DEVELOPMENT OF WORD- AND SENTENCE- LEVEL WORKING MEMORY TEST FOR TYPICALLY DEVELOPING CHILDREN

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CERTIFICATE

This is to certify that this dissertation entitled ***"Development of word- and sentence-level working memory test for typically developing children"*** is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech Language Pathology) of the student Registration No.: 11SLP006. This has been carried out the under guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any diploma or degree

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DECLARATION

This is to certify that this master's dissertation entitled ***"Development of word- and sentence- level working memory test for typically developing children"*** is the result of my own study under the guidance of **Mr. R. Rajasudhakar,** Lecturer, 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 diploma or degree.

Mysore

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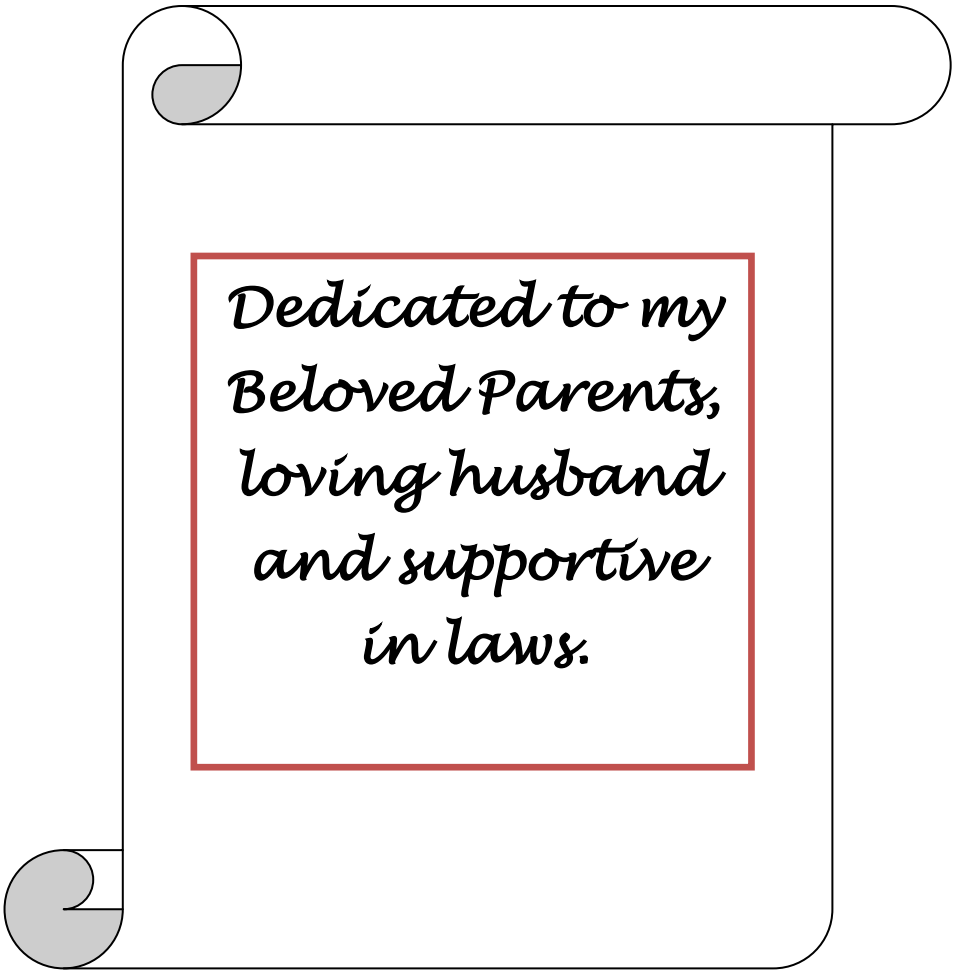
Dedicated to my
Beloved Parents,
loving husband
and supportive
in laws.

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CHAPTER I

INTRODUCTION

Human beings are unique in their innate ability to acquire language almost without effort and are extremely quick. Children generally begin to speak at about the age of two years, when they begin to absorb the language. Neurologists, psychologists, and linguists have studied this unique human ability.

Following are the six pre- requisites identified for normal speech and language development in children (Van Riper & Erickson, 1996). They are as follows:

- Presence of a normal vocal tract
- Normal neuro-muscular development
- Normal auditory functioning
- Normal growth in terms of oral language influenced by appropriate physical and emotional stability
- Age appropriate intellectual functioning and cognitive development
- Nurturing home environment

Language aspects are localized to left hemisphere. Right hemisphere also plays a minor role in language processing in terms of processing of figurative language. Most of the models of language processing either computational or descriptive, did not focus on the inter connectivity of the two hemispheres. Alternatively these were the models which spoke only about the component of expression that is left hemisphere, when damaged causes aphasia. The brain is equipped with at least certain Language Acquisition Device (LAD) sub-modules,

which of its parameters for proper operations are set early. The parameters are subjected to critical age concept unlike other cognitive models, which has to get its input for normal development of speech and language skills. If these modules do not receive necessary input within the stipulated time, then the needed parameters of language are not set accurately leaving the language user with lacunae in the syntactic ability and pronunciation.

Experimental neurologist and most clinical works showed indeed interest in localizing these sub-modules in the brains of the patients with damage. Split brain procedures and electrical stimulation techniques have been adopted by researchers to the study the epileptic forms in the brain. In parallel, psycholinguists were charged for characterizing the language sub-modules in terms of their number, responsiveness, form of action and representation. Thus language processing in terms of acquisition and use is largely influenced by cognition.

Cognition and language are highly interdependent. Cognition has been defined as the process of understanding and includes factors such as awareness, perception, conceptualization, and judgment. The term cognition can be referred as higher domain which facilitates information processing, understanding and also helps to bring about a change in preferences. In other terms cognition encompasses the following:

- Through our different senses and perception, enables us to receive information regarding the external world.
- Helps in identifying relevant information, deducing meaning out of the information obtained, to distinguish between correct and incorrect message, compare with previously stored information, storing the same for future requirements.

- Using the stored information for decision making, problem solving and also for communication.

Cognition refers to all process by which the sensory input is transformed, elaborated, stored, recovered and used (Neisser, 1967). Cognition is the process or result of recognizing, interpreting, judging, and reasoning andperception. Cognition includes a wide range of mental structures and processes (Craik, 1991). One of the components of cognition is memory. Memory is defined as serial process where in by we store whatever we have learnt, this information is retained based on the amount of rehearsals and can be recollected from the store whenever required.

Attempts have been made to explain the processes involved in memory**.**The processing of memory is said to be organized into four aspects, they are learning, aggregation, storage and retrieval. First is the learning or perception of new information by brain and different senses into the memory system. Next is the organization of the newly learnt information in order to facilitate storage in long term memory. Storage refers to formation of permanent representation regarding any concept and retrieval is passing the stored information to the level of consciousness.

Term ‘working memory’ was first used by Miller, Galnter, and Pribramand came into usage in 1960. Working memory is considered as an experimental layout, which is meant for storage and manipulation of perceived information. There exist synonyms for working memory such as short-term memory, sometimes also as primary memory, immediate memory, operant memory, or provisional memory.Working memory is a system that enables temporary storage of the intermediate products of cognition and supports transformation of those products. In the present literature the term working memory is replaced for short term memory

which facilitates in experimenting with the perceived/stored information rather than passivity (Baddeley, 1999).

Recent research has established strong relation across the process of storage and experimentation of the information and its influence on literacy development in different domains in the initial schooling years (Bull, Johnson, & Roy, 1999; Gathercole & Pickering, 2000; Gathercole, Pickering, knight, & Stegmann, 2004; Jarvis & Gathercole, 2003). The strongest link is been established between the academic progress and performance on complex memory task which impose load on the cognitive system. In a study done by Altemeier, Jones, Abbott and Berninger (2006), they found that both lower order executive functions (Inhibition and rapid automatic switching) and higher order functions (Planning) contributed to the reading and writing success in third and fifth graders.

Most of the researches have validated that phonological working memory important source of individual differences in learning to read (Wagner & Torgesen, 1987; Ehri, 2004). Also, the activities of phonological awareness have been proven to be effective components of early literacy development, which require the children to with hold the spoken word in working memory and analyze the sounds in them (Adams, Foorman, Lundberg, & Beeler, 1997).

Relevance of working memory has been researched by many researchers in the past few decades. It has been found that working memory has different units for processing and storage of spoken words (phonological), written words (orthographic) and word structures (morphological). Coding of these three different forms into the memory, processing and retrieving them contributes to the reading and writing of typically developing readers and writers (children and adults) and even in children

and adults with dyslexia (Berninger, Abbott, et al., 2006; Berninger & Raskind, et al., 2008; Berninger et al., 2008). Studies using fMRI have also documented the unique activation for the three word forms (phonological , orthographic and morphological) in working memory of children and also state that the brain forms an unique relationship across these word forms (Richards, Aylward, Raskind, et al., 2006) supporting the success in reading and writing in children.

Impairment at any level of these word forms lead to devastating effect in domains such as reading and writing. Berninger and Richards (2002) stated that children with impairments in phonological word form storage and processing are likely to have reading and spelling difficulties, which in turn cannot be attributed to auditory processing problems. Vellutino (1979) identified the importance of orthographic word form in storage and processing of written words and letters embedded within it, and noted that any impairment in this word form would lead to poor reading and writing ability. The most important is the morphological word form which is said to have a role in the integration of phonological and orthographical form across both spoken and written forms. Any impairment in these forms hampers reading and writing, and also oral language both at single and multi word syntactic structures (Berninger et al., 2008).

There are commercially available tests to assess the role of working memory in the western context, for e.g. Children's Test of Non-word Repetition (CNRep), developed by Gathercole in 1994. Competing Language Processing task (CLPT) developed by Gaulin & Campbell in 1994. Working Memory Test Battery for Children (WMTB-C). Wechsler Individual Achievement Test- Second Edition (WIAT-II; The Psychology Corporation, 2001) so on. But all of these are dictated in

western context. And also no attempt is made to standardize for the usage in Indian context.

Need for the study

- By all the above reviews it is evident that working memory and its components has an effect on reading and writing skills.
- Majority of the child language studies have concentrated on assessing the relation between working memory and sentence comprehension, and effect on working memory span and its performance by processing complexity.
- There is an increasing need to understand and document the finer aspects of the influence of word-level and sentence- level working memory on reading and writing skills.
- Tools used in the routine clinical evaluation fall short to address the concrete differences in the different linguistic levels of working memory.
- Increasingly in the recent past, speech language pathologists are expected to address the language based reading and writing difficulties of primary school children. SLPs assess routinely the oral language and written language at different levels and they must be aware of the related working memory mechanism associated with reading and writing that support language learning.
- Hence, the present study evaluate the association of working memory factors based on word and sentence levels in typically developing children (2^{nd} to 4^{th} grade).

Aim of the study

To investigate the role of working memory at word- and sentence levels of language to reading and writing skills in 2nd to 4th grade typically developing children.

Objectives of the study

- To develop a test material that taps the working memory capacity at two levels of language i.e. word and sentence level.
- To establish norms for the developed test among 2nd, 3rd and 4th grade typically developing children.
- To compare between the performance at word level working memory and sentence level working memory among 2nd, 3rd and 4th grade typically developing children.
- To evaluate the developmental trend at word and sentence level working memory in these 3 different grades.
- To analyse gender difference, (in any) in the performance at word and sentence level working memory tasks.

CHAPTER II

REVIEW OF LITERATURE

Memory is an aspect of cognition that regularly intrudes into everyday activities. Memory adds to the individual's ability to store, retain and retrieve information whenever required. Memory is an essential boon to normal functioning of life and facilitates required mental process which is mediated by memory. Human brain has evolved and acquainted with the ability to remember incidents. One can associate the new learning with the past experience only because of the memory, and which helps in solving or counteracting with the present situation. Learning is also made possible only because of the presence of cognitive factor called memory. It is also part of self identity and perceptibility of an individual as it helps in past experiences, thoughts, and feelings informs as to where is the person, what is been done presently and who the person is now etc. Memory can hold information ranging from the performance of daily activity, to the composition of the stars (Anderson, 1976).

Attempts have been made to explain the processes involved in memory**.** The processing of memory is said to be organized into four aspects, they are learning, aggregation, storage and retrieval. First is the learning or perception of new information by brain and different senses into the memory system. Next is the organization of the newly learnt information in order to facilitate storage in long term memory. Storage refers to formation of permanent representation regarding any concept and retrieval is passing the stored information to the level of consciousness. These processes are said to occur in three different divisions of memory system, based on the storage capacity in terms of duration and amount of information chunks that

can be held. And these three divisions are sensory memory, short term memory and long term memory.

Each of the three types of memory has been subjected to experimentation. The first division is the sensory memory which is involved in the initial process and holds the information in its raw form for a brief period of time to several seconds. It is said to have the largest storage capacity that records the information accurately from different senses. Sensory memory corresponds approximately to the initial 200 - 500 milliseconds after an item is perceived. This initial division helps the individual to perceive and discriminate between the objects and to remember the same.

There exists different sensory storage for different senses. Incoming information is held for about ½ to 2 seconds in the sensory memory as a copy of the perceived object with visual storage capacity of 250-300 msec. On the other hand auditory stimuli has10 times larger storage capacity to that of visual stimuli. Sensory memory cannot be prolonged via rehearsal. Sensory memory is restricted with its functioning only to the ability of perception not processing. The sensory memory permits some trace of a stimulus to remain after the stimulus itself has disappeared (Sperling, 1960). Norman (1972) suggested that there may initially exist a very low level internal recording equipped to hold, for brief periods, information about the acoustic waveform internalized as an equivalent sensory waveform. This sensory information imprinting involves fast fading; continuous, serial-ordered information referred to by Neisser (1967).

The next form of memory is the short term memory. Short term memory constitutes an active part of memory processing, which helps in rehearsals, aggregation of the information and finally aids in storage to long term memory

(O'Brien, 1994). Information in the short term memory can be held for a short time frame before it moves to the long term memory or disposed. Any information to be stored successfully in to the long term memory it needs to be rehearsed several times; even without rehearsal information can be retrieved for several seconds to minutes. Short term memory is equipped with the capacity to hold five to nine chunks of information lasting for about seconds to few minutes.

According to O'Brien (1994), these chunks of information can be hold as a single piece such as an individual's name, or multiple information may be combined to form a single chunk such as names of all the family members. This process of using single item to represent multiple information is called chunking, with which a person can hold larger information in the short term memory. If presented with a string (FBIPHDTWAIBM), it can be better remembered in a better way when the string is chunked (FBI PHD TWA IBM). There are many factors which plays an important role in deciding as to which information enters the long term memory.

The third division long term memory has been the main core for many researchers. It holds all the information that has crossed through first two memory division that is sensory and short term memory. In contrast to the storage limitation seen in sensory and short term memory long term memory can hold larger information for unlimited duration. Long term memory is compared to an encyclopedia in terms of its storage capacity of varied variety of information. Long term memory is based on strong connection that has a larger network localized in the entire brain. Hippocampus is said to play a role in consolidation of information from short term to long term memory, also this region helps in storing new information, without which new learning is said to be impossible.

There are attempts to differentiate long term memory into different types they are episodic memory, semantic memory and procedural memory (Tulving, 1984). Episodic memory as the name suggests it relate to the recollection of any episode in an individual's life. Semantic memory is the knowledge regarding the external environment and the world but not directly relating to the individual. Procedural memory helps in recollection of any serial steps involved in any aspect e.g. riding a bike, making coffee etc.

Research in the field of long term memory is highly specialized in terms how the information is stored and retrieved (Tulving, 1984). It has assessed using wide variety of tasks such as recognition, recall, or relearning tasks. In recognition task subject is asked to choose from the list multiple choice regarding items they have presented before. Subjects are instructed to reproduce the materials shown before. In relearning the subjects are expected to learn new information.

Models of working memory and studies

Memory and its related processing cannot be well appreciated by observation. Hence, various models have been put forth by the researchers working in the field of memory to clearly track the processes involved in memory. Below explained are few representation of models of memory regarding how is said to work.

Atkinson-Shiffrin Memory model

It is considered as an multi- stage model comprised of three divisions; sensory memory, short term memory and long term memory, as this was first recognized by Atkinson-Shiffrin in 1968.

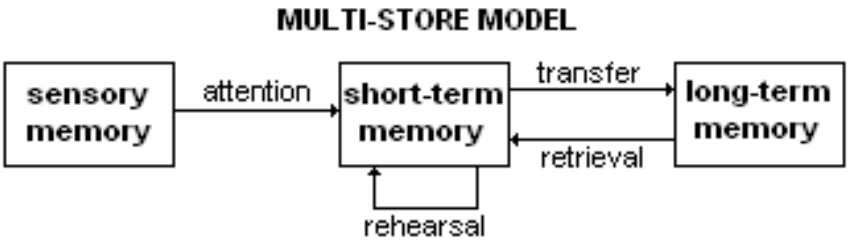


Figure 1: Atkinson-Shiffrin Memory Model

The multi store memory model was proposed by Atkinson and Shiffrin and the model is graphically represented in figure 1. First store is the sensory memory which helps in perception of new information mediated through the senses, which when attended is transferred on to the short term storage. Multiple rehearsals at this stage help in better storage of the information into the long term memory, which can be retrieved into consciousness on demand.

Short term memory

Short term memory is considered as an experimental space where in the storage, processing and manipulation of the information takes place. It has a capacity of holding information upto seven chunks or even lesser, in an active state so that it is readily available to the user at any point of time.

The terms used for short-term memory are:

- **Primary memory:** It points out that the short-term memory comes before the secondary memory synonym for long-term memory.
- **Active memory**
- **Working memory:** Experimental storage used to describe as the single short term storage of limited capacity responsible for various phenomena. But

studies have shown that short-term memory is more than single system. Therefore, the term working memory was used.

Term ‘working memory’ was first used by Miller, Galnter, and Pribram and came into usage in 1960. Working memory is considered as an experimental layout, which is meant for storage and manipulation of perceived information. There exist synonyms for working memory such as short-term memory, sometimes also as primary memory, immediate memory, operant memory, or provisional memory. Working memory is a system that enables temporary storage of the intermediate products of cognition and supports transformation of those products. In the present literature the term working memory is replaced for short term memory which facilitates in experimenting with the perceived/stored information rather than passivity (Baddeley, 1999).

Alan Baddeley (1986), a British psychologist, proposed a model of working memory with several components. Figure 2 represents the Baddeley’s working memory model.

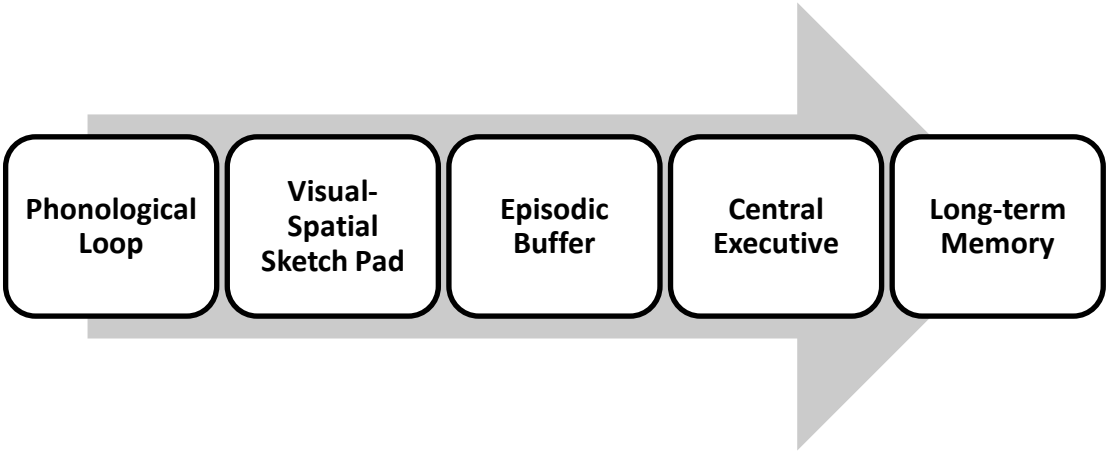


Figure 2: Components of Baddeley’s model of working memory

The components are as follows:

- **Phonological Loop:** It mainly deals with sound and its storage, by helping to maintain the verbal information with adequate rehearsals.
- **Visual-Spatial sketch pad:** Helps in maintaining visual stimuli and spatial information thereby helping one to visualize the situation and seek a solution for the same, mediated in the right hemisphere.
- **Episodic buffer:** Plays a role majorly in integrating the information perceived by different senses with that of the long term memory. This is the revised addition by Baddeley in 2001.
- **Central executive:** It is the final component of the working memory model. It is the executive attentional component whose function is to control the use of short-term and long-term memory stores. It serves to control and regulate the memory stores in carrying out more complex mental tasks. Both verbal and visuo-spatial representations are needed to read, for instance, and the memory stores holding these must be co-ordinated.
- In everyday thought tasks and in tasks for measuring working memory capacity, attention must be focused on different stimuli and switched at appropriate moments. Relevant information must also be retrieved from long-term memory and bought into focus of attention as one reads, writes, or solves problems.

Many of the researchers have regarded this working memory as multi- modal systems of multiple inter linked processes. These include a phonological short-term memory storage buffer and a visuo-spatial short-term memory buffer, an attentional resource control function, and processing speed. Out of which phonological short

term memory is said to play a crucial role in language learning, by helping to gradually construct a strong lexical foundation with respect to an unfamiliar sound system and vocabulary

Different task used to assess working memory

There exist many tasks to assess the efficacy of working memory in wide variety of population. Different authors have used different material for their study and have validated their efficiency in many ways. At the mean time there also controversies with respect to how efficiently they tap the working memory storage and processing. Below given are few studies depicting different task and author's opinion about the same.

Bayliss et al. (2005); Gathercole et al. (2004) put fort that age and phonological development in children were directly proportional to each other. They have investigated and put forth the above findings by using wide variety of tasks such as digit recall, word recall and/or non-word repetition. Non word repetition is considered as one of the sensitive measure in which child has to repeat the non words heard of increasing length. This task is said to invoke many of phonological short memory processes such as storage, processing and retrieval (Gathercole & Baddeley, 1990; Henry & Millar, 1991).

The non words are mainly formed based on the phono-tactic rule which dictates the arrangement of the sound structure in the native language, and the repetition is said to put a constraint on phonological short term storage (Coady & Aslin, 2004). These pseudo words can be read and written, but without any semantic correctness attributed to the same (Santos & Bueno, 2003). Repetition of such as pseudo words are influenced by many factors such as consonant structure, similarity

with respect to a real word and the stress factor with respect to production. Afore mentioned factors facilitates the individual to better repeat the pseudo words and enhance the performance of phonological short term store.

There is continued debate with respect to the efficiency of the non word repetition task in targeting the phonological short term store, rather it is considered to be a part of language measure. Snowling, Chiat, and Hulme(1991) do not consider non word repetition task be as pure measure revealing the performance of cognitive store. Another argument states that non word repetition task is dependent on multiple processes, hence it can be considered as a crucial measure to assess which can be utilized in the clinical use (Coady & Evans, 2004).

Most of the researches have been successful in establishing a relation between these cognitive store and language development. This relation was established by incorporating non word repetition task, as a measure to assess phonological memory. It is also strongly associated with language skills other than verbal memory task, digit span task (Gathercole, Willis, Baddeley, & Emslie, 1994). It is also a sensitive measure in identifying children with language impairment or children whose language impairment has already resolved.

Sentence comprehension is said to be influenced by working memory and this is been confirmed by many of the memory researchers. The state that human beings are acquainted with several resources which is mainly dedicated to play a role in performance of different verbal tasks (Just, Carpenter, & Keller, 1994). Alternate view point is that this resource is specialized for sentence comprehension abilities; where in by helps in deriving the meaning of a sentence (Caplan & Waters, 1995, 1996).

There exist two investigation methods in which the possible role of working memory in sentence interpretation can be exploited. One is by understanding the degree of mutual interference offered by working memory for the sentence interpretation. Another route is to find out the possible association with respect to individual differences and its efficacy in sentence interpretation.

According to the working memory model proposed by Just and Carpenter (1992), individual differences seen in language comprehension might be explained by differences in working memory capacity. For example, a larger working memory capacity could assist individuals in resolving syntactically ambiguous sentences by allowing them to maintain multiple interpretations.

From the above literature it is clear that most of authors prefer to use non word repetition task and digit backward task. But at the same time controversies continue regarding the efficiency of each of the task. With this regard still studies are required to validate each tasks efficiency.

Working memory in adults and elderly individuals

With respect to the literature regarding the working memory, there exist many studies with respect to aging and its effect on storage capabilities and processing abilities. Authors put forth different hypothesis affecting working memory in turn hampering the language proficiency in adults and also in older individuals. Below mentioned are few viewpoints regarding performance of adults and elderly participants on tasks of working memory.

It is evident that language performance is influenced by working memory. Bowles and Poon (1985) studied two groups of individuals who were young and older adults on two tasks depicting the knowledge of word meaning (lexical decision and definition naming). The authors found that both young and older adults did not differ on the task of lexical decision. But essentially the older adults showed differences in performance based on accuracy and speed on task of definition naming. This reflects the load on working memory dependent on the task demands, and also reflects the degree of age differences in linguistic performance.

Daneman and Carpenter (1980) investigated the correlation between young adults in comprehension ability and working memory capacity. They found that as the length and/or syntactic complexity of sentences increases, older people have significantly more difficulty than younger adults in sentence comprehension (Olber, Fein, Nicholas, & Albert, 1991) and difficulty in accuracy of recall (Norman et al., 1991).

Age related decline in the working memory span has been noted inmany of the studies done on elderly individuals. There is debate whether this memory decrement is because of the limitation in the processing ability or due to the restricted storage space. Study done by Baddeley (1986); Dobbs and Rule (1989); Salthouse and Babcock (1991) used many paradigms and have put forth the fact that decline in the memory is related to the limitations in the processing ability. On the other hand, researchers have failed to establish a relation between age and cognitive decline. This might be due to the fact that variation in the tasks used to assess this relation. There is also an entirely alternative explanation provided by Fisk and Warr (1996) stated that overall decrement in the cognitive functioning in elderly was attributed to the increased interference by irrelevant information.

Age related differences were studies in adults using active and passive tasks including digit forward and backward task and also task that requires active manipulation of the stored items (Dobbs, Allen, Rule, & Brendan, 1989). Two hundred and twenty eight volunteers, aged 30 to 99 years performed on the tasks. Results suggested that there was decline for the digit backward and forward tasks noted in individuals aged 60 to 69 and 70+ years. It was concluded that this decline is seen due to the lack of flexibility in the processing of the information

Feyereisen (1999) examined the contribution of processing speed, working memory capacity, and inhibition capability to the effects of aging on language performance. A total of 151 participants aged 31-80 years completed language processing tasks and a battery of tasks based on the variables mentioned above. Latent-construct structural equation modeling was used to examine the relationships of these factors and age to different types of language tasks. This model significantly established a relation between age and language performance which was mediated by the above mentioned variables. Authors concluded that as age increases there is reduced processing and inhibition.

Caplan and Waters (1999) determined the role of verbal working memory system used in sentence comprehension. They aimed at identifying whether the working memory component used in the syntactic process is similar or different for verbally mediated working memory tasks. Results obtained showed that there is specialization in verbal memory tasks involved in analyzing the syntactic structure of a language in order to derive the meaning. But this ability was different for working memory used for sentence analyzing to perform other functions.

Chiappe, Hasher, and Siegel (2000) studied the role of working memory and reading skills in individuals aged 6-49 years. Results indicated that decline in the working memory as influence by the inhibitory controls was characterized in the reading tasks. It was concluded the decline in the working memory as factor of aging is due to the inefficient inhibitory control.

Hedden and Park (2001) investigated the relation between aging and interference offered by verbal working memory. According to the inhibitory view in decline of working memory, authors stated that older adults have problem in deleting the irrelevant information from the working memory when compared to younger adults. The authors investigated the above mentioned hypotheses by using recognition measures by assessing both accuracy and reaction time. Results indicated that older adults exhibit interference effect when compared to younger adults. With respect to activation of the target material similar amount of action was seen in both the groups, but in case of older adults there was sustained activation for irrelevant target that enters working memory.

Brigman and Cherry (2002) examined the relation between age, working memory and processing speed in both younger and older adults. Younger and older adults were trained on an alphabet-arithmetic task administered across three consecutive days. Although older adults were slower than younger adults, and response latencies were decreased as a result of practice in both age groups. Contrary to expectations, working memory and processing speed were significantly correlated with performance rate in training. The authors found partial correlations between age and processing speed and they concluded that age difference in performance at the end of training were mediated by individual differences in cognitive processing speed.

Waters and Caplan (2005) investigated the relationship between age, processing speed, working memory capacity, and language comprehension. They tested a total of 50 elderly individuals and 48 college students on several measures of processing speed and of working memory capacity. Language processing was assessed using online sentence processing task such as grammaticality judgment and paragraph comprehension abilities. Elderly subjects performed poorly and required longer duration for sentence comprehension tasks. The data provide evidence that the working memory system used to structure sentences syntactically is separate from that used in other aspects of language comprehension.

The afore mentioned studies indicated the influencing of aging in various domains of cognition and this issue is strong when the contribution of working memory capacity is also age related. Therefore, it was concluded that the language performance depends on the age related changes in working memory.

Working memory skills in clinical population

Literature highlights the working memory deficits in different experimental population such as Aphasia, Dementia, Parkinson's and Alzheimer's and also in SLI. Hence different tasks can be used to assess the plausible influence of cognitive deficits on their language abilities and this might help to rehabilitate such population in a better possible way.

Caplan and Waters (1999) had established a link between working memory and its related processing. Some studies have included patients with aphasia or dementia of the Alzheimer's type (DAT), whose working memory capacities are impaired.Rochon, Waters, and Caplan (2000) assessed patients with DAT and also neuro typical elders on wide variety of tasks such as digit span task, tasks to tap the

central executive and also offline sentence comprehension tasks. The DAT patients showed reduced spans and impaired central executive processing relative to controls, Rochon et al. (2000) concluded that the working memory impairments of individuals of DAT is because of the impairment in the ability to map meaning on to the world, rather than to their ability to assign syntactic structure initially.

Hoppe et al. (2000) presented results from a study on the properties of the Digit Ordering Test (DOT) which was used for the assessment of verbal working memory. The most sensitive measure in identifying the verbal memory deficits is decided by the presentation rate that is seven digits in five seconds. Findings suggested that DOT is crucial task in tapping the experimental changes of verbal working memory space hence can be widely used for most clinical testing.

In a study where authors tried to establish a relation between working memory and processing in Dementia of Alzheimer's type (DAT) patients and elderly individuals (Waters & Caplan, 2003). They used tasks which assessed the syntactic processing in different varieties of sentences. Listening times for each sentence patterns were recorded. Results stated that there was no strong relation between working memory and processing complexity for complex sentences.

Bagner, Melinder and Barch (2003) established a relation between working memory capacity and language processing in twenty five schizophrenics and eleven, age and literacy matched control subjects. They were tested for two aspects of language processing: grammaticality judgment and presentation rate. In contrast to the control subjects schizophrenics showed poor language comprehension reflecting decrement in the working memory capacity. They showed more errors in understanding the sentences accurately rather on exhibiting grammatical errors. Both

the group had difficulty when presentation rate and the sentence complexity increased. Hence, the authors concluded that there was general dysfunction with respect to working memory in schizophrenic reflecting on their language skills.

Anastasia and Panayiota (2011) had made an attempt to put forth the cognitive profile on literacy, working memory and phoneme awareness task in dyslexics. The author studied 12 dyslexic children at the end of their 6^{th} grade and eighteen months later on several tasks of phoneme awareness, phoneme perception, word and nonword reading and spelling tasks, as well as on the Working Memory Test Battery for children (WMTB-C). Authors found that there was no improvement seen for phoneme awareness and speech perception task between two testing's, but there was improvement on working memory span tasks between two testing condition. Author concluded that reading and writing deficits seen in dyslexics is observed because of the imperfect phonological representation in the long term memory.

Working memory skills in typically developing children

Researchers have also contributed in the area of developmental memory aspects in children of different grades with different tasks. Such literature fosters our knowledge on the normal aspects of development and tracking the same in typically developing children and in turn helping to identify the working memory deficits or impairments in clinical population.

Montgomery (2000) studied the influence of working memory on language comprehension in twelve children with Specific Language Impairment (SLI)and twelve typically developing children matched for age and receptive vocabulary. They were tested on two tasks; verbal working memory in which children had to recall as many real words as possible and sentence comprehension for both short and long

sentences. Authors found that children with SLI recollected fewer real words when compared to the age matched control groups. And also in sentence comprehension task children with SLI comprehended only fewer sentences when compared to control groups. The author concluded that children with SLI exhibited limited functional verbal working memory space and had difficulty in coordinating the working memory and processing ability.

Santos, and Bueno (2003) investigated the developmental aspects of phonological memory processing in non word repetition task through error analysis. They examined phonemic errors (substitution, omission and addition) and ordering errors (migration) using non word repetition in 180 normal children within the age range of 4-10 years. The results suggested that the performance was age related and the dominant errors seen were substitution. The length effect was also observed, i.e. more errors were reported in longer than shorter items.

Montgomery (2008) investigated the role of working memory in typically developing children on complex sentence comprehension. The study was carried out in English language. The author considered fifty two children (6-12 years) for the non word repetition task, verbal processing-storage task, auditory-visual reaction time (RT) task, and a sentence comprehension task including complex and simple sentences. Author found that none of the memory variables correlated with simple sentence comprehension. Authors concluded that working memory was significantly involved in school age children's comprehension of familiar complex sentence structures.

In a study done by Magimairaj and Montgomery (2012), on the role of processing complexity of working memory and its effect on sentence comprehension. Children of age 6-12 years participated in the study. They were tested for listening span task of varying syntactic complexity. The authors found that performance decreased with respect to complex sentence blocks. The authors also found a significant correlation between simple and complex memory task and sentence comprehension task.

From the above studies, it is clear that there exist no single protocol for assessing complete developmental trend with respect to working memory abilities. Hence the present study aimed at construction of full fledges material to track the developmental memory abilities in typically developing children.

Association between working memory and literacy skills

Below discussed are few studies which focused on the influence of working memory and literacy development.

Relevance of working memory has been the focus of research by many researchers in the past few decades. It has been found that working memory has different units for processing and storage of spoken words (phonological), written words (orthographic) and word structures (morphological). Coding of these three different forms into the memory, processing and retrieving them contributes to the reading and writing skills of children and adults with dyslexia (Berninger, Abbott, et al., 2006; Berninger & Raskind, et al., 2008) and also in typically developing readers and writers (Berninger, Raskind, et al., 2008). Studies using fMRI had also documented the unique activation for the three word forms (phonological, orthographic and morphological) in working memory in children and also stated that

the brain forms an unique relationship across these word forms (Richards, Aylward, Raskind, et al., 2006) supporting the success in reading and writing in children.

Impairment at any level of these word forms lead to devastating effect in domains such as reading and writing. Berninger and Richards (2002) stated that children with impairments in phonological word form storage and processing are likely to have reading and spelling difficulties, which in turn cannot be attributed to auditory processing problems. Vellutino (1979) identified the importance of orthographic word form in storage and processing of written words and letters embedded within it, and noted that any impairment in this word form will lead to poor reading and writing ability. The most important is the morphological word from which is said to have a role in the integration of phonological and orthographical form across both spoken and written forms. Any impairment in this form leads to problem not only in reading and writing, but also in oral language both at single and multi word syntactic structures (Berninger, Raskind, et al., 2008).

With respect to the short term storage and reading acquisition a common opinion is that, children learn the letter-sound mapping and store each letter in the short term memory before they blend and obtain the meaning of the word. Authors have verified different variables like phonological similarity and word length effect in deciding the difficulties encountered by the poor readers. With respect to phonological similarity, there was direct relation seen in poor readers indicating a deficit in the use of phonological coding. And also with respect to the word length, there was a positive correlation seen because the word length taken exceeded the memory span of the poor readers (Alloway et al., 2004; Gathercole & Baddeley, 1993).

In a study conducted by Irausquin and de Gelder (1997) contrasting effect was found, using auditory and pictorial representation and non verbal recall procedures; authors found that similarity effect and word length effect in poor readers as well as age matched controls. Authors concluded that even poor readers use same phonological strategies to that of normal peer group.

Alloway, Gathercole, Willis, and Adams (2005) aimed at finding whether there exist any relation between working memory in children and teachers ratings with respect to their learning goal during school entry. One hundred and ninety two children were assessed on different measures of working memory, phonological awareness etc. Also assessment at school was carried out in areas such a reading, writing and mathematics. Authors found significant correlation between clinical and school based assessment procedures. The findings indicated that the working memory, and the awareness of phonological structure, plays a crucial role in key learning areas for children at the beginning of their formal education.

Smythe et al. (2008) conducted a study to establish predicting factors of word-level literacy skills in 3rd graders of different language background (Arabic, Chinese, English, Hungarian or Portuguese). Authors included wide variety of tasks for storage, processing of working memory, and phonological awareness tasks. Findings of the study indicated that measures of decoding and phonological-processing skills were good predictors of word reading and spelling among Arabic- and English-speaking children, but were less able to predict variability in some early literacy skills among Chinese- and Hungarian speaking children, and were better at predicting variability in Portuguese word reading skills than spelling skills.

Steinbrink and Klatte (2008) stated that deficits in short- term memory has a devastating effect on the individual's ability to read and spell. But yet the clear cut

nature of the deficits has not been explored. The above authors explored the serial recall abilities in German 2nd grade children with poor reading and spelling abilities. Authors found that poor readers use the similarity and length effect when compared to typically developing children. Hence, the results of their study stated that the poor readers' difficulties do not arise from an avoidance of the phonological loop, but from its inefficient use.

Berninger, Abbott and Swanson et al. (2010) aimed at studying the contribution of working memory at word and sentence level to reading and writing skills in grade II, IV and VI graders. They were tested on wide variety of working memory tasks. Structural equation modeling was used to establish the predictors for each of five outcome measures such as handwriting, spelling, composing, word reading and reading comprehension. The results revealed that word and sentence level working memory uniquely predicted the reading and writing skills. The text level working memory contributed to the reading comprehension of 4th and 6th graders. Hence the authors concluded that such research would aid in clinical assessment and management.

From the above mentioned studies it is very clear that, the present test available to assess working memory abilities is based on western context. There exists no single test to assess the verbal working memory abilities in typically developing children. No attempts are put forth to develop and standardize a complete package of test to assess working memory in Indian scenario. Also, there is lack of studies which evaluate at different levels of working memory capabilities such as word level, sentence level and text level. So, the present study made a preliminary attempt to develop and standardize a test to assess word and sentence level working memory in typically developing children.

CHAPTER- III

METHOD

The study was planned to be carried out in six phases.

I: Development of the test material

II: Selection of the subjects

III: Familiarity testing

IV: Administration and scoring

VI: Data Analysis

Phase I: Development of the test material

Outline of the test

Table 1: *Frame work of the test material designed for the study*

Working memory	Forms	Tasks	Max Scores
Word level working memory	Phonology	1. Non-word repetition	10
	Phonology	2. Digit backward	10
	Orthography	3. Letter retrieval	10
	Orthography	4. Word backspell	10
Sentence level working memory	Aural-oral	5. Sentence repetition	10
	Aural-oral	6. Sentence comprehension	10
	Aural-written	7. Answering according to directions	10

The test material consisted of 7 tasks to assess working memory at two levels- words and sentence level. The tasks involved in the test are given in the table 2. These tasks were compiled from different literature on reading and writing (Berninger et al., 2010; Woodcock & Johnson, 1990), books and various existing test materials (WIAT II, The Psychological Corporation, 2001). The material was developed in English language and maximum scores one could get would be 70. The duration required to administer the test would be 15- 20 minutes.

Description of each subtest

Subtest 1: Non word repetition

Child will be made to listen to non words of increasing complexity, and will be instructed to repeat each one exactly as heard.

Instruction:*"Now I will play certain meaningless words to you. You will have to repeat each one as you hear it immediately after hearing it."*

Scoring: 1 point will be graded for each correct repetition.

E.g. Zord; Releat

Subtest 2: Digit backward

Successive series of digits from two single digit numbers to eight single digit numbers randomly will be presentedand the child will beasked to repeat each set in the reverse order.

Instruction: *"Now I will play a set of random numbers, you need to hear them carefully and repeat the same in backward direction. Examples will be provided before start of the actual test trial".*

Scoring: 1 point will be graded for the correct production of all numbers in the same order.

E.g. 3 7

2 9 5

Subtest 3: Letter retrieval

Child will be presented with written material containing of alphabets for a brief period of time, later the material would be removed. Later he/she will be instructed to recollect a letter before/after any specified target letter.

Instruction: *"Now I will present a series of randomized alphabet to you, listen to all the series carefully and once I finish telling the series, I would name a target letter, and ask you to recollect an alphabet either preceding or succeeding the target letter".*

Scoring: Child receives 1 point for correct retrieval

Subtest 4: Word backspell

Childhears a 'word' initiallyand both child and examiner will spell out the 'word' in unison. Later he/she will be instructed to imagine the word and repeat in backward fashion.

Instruction: *"Now I will present you with few words starting from simple to complex, listen to the words carefully and spell those words in the backward or reverse fashion".*

Scoring: Child receives 1 point for the correct backward spelling of the word.

E.g. School – loohcs

Market- tekram

Subtest 5: Sentence repetition

Child will be presented with list of sentences one after the other with increasing complexity. At the end of each sentence, the child will be instructed to repeat back the sentence in the same way as it was told.

Instruction: *"Now I will present some sentences to you ranging from simple to complex, listen to it carefully and repeat the same".*

Scoring: Child receives 1 point for correct repetition of the sentence.

E.g. The big ship sailed across the sea.

Subtest 6: Sentence Comprehension

Child will be presented with a sentence, and will be asked questions relating to the content of the sentence.

Instruction: *"Now I will present you with some statements ranging from simple to complex, listen to it carefully and answer to the questions asked related to the statement".*

Scoring: Child receives 1 point for the correct answer.

Subtest 7: Answering according to the direction

Child will be provided with a block, containing 2 to 4 sentences. Child will be instructed to pay attention to the entire block and then repeat the last word of all the

sentences. Complexity will be increased with respect to the sentence structure and the final word which would be repeated by the child.

Instruction: *"Now I will present you with a series of blocks, each containing sentences varying from 2 to 4. Listen to the entire block carefully and repeat the last word of the each sentence of a given block".*

Scoring: Child receives 1 point for correct recollection of the sentence final words in the given set.

Phase II: Selection of the subjects

Participants

The participants for the present study were divided into 3 grades of typically developing children. Group 1 included 2nd grade children of 6-7 years of age, group 2 included children of grade 3rd of age 7-8 years and group 3 consisted of 4th grade children of 8-9 years of age. Each group consisted of 60 children, including 30 boys and 30 girls. Thus, totally 180 children participated in the present study. Table 2 shows the details regarding the participants of the study.

Table 2: *Participants details of the study*

Grade	Age range (years)	Males	Females	Total
II	6-7	30	30	60
III	7-8	30	30	60
IV	8-9	30	30	60
Total		90	90	**180**

Participant's selection criteria

All the children demonstrated the following criteria;

- No history of any speech, language, hearing, neurological, developmental and intellectual disorders, which was ensured using WHO ten question disability screening checklist (Singhi, Kumar, Malhi & Kumar, 2007).
- Participants belonging to middle and higher socio economic status was selected in the study, which was ensured using NIMH socioeconomic status scale developed by Venkateshan (2011).
- Kannada as their spoken language/mother tongue and English as their medium of instruction.
- No oral peripheral mechanism impairments affecting speech or non-speech movements of the articulators.

Phase III: Contentand Familiarity testing

As a part of the selection of the material to assess working memory ability using following task such as non word repetition, digit backward, letter retrieval, word backspell, sentence repetition, sentence comprehension and answering according to the direction, a familiarity test was carried out to find out the familiarity and feasibility of administering each task.

For the above mentioned purpose three Speech language pathologist (SLP's) experienced in the area of reading and writing were chosen and three teachers were also taken from the grade 2^{nd}, 3^{rd} and 4^{th} to check for the content and familiarity of the stimulus material in the test.

Teachers who involved in the familiarity check were asked to rate the familiarity of words/sentences used in the test material were known to the children of grade 2nd to 4th. Familiarity from the teachers was obtained for all the 7 tasks based on the rating scale which is shown in Appendix II.

Familiarity for the contents, suggestions regarding the arrangement, agreeability and complexity for all the seven domains of the test were measured by three SLP's and the overall rating regarding the **arrangement** of the stimuli was based on the rating scales given in Appendix III.

Based on the rating/suggestions given by both the SLP's and teachers the relevant and familiar content were chosen and incorporated for all the seven domains and the stimulus hierarchy was also maintained starting from simple to complex in the test material.

Phase IV: Administration and Scoring

Collection of the data was carried out in the schools in and around Mysore. The objectives and the outcomes of the present study were explained to the teachers, and few parents. Written consent was obtained from each participant. Each participant was seated comfortably on a chair facing the investigator across the table in a quiet and distraction free room. The examiner ensured that there was no interference from extraneous noise or visual distractions, so as to derive their concentration and complete attention towards the task and to control the effect of variables that would affect the subject's performance. In order to get the co-operation from the participant for testing, rapport was built by talking about daily activities of the child, games played by the child etc. Appropriate social and verbal reinforcement (i.e. patting on the shoulder and saying "good") was given before administration of the tasks.

Prior to commencement of the task, the necessary demographic data from the participant were collected and they were informed that the procedure would take approximately 15-20 minutes to complete. Each of the seven task were administered by dictating the instruction for the same and an trail tasks were also provided before the start of the actual test. In this way all the seven tasks were administered and an online binary scoring system was incorporated for all the seven tasks.

Phase V: Data analysis

Thus all the subjects in grade II, III and IV were tested in the same manner for each of the task and their scores were tabulated and analyzed. Scores were tabulated separately for each group. Using SPSS 17- statistical software the mean and standard deviation was computed for all the grades, gender and across tasks and further grade wise and task wise comparison and interaction effect between grade and gender was done using MANOVA and Paired sample t-test was used to obtain the comparison or significant difference between word and sentence level tasks. Test re-test reliability measures were obtained using Pearson's correlation co-efficient.

CHAPTER- IV

RESULTS AND DISCUSSION

The present study was carried to find out the working memory capacity at two different levels that is at word level and sentence level across three different grades. To fulfill the primary aim a secondary aim was planned, to develop a test material to tap the working memory capabilities across three grades II, III and IV. In the present study, 30 males and 30 females were taken from each grade and tested for seven different working memory task; both word level and sentence level. The scores obtained for each of the tasks were tabulated and statistically analyzed using the SPSS software version 17.0.

The scores obtained for males and females were subjected to descriptive statistical analysis and the mean and standard deviation were obtained. Multivariate Analysis of variance (MANOVA) was carried out to find the effect of age and gender on each of the tasks. Scheffe's post hoc test was also carried out to find the significant difference between the age groups for each task. Paired sample T test was carried out to study the difference in performance between the levels that is word level and sentence level with respect to all the grades and also to find out the gender differences if any across the grades and task. Pearson's correlation co-efficient was carried out to find the test re-test reliability of the test developed. The results will be discussed under the following sub-headings.

1. Comparison across seven tasks of the test developed
2. Comparison between word and sentence level tasks
3. Test re-test reliability

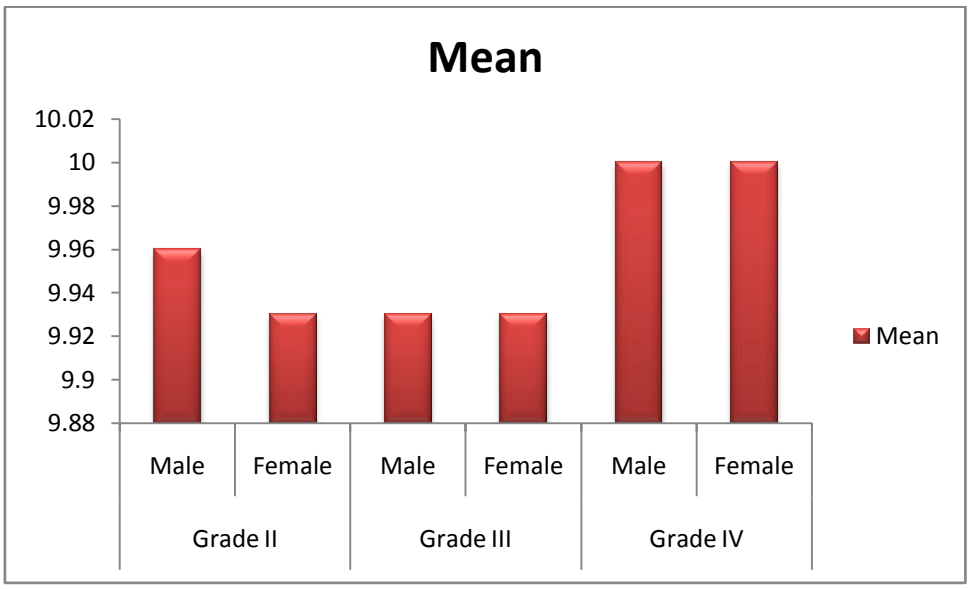
I. Comparison across seven tasks of the test developed

Task 1: Non word repetition task (NWR)

The mean scores and standard deviation for non word repetition task by the subjects of all the three grades have been shown in table 2 and graph 1. From the table 3, the mean scores for IV grade were the highest in both males and females obtaining the same mean score of 10. This was followed by next higher mean score was obtained by grade II with males obtaining a mean of 9.96 and females obtaining a score of 9.93. The least mean scores were obtained by grade III, whereboth males and females obtained a mean of 9.93. Grade III had the highest standard deviation score in both the males and females of 0.25, indicating higher variability for the task of non word repetition when compared to grade II and IV.

Table 3: *Mean and standard deviation scores for non word repetition task across the subjects grades and gender*

Grades	Gender	Mean	SD
Grade II	Male	9.96	0.18
	Female	9.93	0.25
	Total	9.95	0.21
Grade III	Male	9.93	0.25
	Female	9.93	0.25
	Total	9.93	0.25
Grade IV	Male	10.00	0.00
	Female	10.00	0.00
	Total	10.00	0.00



Graph 1: Mean scores for non word repetition task across the three grades.

Table 4: *Results of MANOVA for non word repetition task across the three variables*

Sources of variation	df	F	Sig.**
Grade	2	1.88	0.15
Gender	1	0.14	0.70
Grade X Gender	2	0.14	0.86

As it can be noted from the table 4, there was no significant main effect seen ($p>0.05$) for all the three variables that is grade, gender and the interaction effect of grade and gender for the non word repetition task.

Thus the results on non word repetition task showed that participants of all the three grades performed similarly. Though, there was increase in the mean scores

across the grades but it was not statistically significant. Participants of grade III and IV performed better comparatively to that of grade II. The results of the present study are support the previous studies (Dollaghan & Campbell, 1998; Dollaghan et al., 1993 &Ellis Weismer et al., 2000). Many of the research literature have put forth the capacity-limited phonological episodic buffer (Baddeley, 2003; Gathercole & Baddeley, 1990; Montgomery, 2004, 2008).

Santos and Bueno (2003) investigated the developmental aspects of phonological memory processing of non word repetition in typically developing children aged 4-10 years through error analysis. The results of the study stated that performance on non word repetition task was age dependant, and the major error found was substitution. Though error analysis was not taken up in the present study, the study supports that there is clear cut developmental trend in performance of children from grade II to grade IV for the non word repetition task.

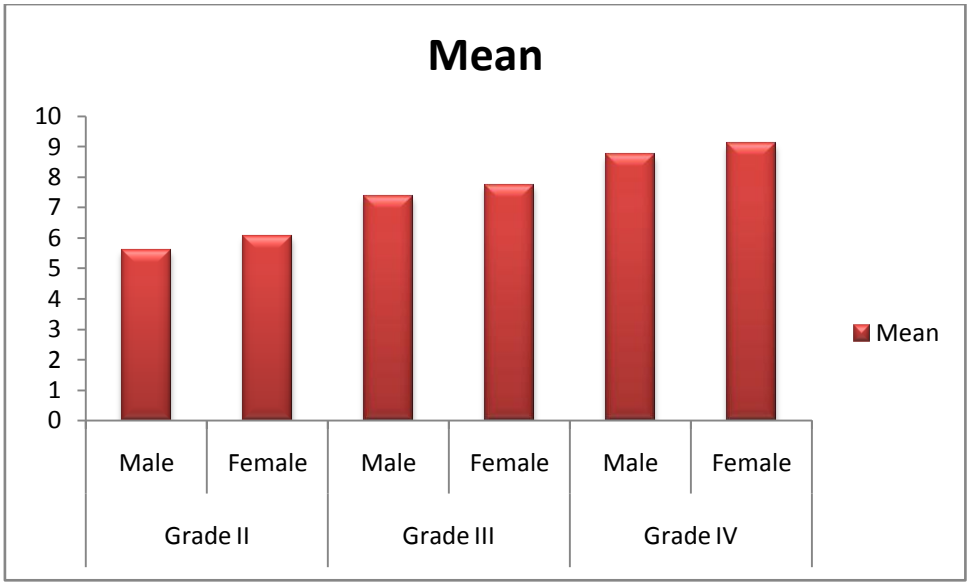
Task 2: Digit backward task (DB)

The mean scores and standard deviation for digit backward task by the subjects of all the three grades was shown in table 5 and graph 2. From the table 5, it was evident that grade II had the least mean score compared to the other two grades, with males and females obtaining a score of 5.6 and 6, respectively. Grade IV obtained the highest mean score in males and females obtaining a mean score of 8.7 and 9.1, respectively. Grade III performed in between grade II and IV with respect to the obtained mean scores in males obtaining a mean of 7.3 and females obtaining a score of 7.7.

Table 5: *Mean and standard deviation scores for the digit backward task across grades and gender*

Grades	Gender	Mean	SD
Grade II	Male	5.60	1.06
	Female	6.06	1.61
	Total	5.83	1.37
Grade III	Male	7.36	1.90
	Female	7.73	1.63
	Total	7.55	1.77
Grade IV	Male	8.73	0.98
	Female	9.10	0.85
	Total	8.91	0.93

The standard deviation score was the highest for grade III, with a score of 1.9 and 1.6 for both males and females, respectively indicting higher variability for the task of digit backward. Grade IV exhibited the least standard deviation, with males having a score of 0.9 and females 0.8, suggestive of lesser variability for the current task. Grade II had obtained standard deviation scores that lie in between grade III and IV, with values 1.06 and 1.6 for both males and females, respectively.



Graph 2: Mean scores for digit backward task across the three grades.

Table 6: *Results of MANOVA for digit backward task across the three variables*

Sources of variation	df	F	Sig.**
Grade	2	72.280	0.000
Gender	1	3.659	0.057
Grade X Gender	2	0.024	0.976

The results of MANOVA were presented in the table 6. There was a significant main effect ($p<0.05$) seen for grade on the performance of digit backward task. It was seen that the interaction effect for grade and gender also had no significant effect ($p>0.05$) on the performance on digit backward task.

Table 7: *Results of Scheffe's test for digit backward task across the three grades*

Grade	Subtest		
	1	**2**	**3**
Grade II	5.8333		
Grade III		7.5500	
Grade IV			8.9153

The results obtained from the Scheffe's post Hoc test for all the three grades for digit backward task are depicted in the table 7. It revealed that there was significant difference ($p<0.05$) across all three grades. As it was expected, grade IV performed better when compared to grade II and III. And grade II put forth the least performance when compared to grade III and IV.

As depicted in the results, there was progressive increase in the performance across three grades on digit backward task. Participants of grade IV performed better when compared to participant of grade II and III, and the results were statistically different for the variable grade. The results for the present task is in consonance with previous research (Baddeley, 1990) which put forth that it might be because of the dual task paradigm consisting of both the verbal execution process, storage and retrieval process. Also as children age progresses there is increase in flexibility seen with respect to storage and retrieval of verbal representation mediated by the phonological loop.

As the number of digits in each trial increased, participants of grade II exhibited greater difficulty in recalling the digits in the same order when compared to the subjects of other two grades. The difference in performance between the three

grades on the digit backward test may be attributed to developing verbal executive mechanism which affects the executive performance.

Furthermore the increased performance of older children (grade IV) in digit backward task was because of the activation of the phonological loop and sub vocal rehearsal components of working memory. The Echoic memory in the short term storage was activated where one register the digits one after the other by activating the phonological loop. The participants were able to recall precisely all the digits (in the reverse order) due to the involvement of the sub vocal rehearsals.

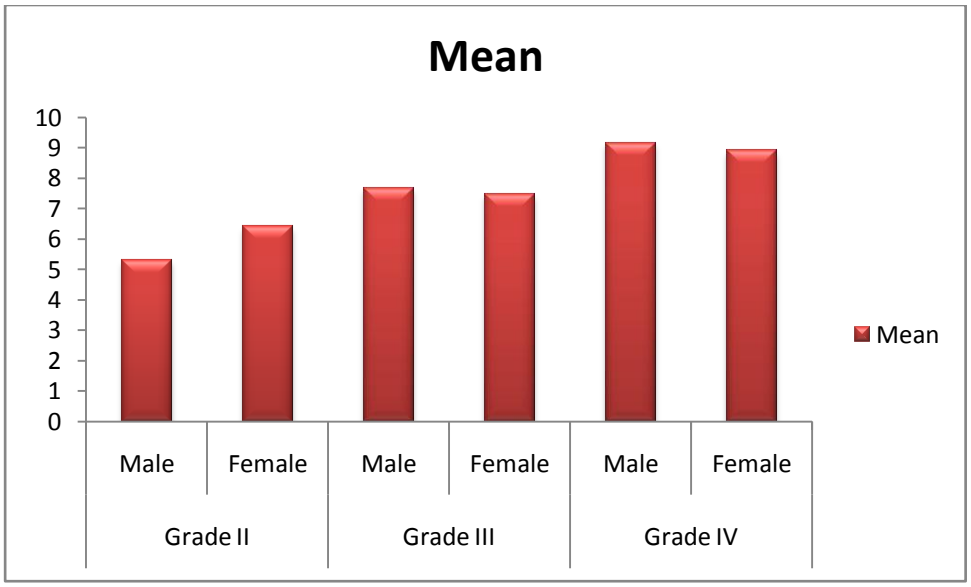
Task 3: Letter retrieval task (LR)

The mean scores and standard deviation for letter retrieval task by the subjects of all the three grades was shown in table 8 and graph 3. As it was evident from the table 8, there was a progressive increase in the mean value obtained across three grades that is II, III and IV. The mean scores obtained for grade II was the least, in males and females obtaining a score of 5.3 and 6.4, respectively. Grade III performance laid in between grade II and IV, with the mean scores of 7.6 and 7.4, respectively for males and females. Grade IV obtained the highest mean values; with males obtained a score of 9.1 and females had a score of 8.89.

With respect to standard deviation there was a decline seen from grade II to IV that is grade II obtained higher standard deviation when compared to grade III and IV with a value of 1.82, indicating greater variability with respect to letter retrieval task. Grade IV obtained the least value for standard deviation, which is of 0.91, indicating lesser variability with respect to letter retrieval task. Standard deviation for grade III is in between grade II and IV, with the score of 1.45.

Table 8: *Mean and standard deviation scores for the letter retrieval task across grade and gender*

Grades	Gender	Mean	SD
Grade II	Male	5.30	1.05
	Female	6.40	2.23
	Total	5.85	1.82
Grade III	Male	7.66	1.44
	Female	7.46	1.47
	Total	7.56	1.45
Grade IV	Male	9.16	0.91
	Female	8.89	1.23
	Total	9.03	1.08



Graph 3: Mean scores for letter retrieval task across the three grades.

Table 9: *Results of MANOVA for letter retrieval task across all the three variables*

Sources of variation	df	F	Sig.**
Grade	2	70.859	0.000
Gender	1	0.926	0.337
Grade X Gender	2	4.179	0.017

MANOVA results were shown in table 9, as it was evident from the table there was significant effect ($p<0.05$) seen for both grade and combined effect for grade and gender. But, for gender there was no significant effect ($p>0.05$) noticed for the letter retrieval task.

Table 10: *Results of Scheffe's test for the letter retrieval task across the three grades*

Grade	Subtest		
	1	**2**	**3**
Grade II	5.8500		
Grade III		7.5667	
Grade IV			9.0339

The results obtained from the Scheffe's post Hoc test for all the three grades for letter retrieval task are depicted in the table 10. It revealed that there was significant difference ($p<0.05$) across all three grades. As it was expected grade IV performed better when compared to grade II and III. Also grade II put forth the least performance when compared to grade III and IV.

The present study depicts that there is increase in performance on letter retrieval task, which is also obtained to be statistically significant across all the three

grades. These results are in agreement with the previous study done by Berninger et al. (2010). These authors aimed at finding the relation of working memory to literacy skills in children of grades 2nd, 4th and 6th, using variety of tasks and one of which was letter retrieval. The results showed that the performance increased across grades from 2nd to 6th. This result was attributed to the sprouting phonological loop.

Phonological loop is repeatedly shown to be an important component in literacy development (Adams, Foorman, Lundberg, & Beeler, 1997), in which children are required to hold random spoken letters or words in the working memory while they analyze the individual entity in them. Hence forth the present study also put forth the same result stating that the ability to retrieve the chunks of sounds develops in children as they move to higher grades due to constant mounting of phonological loop.

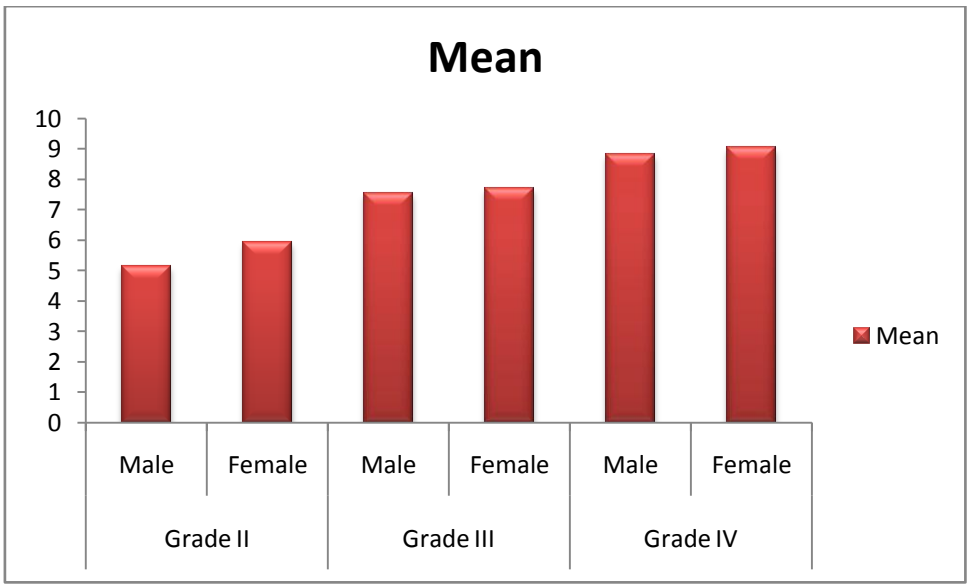
Task 4: Word Backspell task (WB)

The mean and the standard deviation scores for the word backspell task are depicted in the table 11 and graph 4. From the table 11, it was found that there was a progressive increase in the scores from grade II to grade IV. Grade IV got the highest mean score values, in males and females getting a mean score 8.83 and 9.03, respectively. Grade II obtained the least mean scores, with males obtaining a score of 5.13 and females obtained a score of 5.93. Grade III lies in between the performance that is put forth by both grades II and IV, with males obtaining a mean value of 7.53 and females obtaining a score of 7.70. The standard deviation scores indicate that grade IV exhibit lesser degree of variability in the performance for the word backspell task with a standard deviation of 1.03. Followed this was grade III, who got the

standard deviation score of 1.69. Grade II exhibited comparatively higher degree of variability in the word backspell task, with a standard deviation score of 1.71.

Table 11: *Mean and standard deviation scores for the word back spell task across grades and gender*

Grades	Gender	Mean	SD
Grade II	Male	5.13	1.10
	Female	5.93	2.09
	Total	5.53	1.71
Grade III	Male	7.53	1.69
	Female	7.70	1.72
	Total	7.61	1.69
Grade IV	Male	8.83	0.79
	Female	9.03	1.23
	Total	8.93	1.03



Graph 4: Mean scores for word backspell across the three grades.

Table 12: *Results of MANOVA for word backspell task across the three variables*

Sources of variation	df	F	Sig.**
Grade	2	76.851	0.000
Gender	1	2.975	0.086
Grade X Gender	2	0.833	0.437

MANOVA results are depicted in the above table 12, there was a statistically significant effect ($p<0.05$) seen for the variables such as grade and not for the variable, gender. But the combined effect of grade and gender for the task of word backspell did not revealed any significant effect ($p>0.05$).

Table 13: *Results of Scheffe's test for the word backspell task across the three grades*

Grade	Subtest		
	1	**2**	**3**
Grade II	5.5333		
Grade III		7.6167	
Grade IV			8.9322

As it can be noted from the Scheffe's post Hoc test depicted in the table 13, there was significant difference with respect to performance on word backspell task across three grades. As it is expected, performance of grade IV was highest when compared to grade II and III children. And performance of grade III children lies in between grade II and IV.

In the backward spell task, the same literature holds good as stated for the letter retrieval task. And this domain also put forth the progressive improvement in scores across three grades which are statistically significant.

The results for the present task are in consonance with previous research (Baddeley, 1990) which put forth that it might be because of the dual task paradigm consisting of both the verbal execution process, storage and retrieval process.

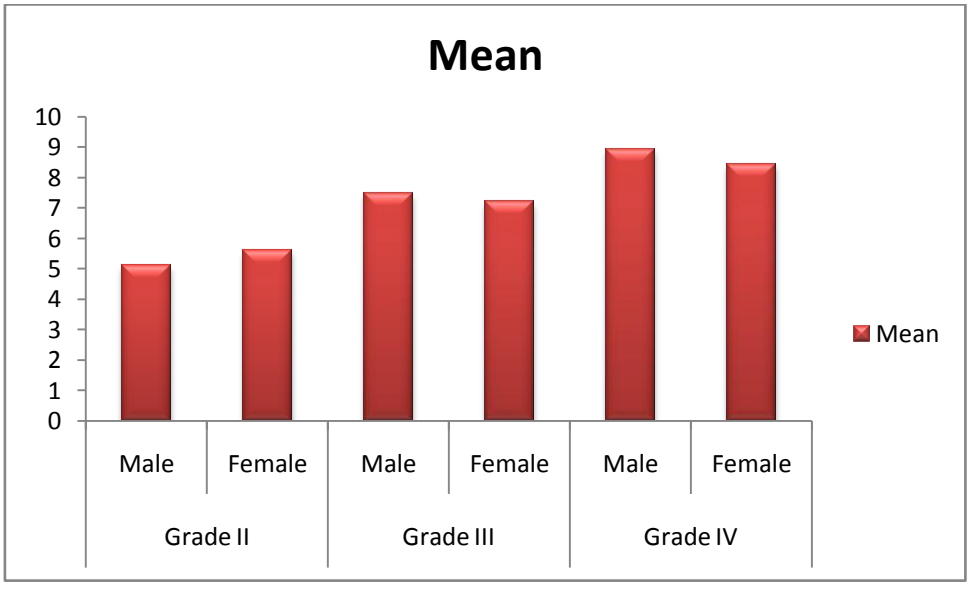
Task 5: Sentence repetition task (SR)

The mean and standard deviation for the sentence repetition task are tabulated in table 14 and graph 5. As it can be noted from the table 14, the mean are taking the route of progressive increase from graded II to IV. As expected grade II obtained the least mean values of 5.10 and 5.6 in males and females, respectively. Followed by grade II, performance of grade III was little higher, with males obtaining a mean value of 7.4 and females with the mean value of 7.20. The highest performance was secured by grade IV, with mean values of 8.9 and 8.4 in males and female, respectively.

Standard deviation values are seen to be higher for grade III, with the value of 1.72, indicating of variability with respect to the task of sentence repetition. This was followed by grade II, with deviation value of 1.48. Grade IV had the least standard deviation value of 1.07, indicating comparatively lesser degree of variability with the task of sentence repetition.

Table 14: *Mean and standard deviation scores for the sentence repetition task across grades and gender*

Grades	Gender	Mean	SD
Grade II	Male	5.10	1.24
	Female	5.60	1.67
	Total	5.35	1.48
Grade III	Male	7.46	1.65
	Female	7.20	1.80
	Total	7.33	1.72
Grade IV	Male	8.93	0.90
	Female	8.44	1.18
	Total	8.69	1.07



Graph 5: Mean scores for sentence repetition task across the three grades.

Table 15: *Results of MANOVA for sentence repetition task across the three variables*

Sources of variation	df	F	Sig.**
Grade	2	80.07	0.00
Gender	1	0.15	0.69
Grade X Gender	2	1.90	0.15

The above table 15 depicted the MANOVA results. From the table, it is evident that there is significant main effect ($p<0.05$) seen for only the variable grade. But for the other variables such as gender and combined effect of grade and gender, there was no significant effect obtained ($p>0.05$).

Table 16: *Results of Scheffe's test for the sentence repetition task across the three grades*

Grade	Subtest		
	1	**2**	**3**
Grade II	5.3500		
Grade III		7.3333	
Grade IV			8.6949

As it can be noted from the Scheffe's post Hoc test depicted in the table 16, there was significant difference between the three grades on sentence repetition task. As it is expected, there was a progressive increase in the performance for the sentence repetition task from grade II to IV.

From the study it is evident that grade II performed comparatively poor on sentence repetition task when compared to grade III and IV. This may be attributed to the fact that grade II children are not exposed to complex sentence like having subordinate clauses or embedded sentence structure. Also, it may be because of limited storage capacity in terms of chunks in the working memory. This could also be because of difficulty in retrieval process. Baddeley (1999) found retrieval process difficulties in children as the word length increased. Furthermore, younger children omit few functional words. Probable reasons for the omission by younger children are limitations in the neuro- motor skills and developing verbal memory skills.

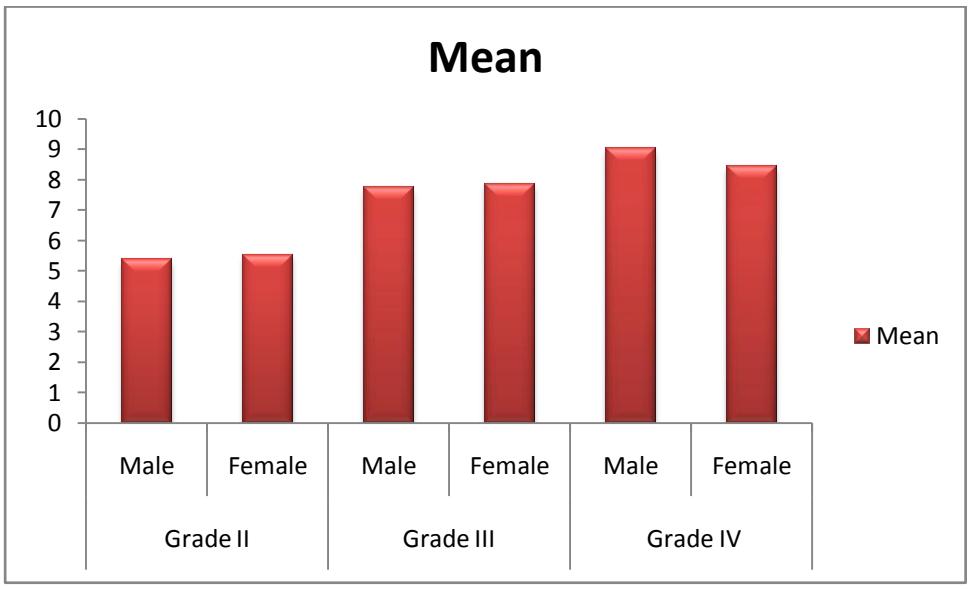
Task 6: Sentence comprehension task (SC)

The mean and standard deviation values for the sentence comprehension task are tabulated in table 17 and graph 6 below. There was a increase in the mean values from grade II to grade IV. The mean value of grade II was 5.3 and 5.5 for both males and females respectively. Grade III exhibited a mean value comparatively higher than grade II, with males obtaining a mean of 7.7 and females obtaining a value of 7.8. Higher mean values were secured by grade IV, which was of 9.03 and 8.4 for both males and females, respectively.

Moving on to the standard deviation, there was a progressive decrease in the values obtained from grade II to IV. With grade II getting the highest SD values of 1.5, indicating higher degree of variability in the sentence comprehension task. Grade III and IV obtained a deviation score of 1.1 and 0.9, respectively, indicative of lesser degree of variability when compared to grade II.

Table 17: *Mean and standard deviation scores for the sentence comprehension task across grades and gender*

Grades	Gender	Mean	SD
Grade II	Male	5.36	1.18
	Female	5.53	1.77
	Total	5.45	1.50
Grade III	Male	7.73	1.25
	Female	7.86	0.93
	Total	7.80	1.10
Grade IV	Male	9.03	0.85
	Female	8.44	1.05
	Total	8.74	0.99



Graph 6: Mean scores for sentence comprehension task across three grades.

Table 18: *Results of MANOVA for sentence comprehension task across the three variables*

Sources of variation	df	F	Sig.**
Grade	2	115.840	0.000
Gender	1	0.273	0.602
Grade X Gender	2	1.808	0.167

As can be noted from the above depicted table 18, significant effect ($p<0.05$) was seen only for the variable, grade. No significant effect ($p>0.05$) was seen for the other two variables that is gender and combined effect of grade and gender.

Table 19: *Results of Scheffe's test for the sentence comprehension task across the three grades*

Grade	Subtest		
	1	**2**	**3**
Grade II	5.4500		
Grade III		7.8000	
Grade IV			8.7458

As it can be noted from the Scheffe's post Hoc test depicted in the table 19, there is significant difference with respect to performance on sentence comprehension task across three grades. As it is expected there is a progressive increase in the performance for the sentence repetition task from grade II to IV.

Performance of children in grade II in sentence comprehension task was poorer when compared to children in grade III and grade IV. On the other hand

children in grade IV out performed in the sentence comprehension task. The findings of the present study are in agreement with the previous reports of Feier and Gertsman, (1980) who reported that younger children performed poorly than older children on many tests of sentence comprehension.

Generally, the higher order cognitive functions like comprehension of complex sentences are essentially associated with working memory functions (Caplan & Waters, 1999). Subjects within the age group of 9-12 years had difficulty in processing sentences with increased syntactic complexity due to the limitations in the sentence comprehension abilities that is related to age (Magimairaj & Montgomery, 2012).

Literature on sentence comprehension has focused on the role of the central executive or the phonological loop. Literature has shown that on-line tasks are sensitive to the time-course of syntactic processing (MacDonald, Pearlmutter & Seidenberg, 1994). Hence, in the present study similar on- line measures were utilized, which turned out to be a sensitive measure to detect the developmental trend in sentence comprehension in typically developing children.

According to a literature on developmental aspect of memory; the authors hypothesize that memory span is significantly poorer for complex sentence in comparison with the simpler sentences. This is because of complex sentence requires children to drive their attentional focus in processing the complex sentence hence by diverting their focus from storage to processing. The poorer performance by grade II children (younger) can be attributed to limited working memory functions and limited focus on storage. As a function of age, these skills would improve as children move to

higher grades. The results of the present study support the findings of (Caplan & Waters, 1999; Mac Donald et al., 1994 and Magimairaj & Montgomery, 2012).

Task 7: Answering according to the direction task (AAD)

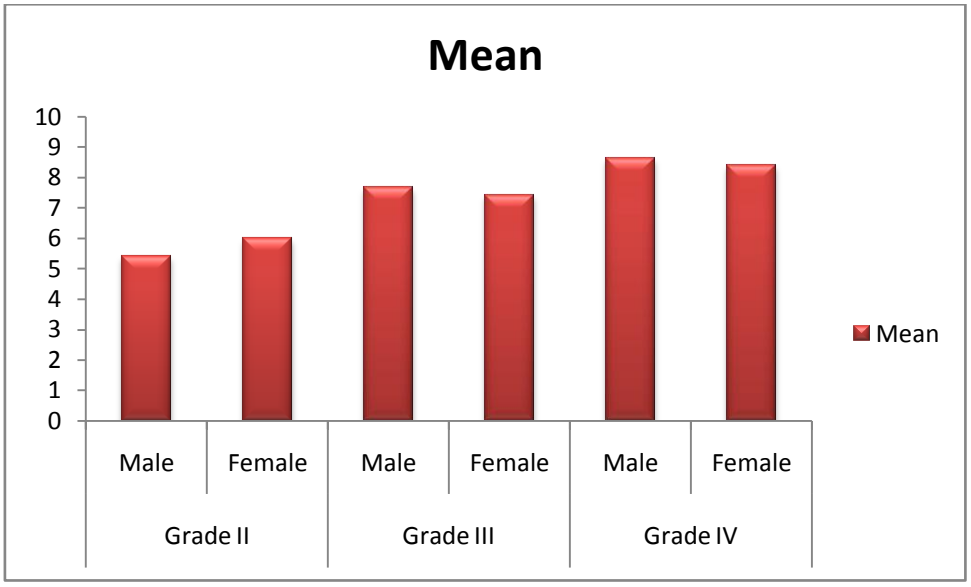
The mean and standard deviation values for the answering according to the direction task are tabulated in the table 20 and graph 7. It was found that there was increase in the mean values from grade II to grade IV. The mean value of grade II was 5.4 and 6 for both males and females, respectively. Grade III exhibited a mean value comparatively higher than grade II, with males obtaining a mean of 7.6 and females obtaining a value of 7.4. Higher mean values were secured by grade IV, which was of 8.6 and 8.4 for both males and females, respectively

Table 20: *Mean and standard deviation scores for the answering according to the direction task across grades and gender*

Grades	Gender	Mean	SD
Grade II	Male	5.40	1.35
	Female	6.00	1.94
	Total	5.70	1.69
Grade III	Male	7.66	1.24
	Female	7.43	1.00
	Total	7.55	1.12
Grade IV	Male	8.63	0.96
	Female	8.41	0.86
	Total	8.52	0.91

For standard deviation, it was found that there was a progressive decrease in the values obtained from grade II to IV. With grade II getting the highest SD values of

1.6, indicating higher degree of variability in the performance of participants on the task answering according to the direction task. Grade III and IV obtained a deviation score of 1.1 and 0.9, respectively, indicative of lesser degree of variability when compared to grade II.



Graph 7: Mean scores of answering according to the direction across all the three grades.

Table 21: *Results of MANOVA for answering according to the direction task across all the three variables*

Sources of variation	df	F	Sig.**
Grade	2	74.365	0.000
Gender	1	0.065	0.799
Grade X Gender	2	2.066	0.130

As can be noted from the above table 21, significant effect ($p<0.05$) was seen only for the variable, grade. No significant effect ($p>0.05$) was seen for the other two

variables that is gender and combined effect for grade and gender on the task of answering according to the direction.

Table 22: *Results of Scheffe's test for answering according to the direction task across the three grades*

Grade	Subtest		
	1	**2**	**3**
Grade II	5.7000		
Grade III		7.5500	
Grade IV			8.5254

As it can be noted from the Scheffe's post Hoc test depicted in the table 22, there was significant difference found across three grades on answering according to the direction task. As it was expected, that children in grade IV performed significantly better than children in grade II and III. Also children in grade II performed lower than grade III and IV. Grade III performed in between grade II and IV on answering according to the direction task.

Answering according to the direction was the final task used in the present study, were the participants was presented a block of sentences varying from 2-4 sentences in each block. They were instructed to listen to the entire block of sentences one after the other and once it was done, they were asked to recollect the final words of the sentences in the block presented. As expected grade II performed poorly when compared to grade III and IV. Also, when the sentences were increased in length and complexity they obtained poorer scores. Hence, this processing complexity is said to be influenced by working memory capacities both in children and adult as studies by

many authors (Barrouillet, Bernardin, Portrat, Vergauwe, &Camos, 2007; Barrouillet&Camos, 2001; Barrouillet et al., 2009).

The results of the present study are in agreement with the previous literature by Barrouillet and Camos, (2001); Gavens and Barrouillet, (2004)who investigated the influence of processing complexity on children's verbal working memory abilities by using both tradition and computer paced operation span task. The number of processing items increased from one to six strings. The researchers found that processing complexity necessarily had an influence on children's verbal working memory. As the load for processing increases it resulted in poor memory span when compared to lesser load. The similar results were found in the present study also.

In a study done by Magimairaj & Montgomery (2012), on the role of processing complexity of working memory and its effect on sentence comprehension. The authors found that performance decreased with respect to complex sentence blocks. The authors also found a significant correlation between simple and complex memory task and sentence comprehension task. Hence the poorer performance on answering according to the direction task by grade II is due to limited complex verbal working memory. As a function of age, this task improves as the children moves to higher grade (grade IV). The obtained results are in agreement with Magimairaj & Montgomery's (2012) findings. The mean and standard deviation scores for all the tasks across three grades are tabulated in APPENDIX V

II. Comparison between word and sentence level tasks

Mean and standard deviation was computed between word and sentence level tasks. There were four tasks that come under word level domain namely; non word repetition, digit backward, letter retrieval and word backspell. The overall score for the word level tasks is 40. The sentence level tasks were of three in number, namely; sentence repetition, sentence comprehension and answering according to the direction, and the overall score this domain is 30. Hence to counter balance the existing difference in scores between the two domains, the sentence level tasks were converted into percentage for a score of 40.

Table 23: *Mean and standard deviation for word and sentence level tasks*

		Mean	SD
Pair 1	**Word 40**	32.2	5.50
	Sentence 40	28.9	6.92

As it can be noted from table 23, there was greater mean for word level tasks when compared to sentence level task. With word level tasks obtaining a mean score of 32.2, and sentence level tasks obtaining a mean value of 28.9. And the standard deviation value for word level task is 5.5 and for sentence level is 6.9. Hence it is clear from the standard deviation value that there was lesser variability on the word level tasks when compared to sentence level tasks. Significance was established using paired sample T- test and the results showed that there is a significant difference ($p<0.05$) with respect to word and sentence level working memory tasks.

With respect to comparison between word level and sentence level working memory tasks, performance across word level working memory (WL-WM) tasks (non word repetition, digit backward, letter retrieval and word backspell) were better across all the three grades, and gender when compared to sentence level working memory (SL-WM) tasks (sentence repetition, sentence comprehension and answering according to the direction). The above findings are in agreement with the literature quoted by Gough and Hillinger (1980), who stated the importance of WL decoding abilities influencing the beginning stages for all reading skills in second to fourth graders.

But SL-WM is also said to influence the development of text reading comprehension and decoding, but it is not directly related and developed to its fullest in the elementary grade children (Graham, Berninger, Abbott, Abbott, & Whitaker, 1997). Thus, in elementary graders WL-WM plays an imperative role in reading and writing across the three grades taken up in the present study.

In a study conducted by Berninger et al. in 2010, to verify the role of WL-WM and SL-WM in typically developing children of 2^{nd}, 4^{th} and 6^{th} graders, and their results stated that WL-WM is good predictor of literacy skills in comparison to SL-WM skills. The present study found similar results and results of the present study, support the earlier studies (Berninger et al., 2010).

III. Test- retest reliability

Intra judge reliability for test- retest was obtained by using Pearson's correlation co-efficient. Intra judge reliability score was found to be 0.89, which denotes higher degree of reliability for test- retest scenario.

Overall the present study aimed at finding the developmental trend with respect to word and sentence level working memory using wide variety of tasks. The participants chosen were typically developing children from three grades that is grade II, III and IV. As expected the performance increased from grade II to grade IV across all the tasks except for non word repetition. Also, the developmental trend was also found to be statistically significant for all the grades except for non word repetition task. Furthermore statistically significant gender differences were not obtained for any of the tasks.

CHAPTER V

SUMMARY AND CONCLUSIONS

In the recent years many researchers have contributed to the literature of working memory and its development in typically developing children, using variety of task to tap the different components of memory. They have also explored the possible trends in the developmental aspect of working memory and its relation with respect to sentence comprehension, literacy skills and higher cognitive functions (Caplan& Waters, 1999; Berninger et al., 2010; Magimairaj & Montgomery, 2012). Since there is a dearth of literature to support the developmental trend in working memory abilities in typically developing children in Indian context.

Therefore the present study made an attempt to track the developmental trend in the working memory abilities in typically developing children. For this purpose two levels of working memory were taken into consideration that is word level and sentence level working memory. To fulfill the primary need, a test material was constructed which consisted of seven different task which assesses the working memory at two different levels. Children of grade II, III and IV served as the participants for the present study.

The task chosen for the study was split into two types, word level working memory (WL-WM) tasks and sentence level working memory (SL-WM) tasks. WL-WM domain comprised of four tasks (non word repetition, digit backward, letter retrieval and word backspell) and SL-WM domain comprised of three tasks (sentence repetition, sentence comprehension and answering according to the direction). All the seven tasks were chosen as it reflects the developmental aspects of phonological short

term memory abilities, which in turn reflects the storage and retrieval process for reading and writing skills.

The study was carried out in five phases; they were, development of the test material, subject selection, familiarity testing (validating), administration and scoring and data analysis. The statistical analysis was carried out using Multivariate Analysis of variance (MANOVA) to find the effect of grade and gender and interaction effect of both grade and gender on each of the tasks. Scheffe's post hoc test was employed to find out the significant difference between the age groups or grades for each task. Paired T- test was done to find the differences in performance between word level and sentence level working memory tasks. Pearson's correlational co-efficient was used to check for the intra- judge test re-test reliability.

The results of the present study revealed several points of interest;

First, analysis of the working memory tasks shown a significant main effect for the variable, grade that is there is progressive improvement in the performance across the three grades from grade II to grade IV, except for the task of non word repetition. The younger children (grade II) performed poorly in all the WM tasks as compared to older children (grade III & IV) is because of limited verbal WM capacity/ function, limited storage capacity, limited sentence comprehension and phonological episodic buffer (Feider & Gerstsman, 1980; Gathercole & Baddeley, 1990; Barrouillet et al., 2009). The performance of higher grade (grade IV) children shown the best which indicates the WM capacity continue to improve from grade II to grade IV.

The results of the present study supports the earlier findings that the improvement by grade IV is due to development in the verbal execution mechanism

in terms of storage and retrieval of verbal representation mediated by phonological loop (Baddeley, 1990; Berninger et al., 2010). The present study found developmental trend across all the grades from II to IV supports the earlier findings of Santos, and Bueno (2003).

Second, gender difference in performance was not found for any of the task. This indicates both the males and females performed similarly in all of the WM tasks.

Third, children across all the three grades performed better on word level working memory tasks, rather on sentence level tasks. The present findings are in consonance with the findings of Gough and Hillinger (1980) who reported the importance of word level WM abilities influence the beginning stage of the reading skills in II and IV grade children that is in younger children the word level WM predominates for early literacy development and could be good predictors for literacy which needs to be investigated further.

Fourth, test re-test reliability was found to be high which was obtained using ten percent of the study group re-evaluated with the developed test material within two weeks of administration. This indicates that the present test material had a good reliability.

Implication of the study

- The results of the present study can be used as norms to compare with clinical groups.
- The results of the study give insight to the speech language pathologist regarding the role of working memory in reading and writing success in primary school children.

- The tasks that were used in the present study can be utilized in assessing special population like dyslexic, SLI etc.
- The recognition of the nature of working memory at different linguistic levels in typically developing children would help in implementing appropriate assessment procedures and also for selecting and incorporating appropriate strategies to enhance the working memory aspect.
- Level of working memory ability may have implications for the amount of teacher-directed, explicit instruction that a student requires to learn to become a successful reader and writer.

Limitations of the present study

- Only three grades that is grade II, III and IV were considered for the present study to investigate the developmental trend in the working memory.
- Children belonging to middle and higher socio- economic status were considered, excluding the lower socio- economic status group in the present study.
- Only binary scoring system was incorporated in the present study.
- The study incorporated only two levels of working memory that is at word and sentence level, excluding the text level memory aspects.
- The test was designed or developed in English language for Kannada speaking children.

Future research directions

- This study can be regarded as a preliminary attempt, hence many such studies can be done by incorporating the regional and cultural differences and standardize the same on different grades.

- Further studies can also be taken up to shed the light on the areas of literacy skills and establish the predictors for literacy skills in typically developing children in response to working memory.
- The probable presence of memory deficits in language impaired children needs to be investigated (e.g. learning disabled and specific language impairment), which would further facilitate to rehabilitate these groups in a better possible dimensions.

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APPENDIX I

DEVELOPMENT OF WORD- AND SENTENCE LEVEL WORKING MEMORY TEST FOR TYPICALLY DEVELOPING CHILDREN

The present test consists of seven tasks which assess the working memory in typically developing children. It has been organized at two levels word and sentence level. Total score for each section is 10 constituting an overall grand total of 70.

Grade: Grade II to Grade IV

Time for administration: 15-20 minutes

Language: English

Task 1: Non word repetition

Instruction: "Now I will play certain meaningless words to you. You will have to repeat each one as you hear it immediately after hearing it."

Sl. No	Non-Words
1.	/dute/
2.	/Kondi/
3.	/Laker/
4.	/Takare/
5.	/Ranyaku/
6.	/Kolvano/
7.	/Shompetikon/
8.	/Tamerwelen/
9.	/Risvadeki/
10.	/Dintergarken/

Scoring: 1 point for each correct repetition.

Task 2: Digit backward

Instruction: "Now I will play a set of random numbers, you need to hear them carefully and repeat the same in backward direction. Examples will be provided before start of the actual test trial".

Sl No	Digits
1.	8, 3
2.	4, 7
3.	2,9
4.	7, 2, 5
5.	6, 9, 4
6.	3, 8, 2
7.	8, 3, 1, 5
8.	5, 9, 4, 1
9.	2, 7, 1, 9
10.	1, 8, 5, 9, 2

Scoring: 1 point for the correct production of all numbers in the same order.

Task 3: Letter retrieval

Instruction: "Now I will present a series of randomized alphabet to you, listen to all the series carefully and once I finish telling the series, I would name a target letter, and ask you to recollect an alphabet either preceding or succeeding the target letter".

Sl. No	Alphabet set
1.	**S**, B, L
2.	M, **T**, O
3.	**P**, A, O
4.	E, **M**, R
5.	I, E, **T**, H
6.	D, T, **N**, E

7.	F, **O**, E, S
8.	D, I, **A**, M
9.	I, P, Z, **M**
10.	D, F, **R**, B, S

Scoring: 1 point for correct retrieval

Task 4: Word backspell

Instruction: "Now I will present you with few words starting from simple to complex, listen to the words carefully and spell those words in the backward or reverse fashion".

Sl. No	Words
1.	Read
2.	Cycle
3.	Carrot
4.	Timid
5.	Demon
6.	Picture
7.	Garden
8.	Captain
9.	Motorbike
10.	Education

Scoring: 1 point for the correct backward spelling of the word.

Task 5: Sentence repetition

Instruction: "Now I will present some sentences to you ranging from simple to complex, listen to it carefully and repeat the same".

Sl. No	Sentence Types
1.	The dog is chasing the cat
2.	Walking is a good exercise
3.	The hens are pecking the grains
4.	The lady is carrying fruits in her baskets
5.	Computers are useful to us in many ways
6.	Eskimo live in the house made up of ice blocks
7.	The birthday house was decorated with balloons
8.	Boys wanted to play football, but it was hot outside
9.	The girl who is watering the plants is Ramu's sister
10.	The exam was in four days, and the students were studying hard

Scoring: 1point for correct repetition

Task 6: Sentence comprehension

Instruction: "Now I will present you with some statements ranging from simple to complex, listen to it carefully and answer to the questions asked related to the statement".

Sl. No	Statement and probe question
1.	The Kangaroo is found in Australia. Q: Is kangaroo found in Australia?
2.	Lion was caught in hunters net Q: Who was caught in the net?
3.	Pigeons which sat on the tree flew away. Q: Where were the pigeons sitting?

4. The dog was carrying a large bone in his mouth.
   Q: What was dog carrying in its mouth?
5. Greeks originally started the Olympic games.
   Q: Who started the Olympic games?
6. When the ladder slipped, man fell and broke his arm.
   Q: How did the man break his arm?
7. People appreciated the boy for his love towards nature.
   Q: Why was the boy appreciated?
8. Crane has long beak, it could not have the soup served.
   Q: Why the crane could not have the soup?
9. Throw the rubbish in a proper litter boxes.
   Q: Why should you throw the rubbish in the litter boxes?
10. Bravery Awards are distributed on Nov 14th by Prime Minister of India.
    Q: Why are the bravery Awards given?

Scoring: 1 point for the correct answer.

Task 7: Answering according to the direction

Instruction: "Now I will present you with a series of blocks, each containing sentences varying from 2 to 4. Listen to the entire block carefully and repeat the last word of the each sentence of a given block".

Presentation starts from two sentences block, present two sentences at a time and ask the subject to recollect the last two words of that set if two words are correctly repeated then give a score of 1, similarly for three sentence set and four sentences set.

Two sentences block	Bun is small round **cake** The dog ate the **candy** Kids love to play in the **park** Little rabbits can really run **fast** Children in the park are **swinging** The little cat climbed the tall **tree** The crow that sat on the tree was **tired** The elephant that was caught was **old** The ant that went to the river bank was **thirsty** Mother cut herself with a knife which was **sharp**
Three sentences block	The man who won the race was **fast** The poor John who ran away was **scared** The lion in the hunters net was **sleeping** The boy that the crab bit was **crying** The car that crashed the shop was **black** The marble that the girl held was **small** The kangaroo which was attacked was **timid** The man was tired after a rigorous **exercise** The girl who won the Nobel prize was **dancing** The lady that the boy hugged was very **old** The snake that scared the people was **poisonous** The boy who was watching the TV was **furious**
Four sentences block	The thief who was caught by the police was **scary** Most of the kids know how to use the **computer** The deer that the lion caught was **struggling** The principal congratulated the boy for his **bravery**

Scoring: 1 point for correct recollection of the sentence final words in the given set.

APPENDIX II

Familiarity rating scale used for teachers

Highly familiar= 4; familiar= 3; Unfamiliar= 2; Highly unfamiliar=1

Sl. No	Words	Highly familiar	Familiar	Unfamiliar	Highly unfamiliar
1.	Read				
2.	Cycle				
3.	Carrot				
4.	Clucked				
5.	Whacked				
6.	Mocking				
7.	Captain				
8.	Timid				
9.	Demon				
10.	Picture				
11.	Ancient				
12.	Innocent				
13.	Pavement				
14.	Nuisance				
15.	Dictionary				
16.	Motorbike				
17.	Garden				
18.	Wandering				
19.	Homophones				
20.	Slumbering				
21.	Photograph				
22.	Audience				
23.	Education				
24.	Traditional				
25.	Musician				
26.	Reflection				
27.	Delicious				
28.	Gratitude				
29.	Disinfectant				
30.	Similarity				

APPENDIX III

Content validity checklist for SLP's

Sl. No	Words	Highly Complex	Moderately Complex	Adequate	Very simple
1.	Read				
2.	Cycle				
3.	Carrot				
4.	Clucked				
5.	Whacked				
6.	Mocking				
7.	Captain				
8.	Timid				
9.	Demon				
10.	Picture				
11.	Ancient				
12.	Innocent				
13.	Pavement				
14.	Nuisance				
15.	Dictionary				
16.	Motorbike				
17.	Garden				
18.	Wandering				
19.	Homophones				
20.	Slumbering				
21.	Photograph				
22.	Audience				
23.	Education				
24.	Traditional				
25.	Musician				
26.	Reflection				
27.	Delicious				
28.	Gratitude				
29.	Disinfectant				
30.	Similarity				

Overall rating regarding the **arrangement** of the stimuli in the domain

Poor (1)	Fair (2)	Good (3)	Excellent (4)

APPENDIX IV

WORD AND SENETNCE LEVEL WOKING MEMORY TEST

Score sheet

Child's Name: Age/Sex:

Class: School:

Socio- Economic Status:

Speech and language skills:

Articulation Abilities:

Intelligence:

Domain	Score obtained
Non word repetition	
Digit backward	
Letter Retrieval	
Word backspell	
Sentence repetition	
Sentence comprehension	
Answering According to directions	

Total Score: ------- out of 70

APPENDIX V

MEAN AND STANDARD DEVIATION SCORES FOR ALL THE TASKS ACROSS GRADES

Tasks	Grade II		Grade III		Grade IV	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**
1. Non word repetition	9.95	0.21	9.93	0.25	10.00	0.00
2. Digit backward	5.83	1.37	7.55	1.77	8.91	0.93
3. Letter retrieval	5.85	1.82	7.56	1.45	9.03	1.08
4. Word backspell	5.53	1.71	7.61	1.69	8.93	1.03
5. Sentence repetition	5.35	1.48	7.33	1.72	8.69	1.07
6. Sentence comprehension	5.45	1.50	7.80	1.10	8.74	0.99
7. Answering according to the direction	5.70	1.69	7.55	1.12	8.52	0.91