VERBAL RECALL ABILITIES IN YOUNGER AND OLDER ADULTS

Veena S Ramkumar

Register No.: 14SLP034

A Dissertation Submitted in Part Fulfilment of Final Year

Master of Science (Speech-Language Pathology)

University Of Mysore, Mysore

ALL INDIA INSTITUTE OF SPEECH AND HEARING

MANASAGANGOTHRI, MYSORE-570 006

May, 2016

CERTIFICATE

This is to certify that this dissertation entitled **"Verbal Recall Abilities in Younger and Older Adults"** is a bonafide work submitted in part fulfilment for degree of Master of Science (Speech-Language Pathology) of the student Registration Number: 14SLP034. 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
May, 2016

Dr. S.R. Savithri
Director
All India Institute of Speech and Hearing
Manasagangothri, Mysore-570006

CERTIFICATE

This is to certify that this dissertation entitled **"Verbal Recall Abilities in Younger and Older 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.

Mysore
May,2016

Dr. Abhishek B.P
Guide
Lecturer in Speech Sciences
Department of Speech Language Sciences
All India Institute of Speech and Hearing
Manasagangothri, Mysuru.

DECLARATION

This is to certify that this dissertation entitled **"Verbal Recall Abilities in Younger and Older Adults"** is the result of my own study under the guidance of Dr. Abhishek B. P, Lecturer in Speech Sciences, Department of Speech Language Sciences, All India Institute of Speech and Hearing, Mysore, and has not been submitted earlier to any other University for the award of any other Diploma or Degree.

Mysore, **Registration No. 14SLP034**

May, 2016

Dedicated to Pappa and Amma for their endless love, blessings and encouragement.

A special dedication to my guide Dr. Abhishek Sir without whose support this wouldn't have been possible.

ACKNOWLEDGEMENT

First and foremost praises and thanks to the **God, the Almighty**, without whose blessings I simply couldn't have made it this far. Thank you, lord for being there for me always.

The success of this thesis is attributed to the extensive support and assistance from my **Guide Dr. Abhishek B.P**. I would like to express my grateful gratitude for your guidance, valuable advice, supervision and for inspiring and motivating me throughout this journey, at AIISH. Thank you Sir, for appreciating my research strengths and patiently encouraging me to improve in my weaker areas.

I would like to thank my **Parents,** to whom I humbly owe what I am today. **Papa** and **Amma**, you are the greatest treasures life has bestowed me with and I thank the almighty for showering me with such blessings. Thank you both for giving me strength to reach for the stars and chase my dreams. My dearest **brother**, **Kanna**...you are my most precious gift and deserve my wholehearted thanks as well. I am also very much grateful to all my family members for their constant inspiration and encouragement.

My respect and gratitude is due to all my **beloved teachers at AIISH** for all their support and guidance throughout the course of my study. Special thanks to **Dr. Vasanthalakshmi Ma'm** for her guidance in statistical analysis.

My special regards to my teachers at **Manipal University**, whose teaching has made it possible for me to see this day. Thank you **Vivian**, for always encouraging me to strive for greater heights.

I am deeply indebted to my friends **Ceana & Deepthi**. You guys rendered a true meaning to the proverb "a friend in need is a friend indeed". I have no words to describe what you both mean to me.I pray that this friendship should continue forever.

There are some **friends** who come into our lives to make it so beautiful that you cannot believe you have been so blessed. **Adhi,** you have been my pillar of strength. Thank you for understanding my goals and aspirations and for supporting me at every step.

Irfana chechi, words are short to express my deep sense of gratitude towards you. You were always beside me during the happy and hard moments to push me and motivate me. Thank you doesn't seem sufficient but it is said with appreciation and respect for your support, encouragement, care, understanding and precious friendship and most of all you are my (*foodie*) partner.

I cannot miss thanking you guys **Rini (the great BR singer), Merin (the gurl with mobile), Haritha (our DQ), Indu (the independent).** Thank you for making me a part of you all and for keeping me in good spirits throughout these two years...will treasure the fun and love we all shared.

Special thanks to **Nikitha** (**Macha**), can't stop without mentioning about you, will cherish all those late night discussions we had about (*movies, dialogues and actors*) **academics.** My cute thanks to the cute baby group **Vimala** and **Yashaswini.**

Special thanks to all my **classmates "The Masterminds".**

I extend my sincere thanks to all my **juniors Varsha, Laya, Drishya and Reshma** for their support and help**, Devi and Bincy** for their care and concern**, Devika (PP)** for being my close one and numerous others for helping me whenever I needed it.

I acknowledge all the **authors** for sending me the journal articles.

Thanks to the **participants** who voluntarily participated in the study, none of this would have been possible without them.

I also place on record, my sense of gratitude **to one and all**, who directly or indirectly, have lent their hand in this venture.

Table of Contents

Chapter No.	Title	Page No.
	List of tables	i
	List of figures	ii
I	Introduction	1-6
II	Review of literature	7-30
III	Method	31-38
IV	Results and Discussion	39-62
V	Summary and conclusions	63-67
	References	68-79
	Appendix	80-83

List of Tables

Sl. No.	Title	Page No.
3.1	Demographic details of the participants.	31-33
4.1	Mean, SD and Median for Group I (n=15) and Group II (n=12) across free recall and serial recall tasks.	41
4.2	Mean, SD, Median score for Group I (n=15) and Group II (n=12) across gender.	43
4.3	Performance of Group I (n=15) and Group II (n=12) on words vs. digits.	46
4.4	|Z| scores and p value (Wilcoxon's Sign Rank Test) for words and digits across tasks in each group.	47
4.5	Performance of Group I (n=15) and Group II (n=12) on semantically related vs. semantically unrelated words.	48
4.6	|Z| scores and p value (Wilcoxon's Sign rank Test) for semantically related and semantically unrelated words across tasks in each group.	49
4.7	Performance of Group I (n=15) and Group II (n=12) on words vs. non-words	50
4.8	|Z| scores and p value (Wilcoxon's Sign rank Test) for words and non words across tasks in each group.	51
4.9	Performance of Group I (n=15) and Group II (n=12) on free and serial recall tasks across immediate and delayed conditions.	52
4.10	Performance of Group I (n=15) and Group II (n=12) on free and serial recall tasks across immediate and delayed conditions across gender.	54
4.11	Performance of Group I (n=15) and Group II (n=12) for stimuli of different complexity level.	56
4.12	|Z| scores and p value (Wilcoxon's Sign rank Test) for stimuli of different complexity level.	57

List of figures

Sl. No.	Title	Page No.
2.1	Types of Human Memory.	7
2.2	Multi-component Working Memory Model.	9
2.3	Stages of Memory.	11
3.1	Summary of materials adopted for the study.	34
3.2	Summary of test conditions and tasks.	37
4.1	Mean scores for group I and group II on free and serial recall tasks.	41
4.2	Mean scores for group I and group II on free and serial recall tasks across genders.	43
4.3	Mean scores for group I and group II on words and digits across free and serial recall tasks	46
4.4	Mean scores for group I and group II on free and serial recall tasks across immediate and delayed conditions.	53
4.5	Mean Scores of Group I and Group II on free and serial recall tasks across immediate and delayed conditions across gender.	54

Chapter I

Introduction

"Our memory is a more perfect world than the universe: it gives back life, to that no longer exists."

— Guy de Maupassant

Cognition can be defined as the process an organism uses to organize information. As stated by Matlin (2005), "it is a mental activity which describes the acquisition, storage, transformation and use of knowledge". Cognition involves spectra of mental processes such as attention, memory, language, reasoning, pattern recognition, problem solving, organization of information, concepts and classification (Best, 1999). Study of cognitive processes helps us to learn how we acquire, store, retrieve and utilize knowledge (Matlin, 1983).

Memory is one of the important aspects of cognition. Functions of memory allows to recall what we know and help us to learn new information. "Memory is the process in which information is encoded, stored and retrieved" (as quoted in McLeod, 2007). The process of binding information to the senses from the outside world is known as encoding which is the first stage of memory. Storage is the second stage of memory process and this entails that information is retained over a long period of time. Third stage is the recall or retrieval of the information that has been previously stored. The rate at which information is encoded into the system it can be fast or slow. In certain instances a single exposure to an event or information is adequate enough for a memory trace to be encoded, stored and then recalled. However, the information that is stored is much less

likely to be forgotten if it can be repeatedly re-encoded from the surroundings and/or re-activated within the memory system through a process called consolidation. Hippocampus is the area of brain which combines different pieces of information to generate a single memory trace during encoding and regions within the pre frontal cortex are responsible for recall of this memory trace (Lum, Ullman & Conti-Ramsden, 2015). Recall in memory implies the re-accessing of experience or events from the past, which has been encoded and stored in the brain. It involves remembering of information, events or objects that is not physically present at the moment. Human long term memory consists of traces of many thousands of words, pictures, episodes and other types of information and hence retrieving or 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.

Simple tasks such as recalling a telephone number to complex tasks as language comprehension, formulation and production require the need 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. Conti-Ramsden, Botting and Faragher (2001) suggested that "recall is an effective psycholinguistic marker of children with specific language impairment as a consequence of the involvement of short-term memory in the task". Language factors like lexicality, word frequency and semantic similarity are thought to influence the successful recall of the words (Hulme, Maughan & Brown, 1991; Schweickert, 1993). It is hypothesized that during immediate serial recall, the recall of an item is higher when they are from the same semantic category (Murdock, 1976; Poirier & Saint- Aubin, 1995; Multhaup, Balota & Cowan, 1996). In patients with aphasia impairments in both long term memory and working memory have been reported (Chapey, 2001). Albert (1976) reported that aphasic individuals show overall reduction in recall and memory.

A major concern for older adults is that they might experience loss of memory skills as they age (Johnson & Halpern, 1999). Handler (1960) stated that "aging is deterioration of a mature organism resulting from time independent, essential irreversible changes intrinsic to all members of species". In addition to the physical changes, ageing also leads to alterations in the ability of an individual in processing, understanding and using language. An overall regression in linguistic functions is not reported with ageing, whereas deterioration in cognitive processes like attention, memory has been reported with increasing age (Cerella, 1985). These changes in cognitive functions impinge on the linguistic abilities leading to word retrieval difficulties (Kemper, 1992) and also in the ability to carry out complex discourse processes (as cited in Manjunath, 2011). As

discussed earlier memory is affected with aging and among the memory processes the most affected is recall . Miller (1956) reported that older adults had poorer recall abilities when compared to younger adults and Nilsson (2003) reported that episodic memory which involves recall is primarily affected in normal aging processes. Serial position functions in younger adults are different from those produced by older adults (Brown, Vousden & Maylor, 1999). Chalfonte and Johnson (1996) reported that older adults have particular difficulty in memory processes that requires the binding of information or events to contextual elements. On the other hand, Naveh-Benjamin, Husain, Guez and Bar-on (2003) suggested that age related decline in working memory capacity appears to account for deficits in memory for spoken language.

Memory problems are associated with many psychiatric and neurological illnesses. Recall abilities are affected in many neurological disorders and often recall is used as a measure to diagnose and differentially diagnose these disorders. This also helps in early identification of diseases like Alzheimer's disease (AD), Dementia and to track the progress of these disorders. Mild Cognitive Impairment (MCI) (Fleisher, Sowell & Taylor, 2007) is a commonly used terminology to describe the intermediate stage between normal ageing and dementia. Considerable research has been carried out in developing strategies to recognize individuals who are at high risk of developing dementia in future. MCI is associated with a high risk of developing dementia. It is seen that patients diagnosed with MCI tend to develop dementia at a rate of 10- 15% per year when compared with healthy adults who only develop dementia at a rate of 1-2% per year (Peterson, 2004; Tierney, Yao & Kiss, 2005; Tabert, Manly & Liu, 2006). Various types of memory tests are being used to address the issue of predicting the conversion of MCI

to AD recently. Memory functions like recall are seen to have the highest predictive power for indicating early AD. In most of the neuropsychological measures, delayed recall of a word list was the most successful task to discriminate and classify appropriately 96% of normal subjects and 86% of mild AD subjects (Morris, Heyman & Mohs, 1989; Welsh, Butters & Hughes, 1991). Lesions in the frontal lobe were also seen to significantly affect recall abilities as they recall only fewer words in total and they exhibit lower serial recall scores and make more intrusions and intra-list repetitions from previously studied lists (Hildebrandt, Brand & Sachsenheimer, 1998). Recall in neurological disorders are not explored in this particular study, but has been mentioned here as there is greater significance of recall tests in identifying memory disturbances in the initial stages of the disease compared to other tests or functions of memory.

Need for the study

Memory abilities like recall decline over the adult lifespan (Salthouse, 2009); is a crucial feature in the diagnosis of disorders like Dementia, Alzheimer's (McKhann, Knopman, Chertkow, Hymna, Jack & Kawas, 2011), and critically support the quality of life and in activities of daily living (Woods, Velnoweth, Weinborn, Rooney & Bucks, 2012). Hence, the need for the study is derived based on the following observations;

- The close association between recall and language processing indicates the need to develop assessment and treatment methods that address both language and recall abilities. It is also essential for speech and language pathologists to understand the influence of different types of recall abilities on language functions and how impairment in recall can affect communication abilities.

- The issue of memory loss has always been a common concern among aging adults. As age increases there is high chance that there could also be deterioration in memory and other cognitive skills; therefore, the growth of the population of elderly individuals indicates the need to understand age-related changes in recall abilities which will in turn help us to differentiate between senile and senescent changes.
- It is seen that with raise in the life span, the number of aged/older individuals has also increased. As a result, age-related cognitive disorders such as Schizophrenia, Dementia, and AD will become more common in the future. Hence, the need to develop more resources to identify and treat these disorders as early as possible is imperative.

Considering the above notes, the aim of the present study was to investigate the verbal recall abilities in younger and older adults with the following objectives;

a. To compare verbal recall abilities between younger and older adult participants and across genders (male & female).
b. To compare verbal recall abilities for digits and words.
c. To study verbal recall abilities for free and serial recall tasks on two conditions namely immediate and delayed recall.
d. To study the verbal recall pattern for stimuli of different complexity level and serial position effects associated with recall tasks i.e. primacy effect and recency effect.

Chapter 2

Review of Literature

2.1 Cognition

Cognition is defined as the "coordinated operation of active mental processes within a multi-component memory system" (Ashcraft, 1989). It involves a range of mental processes such as attention, memory, language, reasoning, problem solving, pattern recognition, organization of knowledge, concepts and classification (Best, 1999). Memory is one of the important aspects of cognition as it is important in our everyday life.

2.2 Memory

As stated by McLeod (2007), “memory is the process of maintaining information over time”. Matlin (2005) defined it "as the structures and processes that are involved in the storage and subsequent retrieval of the information". Memory deals with processing enormous amount of information. This information may take different forms such as sounds, images or meanings. According to literature, the three different types of memory are; Sensory Memory (SM), Long Term Memory (LTM) and Short Term (Working) Memory (STM) (Atkinson & Shiffrin, 1968).

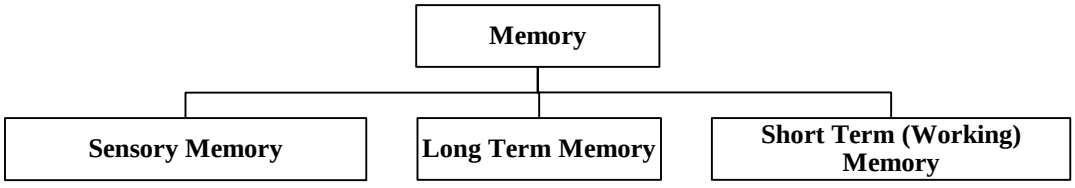

*Figure 2.1.*Types of Human Memory. Adapted from "*Human Memory and Cognition*," by M. H. Ashcraft, (1989). Glenview, IL: Scott, Foresman.

2.2.1 Types of Memory

First stage of memory is the Sensory Memory (SM) which is beyond our cognitive control and is an automatic response. Here, the information will be taken from sensory organs and then transmitted to the other types of memory systems depending upon the need of the individual. The various sensory systems are hearing, sight, touch, taste and smell. SM allows individuals to hold on to the impressions of sensory information even after the cessation of stimulus. The three subtypes of sensory memory are iconic memory, echoic memory and haptic memory (Neisser, 1967).

Long Term Memory (LTM) is considered as a system that stores vast amount information and a record of past events (as cited in Cowan, 2008). The information that is stored in LTM is quite permanent, and not likely to be lost. This information can be encoded via semantic, visual and also through acoustic modes.

Short-term memory was previously termed as primary memory by James (1890). Broadbent (1958); Atkinson and Shiffrin (1968) inferred this term in different ways. They defined it as to "reflect the faculties of the human mind that can hold a limited amount of information in a very accessible state temporarily". The distinction between the terms “primary memory” and “short-term memory” is that primary memory is considered to be more restricted than short term memory. Short-term memory is thought to act as a sort of “scratch-pad” for recall of the information temporarily which is processed at any given point in time. It is basically the ability of an individual to remember the information and process it at the same time. STM can hold only little amount of information unlike long term memory. According to Miller, Galanter and

Pribram in 1960, the STM can store around 7+ or - 2 items an active readily-available state of mind, but only for a short time ranging from 10 to 15 seconds, or up to a minute.

Working Memory (WM) is not distinct completely from the short-term memory. This was a term that was used by Miller et al., (1960) to refer to memory, "as it is used to plan and carry out behavior". The term “working memory” became dominant in the field of cognitive psychology after Baddeley and Hitch (1974) confirmed that all kinds of temporary memory could not be explained by a single module i.e., memory systems are not unitary. Their thinking led to an influential model termed as the Multi-component Working Memory Model (Baddeley, 1986) as shown in figure 2.2, in which working memory is not considered as a unitary store rather a combination of four different systems namely: Central executive, Phonological loop, Visuospatial sketch pad and Episodic Buffer , which was later added (Baddeley, 2000) and each of this component has an independent capacity.

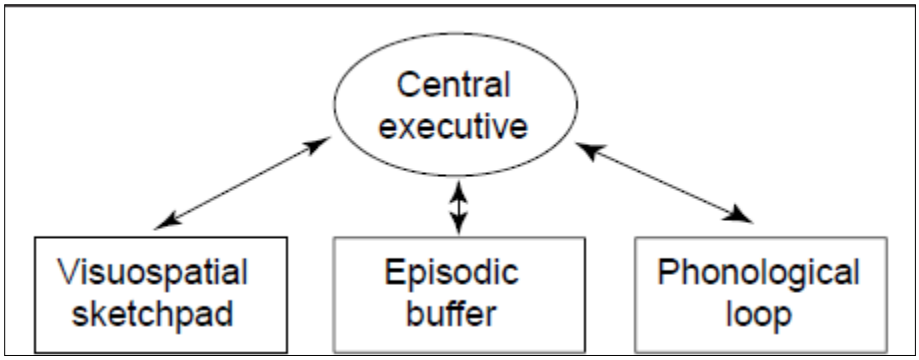

Figure 2.2. Multi-component Working Memory Model. Adapted from"The episodic buffer: a new component of working memory?," by A. Baddeley, 2000, *Trends in cognitive sciences, 4*(11), 417-423.

The central executive is considered as the system responsible for the regulation and control of different cognitive processes. The verbal phonological loop has a phonological store that stores auditory phonological information and a sub-vocal rehearsal mechanism which rehearses the traces in phonological store preventing it from decay and thus helping in recalling the memory traces. This loop specializes in processing linguistic information. The visuo-spatial sketch pad specializes in processing visuo-spatial information. It also stores information encoded from verbal stimuli after converting it into visual code. The last component is the episodic buffer which is involved in linking information across the components i.e., visual, spatial and verbal information with time sequencing/chronological ordering, such as the memory of a story. This also interfaces these memory traces with LTM.

In summary, according to this model the verbal-phonological representations and visuo-spatial representations are held independent of each other and these are manipulated and managed by the attention-related process, central executive. Thus, working memory is viewed as a combination of these multiple components working together. Thus, it can be concluded that WM includes short-term memory (STM) and additional mechanisms that help to make use of the STM

2.2.2 Stages of Memory

Memory covers the three important aspect of information processing: encoding, storage and recall".

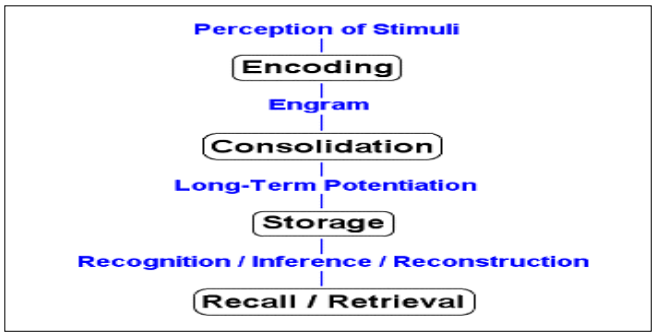

Figure 2.3. Stages of Memory. Adapted from *"Stages of memory - encoding, storage and retrieval,* " by S. A. McLeod, (2007), http://www.simplypsychology.org/memory.html.

As depicted in figure 2.3, encoding is the first step in creating a new memory. During encoding an item of interest will be changed into a code that can be stored in brain and then recalled later from STM or LTM. The different types of encoding are; Acoustic encoding which involves the processing and encoding of words, sound and auditory input for storage and for later recall. It is also assisted by the notion of the phonological loop, which plays a vital role in sub-vocally rehearsing the input in order to assist in recall. The second type of encoding is visual encoding where the encoding of visual sensory information and images takes place. Before being encoded into long-term storage it is stored in the iconic memory temporarily. Tactile encoding is through the sense of touch, for example, how an object feels. If sensory input which has a meaning or that can be applied to a certain context is encoded, then it is called as semantic encoding. In general, it is assumed that acoustic encoding takes place for short-term memory storage, where as semantic encoding is for long-term storage.

Consolidation is a process of maintaining the memory trace following initial acquisition. This can be thought of as an element of the process of either encoding/or of storage, or it may also be regarded as a process of memory in its own way. Storage is a passive process of holding information in the brain. It can be in the sensory memory, short-term memory

or in permanent long-term memory. If the information is repeatedly used, then more likely it is to be held in the long-term memory. Penfield (1952) reported that the storage of long-term memory is not restricted to just one part of brain; rather it is distributed throughout the entire cortex. Memory storage is a continuous process of reclassification which results from constant changes in neural pathways, and the parallel processing of the information in our brain.

The intermediate stage between storage and recall is recognition. It is the ability to know previously encountered events, objects, or people and largely is an automatic process. When the previously encountered event is re-experienced by the individual, the current environmental content is then matched to the already stored memory traces and thus elicits matching signals.

Recall or retrieval of memory is the last stage in the memory process. Besides encoding and storage, recall is one of the three core process of memory. As cited in Matlin (2005), recall refers to the "subsequent re-accessing of events or information from the past, which have been previously encoded and stored in the brain". In common terms, it is known as the act of remembering.

2.2.3 Recall

Verbal recall refers to the recollection of verbal information and it forms a major crux in the study of memory. Studying recall helps to give an insight into the memory process of an individual. Several models have been put forth to describe the process of recall. One such model is the Generate-Recognize model given by Kintsch (1970). The model assumes that during the process of recall, an item is retrieved from memory by the search

process first, and then the respective item is tested by the recognition process to determine if it is from the to-be-recalled list. Thus, to recall a word it must both be successfully retrieved and recognized.

Another explanation is based on the Encoding Specificity principle by Tulving and Thomson in 1973. This principle implies that memory uses information from the context in which it is learned, the memory trace and also from the environment in which it is retrieved from, i.e. memory is improved when the information that is available at encoding is also available at the time of retrieval. Encoding specificity principle takes into account the effect of these contextual cues.

Scientific study of recall dates back to Ebbinghaus (as cited in Crowder, 1993), who has checked his own acquisition and failure in remembering information in form of a series of nonsense syllables which as tested at different time periods up to 31 days. One of the important observation that he made was a "first fleeting grasp of the series in moments of special concentration" but this kind of immediate accurate recall did not ascertain that the list had been learned in a way that would allow its recall later. He also observed that to acquire a stable memory state it required added repetitions of the series. Throughout the twentieth century it was Ebbinghaus' research which influenced the research carried out on recall and memory.

During the mid-twentieth century, Bartlett was an important researcher in the field of recall and memory. His studies focused on the errors that people made when they were recalling new information. Bartlett and Burt (1933) provided participants with a small passage from a story and then were asked to recall the stories. Intervals from presentation

to recall of the story would vary from immediately after reading the story to days later. Bartlett observed that people attempted to understand the overall meaning of the story and then recall based on that but their current sets of knowledge intruded their ability to recall the story accurately. In the 1950s, cognitive revolution came up which changed the overall study of memory which included new theories on how to view memory and recall. Peterson (1967) observed that when people were given a small list of words to learn and later distracted from the task for a slight duration the number of items recalled from the list decreased significantly.

From these earlier studies it was seen that recall can be categorized into different types like serial and free based on the order of recall, cued recall if a cue is given and immediate and delayed based on the time duration given for recall. The ability to recall in these different ways can give insight into the different ways in which memory processes are functioning in the brain.

2.2.3.1 Types of Recall

There are three different types of recall namely free recall, serial recall and cued recall and each of this can be recalled in two ways/patterns depending on time duration given: immediate and delayed.

a. **Immediate recall:** The ability to recall events or objects immediately after it is learnt. Here the recall period starts immediately after the final item in the presented list.
b. **Delayed recall:** The ability to recall events or objects after given period of time after it is learnt. Here, a short distraction period is interpolated amidst the final item in the list and the initiation of the recall period.

c. **Free recall:** The ability to recall events or objects without any cues in any order. Here, the participants are presented with list items that need to be remembered, one at a time. After the presentation of the entire list, the participants are asked to recall items in any order that he or she prefers and hence called free recall task.

d. **Cued recall:** The ability to recall events or objects when partial information or cues relating to the target is given. Here cues are given during the experiment to help in the recall. If the link between the cue and the target word is stronger, then recall would be improved.

e. **Serial recall:** The ability to recall events or objects in a serial order. The ability to store items in memory in an order and recall them later is important in the use of language. Serial-order recall helps us in remembering the particular order of events in our lives, our autobiographical memories etc.

The ability to recall is also governed by certain factors like attention, motivation, linguistic abilities etc. These factors determine how well an individual can recall.

2.2.3.2 Factors affecting recall abilities

Recall abilities are determined by factors such as;

1. **Cognition and Behavior:**

a. Attention & Motivation: Attention affects the recall during the encoding phase. When parallel tasks are performed during the encoding the phase, with less attention given to individual tasks, recall abilities are impaired as the parallel task does not allow for encoding of appropriate input and it also reduces the amount of information that is learned (Craik, Naveh-Benjamin, Ishaik & Anderson, 2000). Where as motivation

leads to better recall. It was observed that when reinforcements are paired with recall tasks, the recall abilities are better (Hill, Storandt & Simeone, 1990).

2. **Age and Gender:**

a. Age: Younger adults are assumed to recall more items than children/older adults (Light, 2011).

b. Gender: Gender differences are less examined in research associated with recall and out of the available research the results are mixed in nature. Certain authors like Freides and Avery, 1991; McCarty, Siegler and Logue, (1982) reported that there is no relation between gender and 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 and attributed this difference to age related changes in brain volume. They observed that males had larger cerebral volume than females. Contradicting to this finding was that of Xu, Kobayashi, Yamaguchi, Iijima, Okada and Yamashita (2000) who reported that atrophy was more in males compared to females and that atrophy also differed according to brain regions.

3. **Language:**

a. Word Length Effect: Recall abilities reduce as the word length increases. This is because more short words can be rehearsed than long words in the phonological store of working memory (Baddeley, 2000).

b. Serial Position Effect:

i. Primacy effect: In any list, the first few items may be recalled better. This is because there are higher chances for these words to be repeated and rehearsed, and thus encoded into a more stable memory stores.

ii. Recency effect: Here, the items in the last may be recalled well as these items would be still present in the rehearsal buffer at the time of recall.

c. Similarity Effect: Related words are recalled better compared to unrelated words (Semantically) because of the properties of the words that are encoded are similar and hence easy to retrieve.

d. Word frequency: Words that are more frequently encountered (familiar) are easier to recall. This is because these words are used more often and are readily available and accessible in their memory storage.

e. Imageability: Words that can be visualized are easily recalled (concrete vs abstract words). Concrete words have a verbal and imaginal system. The verbal information is processed by the verbal system and the imaginal system processes the non verbal information. These images provide additional information during encoding and hence contribute to better recall.

4. Stimulus factors and Physiological state:

a. Presentation rate: Items presented at a slower pace enhances the ability to recall items. When the words are presented slowly, there is more time for encoding and hence facilitating a better recall.

b. Physiological state: Drugs such as marijuana and alcohol impair recall performance as they have an effect on the hippocampus functioning.

2.2.3.3 Neurological substrates of recall

Different brain structures are involved in the process of recall. Post mortem studies were used initially to study the areas involved but it was seen that such approaches were more beneficial, in identifying the neuro-anatomical pathways and structures necessary to carry out the memory tasks rather than the identification of specific components of memory. Recently, with the advent of neuro-imaging techniques considerable research has been carried out to explore the brain areas involved in specific components of memory like recall.

To identify the areas involved in recall, Cabeza, Kapur, Craik, McIntosh, Houle and Tulving (1997) carried out Positron Emission Tomography (PET) study using a paired associate word task. The participants for the study were 12 students within an age range of 19 to 31 years. The stimuli used were 192 word pairs (e.g., parents-piano). Here, participants were made to read the paired words on a computer and then were given one word from the pair and were requested to recall the second word verbally aloud. The stimulus was presented for four seconds with an inter-stimulus duration of one second. Regional Cerebral Blood Flow measures (RCBF) were used to identify the areas involved. It was observed that during the process of recall, right prefrontal cortex, anterior cingulate cortices, right inferior parietal cortex and also the cerebellum was activated.

The right prefrontal area is often attributed to the process of recall attempt, which was earlier reported by Tulving (1983). He reported that right prefrontal area is not directly related to the actual recall of the information that is stored but rather to the attempt the effort that is put for such recovery.

The anterior cingulate cortex is generally, activated during tasks that require more initiation, like the generation tasks where participants are given a category and then asked to name items from that category e.g., verbs relating to nouns, semantic categories (Petersen, Fox, Posner, Mintun & Raichle, 1988), willed action tasks, where participants need to choose between two responses that are equally appropriate (Frith, Friston, Liddle & Frackowiak, 1991), metaphor interpretation tasks (Bottini, Corcoran, Sterzi, Paulesu, Schenone, Scarpa & Frith, 1994). The authors report that the initiation hypothesis is also true in case of recall as it is a task that involves more self-initiated processing (Craik, 1983). Initiation hypothesis states that encoding of a specific event is governed by the internal states of the individual like comprehension, elaboration of the event and in part by the external state or the environment. Successful recall happens when these mental states are reintstated and if the environment is similar to the encoding phase. If this doesn't happen, then the individual has to rely on a self initiated processing in order to recreate the original encoded environment. Free recall tasks are usually devoid of environmental cues and hence is highly dependent on self initiated activities which depends on the integrity of the frontal lobes and anterior cingulate cortices. 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). Cerebellar damage produces deficits in processing speed, cognitive planning,

verbal fluency and recall (Akshoomoff & Courchesne, 1992; Seitz, Canavan, Yagüez, Herzog, Teilmann, Knorr & Hömberg, 1994). 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).

Differential activation of brain regions is reported with respect to the types of recall. One of the evidences using RCBF measures is provided by Cabeza, Habib, Mangels, Nyberg, Houle, McIntosh, and Tulving in 1997 who studied free recall and temporal-order memory (serial recall) on 12 students with mean age of 25. The stimuli used for the study were 560 concrete nouns of word length between 4-8 letters, which was divided into retrieval and study lists. Participants were asked to retrieve the studied word from a given pair (one word from study list and a new word) in the free recall test and in the serial recall task both the word pairs were from the study list but participants had to choose which item appeared first and which appeared at a later stage in the study list. It was found that compared to serial order task, free recall was more related to increase in activations in bilateral temporal regions, forebrain regions including anterior part of parahippocampal gyrus; whereas, serial recall was related to differential activations in the frontal, posterior midline and the lateral parietal regions.

2.2.3.4 Language and Recall

Cognition plays a role in language and communication. Language comprehension and formulation are part of the cognitive system. This is evident from studies that have tried to correlate neuro-anatomical sites of language and comprehension. Transcranial

magnetic stimulation investigations have provided evidence that the left inferior frontal gyrus has a role in successful interference resolution (Feredoes, Tononi & Postle, 2006). This region also includes Broca's area which is associated with language functions especially syntactic processing (Rogalsky & Hickock, 2010). Lewis, Vasishth and Van Dyke (2006) described a computational model of sentence processing which emphasizes that recall is necessary for accurate sentence processing. Evidence from research in Aphasia suggests that there is close association between processing of words and verbal STM (Saffran & Martin, 1990). Albert (1976) reported that aphasic individuals show overall reduction in recall and memory.

Recall is also influenced by linguistic contexts in a number of different ways. The language spoken helps to create the external context (Smith, 1988); language in which the mental activities are carried out creates the internal context (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". These findings suggest that recall is uniquely linked with language abilities. Difficulty in recalling is the most vexing problem human beings face.

Recall abilities vary according to the linguistic stimulus presented. Evidences provided from Haarmann, Ashling and Usher in 2005, on older and younger participants indicate that there was age related differences in semantic tasks and digit span tasks. It was seen that in older and younger adults the performance in digit span tasks were better compared to performance in the conceptual span tasks or semantic tasks. The authors argue that for processing the conceptual span task contribution from the semantic short term memory (SSTM) was necessary but in contrast digit span recall relies on the phonological STM to

a greater extent because digits have a shallow meaning and that recall of digits require sequential rehearsal in phonological loop (Baddeley, 1986). This is supported from neuropsychological data which showed that patients with phonological STM deficits are impaired in this test.

Naveh-Benjamin and Ayres (1986) studied recall abilities for digits from 1-10 in English, Hebrew, Arabic and Spanish. They observed that recall was better for English digits, compared to the other languages. The English numbers could be spoken rapidly and hence requires only less pronunciation time, whereas the numbers in other languages contained more number of syllables. This suggests that greater recall is associated with less pronunciation rate and also less number of chunks in the short term memory.

Certain authors reported that the length of the stimulus also had an effect on recall abilities as the length of the words in the list increased recall abilities decreased. Baddeley, Thomson and Buchanan (1975) studied the effect of length of the syllable on immediate serial recall and found that with increase in length recall abilities decreased. In addition, Baddeley et al., (1975) found that reading rate and articulation rate correlated with serial recall across participants and materials, which suggests that time taken to articulate the list items matters more rather than number of syllables. It was argued that this effect arises because more short words can be rehearsed in the phonological store before decay occurs (Baddeley, 1986). This was mainly called as the globalist view. On the other hand localist assumption (Neath & Nairne, 1995) is that recall of words depends not on the list context, but on the characteristics of the word itself. Both types of models suggest that, the overall proportion of correct items should decrease for list of fixed length, as proportion of long words increase. This was again reexamined by Cowan,

Baddeley, Elliott and Norris (2003) on 40 undergraduate students. The stimulus included lists of words with increasing length of complexity upto seven letters. Significant effect of length on the recall was obtained in their study.

Language factors like lexicality, word frequency and semantic similarity are thought to influence the successful recall of the words (Hulme, Maughan & Brown, 1991; Schweickert, 1993). It is hypothesized that during recall, items are recalled better when they are from the same semantic category (Murdoch, 1976; Hulme et al., 1991; Multhaup, Balota, & Cowan, 1996; Poirier & Saint- Aubin, 1995; Stuart & Hulme, 2000). The reconstruction hypothesis was put forward to account for this (Hulme et al., 1991; Schweickert, 1993; Saint-Aubin & Poirier, 1999). According to this hypothesis, similar lists would be recalled better because, at recall, the category of the list will contribute to the increase in the probability of recalling the long-term representations, either because the category would supplement as a retrieval cue (Crowder, 1979; Poirier & Saint-Aubin, 1995; Saint-Aubin & Poirier, 1999) or because the long-term representations of these similar items would be activated to a higher extent due to their long-term associative links (Stuart & Hulme, 2000) and hence would predict improved item recall for semantically similar lists.

An effect of semantically similar words on recall was explored by Saint-Aubin, Ouellette and Poirer in 2005. In their study an immediate serial recall task was performed either alone or under articulatory suppression with semantically similar or dissimilar lists. Articulatory suppression is process of preventing rehearsal by asking the individual to speak during the experiment or during the retention interval. The participants were 252 younger adults (French speakers) and each list had contained seven items. The same

items were used in similar and dissimilar list but words were sampled across categories in the dissimilar list. The participants were asked to write in the same order of presentation. The participants repeated aloud the word mathématiques in the articulatory suppression condition, continuously at a rate of about three utterances every two seconds. As soon as they initiated a trial they started suppressing and continued until recall was completed. Results revealed that, the number of items recalled from similar were more than dissimilar lists during quiet and suppression conditions. There were more order errors in the suppression condition than in the quiet condition. The authors attribute that the lower recall under suppression is because of a greater reduction or degradation of the phonological traces. The phonological traces are viewed as basic retrieval cues, their greater degradation would lead to lower item recall (Saint-Aubin & Poirier, 1999).

Saint-Aubin and Poirier (2000) did a similar study on recall of words and non-words. They found that recall of words had a superior effect than that of non-words. In case of words decayed memory traces in phonological short-term memory can be reconstructed using either lexical or phonotactic knowledge (Gathercole, Susan, Frankish, Clive, Pickering, Susan, Peaker & Sarah, 2000) and hence result in better recall of than non-words.

2.2.3.5 Aging and recall

Advanced aging is often associated with changes in brain morphology and structure (Raz, Gunning, Head, Dupuis, McQuain, Briggs, Loken, Thornton & Acker 1997). Post-mortem examinations of brain tissue have revealed a varied array of age related changes in the brain. Raz et al., (1997) examined patterns of change in brain structure with aging in 148 normal adults (48-77 years) using Magnetic Resonance Imaging (MRI). The

prominent changes were reported in the Pre Frontal Cortex (PFC) at a rate of 4.9% per decade. Shrinkage in the area of PFC is also reported which mediates the increase in perseveratory errors in older adults (Raz, Gunning-Dixon, Head, Dupuis & Acker, 1998). Theories of ageing explains decline in the performance across age in a variety of tasks, either with respect to a deficit in the core cognitive function, or according to deficits in small set of cognitive functions like processing speed (Salthouse, 1996), inhibition (Zacks & Hasher, 1988), working memory capacity (Craik, Morris & Gick, 1990) and attention (West & Bell, 1997). It is well known that ageing interact with memory performance and among the memory processes recall is affected the most.

Zelinski, Elizabeth, Burnight and Kerry (1997) performed a study of list recall and text recall on 106 adults over a span of 16 years and reported age related decline in recall abilities. Miller (1956) reported that older adults had poorer recall abilities when compared to younger adults and subsequent work done by Kynette, Kemper, Norman and Cheung (1990) indicated that with aging the recitation rate slows down and hence will have difficulty in rehearsing leading to poor recall. Certain authors like Broadbent (1975) argued that this is because of the limitation in the capacity to hold information and others like Cowan (2001) hypothesized that it could be due to difficulties in the process of chunking information. He also stated that older adults make weaker item-to-item associations compared to younger individuals and this in turn leaves the elderly at a disadvantage in being able to use these associations in forming multiple chunks in serial order recall. Chalfonte and Johnson (1996)reported that older adults particularly lack in memory that requires the binding of information to contextual elements.

Craik (1983) suggested that during recall a "self-initiated processing" is involved, and that older people have difficulty to carry out such operations than younger adults because with aging again frontal lobe atrophy happens which helps in this initiation process. Hasher and Zacks (1979) proposed that older people are less impaired on tasks that involves either "automatic" processing or if large amount of environmental support is available (e.g., recognition tasks), but they would show an age-related reduction in performance on tasks like free & serial recall where these cues are absent.

On similar lines, Craik and McDowd (1987) studied differences in recall and recognition in younger and older individuals. They hypothesized that participants would show more difficulty with recall than with recognition and also that older people would show greater loss than their younger counterparts on recall tasks as opposed to recognition tasks. The participants were 15 younger adults with mean age, 20.7 and 15 older adults with mean age of 72.8 years. Total of 144 items was included in the study, classified into 12 lists of 12 phrase word items, presented on a computer screen at rate of 1 item/5 s. Among these 2 lists were given for practice. Finally 60 items served as target for the cued recall task and 60 items for recognition. Participants were asked to perform both recall and recognition tasks. In the recall test participants were asked to respond by saying aloud the target for each of the cue phrases. In the recognition task, participants had to respond by saying "yes" or "no," depending upon whether the target appeared in the presentation lists. Results revealed that, older participants performed poorly than their younger group on recall, i.e. there was a reliable age decrement in recall, whereas they performed slightly better than the younger participants in recognition task. The authors conclude by saying that during recall tasks more processing resources such as attention, speed,

initiation, inhibition are all required than the recognition task. Older people are limited in these processing resources and hence show poor recall abilities. Where as in recognition task, the information is re-presented to the participant and the mental operations are determined by the external stimuli that are associated with the task itself, which makes it easier. In recall by comparison, there are very few cues the individual should self initiate the accurate mental operations and hence at a disadvantage when recall is involved.

Serial position functions in younger adults are also dissimilar from those produced by older adults as reported by Maylor, Vousden and Brown, 1999. Probability of First Recall (PFR) curves of younger adults (18-21) and older adults (66-88 years) were studied by Kahana, Howard, Zaromb and Wingfield (2002). PFR curves are serial position curves for the first items recalled (Hogan, 1975). Recency and lag-recency effects were studied. Lag recency effects means, individuals recall items that are in temporal proximity or in contiguity with each other i.e., successively recalled items are likely to be from adjacent serial positions than from the remote serial positions (Howard & Kahana, 1999; Kahana, 1996). They found that both groups started to recall the recent items initially, but the lag-Recency effect was notably reduced in older adults compared to younger, which suggests a deficit in the associative processes which are consistent with Naveh-Benjamin's (2000) findings.

Age-related changes with respect to temporal associations in different task conditions were also explored by certain authors. Golomb, Peelle, Addis, Kahana and Wingfield (2008) experimented the abilities of younger and older adults to recall in "conditions were temporal organization was largely incidental (free recall) with those in which temporal organization was largely intentional (serial recall)", by using an uncategorized

list. The study found that serial order recall was more hard than free recall, for both age groups resulting in fewer correct responses and also reported that compared to younger adults (mean age, 20 years), there was a greater decline in serial order performance in the older adults (mean age, 73 years). The younger group also demonstrated a greater ability to recall more number of words in the list than the older group. A follow-up analysis was then carried out to examine the position of the items recalled in relation to the other items in the list which showed that older adults were not able to utilize order information. On observation, it was seen that the effect of contiguity differed by age i.e. in free recall, younger adults tended to recall items together when these items had been originally presented together.

Golomb et al.,'s (2008) analyses of order in older adults revealed that they were at a disadvantage in using the temporal context information and hence they might rely on semantic information even when it is not helpful. This lack of temporal organization is on par with recent the work of Cabeza, Anderson, Houle, Mangels and Nyberg (2000) that indicated older adults' deficits in maintaining order information and in generating associations between units of information (Howard & Kahana, 1999; Naveh-Benjamin, 2000; Howard, Kahana & Wingfield, 2006; Naveh-Benjamin, Guez & Shulman, 2004). Similar findings were obtained by Craik, Morris and Gick (1990), but they hypothesized the difficulty arises in these tasks because in free recall tasks "on-line" storage and manipulation of the available information is required whereas in serial recall tasks active maintenance and monitoring of previous responses are also important, which is difficult as age increases.

2.2.3.6 Recall abilities in neurological disorders

Memory problems are associated with many psychiatric and neurological illnesses. Recall abilities are affected in many neurological disorders. Often recall is used as a measure to diagnose and differentially diagnose several neurological disorders. This also helps in early identification of disorders like Alzheimer's, Dementia and to track the progress of the disorder.

A lot of research has been done in exploring the serial position effects during recall in individuals with neurological disorders. Carlesimo, Marfia, Loasses and Caltagirone (1996) did a study on patients diagnosed with amnesia and reported that amnesic individuals show a recency effect but have poor ability to retain primacy items. Compared with preoperative performance, patients who had undergone resections of the anterior temporal lobe show considerable difficulty in recalling from primary and middle portions of a word list, but have the recency portion preserved (Hermann, Seidenberg, Wyler, Davies, Christeson, Moran & Stroup, 1996). One of the most defining features of word-list learning in individuals with Alzheimer's disease is lack of primacy effect (Carlesimo, Fadda, Sabbadini & Caltagirone, 1996).

A comparative study of recall total, across five trials of primacy and middle portions of the list with the items in the recency region were done by Foldi, Brickman, Schaefer and Knutelska (2003). The results revealed that primacy and recency regions were recalled equally by the controls, while the Alzheimer's Disease group recalled recency items better than the items in the middle. The most affected was the items in the primacy region, which is similar to the findings in previous research. Individuals with mild and very mild Alzheimer's disease showed recency effect but no primacy effect (Bayley,

Salmon, Bond, Bui, Olichney, Delis, Thomas & Thal, 2000). Gainotti, Marra, Villa, Parlato and Chiarotti (1998) reported that it is because of difficulty in consolidating information into long term memory.

From a systematic review of literature, it can be inferred that recall pattern declines with normal ageing as well as in clinical conditions such as MCI, Dementia and Alzheimer's Disease. In addition to this, the previous studies have analysed recall abilities only in terms of a particular linguistic task or based on a specific type of recall like cued or serial. Thus it was noted that there is a dearth of studies which explored recall abilities in a wholistic manner.

Chapter III

Method

To meet the aim of the study the following conditions were considered: Free recall immediate, free recall delayed, serial recall immediate and serial recall delayed. Each of these conditions included further tasks such as 3 syllable, 4 syllable and 5 syllable word recall, semantically related word recall, semantically unrelated word recall, digit recall and non-word recall.

3.1 Participants

Two groups of participants were involved in the study, thirty younger and thirty older adults between the age range of 18 years to 25 years (mean age-21.8) and 55 years to 65 years (mean age-59.1) respectively. Deliberate sampling method was used to recruit the participants for the study. 15 male and 15 female participants were recruited both in the younger and older group. All participants were native speakers of Kannada language. A written consent was obtained from all the participants prior to the experiments. Demographic details of the participants are as shown in table 1.

Table 3.1

Demographic details of the participants.

Participant number	Age (years)	Gender	Education/Occupation
01	22	M	UG
02	24	M	PG
03	22	M	UG
04	25	M	PG
05	22	M	UG
06	18	M	UG
07	20	M	UG
08	24	M	PG
09	18	M	UG

Table 3.1 continue.

Participant number	Age	Gender	Education/Occupation
10	22	M	UG
11	21	M	UG
12	22	M	UG
13	19	M	UG
14	20	M	UG
15	25	M	PG
16	22	F	UG
17	19	F	UG
18	19	F	UG
19	25	F	PG
20	20	F	UG
21	25	F	PG
22	24	F	PG
23	22	F	UG
24	18	F	UG
25	22	F	UG
26	20	F	UG
27	25	F	PG
28	21	F	UG
29	23	F	UG
30	25	F	PG
31	56	M	MA
32	58	M	BA
33	57	M	B.com
34	56	M	MA
35	55	M	B.com
36	59	M	SSLC
37	63	M	PUC
38	62	M	SSLC
39	60	M	B.ed
40	56	M	BE
41	55	M	MBBS
42	56	M	BE
43	59	M	PUC
44	62	M	BA
45	65	M	B.ed
46	64	F	SSLC
47	63	F	SSLC
48	56	F	PUC
49	55	F	B.ed
50	58	F	BA

Table 3.1 continue.

Participant number	Age	Gender	Education/Occupation
51	60	F	SSLC
52	55	F	LLB
53	59	F	PUC
54	60	F	SSLC
55	58	F	B.com
56	62	F	B.ed
57	65	F	PUC
58	56	F	SSLC
59	68	F	PUC
60	55	F	BA

Participant Inclusion Criteria

Participants were screened with Mini Mental State Examination, MMSE (Folstein, Folstein & McHugh, 1975) to rule out pre-existing memory disturbances. All participants who received a score of 25 or more were included in the study. Informal hearing screening was carried out for the participants to rule out hearing loss by using Ling's six sounds. Participants were also matched according to their educational background, and participants with a minimum education level of standard 10^{th} (SSLC) were recruited for the study.

3.2 Stimulus Preparation & Presentation

All stimuli were presented in Kannada. The lists were recorded on CSL 4500, one word being presented every 1 sec and was presented through headphones. The last item of the list was indicated by changing the inflection, similar to that at the end of a spoken declarative sentence. The stimulus was randomized during the presentation.

3.3 Materials and Tasks

The test material consisted of words of different complexity level i.e., 3 syllable words, 4 syllable words and 5 syllable words; semantically related words lists, semantically unrelated word lists, digit lists and non-word list. The word lists were made in Kannada. List was prepared separately for traning and testing phase. Twe sets of lists were prepared testing phase. Materials used for the different tasks and their source are described below in figure 3.1 and the list is appended (Appendix 1).

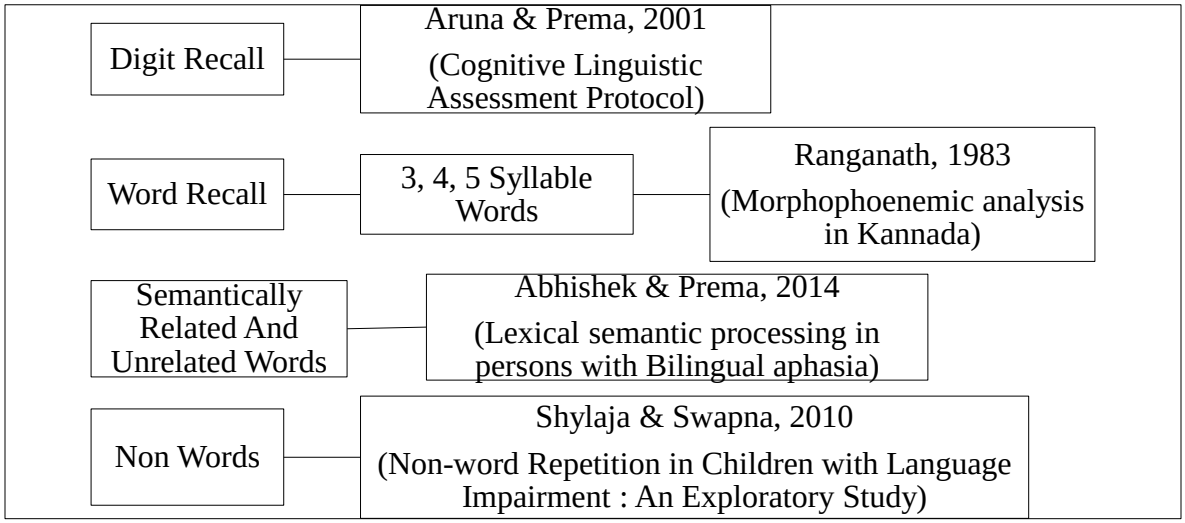

Figure 3.1. Summary of materials adopted for the study.

1. Word recall:This task comprised of 3 subtasks with syllable length varying from three to five syllables. These words were taken from Morpho-phoenemic analysis in Kannada (Ranganath, 1983).

i. Three syllable word recall: e.g.; ba:gilu, mamate, devaru, janani.

ii. Four syllable word recall: e.g.; gaDiya:ra, guruva:ra, nagegaLu.

iii. Five syllable word recall: e.g.; vya:vaharika, paNigrahaNa, utpadaneya.

2. Semantically related word recall: In this task, 2 semantically similar lists were assembled. Each list comprised of 10 words from the same semantic category (eg., animals, household objects). The stimulus was adopted from Lexical semantic processing in persons with bilingual aphasia (Abhishek & Prema, 2014).
3. Semantically unrelated word recall: In this task, 10 items distinct from each other with respect to their semantic category were used. This was prepared by mixing the words from different semantic categories. The stimulus for this task was also adopted from Lexical semantic processing in persons with bilingual aphasia (Abhishek & Prema, 2014).
4. Digit recall: Single digits were used for this task. The stimulus material for this task was adopted from Cognitive Linguistic Assessment Protocol abbreviated as CLAP (Aruna & Prema, 2001). e.g.: 3, 4, 6, 7.
5. Non-word recall: In this task participants were made to recall non-words of 3 -5 syllable length. The non words were prepared by transposing the syllables in the true words. The stimuli for non words were taken from Non-word Repetition in Children with Language Impairment: An Exploratory Study (Shylaja & Swapna, 2010). e.g.: garasaga (garagasa), thipa:cha (chapathi), shanega (ganesha).

3.4 Procedure

Testing was carried out in a quiet and non distracting environment. This was carried out in two phases:

Training Phase: Two practice trials were given to the participants before the presentation of test items in auditory mode under each condition i.e. free recall and serial order recall. After the 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 with one session lasting for about 20 minutes in 7x4 (tasks x conditions) experimental conditions. They were made to sit in front of a computer about 50 cm away from the screen in a comfortable posture. The stimulus was presented in the auditory mode through headphones. A string of ten units was presented one after the other, each with an inter stimulus duration of 1sec. The testing was carried out in the order of free recall immediate, free recall delayed, serial recall immediate and serial recall delayed across 7 tasks (3 syllable, 4 syllable and 5 syllable word recall, semantically related word recall, semantically unrelated word recall, digit recall and non - word recall).

The study included the following conditions and the summary of test conditions and tasks are depicted in figure 3.2;

- Free Recall Immediate (FRI): In this condition, participants were instructed to recall the units immediately after the presentation of the stimulus in any order of presentation of stimulus.
- Free Recall Delayed (FRD): In this task, participants were instructed to recall the units after a delay of 15 seconds in any order of presentation.
- Serial Recall Immediate (SRI): In this task, participants were instructed to recall, in the same order of presentation of the stimulus, immediately after presentation.
- Serial Recall Delayed (SRD): In this task, participants were instructed to recall after a delay of 15 seconds but in the same order of presentation of stimulus.

For both delayed free and serial recall conditions, during the delay of 15 seconds, participants were made to repeat a particular stimulus to prevent verbal rehearsal. Numbers '1234' were used to prevent verbal rehearsal for the word recall tasks and for the digit recall tasks, participants were made to repeat alphabets 'jacbd' aloud. The sets were counterbalanced in the order of presentation to minimize practice effects. The responses of the participants were recorded using Sony Voice Recorder.

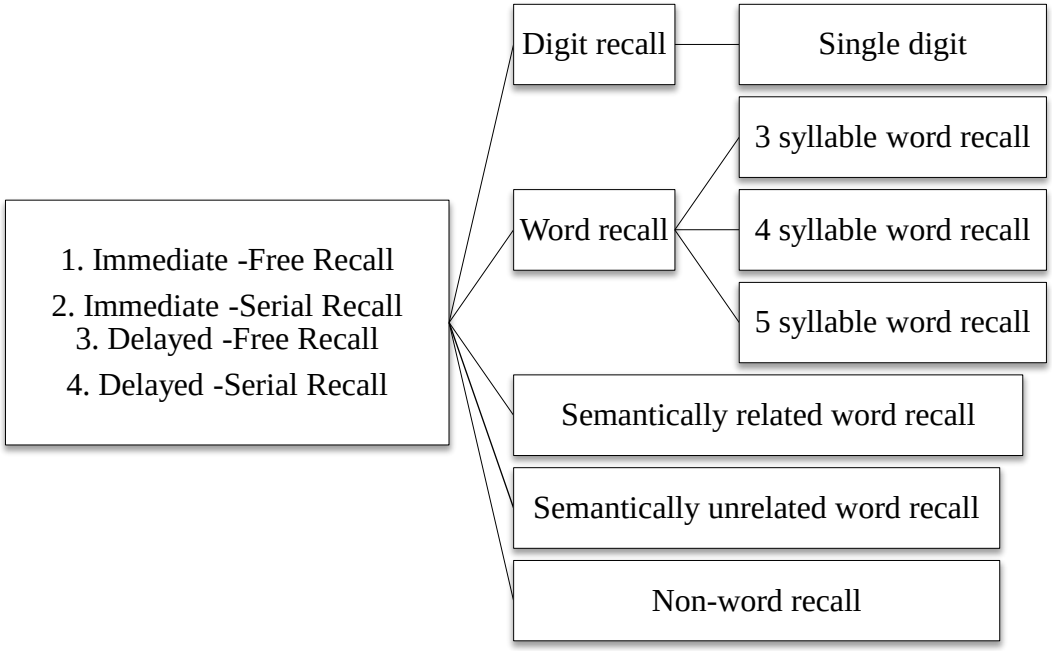

Figure3. 2. Summary of test conditions and tasks.

3.5 Scoring and Analysis

Quantitative and Qualitative analysis of the data was carried out.

Quantitative Analysis: A maximum score of '1' was given for each set that was recalled appropriately and a score of '0' was given if the participants recall were not appropriate at any level. For free recall task score of '1' was given for correctly recalled item from any

position in the list. For Serial recall, a score of '1' was given if the item was recalled from the same position or order.

Qualitative Analysis: This was carried out in terms of analysis 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 software version 21.0.

Chapter IV

Results and Discussion

The primary aim of the study was to analyze verbal recall abilities in younger and older adults. Four different conditions were considered for the study : free recall immediate, free recall delayed, serial recall immediate and serial recall delayed across 7 tasks with 3 syllable words, 4 syllable, words, 5 syllable words, semantically related words, semantically unrelated words, digits and non-words as stimuli. Total of 60 individuals were recruited for the study and were divided into two groups. Group I comprised of 30 younger adults and Group II consisted of 30 older adults with equal number of male and female participants in both the groups. Qualitative and quantitative analysis were carried out in which quantitative analysis was carried out using Statistical Package for Social Sciences (SPSS) software version 21. The data was subjected to test of normality by using Shapiro Wilk's test and it was seen that the data was not abiding to properties of normal distribution and hence 6 outliers were removed. All these outliers belonged to group II (older group). Hence the final number of participants in group II reduced to 24 from 30. In spite of removal of outliers, the data adhered to non normal distribution owing to which non-parametric tests were used for all objectives except for comparison of verbal recall abilities for free and serial recall tasks across immediate and delayed recall, for which parametric test was used.

The objectives of the study are as follows;

I. To compare verbal recall abilities between younger and older adult participants and across gender (male & female).

II. To compare verbal recall abilities for digits and words.

III. To study verbal recall abilities for free and serial recall tasks on two conditions namely immediate and delayed recall.

IV. To study the verbal recall pattern for stimuli of different complexity level and serial position effects associated with recall tasks i.e. primacy effect and recency effect.

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

A. Quantitative Analysis

The following analysis was carried out to address objective I;

a. Comparison of verbal recall abilities between younger and older adult participants (across age groups).

b. Comparison of verbal recall abilities across gender within age groups.

The following analysis was carried out to address objective II;

a. Comparison of verbal recall abilities for digits and words.

b. Comparison of verbal recall abilities for semantically related words and semantically unrelated words.

c. Comparison of verbal recall abilities for words and non words.

The following analysis was carried out to address objective III;

a. Comparison of verbal recall abilities for free and serial recall tasks on two conditions namely immediate and delayed recall.

The following analysis was carried out to address objective IV;

a. Comparison of verbal recall pattern for stimuli of different complexity level (3 syllables vs. 4 syllables vs. 5 syllables).

B. Qualitative Analysis

b. Recency and Primacy effect during recall and error analysis during recall in younger and older adults.

A. Quantitative Analysis

Objective I

a. Comparison of verbal recall abilities between younger and older adult participants (across age groups).

The overall mean, standard deviation (SD) and median were calculated for the performance of Group I (younger adults) and Group II (older adults) across the two tasks free recall (immediate and delayed) and serial order recall (immediate and delayed). Table 4.1 shows the performance of both the groups across the two tasks.

Table 4.1

Mean, SD and Median for Group I (n=30) and Group II (n=24) across free recall and serial recall tasks.

Tasks	Group I			Group II		
	Mean	**SD**	**Median**	**Mean**	**SD**	**Median**
FRTOTAL	50.23	3.78	50.71	29.04	3.64	28.57
SRTOTAL	44.83	4.72	45.71	24.88	3.20	24.28

Note: FRTOTAL=Free Recall (Immediate+Delayed), SRTOTAL=Serial Recall (Immediate+Delayed)

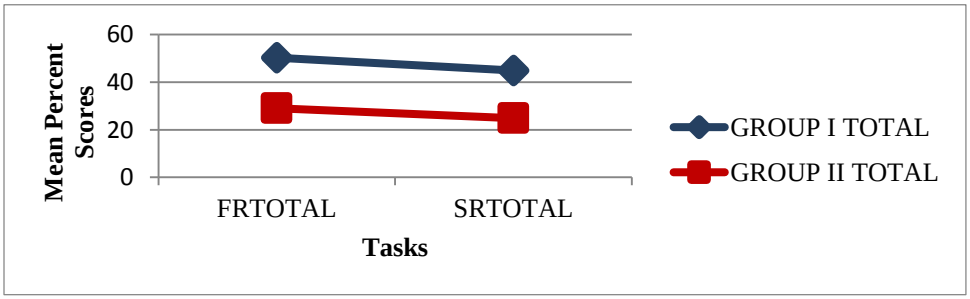

Figure 4.1. Mean scores for group I and group II on free and serial recall tasks.

As depicted in table 4.1, Group I (Mean (SD) =50.23(3.78), Median=50.71) performed better than Group II (Mean (SD) =29.04 (3.64), Median=28.57) in the free recall task. Similar trend was seen in serial recall task, where the performance of Group I (Mean (SD) =44.83 (4.72), Median=45.71) was superior to that of Group II (Mean (SD) =24.88 (3.2), Median=24.28). From figure 4.1, it can also be observed that for both the groups the scores of free recall were higher than that of serial order recall tasks.

Further statistical analysis was carried out to verify if there was a significant difference between the younger and older group. A check of normality was done using Shapiro-Wilk's test on the data in both the groups. The data did not follow properties of normal distribution ($p<0.05$) even after the removal of 6 outliers from Group II: 3 each in older male and female group, hence non parametric test were used. Mann-Whitney U test, was used which revealed significant difference between younger and older group on the two tasks i.e., in free recall $|Z|=6.27$, $p<0.01$ and serial recall $|Z|=6.27$, $p<0.01$. This indicated that verbal recall abilities differed significantly between age groups (younger and older) with younger adults performing better than older adults.

b. Comparison of verbal recall abilities across gender within age groups.

The mean, standard deviation (SD) and median scores across gender within age group (Group I and Group II) for the two tasks (free recall and serial recall) were obtained using descriptive statistics. The performance of the two groups across gender is depicted in Table 4.2.

Table 4.2

Mean, SD, Median score for Group I (n=30) and Group II (n=24) across gender.

Tasks		Group I			Group II		
		Mean	**SD**	**Median**	**Mean**	**SD**	**Median**
FRTOTAL	**Males**	49.52	3.31	50.71	31.78	2.96	31.42
	Females	50.95	4.18	51.42	26.30	1.63	26.42
SRTOTAL	**Males**	45.14	2.40	45.71	27.38	2.53	27.14
	Females	44.52	6.34	47.14	22.38	1.19	22.14

Note: FRTOTAL=Free Recall (Immediate+Delayed), SRTOTAL=Serial Recall (Immediate+Delayed)

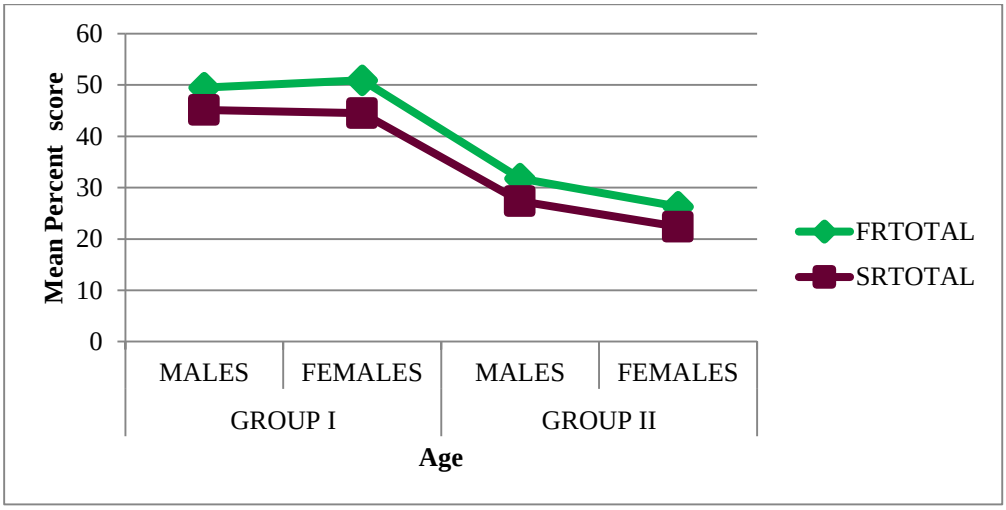

Figure 4.2. Mean scores for group I and group II on free and serial recall tasks across gender.

On comparing the mean scores across gender in group I, it was seen that males (MeanFRTOTAL=49.52;MeanSRTOTAL=45.14) and females (Mean FRTOTAL=50.95; Mean SRTOTAL=44.52) performed on par for free and serial recall tasK. However, as shown figure 4.2, in group II the mean scores of males were better than females in both the tasks. Mann-Whitney U test was used to test for statistical significance across gender as the data did not follow properties of normal distribution. In the younger group, there

was no significant difference between the performance of males and females for free recall |Z|=0.12, p>0.05 and serial recall |Z|=0.77, p>0.05 tasks. In contrast, in group II, there was significant difference between males and females for free and serial recall tasks with |Z|=3.9, p<0.01 and |Z|=4.1, p<0.01 respectively. In younger group, no difference was seen across gender, whereas a significant gender related difference was observed in older group.

Two different analyses were carried out to address objective I, to compare recall abilities across the age groups and across gender. The results of the present study revealed that there was a decline in recall abilities with respect to ageing with younger adults performing better compared to older adults. This can be interpreted based on either the morphological changes associated with normal ageing which include a decline in total brain volume, cortical thinning and gyral atrophy (Raz et al., 1997) or to the decline in the core cognitive functions like speed of information processing (Salthouse, 1996), lack of inhibition or due to poor working 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 ageing can be due to this atrophy in the PFC.

As age increases, there can also be difficulty in the representation, retention, and/or revising of context in the working memory, which are in turn important for successful recall. Serial recall tasks especially require this integration of the outputs from the long-term memory with appropriate binding of the contextual information. Older adults are at a disadvantage when this contextual binding and integration is necessary (Chalfonte &

Johnson, 1996). Another reason for the decline in recall abilities can be due to the lack of environmental support as the tasks used in the study were devoid of any such cue to the participants and hence the participants needed to self initiate the responses. As stated by, Craik (1983) older adults are weaker in these self initiated processes and hence have difficulty in recall. Another support is derived from Kynette et al.'s, (1990) study which indicated that with aging the recitation rate slows down. So it can be assumed that older adults in particular will have difficulty to rehearse more items in the short time span because of their slow recitation rate and hence show poor recall abilities.

On comparison across gender, it was seen that there was no difference with respect to gender in younger group, but in older group there was a significant effect of gender. In literature, there are mixed results for gender effect in recall. Resnick et al., (2000) suggested that this may be due to changes in cerebral volume in males and females associated with the normal aging process.

Objective II

a. Comparison of verbal recall abilities for digits and words.

The mean, median and standard deviation scores of Group I and Group II on word recall (3 syllable, 4 syllable and 5 syllable) and digit recall in free and serial recall tasks were derived from the data. Table 4.3 shows the details.

Table 4.3

Performance of Group I (n=30) and Group II (n=24) on words vs. digits.

	Group I			Group II		
Tasks	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**
FRWDTOTAL	49.44	50.00	4.27	28.61	28.33	4.18
FRDTOTAL	73.00	75.00	10.38	46.04	50.00	8.96
SRWDTOTAL	41.88	41.66	5.61	23.88	23.33	3.42
SRDTOTAL	60.83	60.00	13.00	30.62	30.00	9.12

Note: FRWD=Free Recall Words (Immediate + Delayed), FRD=Free Recall Digits (Immediate + Delayed), SRWD=Serial Recall Words (Immediate + Delayed), SRD=Serial Recall Digits (Immediate + Delayed).

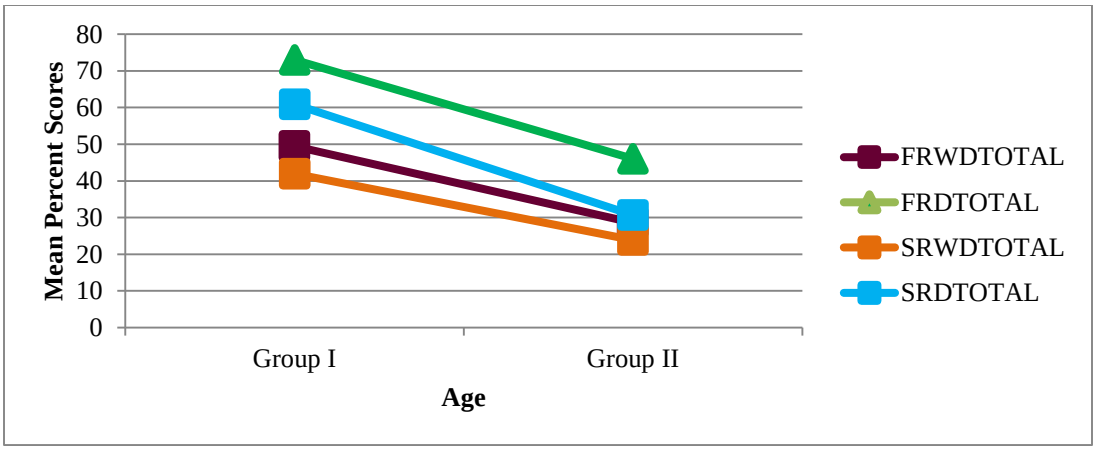

Figure 4.3. Mean scores for group I and group II on words and digits across free and serial recall tasks

In the free recall condition, the mean percent scores for Group I (younger adults) were 49.44 for word recall and 73 for digit recall, which indicates that digit recall was better compared to word recall. The same pattern was also observed for serial recall tasks with mean for words being 41.88 and for digits 60.83. From figure 4.3, it is evident that the percent mean scores for digits were higher for free recall and serial recall tasks in group

II (older adults). The values obtained were subjected to Wilcoxon's Sign rank tests for further analysis. The |Z| scores are shown in table 4.4.

Table 4.4

|Z| scores and p value (Wilcoxon's Sign rank Test) for words and digits across tasks in each group.

Tasks	Group I |Z| SCORES	Group II |Z| SCORES
FRDTOTAL-FRWDTOTAL	4.7**	4.5**
SRDTOTAL-SRWDTOTAL	4.2**	3.0**

****p*<0.01**

The results suggests that there is a significant difference ($p<0.01$) between the recall abilities for words and digits in both the age groups across free and serial recall tasks. The words used for the study were of 3 syllables, 4 syllable and 5 syllable length, whereas the digits used in the study were mainly bisyllabic and trisyllabic words. So, the length of the words was more for words compared to digits. This can be explained based on Baddeley's (1986) working memory (WM) model. The phonological loop of the WM stores the memory traces of the phonological information of the target words temporarily and the traces are prevented from decay by the sub vocal rehearsal mechanism. The trace can be refreshed by this rehearsing only if the time required to pronounce these items internally is less than the time required for trace degradation. As the length of the word increases, the pronunciation time for each word also increases and hence sub vocal rehearsal of the segments would be difficult as the trace decays rapidly contributing the poor performance of words in comparison with digits. This will lead to decay of the

traces for longer words. Similar results were obtained by Baddeley (1986) who reported that more short words can be rehearsed in the phonological store before decay occurs.

b.Comparison of verbal recall abilities for semantically related words and semantically unrelated words.

The mean percent scores, the standard deviation and the median scores of recall of semantically related words and semantically unrelated words on Group I and Group II were computed. Table 4.5 (mentioned below) shows the details.

The mean percent scores for recall of semantically unrelated words in Group I and Group II were much lower than that of semantically related words in both free recall and serial recall tasks. The median scores were also in the same direction as mean scores.

Table 4.5

Performance of Group I and Group II on semantically related vs. semantically unrelated words.

	Group I			Group II		
Tasks	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**
FRSRTOTAL	73.00	7.49	75.00	46.45	4.77	45.00
FRSURTOTAL	59.33	11.72	57.50	30.83	7.89	32.50
SRSRTOTAL	53.66	7.30	55.00	32.70	6.75	35.00
SRSURTOTAL	48.50	9.20	50.00	29.79	5.61	30.00

Note: FRSRTOTAL=Free Recall Semantically Related Words (Immediate + Delayed), FRSURTOTAL=Free Recall Semantically Unrelated Words (Immediate + Delayed), SRSRTOTAL=Serial Recall Semantically Related Words (Immediate + Delayed), SRSURTOTAL=Serial Recall Semantically Unrelated Words (Immediate + Delayed).

Wilcoxon's Sign rank tests were used for further statistical analysis to test the significance between semantically related and unrelated words across free recall and

serial recall tasks in both the groups. The |Z| scores and *p* values are as shown in table 4.6.

Table 4.6

|Z| scores and p value (Wilcoxon's Sign rank Test) for semantically related and semantically unrelated words across tasks in each group.

	Group I |Z| SCORES	Group II |Z| SCORES
FRSRTOTAL-FRSURTOTAL	4.05**	4.31**
SRSRTOTAL-SRSURTOTAL	2.15*	0.803

***p*< 0.05, ***p*<0.01**

It is evident from table 4.6 that recall abilities for semantically related words are superior to the recall abilities of semantically unrelated words in Group I, where as in Group II, a significant difference was only observed for the free recall task. Better recall abilities were observed for semantically related words compared to unrelated words in both the age groups. Although in older adults a significant difference was obtained for only free recall tasks of semantically related items, the mean and median scores was found to be higher even for serial recall. Items from related category are recalled better because the lexical category will contribute to the increased probability of recalling the long-term representations. This could be either because the category would supplement as a retrieval cue (Crowder, 1979; Poirier & Saint-Aubin, 1995; Saint-Aubin & Poirier, 1999) or because the long-term representations of these similar items would be activated to a higher extent due to their long-term associative links (Stuart & Hulme, 2000). The findings also draws support from the study by Andre and Sola (1976) in reading where

better recall of the text was found when the reader was encouraged to make semantic elaborations on the text material, which again signifies the importance of semantics in recall. Reaction time studies have also yielded similar results, wherein the reaction time for semantically related words were better compared to unrelated words, which were attributed to the semantic priming effects (Krishnan & Tiwari, 2010).

c. Comparison of verbal recall abilities for words and non words.

The overall mean, standard deviation (SD) and median were extracted for Group I and Group II across the two tasks for recall of words and non words. The scores are shown in table 4.7.

Table 4.7

Performance of Group I (n=30) and Group II (n=24) on words vs. non-words.

	Group I			Group II		
Tasks	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**
FRWDTOTAL	49.44	4.27	50.00	28.61	28.33	4.18
FRNWTOTAL	41.88	5.61	41.66	23.88	23.33	3.42
SRWDTOTAL	32.16	10.96	35.00	14.37	15.00	6.47
SRNWTOTAL	25.16	7.82	25.00	11.25	10.00	4.94

Note: FRWDTOTAL=Free Recall Words (Immediate + Delayed), FRNWTOTAL=Free Recall Non-Words (Immediate + Delayed), SRWDTOTAL=Serial Recall Words (Immediate + Delayed), SRNWTOTAL = Serial Recall Non-Words (Immediate + Delayed).

As shown in table 4.7, in group I the mean scores ranged from 49.44 for word recall to 41.88 for non-word recall in free recall condition and from 32.16 for word recall to 25.16 in serial recall condition. It is seen that, word recall scores are better compared to non

word recall in serial recall tasks and also free recall condition is superior to serial recall condition both for words and non words. Similarly, analysis of mean scores in group II also provides with similar results. Similar trend was seen in median scores. Wilcoxon's sign rank test was carried out to test the significance between the pairs. The |Z| scores and *p* values are shown in table 4.8.

Table 4.8

|Z| scores and p value (Wilcoxon's Sign rank Test) for words and non words across tasks in each group.

Tasks	Group I |Z| SCORES	Group II |Z| SCORES
FRWDTOTAL-FRNWTOTAL	4.59**	4.20**
SRWDTOTAL-SRNWTOTAL	4.72**	4.29**

****p*<0.01**

Overall, the performance of words was superior to performance of non words within age group and across tasks with |Z| score ($p<0.05$). The number of items recalled in the word list was more than non-word list in both the age groups across both the tasks. This can be because during word recall the long term semantic representations of the words also get activated and facilitates in recall. In contrast, for non-word recall this semantic representation is not available (Schweikert, 1993). While recalling words, even if the memory trace has been decayed, the existing long term representations helps to reconstruct the to-be remembered items, whereas this is not available for the non-words. This receives supports from the findings of the study by Saint-Aubin and Poirier (2000)

who reported that minimal long-term representations for non-words is considered to be responsible for their lower item recall.

Objective III

a. Comparison of Verbal recall abilities for free and serial recall tasks on two conditions namely immediate and delayed recall.

Check of normality was done using Shapiro Wilk's test on the data obtained and it was found that there was normality ($p>0.05$) in both the groups across all 4 tasks (free recall immediate, free recall delayed, serial recall immediate and serial recall delayed). As a result parametric test was done to analyze the significant difference, if any. The mean values and standard deviation were derived and is indicated in table in 4.9 and 4.10.

Table 4.9

Performance of Group I (n=30) and Group II (n=24) on free and serial recall tasks across immediate and delayed conditions.

	Group I		Group II	
Tasks	**Mean**	**SD**	**Mean**	**SD**
FRI	52.61	4.66	31.66	4.58
FRD	51.90	6.26	29.58	3.96
SRI	47.23	5.51	26.13	3.98
SRD	42.42	6.59	23.63	3.15

Note: FRI=Free Recall Immediate, FRD=Free Recall Delayed, SRI=Serial Recall Immediate, SRD= Serial Recall Delayed.

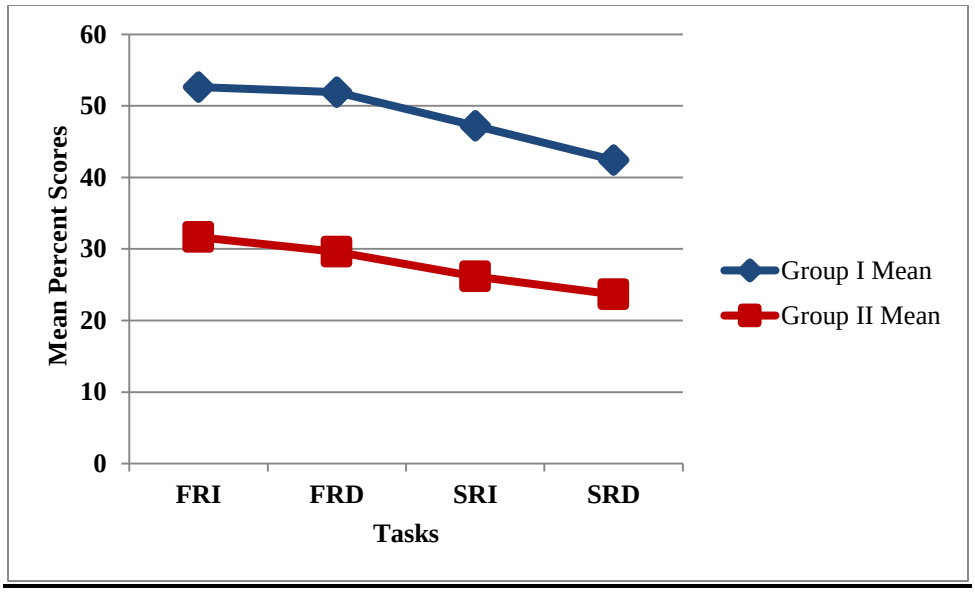

Figure 4.4. Mean scores for group I and group II on free and serial recall tasks across immediate and delayed conditions.

Two way repeated measure ANOVA was carried out to study the effect of type (free recall and serial recall) and duration (immediate and delayed) and between factors as age and gender. Analysis of results shows that mean scores of Group I and Group II were higher for the free recall immediate task than other tasks. There was a significant main effect across age at $F(1, 50) = 613.605$, $p < 0.01$. There was also a main effect of type (free recall and serial recall) at $F(1, 50) = 147.779$, $p < 0.01$ and also main effect of duration (immediate and delayed) at $F(1, 50) = 4.773$, $p < 0.05$. It was also seen that there was significant Interaction effect between type (free, serial) and duration (immediate, delayed) at $F(1, 50) = 14.91$, $p < 0.01$.

Table 4.10

Performance of Group I (n=30) and Group II (n=24) on free and serial recall tasks across immediate and delayed conditions across gender.

Tasks		Group I		Group II	
		Mean	**SD**	**Mean**	**SD**
FRI	**Males**	50.95	3.56	32.97	4.01
	Females	52.85	5.50	26.19	1.64
FRD	**Males**	51.14	5.89	34.16	3.13
	Females	54.09	6.47	29.16	3.07
SRI	**Males**	47.80	3.65	28.04	3.51
	Females	46.66	6.99	23.21	1.50
SRD	**Males**	42.47	3.36	25.71	2.65
	Females	42.38	8.91	21.54	2.06

Note: FRI=Free Recall Immediate, FRD=Free Recall Delayed, SRI=Serial Recall Immediate, SRD=Serial Recall Delayed.

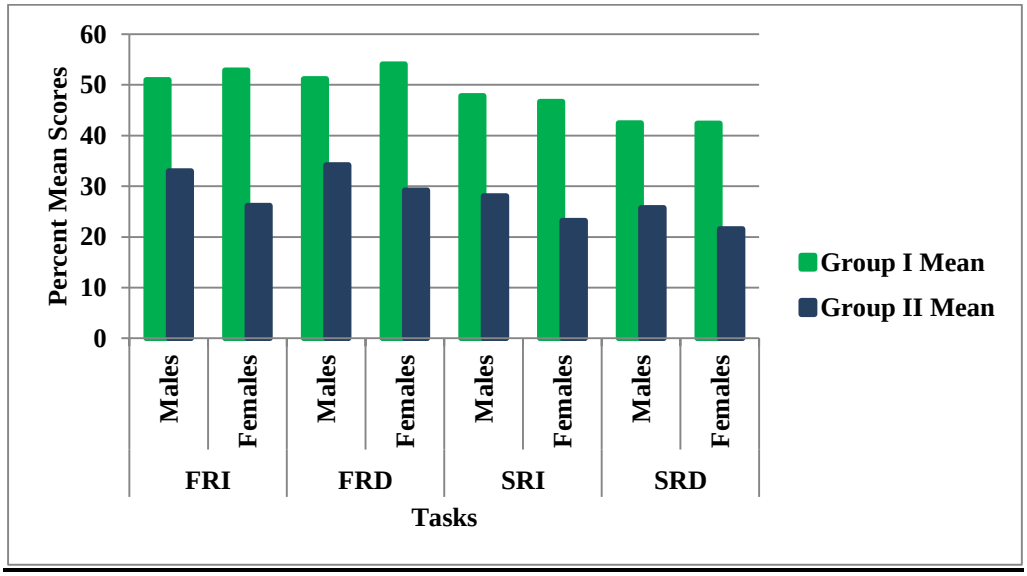

Figure 4.5. Mean Scores of Group I and Group II on free and serial recall tasks across immediate and delayed conditions across gender.

From table 4.10, it is evident that in Group I the performance of males and females were almost similar in all the four conditions, in contrast the mean scores in Group II indicates that there was a difference in the performance across males and females in all the four conditions. Results of Two way repeated measure ANOVA revealed that there was a significant main effect of gender at $F(1, 50) = 7.317$, $p<0.01$. There was also significant interaction effect of gender and age at $F(1, 50) = 14.31$, $p<0.01$. The results obtained shows that on comparing free and serial recall task, the performance was better in free recall compared to serial recall irrespective of age. The difference in performance is because during free recall the individual has to do only an "on-line" storage and manipulation of the available information, in contrast to serial recall tasks where active maintenance and monitoring of previous responses are also important, which is difficult (Craik, Morris & Gick 1990). The results are in consonance with Golomb et al's (2008) study which reported that temporal context information is necessary for serial recall.

On comparing immediate and delayed recall it was seen that, both age groups performed better on immediate recall. During immediate recall participants were asked to recall immediately after the presentation of stimulus, but in delayed recall the participants were made to recall after a delay of 15 seconds during which participants were asked to recite verbally numbers and alphabets to prevent rehearsal. This lack of rehearsal can be one reason for poorer scores in delayed recall (Baddeley, 1975). Another hypothesis is that during immediate recall there is minimal interference and hence superior recall (Burton, Niles & Wildman, 1981). This may be related to a verbatim effect which lingers for a brief period of time but disappears by the time of the delayed measure. When rehearsal is not allowed the items in the phonological store fades away quickly (Healy & McNamara,

1996). An additional explanation is that if tested immediately then the current temporal context can serve as a retrieval cue by itself, which would facilitate recall of more items.

Objective III

a. Comparison of verbal recall pattern for stimuli of different complexity level (3 syllables vs. 4 syllables vs. 5 syllables).

The mean, SD and median scores for stimuli of different complexity level are specified in Table 4.11. It can be inferred from table 4.11 and figure 4.6 that both in group I and group II, the performance decreased in the order of 3 syllable followed by 4 syllable and then 5 syllable for both free recall and serial recall in both the groups.

Table 4.11

Performance of Group I (n=30) and Group II (n=24) for stimuli of different complexity level.

	Group I			Group II		
Tasks	**Mean**	**SD**	**Median**	**Mean**	**SD**	**Median**
FR3SYTOTAL	56.66	8.54	55.00	33.95	5.51	35.00
FR4SYTOTAL	52.33	6.12	50.00	30.62	5.95	30.00
FR5SYTOTAL	39.33	5.83	40.00	21.25	5.75	20.00
SR3SYTOTAL	46.50	8.42	47.50	27.91	4.14	30.00
SR4SYTOTAL	43.00	7.14	45.00	24.16	5.24	25.00
SR5SYTOTAL	36.16	6.52	35.00	19.58	5.88	20.00

Note: FR3SYTOTAL-Free Recall 3 Syllables (Immediate + Delayed), FR4SYTOTAL-Free Recall 4 Syllables (Immediate + Delayed), FR5SYTOTAL-Free Recall 5 Syllables (Immediate + Delayed), SR3SYTOTAL-Serial Recall 3 Syllables (Immediate + Delayed), SR4SYTOTAL-Serial Recall 4 Syllable (Immediate + Delayed), and SR5SYTOTAL-Serial Recall 5 Syllable Total (Immediate + Delayed).

Friedman's test was conducted to evaluate differences among the 3 levels of word complexity in both free and serial recall tasks in both the groups. In free recall tasks in younger group the test was significant at χ^2 (2, N = 30) =39.07, p<0.01. Serial recall tasks also yielded similar result with test being significant at χ^2 (2, N = 30) =22.28, p< 0.01. Friedman's test was conducted even for group II on both free recall and serial recall tasks and the test was significant at χ^2 (2, N = 24) =32.34, p<0.01 and χ^2 (2, N = 24) =22.98, p<0 .01 respectively. Hence Wilcoxon's Sign rank test was performed for free and serial recall tasks in both the groups to test for significance between different levels of complexity. The |Z| scores and *p* values are represented in the table given below (4.12).

Table 4.12

|Z| scores and p value (Wilcoxon's Sign rank Test) for words of different complexity level.

Tasks	Group I |Z| SCORE	*p* value	Group II |Z| SCORE	*p* value
FR3SYTOTAL-FR4SYTOTAL	2.26	0.024**	2.62	0.009**
FR3SYTOTAL-FR5SYTOTAL	4.65	0.000**	3.99	0.000**
FR4SYTOTAL-FR5SYTOTAL	4.51	0.000**	4.08	0.000**
SR3SYTOTAL-SR4SYTOTAL	1.96	0.049**	2.62	0.009**
SR3SYTOTAL-SR5SYTOTAL	4.28	0.000**	3.90	0.000**
SR4SYTOTAL-SR5SYTOTAL	3.75	0.000**	2.55	0.001**

*****p<0.01***

It can be interpreted from the table 4.12 that in both the groups and across free and serial recall tasks there was significant difference between the three levels of complexity namely 3 syllable words, 4 syllable words and 5 syllable words. The findings of the study highlighted that 3 syllable words were recalled better than 4 syllable and 5 syllable words in both the age groups and across tasks. 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. In contrast, 4 syllable and 5 syllable words have an increased syllable length and hence require more pronunciation time. In earlier works of Miller (1976) it was 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 on the amount of rehearsal. In case of 4 and 5 syllable words only 1 or 2 items can be rehearsed whereas for 3 syllable words more items can be rehearsed in the given time and hence better recall. The results obtained for this objective study favors Baddeley's (1975) findings.

B. Qualitative Analysis

b. Recency and Primacy effect during recall and error analysis during recall in younger and older adults.

Recency effect is where items presented at the end of the list may be recalled well at the beginning of recall. During the free recall task, the effect of recency was salient. Both younger and older adult participants showed a greater tendency to recall the last two or

three items in the list initially. In both agee group recency effect decreased for delayed free recall task.Younger and older adult participants started recall in similar ways during initiation from the end of the lists but younger adults successively recalled items from nearby list. This trend was not seen in the performance of older adult group.

During serial recall task, the effect of recency was minimal in both the groups. The effect of primacy was prominent. Primacy effect is where the first few items may be recalled better. Same pattern was seen for both younger and older adults. In both the groups, for both free recall and serial recall the recall of middle items was poor. In terms of errors, it was mainly phonological errors in younger adults, whereas in older adults intrusion errors were more common followed by transposition errors and repetition errors.

The results showed a difference in serial position effects for both free recall and serial recall. In free recall, it was observed that both younger and older adults initiated recall with end of the list items, i.e., a recency effect was seen (Murdock, 1976). Recency effect is related to 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). The recency effect reduced for the delayed recall task because the delay cancelled out the recency effect. During the delay, the temporal context changes and also in the present study during the delay participants were asked to recite numbers and alphabets verbally aloud to prevent rehearsal. This could also have been a reason for reduced recency effect in delayed free recall (Glanzer & Cunitz, 1966).

In serial recall tasks, consistent with earlier findings a primacy effect was seen in both 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 first list item can be rehearsed by itself; the second will be rehearsed along with the first, the third along with the first and second.

Another interesting finding was noted, even though younger and older adults recalled from the end of list items for free recall and items from initial part of list for serial recall, while transforming between items in recall younger adults consistently recalled the items from the nearby positions in the list. This was not observed in older adults. This can be attributed to the fact that older adults form weaker item to item associations during recall (Cowan, 2001) and that they are not able to bind the temporal context of the elements which suggests a deficit in the associative processes which are consistent with Naveh-Benjamin's (2000) findings. Golomb et al., 2008 suggested that it is because the effect of contiguity differed by age i.e. in free recall, younger adults tended to recall items together when these items had been originally presented together but older adults were at a disadvantage in using this temporal context information. This lack of temporal organization indicated that older adults have deficits in maintaining order information and in generating associations between units of information (Howard & Kahana, 1999; Naveh-Benjamin, 2000; Howard, Kahana & Wingfield, 2006; Naveh-Benjamin, Guez & Shulman, 2004).

In terms of errors, it was mainly phonological errors in younger adults, whereas in older adults intrusion errors were more common followed by transposition and repetition errors. Phonological errors may be due to reconstruction process attempted by younger

adults. As the information available in the trace starts to decay, younger adults 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, a phonological error occurs. This is consonance with the findings of Schwickert(1993). An error is termed to be an intrusion when information that is related to the theme of a certain memory but which was not actually a part of the original episode is added with the current event (Jacobs, Salmon, Tröster & Butters, 1990). Intrusion errors in older adults can be due to their lack of inhibition where irrelevant information is brought to awareness while attempting to recall. Another possible explanation is that these errors are a result of lack of new context integration into an already existing memory trace that is related to the appropriate memory (Stip, Corbière, Boulay, Lesage, Lecomte, Leclerc & Guillem, 2007). Older adults are not able to bind the contextual information available and hence they try to recall the items from the lists which was given earlier. Repetition errors can be due to the atrophy of pre frontal cortex (Raz et al., 1998). Transposition errors were also seen in addition to intrusion errors, which show the inability of older individuals in maintaining the correct order of information (Cabeza et al., 2000).

In summary, the results of the present study revealed that there was difference in the recall abilities between younger and older adults. Older adults performed poorly owing to cognitive decline imposed with age. The study also tried to explore the relationship between stimuli of different linguistic load and recall abilities. It was seen that the recall abilities was better for words of shorter syllable length compared to longer syllable length, semantically related words compared to semantically unrelated words, words

compared to non-words and digits compared to words. Recall abilities was also compared across types (free and serial) and duration (immediate and delayed), which showed that recall was better for free with respect to type and in terms of duration immediate was better. Qualitative analysis revealed a recency effect for free recall and a primacy effect for serial recall. Finally, the error analysis showed phonological errors in younger adults and intrusion, transposition and repetition errors in older adults.

Chapter V

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.

Human long term memory consists of traces of many thousands of words, pictures, episodes and other types of information and hence retrieving/recalling this information is challenging. One of the major variables which would influence recall abilities is aging. Recall abilities form an important method in early diagnosis of Mild Cognitive Impairment and neurodegenerative diseases like Dementia, Frontal lobe degeneration and Alzheimer's disease. Hence, understanding recall abilities is very important and especially in Indian context where studies explicitly focusing on recall are limited. Previous researches conducted only experiments based on learning and retention, but the nature of stored material, its structure and its effect on recall has not been explored to a greater extent.

The primary aim of the study was to analyze verbal recall abilities in younger and older adults. The study included 60 normal adults, 30 younger adults in the age range of 18-25 years and 30 older adults in the age range of 55-65 years with equal male and female participants. All the participants had Kannada as their native language and were screened

using Mini Mental State Examination (MMSE) by Folstein and Mc Hugh (1975) with a criteria to obtain a score of 25 or above. Another criterion was to have a minimum of tenth grade education. The stimulus consisted of 2 lists of 3 syllable, 4 syllable and 5 syllable words (Ranganath, 1983), a list of semantically related and unrelated items (Abhishek & Prema, 2014), digit recall list (Aruna & Prema, 2001) and a set of non-words (Shylaja & Swapna, 2010). Each list had 10 items, which was randomized and presented across the 4 conditions i.e., free recall immediate, free recall delayed, serial recall immediate and serial recall delayed. 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. The stimuli was recorded using CSL 4500 and was played to participants through headphones. The responses of the participants were audio recorded using Sony Voice Recorder. The obtained data was analyzed both quantitatively and qualitatively.

The primary objective of the study was to investigate the verbal recall abilities in younger and older adults. Mean and median values was more for younger adults compared to older adults and a statistically significant difference was seen on Mann-Whitney U test (as the data did not abide by the properties of normal distribution). It can be inferred from the results that as age increased the verbal recall abilities decreased (Chalfonte & Johnson, 1996). The second objective was to see the effect of gender on recall abilities. There was no significant effect of gender in younger adults whereas in older adults, the difference was statistically significant with males performing better than females (Resnick et al., 2000).

The second objective of the study was to study the recall of digits and words which revealed superior recall effect for digits as most of the digits in Kannada were either bisyllabic or trisyllabic words (Baddeley, 1986). Recall abilities was also compared for semantically related and unrelated items. The number of items recalled in related list was higher in contrast to the unrelated lists, which illustrates that items within the same semantic category are recalled better as it helps in activating long term memory (Saint-Aubin & Poirier, 1999). Comparison of recall of words and non-words were also carried out which revealed that recall of words were superior to recall of non-words (Schweikert, 1993).

The third objective was to compare across the tasks and conditions it was seen that immediate recall was better than delayed recall (Healy & McNamara, 1996) and free recall abilities were superior to serial recall abilities (Craik, Morris, & Gick 1990). The fourth objective revealed a recency effect for free recall and a primacy effect for serial recall. Finally, the error analysis showed phonological errors in younger adults and intrusion, transposition and repetition errors in older adults. The study also found that recall abilities differed according to the nature of stored material and its structure irrespective of age. It was observed that as the length of the word increased from 3 syllable to 5 syllable, the recall abilities drastically decreased which shows the effect of word length on recall. As word length increases, recall abilities are known to decrease (Cowan et al., 2003).

Thus, the study helps us to infer that along with other cognitive processes recall abilities also declines with increasing age. These recall abilities also vary with respect to the nature of the linguistic stimulus. 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 specific reference to verbal recall abilities. The results of the study reveals age related decline in verbal recall abilities, hence this needs to be kept in mind while evaluating geriatric population.
- The study also has supplemented the current existing theoretical literature on the relation between cognition and language as it was seen that recall abilities varied with respect to linguistic structures with different phonologic, semantic load/complexity and that it influenced recall abilities in the younger and older population. This in turn may have significant effects in planning appropriate assessment and treatment strategies in persons with cognitive linguistic deficits such as Mild Cognitive Impairment and Dementia and in persons exhibiting linguistic deficits such as Aphasia.
- The test protocol used may serve as a comprehensive assessment battery for evaluating / screening recall abilities in younger and older adults.

Limitations of the study:

- The study considered only two age-groups from 18-25 years and 55-65 years. The intermediate age range was not considered, the inclusion of which would have served to track the cognitive decline.
- The study was restricted only to Kannada language and would have been carried out in bilingual context as bilingualism is a common phenomenon in the present society.

Implications for future research:

- The test stimulus used in the current study can be standardized and used as test battery.
- The study can be carried out in clinical population to assist in the early diagnosis of neurodegenerative diseases like Alzheimer's disease and Dementia.
- The study can be extended into bilingual population to study the effect of bilingualism on recall abilities.

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.

Akshoomoff, N. A., & Courchesne, E. (1992). A new role for the cerebellum in cognitive operations. *Behavioral neuroscience*, *106*(5), 731.

Albert, M. L. (1976). Short-term memory and aphasia. *Brain and Language*, *3*(1), 28-33.

Aruna, K., & Prema, K.S. (2001). Cognitive Linguistic Assessment Protocol. Unpublished Masters Dissertation, University of Mysore, Mysore, India.

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

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

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.

Bayley, P. J., Salmon, D. P., Bondi, M. W., Bui, B. K., Olichney, J., & Delis, D. C. (2000). Comparison of the serial position effect in very mild Alzheimer's disease, mild Alzheimer's disease, and amnesia associated with electroconvulsive therapy. *Journal of the International Neuropsychological Society*, *6*, 290–298.

Best, J. B. (1999). *Cognitive Psychology* (5th ed.). pp. 15-17. Belmont : Wadsworth publishing company.

Bottini, G., Corcoran, R., Sterzi, R., Paulesu, E., Schenone, P., Scarpa, P., & Frith, D. (1994). The role of the right hemisphere in the interpretation of figurative aspects of language A positron emission tomography activation study. *Brain*, *117*(6), 1241-1253.

Bower, G. H. (1981). Mood and memory. *American Psychologist, 36*, 129-148.

Broadbent, D.E. (1958). Perception and Communication. New York: Pergamon Press

Burton, J. K., Niles, J. A., & Wildman, T. M. (1981). Levels of processing effects on the immediate and delayed recall of prose. *Journal of Literacy Research*, *13*(2), 157-164.

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.

Cabeza, R., Mangels, J., Nyberg, L., Habib, R., Houle, S., McIntosh, A. R., & Tulving, E. (1997). Brain regions differentially involved in remembering what and when: a PET study. *Neuron*, *19*(4), 863-870.

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. *Cognitive Neuroscience, Journal of*, *12*(1), 197-206.

Carlesimo, G. A., Fadda, L., Sabbadini, M., & Caltagirone, C. (1996). Recency effect in Alzheimer's disease: a reappraisal. *Quarterly Journal of Experimental Psychology A, Human Experimental Psychology*, *49*, 315–325.

Carlesimo, G. A., Marfia, G. A., Loasses, A., & Caltagirone, C. (1996). Recency effect in anterograde amnesia: evidence for distinct memory stores underlying enhanced retrieval of terminal items in immediate and delayed recall paradigms. *Neuropsychologia, 34*, 177–184.

Cerella, A. (1985). Information processing rates in the elderly. *Psychological Bulletin, 98*, 67-83.

Chalfonte, B. L., & Johnson, M. K. (1996). Feature memory and binding in young and older adults. *Memory & Cognition*, *24*, 403–416.

Chapey, R. (2001). Cognitive stimulation: Stimulation of recognition/comprehension, memory, and convergent, divergent, and evaluative thinking. *Language intervention strategies in aphasia and related neurogenic communication disorders*, 397-434.

Conti-Ramsden, G., Botting, N., & Faragher, B. (2001). Psycholinguistic markers for specific language impairment (SLI). *Journal of Child Psychology and Psychiatry*, *42*(6), 741-748.

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. (2008). What are the differences between long-term, short-term, and working memory?. *Progress in brain research*, *169*, 323-338.

Cowan, N., Baddeley, A. D., Elliott, E. M., & Norris, J. (2003). List composition and the word length effect in immediate recall: A comparison of localist and globalist assumptions. *Psychonomic Bulletin & Review*, *10*(1), 74-79.

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

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.

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*.

Feredoes, E., Tononi, G., & Postle, B. R. (2006). Direct evidence for a prefrontal contribution to the control of proactive interference in verbal working memory. *Proceedings of the National Academy of Sciences USA, 103 (51),* 19530-19534.

Fleisher, A. S., Sowell, B. B., Taylor, C., Gamst, A. C., Petersen, R. C., & Thal, L. J. (2007). Clinical predictors of progression to Alzheimer disease in amnestic mild cognitive impairment. *Neurology*, *68*(19), 1588-1595.

Foldi, N. S., Brickman, A. M., Schaefer, L. A., & Knutelska, M. E. (2003). Distinct serial position profiles and neuropsychological measures differentiate late life depression from normal aging and Alzheimer's disease. *Psychiatry Research, 120*, 71–84.

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.

Freides, D., & Avery, M. E. (1991). Narrative and visual spatial recall: Assessment incorporating learning and delayed retention. *The Clinical Neuropsychologist*, *5*(4), 338-344.

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.

Gainotti. G., Marra. C., Villa. G., Parlato. V., & Chiarotti, F. (1998). Sensitivity and specificity of some neuropsychological markers of Alzheimer dementia. *Alzheimer Disease and Associated Disorders, 12,* 152–162.

Gathercole, S. E., Frankish, C. R., Pickering, S. J., & Peaker, S. (1999). Phonotactic influences on short-term memory. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *25*(1), 84.

Geiselman, R. E. (1988). Improving eyewitness memory through mental reinstatement of context. In G. M. Davies & D. M. Thomson (Eds.), *Memory in Context: Context in Memory* (pp 245-266). Chichester, England: Wiley.

Golomb, J. D., Peelle, J. E., Addis, K. M., Kahana, M. J., & Wingfield, A. (2008). Effects of adult aging on utilization of temporal and semantic associations during free and serial recall. *Memory & Cognition*, *36*(5), 947-956.

Haarmann, Henk J., Ashling, G.E, Eddy, J. Davelaar & M. Usher. (2005). Age-related declines in context maintenance and semantic short-term memory." *The Quarterly Journal of Experimental Psychology Section*, 34 (3), 34-53.

Hasher, L., & Zacks, R. T. (1979). Automatic and effortful processes in memory. *Journal of experimental psychology: General*, *108*(3), 356.

Hermann, B. P., Seidenberg, M., Wyler, A., Davies, K., Christeson, J., & Moran, M. (1996). The effects of human hippocampal resection on the serial position curve. *Cortex*, *32*, 323–334.

Hildebrandt, H., Brand, A., & Sachsenheimer, W. (1998). Profiles of patients with left prefrontal and left temporal lobe lesions after cerebrovascular infarcations on California Verbal LearningTest-like indices. *Journal of Clinical and Experimental Neuropsychology*, *20*(5), 673-683.

Hill, R. D., Storandt, M., & Simeone, C. (1990). The effects of memory skills training and incentives on free recall in older learners. *Journal of Gerontology*, *45*(6), 227-232.

Hogan, R. M. (1975). Interitem encoding and directed search in free recall.*Memory & Cognition*, *3*(2), 197-209.

Howard, M. W., & Kahana, M. J. (1999). Contextual variability and serial position effects in free recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *25*(4), 923.

Howard, M. W., Kahana, M. J., & Wingfield, A. (2006). Aging and contextual binding: Modeling recency and lag recency effects with the temporal context model. *Psychonomic bulletin & review*, *13*(3), 439-445.

Hulme, C., Maughan, S., & Brown, G. D. (1991). Memory for familiar and unfamiliar words: Evidence for a long-term memory contribution to short-term memory span. *Journal of Memory and Language*, *30*(6), 685-701.

James, W. (1890). The principles ofpsychology (Vol. 1). *New York: Holt*.

Johnson, S. K., & Halpern, A. R. (1999). Prediction accuracy of young and middle-aged adults in memory for familiar and unfamiliar texts. *The American Journal of Psychology*, *112*, 235-257.

Kahana, M. J. (1996). Associative retrieval processes in free recall. *Memory & Cognition*, *24*(1), 103-109.

Kahana, M. J., Howard, M. W., Zaromb, F., & Wingfield, A. (2002). Age dissociates recency and lag recency effects in free recall. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *28*(3), 530.

Kemper, S. (1992). Adults' sentence fragments who, what, when, where, and why. *Communication Research*, *19*(4), 444-458.

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.

Krishnan, G., & Tiwari, S. (2010). Evidence for the inhibitory control-based language-non-specific lexical selection in bilinguals. *Journal of the All India Institute of Speech & Hearing*, *29*(1).

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

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.

Light, L. L. (1991). Memory and aging: Four hypotheses in search of data. *Annual review of psychology*, *42*(1), 333-376.

Lewandowsky, S., Brown, G. D., Wright, T., & Nimmo, L. M. (2006). Timeless memory: Evidence against temporal distinctiveness models of short-term memory for serial order. *Journal of Memory and Language*, *54*(1), 20-38.

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.

Lum, J. A., Conti-Ramsden, G., Page, D., & Ullman, M. T. (2012). Working, declarative and procedural memory in specific language impairment. *Cortex,48*(9), 1138-1154.

Manjunath, N. (2011). Negative Priming in Aging Population. *Language in India*, *11*(9).

Matlin, M. W. (1983). *Introducing Psychology*. Washington DC: American Psychological Association.

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

Maylor, E. A., Vousden, J. I., & Brown, G. D. (1999). Adult age differences in short-term memory for serial order: Data and a model.*Psychology and Aging*, *14*(4), 572.

McCarty, S. M., Siegler, D. C., & Logue, P. E. (1982). Cross-sectional and longitudinal patterns of three Wechsler Memory Scale subtests. *Journal of Gerontology*, *37*(2), 169-175.

McKhann, G. M., Knopman, D. S., Chertkow, H., Hyman, B. T., Jack, C. R., Kawas, C. H., & Mohs, R. C. (2011). The diagnosis of dementia due to Alzheimer's disease: Recommendations from the National Institute on Aging-Alzheimer's Association workgroups on diagnostic guidelines for Alzheimer's disease. *Alzheimer's & dementia*, *7*(3), 263-269.

McLeod, S. A. (2007). Stages of memory - encoding, storage and retrieval. Retrieved from http://www.simplypsychology.org/memory.html.

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.

Miller, G. A., Galanter, E., & Pribram, K. H. (1960). *Plans and the structure of behavior*. New York: New york publishers.

Morris, J. C., Heyman, A., Mohs, R. C., Hughes, J. P., Van Belle, G., Fillenbaum, G. D. M. E., & Clark, C. (1989). The consortium to establish a registry for Alzheimer's disease (CERAD): I. Clinical and neuropsychological assessment of Alzheimer's disease. *Neurology*.

Multhaup, K. S., Balota, D. A., & Cowan, N. (1996). Implications of aging, lexicality, and item length for the mechanisms underlying memory span.*Psychonomic Bulletin & Review*, *3*(1), 112-120.

Murdock, B. B. (1976). Item and order information in short-term serial memory. *Journal of Experimental Psychology: General*, *105*(2), 191.

Naveh-Benjamin, M. (2000). Adult age differences in memory performance: tests of an associative deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *26*(5), 1170.

Naveh-Benjamin, M., & Ayres, T. J. (1986). Digit span, reading rate, and linguistic relativity. *The Quarterly Journal of Experimental Psychology*, *38*(4), 739-751.

Naveh-Benjamin, M., Hussain, Z., Guez, J., & Bar-On, M. (2003). Adult age differences in episodic memory: further support for an associative-deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *29*(5), 826.

Naveh-Benjamin, M., Guez, J., & Shulman, S. (2004). Older adults' associative deficit in episodic memory: Assessing the role of decline in attentional resources. *Psychonomic Bulletin & Review*, *11*(6), 1067-1073.

Neisser, U. (1967). *Cognitive psychology: Classic edition*. Psychology Press.

Neath, I., & Nairne, J. S. (1995). Word-length effects in immediate memory: Overwriting trace decay theory. *Psychonomic Bulletin & Review*, *2*(4), 429-441.

Nilsson, L. G. (2003). Memory function in normal aging. *Acta Neurologica Scandinavica*, *107*(s179), 7-13.

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.

Penfield, W. (1952). Memory mechanisms. *AMA Archives of Neurology & Psychiatry*, *67*(2), 178-198.

Peterson, L. R. (1967). Search and judgment in memory. In B. Kleinmuntz (ed.), *Concepts and the Structure of Memory* (pp. 153-180).Wiley publishers.

Petersen, R. C. (2004). Mild cognitive impairment as a diagnostic entity.*Journal of internal medicine*, *256*(3), 183-194.

Petersen, S. E., Fox, P. T., Posner, M. I., Mintun, M., & Raichle, M. E. (1988). Positron emission tomographic studies of the cortical anatomy of single-word processing. *Nature, 331,* 585-589.

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.

Ranganatha, M. R. (1983). *Morphophonemic analysis in Kannada*. Central Institute of Indian Languages. Mysore.

Raz, N., Gunning, F. M., Head, D., Dupuis, J. H., McQuain, J., Briggs, S. D., ... & Acker, J. D. (1997). Selective aging of the human cerebral cortex observed in vivo: differential vulnerability of the prefrontal gray matter. *Cerebral cortex*, *7*(3), 268-282.

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.

Resnick, S. M., Goldszal, A. F., Davatzikos, C., Golski, S., Kraut, M. A., Metter, E. J., & Zonderman, A. B. (2000). One-year age changes in MRI brain volumes in older adults. *Cerebral cortex*, *10*(5), 464-472.

Rogalsky, C., & Hickock, G. (2010). The role of Broca's area in sentence comprehension. *Journal of Cognitive Neuroscience, 23(7),* 1664-1680.

Rundus, D., Loftus, G. R., & Atkinson, R. C. (1970). Immediate free recall and three-week delayed recognition. *Journal of Verbal Learning and Verbal Behavior*, *9*(6), 684-688.

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.

Saint-Aubin, J., & Poirier, M. (1999). Semantic similarity and immediate serial recall: Is there a detrimental effect on order information?. *The Quarterly Journal of Experimental Psychology: Section A*, *52*(2), 367-394.

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.

Saint-Aubin, J., Ouellette, D., & Poirier, M. (2005). Semantic similarity and immediate serial recall: Is there an effect on all trials. *Psychonomic Bulletin & Review*, *12*(1), 171-177.

Salthouse, T. A. (1996). The processing-speed theory of adult age differences in cognition. *Psychological Review,103,* 403–428.

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

Schacter, D. L., Alpert, N. M., Savage, C. R., Rauch, S. L., & Albert, M. S. (1996). Conscious recollection and the human hippocampal formation: Evidence from positron emission tomography. *Proceedings of the National Academy of Sciences, USA, 93,* 321-325.

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

Seitz, R. J., Canavan, A. G., Yagüez, L., Herzog, H., Teilmann, L., Knorr, U., ... & Hömberg, V. (1994). Successive roles of the cerebellum and premotor cortices in trajectorial learning. *Neuroreport*, *5*(18), 2541-2544.

Smith, S. M. (1988). Environmental context-dependent memory. In G. M. Davies & D. M. Thomson (Eds.), *Memory in context: Context in memory* (pp. 13-34). Chichester, England: Wiley.

Stuart, G., & Hulme, C. (2000). The effects of word co-occurance 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.

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.*

Tabert, M. H., Manly, J. J., Liu, X., Pelton, G. H., Rosenblum, S., Jacobs, M., & Devanand, D. P. (2006). Neuropsychological prediction of conversion to Alzheimer disease in patients with mild cognitive impairment.*Archives of general psychiatry*, *63*(8), 916-924.

Tierney, M. C., Yao, C., Kiss, A., & McDowell, I. (2005). Neuropsychological tests accurately predict incident Alzheimer disease after 5 and 10 years.*Neurology*, *64*(11), 1853-1859.

Tulving, 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.

Welsh, K., Butters, N., Hughes, J., Mohs, R., & Heyman, A. (1991). Detection of abnormal memory decline in mild cases of Alzheimer's disease using CERAD neuropsychological measures. *Archives of neurology*, *48*(3), 278-281.

West, R., & Bell, M. A. (1997). Stroop color—word interference and electroencephalogram activation: Evidence for age-related decline of the anterior attention system. *Neuropsychology*, *11*(3), 421.

Woods, S. P., Weinborn, M., Velnoweth, A., Rooney, A., & Bucks, R. S. (2012). Memory for intentions is uniquely associated with instrumental activities of daily living in healthy older adults. *Journal of the International Neuropsychological Society*, *18*(1), 134-138.

Xu, J., Kobayashi, S., Yamaguchi, S., Iijima, K. I., Okada, K., & Yamashita, K. (2000). Gender effects on age-related changes in brain structure. *American Journal of Neuroradiology*, *21*(1), 112-118.

Zacks, R. T., & Hasher, L. (1988). Capacity theory and the processing of inferences. *Language, memory, and aging*, 154-170.

Zelinski, E. M., & Burnight, K. P. (1997). Sixteen-year longitudinal and time lag changes in memory and cognition in older adults. *Psychology and aging*, *12*(3), 503.

Appendix-1

Stimulus Materials used for tasks

Test Items-List 1:

3 Syllable words	4 Syllable words	5 Syllable words
agala	guruva:ra	utpa:daneya
ananta	nagegaLu	chathuratike
uthsava	ka:rmikaru	dehaliyalli
janata	namaska:ra	hogaLuvante
tamage	tatvagaLu	rasamayate
daniya	madyavarti	pratibhaTane
taya:ru	manadaTTu	naDeyisalu
prasa:ra	devasta:na	varadhiyannu
magaLu	garagasa	vya:vaha:rika
naDate	taraka:ri	pa:NigrahaNa

Test Items-List 1:

Semantically related words	Semantically unrelated words	Digits	Non-words
simha	ka:Du	mu:ru	naluvi
huli	huNNime	enTu	vabhanura
chirate	so:ma:ri	a:ru	luTTilugama
katte	muLLu	e:Lu	Tabaluniga
karaDi	haLadi	eraDu	giladema
ha:vu	rakta	aidu	niva:shara
na:yi	kannaDi	e:Lu	labata
ko:ti	to:Ta	mu:ru	yellinema
bekku	mahaDi	mu:ru	Dikema
hasu	ko:ti	ondu	Dikkata

Test Items-List 2:

3 Syllable words	4 Syllable words	5 Syllable words
ba:gilu	adhika:ri	nagunaguta
mamate	pativrate	muttugaLannu
de:varu	bi:saNige	ra:gagaLige
janani	manastiti	modalaneya
tabala	tarabe:ti	nischintana:gi
gamana	shivalinga	kuduregaLu
kannaDa	oLagaDe	maraLuga:Du
jami:nu	janmava:di	vruttipararu
divasa	managonDa	nandago:kula
dha:ruNa	de:vadatta	gaganasaki

Test Items-List 2:

Semantically related words	Semantically unrelated words	Digits	Non-words
kurchi	o:le	sonne	garasaga
kapaTu	yantra	ondu	le:ttaka
taTTe	sa:mba:ru	mu:ru	maluvigana
lo:Ta	raste	ombhatu	tipa:cha
gaDiya:ra	maDike	e:Lu	malunega
bi:saNige	kattari	a:ru	gareLukudu
ba:gilu	ga:Li	enTu	shane:ga
kiTaki	hullu	na:lku	sabava
pustaka	ku:dalu	ondu	DinnagakaLu
le:Khani	chatri	na:lku	gaLebaLu