllable	4 syllable	Non-words
/ʃeɾ/	/tʃulha/	/kʌhani/	/nakabʌnd̪i/	/ʃitukʌbʰa/
/bʌkɾi/	/ʈ͡ɾikoŋ/	/tʃʌbana/	/kʌlabadʒi/	/d̪opʌsʌgʌʎo/
/haʈ̪ʰi/	/kʌlʌm/	/nʌgada/	/pʌʈ̪iv͡ɾʌʈ̪a/	/dilom/
/kuʈ̪a/	/ɾɛdio/	/baraʈ̪i/	/mʌnd̪akini/	/lasam/
/bʰalu/	/pʌʈ̪a/	/p͡ɾʌʎogi/	/kumud̪ini/	/mʌnʌʃʌgʌnʌpu/
/bili/	/kala/	/lekʰika/	/d̪ipavʌli/	/kad̪ʰiʌka/
/gaʎ/	/ʈ̪ʌradʒu/	/sʌnsaɾi/	/d̪ʰaravahi/	/ʎiʌn͡ʎa/

List 4: Auditory free recall stimuli

Semantically related	Semantically unrelated	3 syllable	4 syllable	Non-words
/kuɾsi/	/ʌkʰbaɾ/	/kinaɾa/	/mʌharadʒa/	/dʒikʌbala/
/mɛdʒ/	/tʃʰaʈ̪a/	/kʰʌrabi/	/p͡rʌʈ̪ik͡riʎa/	/pʌʎaru/
/pʌlʌng/	/tʃiʈ͡ɾʌ/	/dʰʌmaka/	/hʌʈ̪ʰiʎana/	/nimanuʌʈ̪/
/ʌlmaɾi/	/kʰun/	/balika/	/mʌhod̪ʌʎa/	/kiʎandʌl/
/sofa/	/ʎɐ̃nʈ̪ɾʌ/	l/o͡utana/	/kʌliʎaɾi/	/k͡ʃikama/
/gʰʌdi/	/nila/	/gʌvahi/	/d̪ikʰavʌti/	/latʃʌtʃo/
/ʃiʃa/	/gɪlas/	/pʌʈ̪ɾika/	/d̪ʰaʈ̪uvad̪i/	/lʌʃabʌli/