WORKING MEMORY ASSESSMENT IN INDIVIDUALS WITH AND WITHOUT APHASIA USING DISTINCT [SEM-BACK] LINGUISTIC PROCESSING ABILITY

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(Speech-Language Pathology)

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May, 2019

CERTIFICATE

This is to certify that this dissertation entitled **“Working Memory assessment in individuals with and without aphasia using distinct [Sem-back] linguistic processing ability”** is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech-Language Pathology) of the student Registration No: 17SLP008. This has been carried out under the guidance of a faculty of this institute and has not been submitted earlier to any other university for the award of any diploma or degree.

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CERTIFICATE

This is to certify that this dissertation entitled **“Working Memory assessment in individuals with and without aphasia using distinct [Sem-back] linguistic processing ability”** has been prepared under my supervision and guidance. It is also certified that this dissertation 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 **"Working Memory assessment in individuals with and without aphasia using distinct [Sem-back] linguistic processing ability"** is the result of my own study under the guidance of Dr. Hema. N, Assistant Professor of Speech Sciences, Department of Speech-Language Sciences, All India Institute of Speech and Hearing, Mysuru and has not been submitted in any other University for the award of any Diploma or Degree.

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….."Our Education should make others better than our life better"…..

……"Knowledge is education and education is knowledge"……

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ABSTRACT

One cognitive system believed to be involved in impaired language processing in aphasics is working memory. The N-back task assesses memory component and the ability to process the memorized component simultaneously. There are usual N-back tasks for digits, lexical categories and syntactic aspects of sentence used as a stimulus to measure a person's working memory capacity. The aim of the current study was to assess working memory capacity and its effect on linguistic processing ability in adults with aphasia using Sem-back task programmed with E Prime 2.0 software. A total of 20 age-matched participants were involved in the study with Group A and Group B consisting of 10 individuals with aphasia (IWA) and neuro-typical (NTI) respectively. The Sem-back task is a replicate of the N-back task using three semantic categories like "fruits", "vehicles" and "body parts" as linguistic markers and the pictures of the same were used as test stimuli. It was observed in this study that, the mean reaction time taken to execute Sem-back tasks by IWA was greater compared to NTI. Hence in the present study, we could state that with reference to the IWA the variables like the impaired language processing ability, poor working memory and training on sentence repetition, sentence comprehension as well as attentional control could have contributed in exhibiting enhanced or comparable performance on Sem-back task as that of the group B individuals.

Keywords: *Working memory, N-back, Sem-back, E Prime 2.0*

CHAPTER 1

INTRODUCTION

Aphasia is generally defined as the loss or impairment of language caused by brain damage (Benson & Ardila, 1996). Cerebrovascular accident (CVA) or stroke is one of the most prevalent causes of aphasia (center of Disease control, 1999). When blood flow to an area of brain is interrupted by blockage of a blood vessel or artery (ischemic) or by rupturing of artery (hemorrhagic) then stroke occurs. There are several types of aphasia it includes Broca's aphasia, Wernnicke's aphasia, Conduction aphasia, Amnesic aphasia, Transcortical aphasia, etc. Aphasia can affect the receptive and expressive language and communication skills. Additionally, it affects an individual's reading, writing and gestures. An individual with aphasia often exhibits impairment in word retrieval, syntax, auditory attention span, linguistic processing and memory (Caspari et al., 1998). Consequently, aphasia affects the ability to understand and or expressive language and the severity varies across individuals.

Apart from the language comprehension and expression, the importance of memory to our daily activities cannot be overstated. Memories define who we are and functions of memory allow remembering or retrieving what we know and to learn new information. Memory deficit can result from stroke, head trauma, tumors, anoxia, infections, and from excessive use of alcohol or vitamin B1 deficiency (Osiezagha et al, 2013). Cognitive process includes retrieval, linguistic processing, maintaining, and interpreting information or representations are necessary to comprehend and functionally use language (Martin & Reilly, 2012). One cognitive system accepted to be involved in language processing in aphasia is working memory (WM). Frequent activity of the right prefrontal cortex is seen during WM task (Awh & Jonides, 1998; de Focker, 2001). For the executive processing, linguistic aspects and attention the working memory capacity is conceptualized as a resource pool (Just & Carpenter, 1992). The term used by a psychologist is called Working memory and it is defined as the "ability we have to hold and manipulate information in the mind over short period of time." In the course of our everyday life, the jotting pad or the mental workspace is provided to store information (Susan. et al., 2008).

Working memory involves the temporary storage and manipulation of information that is assumed to be necessary for a wide range of complex cognitive activities. In 1974, Baddeley and Hitch proposed that it could be divided into three subsystems, one concerned with verbal and acoustic information, the phonological loop, second is the visuospatial sketchpad providing its visual equivalent, while both are dependent upon a third attentionally limited control system, the central executive. A fourth subsystem, the episodic buffer, has recently been proposed. These are described in turn, with particular reference to implications for both the normal processing of language, and its potential disorders.

A major division of memory is based on the time duration for information is retained. Short-term memory (STM) or working memory (WM) refers to the retention of information over brief interval of time. By contrast long term memory (LTM) involves the acquisition and retention of information over longer periods of time. Short term memory can be further divided into verbal memory and non-verbal memory. Verbal memory tends to refer to performance on measures of new learning of material that is symbolic, meaningful and conductive to semantic mediation (Mc- Callum, 2003). It may involve processing of material in the auditory sensory modality although it is clear that material that is visually presented may be verbally mediated. Non-verbal memory tends to include learning of material that has been variously described as visual, visual-spatial, perceptual, figural, unfamiliar, difficult to verbalized and difficult to encode verbally (Moye, 1997).

Impairment of both working memory and long-term memory has been observed in patients with aphasia (Chapy, 2001). There is some proof to suggest that there is a relation between aphasic patients working memory and language abilities (Caspari, Parkinson, La-Pointe & Katz, 1998). According to Galdman-Rakic (1995) working memory tend to be very active, flexible, dynamic and predictive of real-life outcome than long term memory. Working memory or short-term memory has been implicated as an important aspect of higher order intellectual functions of language, perception and logical reasoning (Baddeley & Hitch, 1974).

WM capacity has also been related to several cognitive tasks, such as language processing, math skills, learning abilities and verbal reasoning skills, (Conway et al., 2005) in the last 40 years. There are no any other specific cognitive abilities that are not found to be greatly related to the performance of the Short-Term Memory (STM) tasks (Conway & Engle, 1996; Daneman & Carpenter, 1980; Engle, Tuholski, et al., 1999; Turner & Engle, 1989). From this viewpoint, STM may be differing from WM. In typical cognitive functioning, these processes generate with other abilities such as rehearsal, executive functions, and attention to maintain the words activation in short term memory (less than 20 seconds) (Martin & Reilly, 2012).

1.1. WM in Aphasia

In individuals with aphasia (IWA), it is noted that in conjunction with deficits in language processes there is impaired memory systems in the literature (Burgio & Basso, 1997; Erickson, Goldinger, & LaPointe, 1996; Martin & Saffran, 1997). Further, there is also established consensus to their impairment of language processing is the contribution of that Woking Memory deficit in individual with aphasia (Laures-Gore, Marshall, & Verner, 2010; Martin, 2008; Sung et al., 2009; Wright, Downey, Gravier, Love, & Shapiro, 2007; Wright & Shisler, 2005).

Researchers have suggested that conceptualized within different WM frameworks, IWA their WM capacity is poor and the control process of attention also impaired as well as inhibitory mechanism is affected (Caspari et al., 1998; Hula & McNeil, 2008; Murray, 1999). Across studies the authors investigated in IWA and their WM ability in various measures to determine (1) WM ability quantitatively, (2) The relationship between language performance in terms of comprehension ability and WM, and (3) Working memory component which is impaired.

The robust association between working memory and language processing is validated by the results of brain imaging studies with normal subjects. A 186 functional imaging experiments of meta- analysis of employing many WM tasks, showed consisted activation in an extended bilateral fronto-parietal circuit ("core WM network"). The thalamus, the left basal ganglia, the posterior superior frontal gyrus, the medial presupplementary motor area, the anterior insula and the posterior inferior frontal gyrus (BA 44/45) were associated with performance of verbal task and for the non-verbal task the associated sites were left SMA and bilateral dorsal pre-motor cortex. The lateral prefrontal cortical areas have a critical role in WM functions (Petrides, 2005).

Mutually, the above findings suggest that manipulating information in working memory (i.e. control processing) and monitoring that lateral prefrontal cortex plays a key role, while posterior cortical areas short-terms storage of memory traces per se takes place storage (Petrides, 2005). Regardless of methodological differentiation, there is an evident proof regarding the role of anterior cingulated, lateral prefrontal, and parietal cortical areas for WM. Thus, these areas contribute significantly to the performance of both verbal and non-verbal tasks (Chein, Moore, & Conway, 2011; Owen et al., 1998).

Apart from neuro-imaging studies, in the several studies related to neuro-behavioural aspects, the authors have been using Span tasks to examine their WM abilities in IWP (Downey et al., 2004; Laures-Gore et al., 2010). The span tasks usually consist of digits in serial recall or the words also presented either in the reverse order (i.e., backward span) or forward order (i.e., forward span) (Rönnberg et al., 1996; Ween et al., 1996). The back ward span tasks performance is poor in person with and without aphasia when compared to forward spans (Downey et al., 2004; Laures-Gore et al., 2010; Wechsler, 2003) which assume because of the additional WM requirements. The storage and maintenance are required to complete the forward span tasks; whereas the sequence of storage of information, maintenance of the stored information, and mental manipulation of the stored and maintained information is required to complete the backward span tasks (Baddeley, 2007; Wilde, Strauss, & Tulsky, 2004). During this span task, the phonological loop is expected to be active, as the processes of attention-control belonging to the central executive system should be able to maintain the activation of the information.

Apart from the span task, the n-back task is employed on IWA to examine the relationship between auditory comprehension measures and the performance of WM (Wright, Tempe, Ryan, Downey, Michelle, Lewis, & Diego, 2007). Nine IWA were considered to complete three n-back tasks each tapping different types of linguistic information like phonology, semantics and syntax. To check the syntactic sentence comprehension the Subject relative, Object-relative, Active, Passive Test of Syntactic Complexity (SOAP) (Love & Oster, 2002) was used. The Phono-Backstimuli consist of 25 words, with CVC combination in each five frames with five endings. The Sem-Backstimuli from five different semantic categories consist of five words; furniture, animals, tools, clothing, and fruits. The stimulus was controlled for frequency of occurrence and length across categories. The Syn-Backstimuli consist of sentences with five words either passive ("The banker was kissed by the doctor") or active ("The doctor kissed the banker") sentence structures. The considered verbs and nouns were ten in number; these were controlled with reference to frequency of occurrence and length and role (object/subject). The performance of participants' in n-back task was reduced, from 1-back to 2-back as there was increase in the level of difficulty. Further, the performance of participants was better on the phonological and semantic n-back task when compare to the syntactic n-back task. Finally, the result shows significant correlation between participants' performances on the SOAP non- canonical sentences and syntactic 2-back task.

Based on the study report of Wright et al. (2007) it is terminated that WM ability for distinct types of linguistic information can be measured and the result aid the growing literature that indicate distinct WM system for several type of linguistic information (Caplan & Waters, 1999a). Thus, the within WM task requires a number of key processes such as manipulation, on-line monitoring and updating of remembered information is supposed to place great demands. Among many studies altered type of stimuli have been used via various input modalities (olfactory and visual including spatial & auditory) since the processing system make different demands. Callicott et al, (1999) has reported that some authors have questioned the validity of results of such studies. Therefore, here is an attempt to replicate some studies on WM using stimulus in Kannada language on individuals with aphasia.

Evidence obtained from the study of patients with left brain lesions as well as normal individuals provide the notion that the right hemisphere is generally and predominantly involved in visuospatial processing. A consistent review of non-verbal task performance (including visual span) concluded that in most of studies, PWA present poor performance on all non-verbal tasks, when compared to normal individuals and left stroke patients without aphasia (Fonseca et al., 2016). A direct comparison of left stroke patients with and without aphasia showed that significant deficits on verbal and non-verbal STM/WM tasks displayed only PWA (Kasselimis et al., 2013). However, left-hemisphere lesion location deficits were not predicted (anterior vs. posterior). The association between left fronto-parietal network and backward spatial span is found to be present according to Paulraj, Schendel, Curran, Dronkers, and Baldo (2018).

Cautiously accumulating confirmation of non-verbal STM/WM deficits in aphasia (Fucetola, Connor, Strube, & Corbetta, 2009; Fucetola et al., 2006; Kasselimis et al., 2013; Laures-Gore et al., 2011; Martin & Ayala, 2004; Potagas et al., 2011) remains difficult to find. Many hypotheses have been tested, such as the notion that performance of non-verbal tasks based on the degree to which the patient can understand and follow verbal instructions (Fonseca et al., 2016). Some patients use verbal strategies to perform visuospatial tasks (Martin & Ayala, 2004) and the left hemisphere networks is responsible for successive stimulus processing and storing (Baldo & Dronkers, 2006). These hypotheses have not been formally tested with neuropsychological or neuro-behavioural methods of assessing working memory in individuals with aphasia. Hence the present study was planned to assess the working memory capacity using linguistic based Sem-back stimuli with the semantic category like fruits, vehicles and body parts in individuals with Aphasia.

CHAPTER II

REVIEW OF LITERATURE

Cognition refers to all the mental process by which information is transformed, reduced, elaborated, stored, recovered and used (Neisser, 1997). The relation between aspects of language and cognition status of individual with aphasia is not well established although there is some evidence that integrity of non-linguistic skills of attention, memory, executive function and visuo-spatial skills cannot be predicted on the basis of aphasia severity (Helm-Estrabrooks, 2002). Aphasia is an acquired communication disorder caused by brain damage characterized by an impairment of language modalities: listening, speaking, reading and writing, it is not the result of sensory deficit, a general intellectual deficit or a psychiatric disorder (Brookshire, 1992, Goodglass, 1993). Out of all the cognitive processes involved in normal language functioning, memory is one of the most essential aspects. Memory can be defined as stored representation and process of encoding, consolidation and retrieval through which knowledge is acquired and manipulated (Bayles & Tomoeda, 1997). Memory impairment associated with aphasia has been predominantly characterized as a reduction of immediate serial recall or span memory (Gordon, 1983).

Reading span task is used as a measurement of WM capacity to study the relationship between reading comprehension and WM capacity in aphasia (Caspril & Parkinson, 1988). The modified version of Reading span task (Deneman & Carpenter's, 1980) is also used to obtain a measurement of WM capacity. Length of one to six words sets of sentences were presented to 22 aphasic patients. There were two types of tasks the listening and reading span task, where they found strong positive correlation between the reading comprehension, WM and language functions. These results support the view point of WM capacities predicting the ability of language comprehension in individual with aphasia.

It is reported that there is individuals' difference present for reading comprehension reflecting the working memory capacity especially the trend between storage and processing any information. The task was to read aloud the series of sentences and recall the final word from the sentences read. This task differs from regular digit span task but do not correlate with the comprehension (Patricia & Carpenter, 1980). The study uses sentence comprehension and discusses the verbal working memory system (Caplan & Waters, 1999). They summarize a storage and computational system which is required for syntactic processing in sentence comprehension along with the conscious controlled processing of the same using working memory system for any verbal task. Experimental results from these patients with different brain damage and normal subject conclude that there is a specialized WM system used for sentence comprehension. Thus, they concluded that the division of verbal WM system is present at neural basis.

Sentence comprehension in Hebrew speaking aphasic participants in relation to the WM capacity was assessed by Friedmann and Gviona (2002). The participants were three conduction aphasia and agrammatic aphasia. The result shows agrammatic aphasic failed in comprehension of object relatives but not on subject relatives irrespective of their antecedent- gap distance. Conduction aphasia participants showed severe limitation in WM. All type of relative clauses was comprehended and the antecedent-gap distance was unaffected. Phonological reactivation was important for sentence comprehension and this was found to be affected in conduction aphasia. Thus, it is suggested that it is necessary to determine the effect of WM limitation on sentence comprehension required as crucial point for the types of sentences and type of memory overload.

It is found that the n-back task is the appropriate task to assess the WM ability and this contribute for the language processing abilities. Downey, Gravier, Love and Shapiro (2007) suggest that WM deficit is present in adult with aphasia that may contribute to their language processing difficulties. They suggest carrying out the similar study using n-back task with manipulating stimulus type to appropriately tape linguistic specific WM ability. Hence the present study is planned to use lexical category as stimulus for existing n-back task on individuals with aphasia.

Spatial and verbal n-back task, the spatial span and forward digit task and flanker arrows task have also been used. Flanker arrows task and forward digit and spatial span task were used to study working memory deficits in persons with aphasia compared with neurologically healthy adults (Stephanie, Christensena, Wright & Ratiua, 2018). The aim was to prove the language processing difficulty in persons with aphasia is due to the deficit in WM. The IWA performed poor on verbal task when compared to control group but there was no significant difference on the spatial tasks. And IWA illustrated significantly exceptional dispute and interference effects on the Flanker arrows task than control subjects. Although the primary evident in the verbal domain in IWA is WM deficits, they are not alone the result of domain specific verbal deficit. The ability to inhibit irrelevant information may contribute to WM deficits in PWA.

Therefore, the relationship between conceptualization and working memory also need to be studied in aphasia (Wright & Fergadiotis, 2012). It is known from the previous studies that in PWA their language processing is impaired due to working memory deficit. Many research reports suggested that there is deficit in WM, lack of attention control processes as well as poor inhibitory mechanism, consistently poor performance for IWA when compare to neurologically intact participants. Impairment of language processing in IWA due to deficit in WM capacity and also poor performance of complex span measure may be due to demand in comprehension and verbal production.

The validity and feasibility of using novel task related to the assessment of WM in individuals with and without aphasia is also studied (Maria, Ivanona & Hallowell, 2014). They studied working memory assessment for using new modified listening span task in individual with aphasia and without aphasia. In this study they had considered total 60 subjects (with aphasia-27 and without aphasia-33) and had to perform on the novel WM task. The result showed significantly poorer performance in all conditions of the WM task in person with aphasia when compared to persons without aphasia. Further, several patterns of responses were observed in these groups. Thus, the results support validity and feasibility of using novel task to assess WM in individual with and without aphasia.

The major purpose of all these various variety of n-back task is to assess the general retrieval processing ability in any individuals. This was first developed by Kirchner (1958). To measure WM, n-back task was used in various studies. On the peripheral, the utilization of the n-back task shows up perfect for measuring WM. It requires subject's involvement where the subject needs to decide whether every stimulus in an order matches with the n-item that appears before (n is a pre-specified integer, usually 1, 2, or 3). Thus, it needs temporary storage and manipulation of information while at the same period repeatedly updating the contents in WM. The nature of cognitive processes and its activation at the time of n-back task is unclear to date which was documented by many authors. Many such factors have been reported which involves the performance during an n-back task (Jonides et al., 1997; Oberauer, 2005). Firstly, elements (e.g., words or letters) have to be encoded and interpreted. Then elements (number) to be remembered, which is same as the value of n in the task, have to be retained and remain available for intentional processing. Individual's performance directly related to capability to suppress irrelevant activation of elements. (in this case, elements further back than n items). At least, there is some mechanism that allows representations to be bound in a temporal context, which is majorly responsible for successful performance. That is, elements have to be freed for each new item that is been presented and using the necessary items the temporal order has to be re-established. It is believed that n-back has strong face validity because of its simple and classy structure which is similar respects to the definition of WM which likely contributes to its wide use in cognitive neuroscience and neuroimaging studies. However, despite its strong face validity, it appears that the available data in the literature make a mixed case for n-back's construct validity. In various researches, authors have tried to figure out the gist of n-back by trying to place it in a nomological net of interconnected constructs (McDonald, 1999). Figure 1, represent the n-back task with the lexical category (images) as the stimulus of the task.

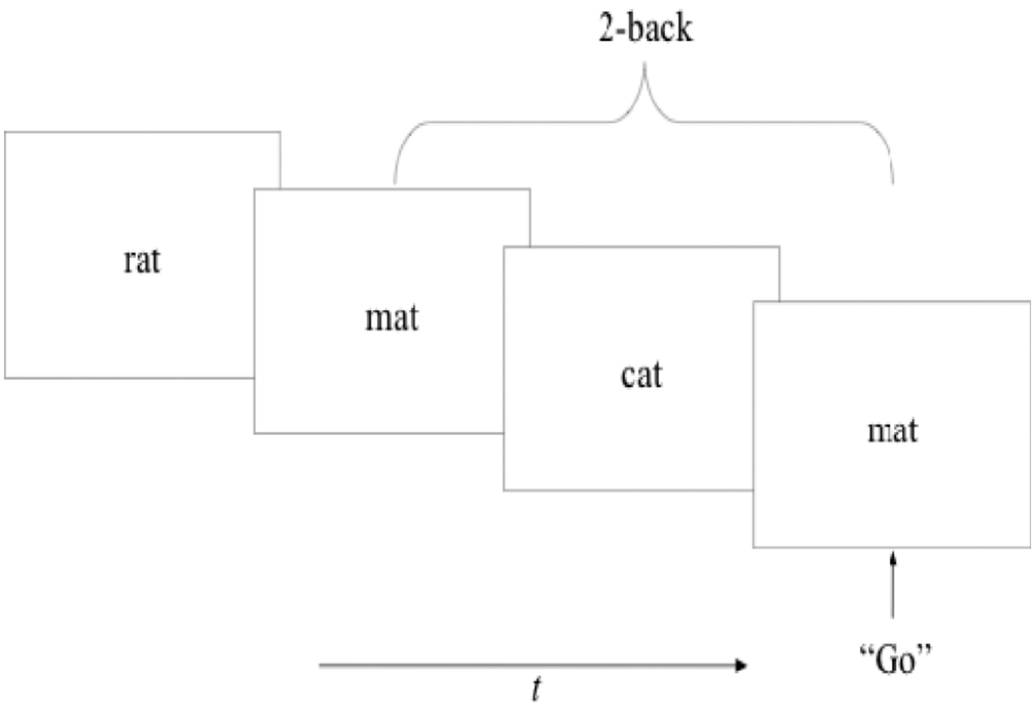

Figure 2.1: Schematic representation of a **2**-back. (McDonald, 1999).

A continuous stream of words will be presented to the participants and the initial items will appear one or two tokens prior and the task of the participants is to respond to any (target token n-back) token (e.g., rat . . . **mat** . . . cat . . . **mat** . . .) which indicate hit by pressing the spacebar on a keyboard. Signal detection theory is generally used to determine their performance. Here is an attempt to mimic such an n-back task on individuals with aphasia.

2.1. Need for the study

Based on the literature it is clear that working memory is essential for the comprehension and expression of language function. Any difficulty in the working memory ability will also lead to language impairment. It is stated that individuals with aphasia will have reduced working memory capacity which could be one of the contributing factors to the deficits in their language ability. Friedman and Gvion (2003) has stated that there is no task which was specifically designed to check the working memory difficulties in individuals with aphasia, performance on the existing working memory task attributed to other problems like difficulty in performing task requiring two responses (e.g. comprehension and recall) or requiring a verbal response, rather assessing the individual deficit in working memory. It is very important to study the relationship between the (1). Aphasia condition, (2). Phonological working memory deficit and (3) Struggle in comprehending sentences that require phonological reactivation in individuals with aphasia.

Therefore, to rule out such relationship of cognitive-linguistic impairment, it is important to perform test which assess working memory abilities in association with their linguistic ability. The Sem-back task can be used to measure the working memory capacity of individuals with aphasia. There are studies conducted using fMRI to determine the verbal working memory abilities (Martin, Wu, Freedman, Jackson, & Lesch, 2003). They have stated that the procedure would take several minutes to administer and can be performed only by a well-trained professional. In addition, the motor movements during scanning cause artefacts that may mimic the activation seen from neural activity (Birn, Bandettini, Cox, Jesmanowicz, & Shaker, 1998).

Thus, the neuro-imaging procedure has its own advantages over the neuro-behavioural approaches. However, to avoid such discrepancies in the cognitive–linguistic assessments of individuals with aphasia, behavioural tests can be administered which is comparatively systematic and easy to carry out by a speech-language pathologist. Hence the present study is planned to assess the working memory capacity of individuals with aphasia using Sem-back task as a preliminary approach.

CHAPTER III

METHOD

3.1 Aim of the study

The aim of the present study was to assess working memory capacity and its effect on linguistic processing ability of adults with and without aphasia using Sem-back task.

3.2 Objectives of the study

1. To examine the working memory capacity in individuals with aphasia and age matched neuro-typical adults in the Sem-back task programme using E-Prime software.

2. To study the effect of working memory abilities in processing distinct linguistic information (semantic) in the Sem-back task programme using E-Prime software.

3.3 Hypothesis

3.3.1 Null Hypotheses

- There is no significant difference in the working memory capacity of individuals with aphasia and age matched neuro-typical adults in the semback task.

- There is no significant effect of working memory abilities in processing distinct linguistic information (semantics) in the semback task programmed using E-Prime software for aphasia group and neuro-typical group.

3.4 Research Design

The present study was a standard group comparison with two groups- clinical group (individual with aphasia) and control group (typically developing individuals).

3.5 Participants

Ten individuals with aphasia who had suffered left middle cerebral artery ischemic strokes were recruited for the study. These individuals in the age range of 30-60 as participant constituted the clinical group. This clinical group was again sub-grouped as Group A and Group B for the purpose of counter balancing of the task. Time post-stroke was varied between 6 and 12 months with pre-morbid right-handedness. The Western Aphasia Battery (WAB; Kertesz, 1982) was administered to determine participants' aphasia type and severity by an experienced, certified Speech-Language Pathologist. WAB Aphasia Quotients (AQ) ranged from 30 to 80 which diagnose the individuals as having anomic aphasia and Broca's aphasia. Auditory comprehension sub-scores had ranged from 5 to 10. And/or because this was an exploratory study, we had not controlled for type and severity of aphasia or site of lesion. These participants were selected for the present study because they could perform the task, and were available and willing to participate in this study. They all were native speaker of Kannada language and knowledge of other language was noted. Individuals with aphasia had reported no prior history of neurological disorders, significant psychiatric history, or substance abuse. Participants had undergone cognitive screening using MOCA. All the participants had sufficient dexterity control to make responses using a computer keyboard or button-box. The demographic details of the participants are as follows (Table 3.1).

Table 3.1: Demographic details of the participants

Sl. No	**Patient Name**	**Age/ Gender**	**Provisional Diagnosis**	**Languages known**	**Education**
1.	P1	73/F	Anomic Aphasia(AA1)	Kannada	PUC
2.	P2	33/M	Transcortical motor Aphasia(TA2)	Kannada	PUC
3.	P3	66/M	Anomic Aphasia(AA3)	Kannada	Undergraduate
4.	P4	55/M	Global to Broca's Aphasia(BA4)	Kannada	Secondary education
5.	P5	42/F	Anomic Aphasia(AA5)	Kannada	Post graduate
6.	P6	51/M	Broca's Aphasia(BA6)	Kannada	PUC
7.	P7	46/F	Anomic Aphasia(AA7)	Kannada, English	Postgraduate
8.	P8	55/F	Anomic Aphasia(AA8)	Kannada	Secondary education
9.	P9	24/M	Anomic Aphasia(AA9)	Kannada, English	Undergraduate
10.	P10	68/M	Anomic Aphasia(AA10)	Kannada, English	Postgraduate

Ten neuro-typical normal controls were considered as participants and matched to the clinical group based on age, gender, and education forming control group. These ten participants also were sub grouped as in the case of clinical group. All participants had demonstrated hearing and visual acuity to normal limit on screening (after correction, if needed). This had to be sufficient for task completion which was screened again during trail phase of the task. Each participant had to sign the informed consent of AIISH ethical committee. The participants had responded using the space bar on a standard US keyboard, which was marked with blue tape for easy identification. Participants' accuracy and response time for each item was recorded by the E-Prime software, and later imported to Microsoft Excel and SPSS spreadsheets for data analysis.

3.6 Procedure

To perform N back task the individual had to store the 'n' number of information in his working memory and updating the content of working memory by dropping the unnecessary information and adding the new information. At phonological, semantic, syntactic aspects of language and the category called shape to assess the working memory at executive function level, this task was used to measure working memory (Wright et al, 2007). With reference to study of Wright et al (2007), Sem-back task was created which replicated the N-Back using lexical items as the stimuli. The lexical items include body parts, fruits, and vehicles, each lexical item consist of five stimuli for 1- back, 2- back task, 3-back and 4-back. For the present study the stimulus was from 1-back to 4 back tasks and stimulus for 1-back and 2–back task is only shown as an example in Table 3.2.

Table 3.2: Sem-back stimulus for 1-back and 2-back task of three lexical category (Type - I)

Lexical Items (Non-Randomised)	**1 – Back**	**2 – Back**
I. Body parts	1. Eyes, leg, **hand** – **hand** **2.** Leg, hand, **ear** – **ear** **3.** Hand, ear, **nose**– **nose** 4. Ear, leg, **eyes** – **eyes** 5. nose, ear**, leg – leg**	1. Eyes, leg, **ear,** nose – **ear** **2.** Leg, ear, **leg**, eyes – **leg** 3. leg, nose, **eyes**, hand – **eyes** **4.** nose, eyes, **hand**, ear – **hand** 5. hand, ear, **nose**, eyes – **nose**
II. Fruits	1. Apple, mango, **banana** – **banana** **2.** mango, banana, **pineapple** – **pineapple** 3. banana, pineapple, **grapes** - **grapes** **4.** Apple, banana, **mango** – **mango** 5. Pineapple, grapes, **apple** – **apple**	1. Apple, mango, **banana**, pineapple – **banana** 2. Mango, banana, **pineapple**, grapes – **pineapple** 3. Banana, pineapple, **grapes,** apple – **grapes** **4.** pineapple, grapes, **apple,** mango - **apple** 5. grapes, banana, **mango**, pineapple – **mango**

III. Vehicle	**1.** Car, auto**, lorry** – **lorry** **2.** Aeroplane, train**, car** – **car** 3. Train, car, **aeroplane** – **aeroplane** **4.** Auto, lorry**, train** – **train** 5. Car, aeroplane, **auto** – **auto**	1. Auto, car**, lorry**, aeroplane – lorry 2. Train, lorry, **aeroplane,** auto – **aeroplane** 3. Lorry, auto, **train**, car – **train** 4. Aeroplane, train, **car**, lorry – **car** 5. Car, aeroplane, **auto**, train – **auto**

3.6.1 Software for data collection:

The Sem-back task of working memory assessment, the test was programmed and ran using Psychology Software Tool's E-Prime software (version 2.0) on a Dell 4500 series desktop computer. In E-Prime, the module called E-Studio and E Data Aid was used to design stimulus with specific fixed stimulus duration with interstimulus duration and response time as shown in Figure 3.1 & 3.2.

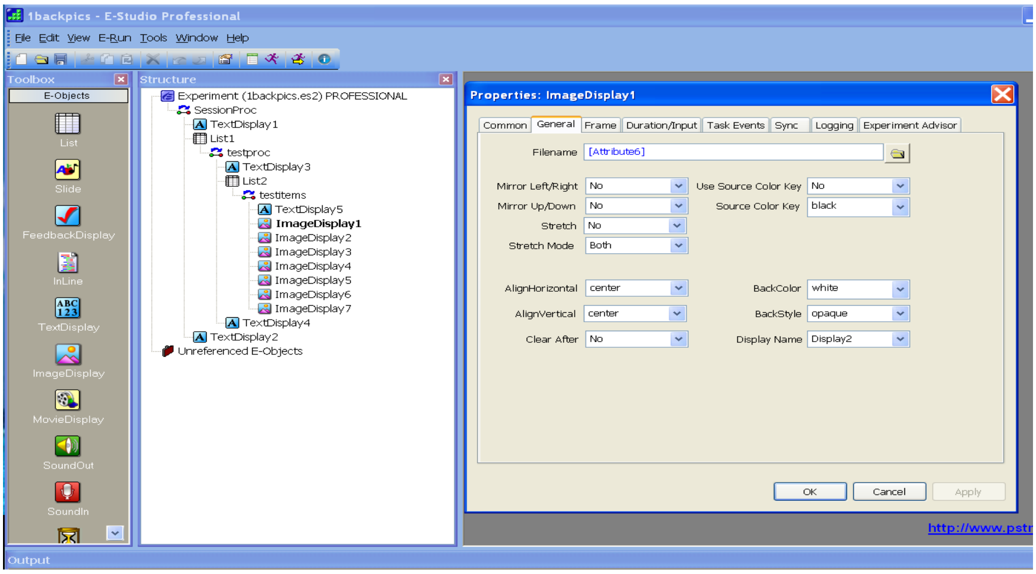

Figure 3.1: Module E-Studio for selection of the stimulus

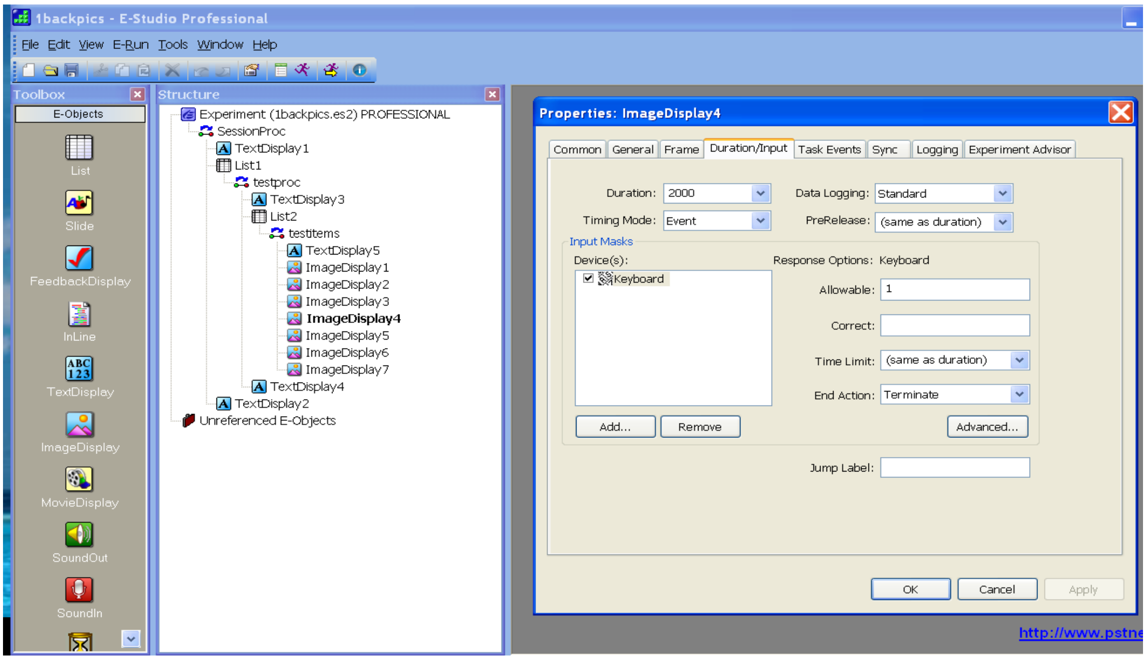

Figure 3.2: E-Studio stimulus presentation duration

Initially, the stimulus was prepared using Microsoft PowerPoint; Step I- each picture of the lexical category was pasted in each slide and followed by a blank slide. Step II- All these slides were converted to .jpg format and saved in the folder where the software was saved. Step III- The .jpg format slides were named according to the sequence which they appear for each n-back (1-back, 2-back, 3-back, and 4-back) and Step IV- The stimulus material was loaded into the software by typing the name of each file. Step V- The properties of each slide were selected like duration 5000m sec, appears in the center, standard display, response yes/no (only for '?' slide). Step VI- The response mode was selected whether to use a keyboard, mouse, etc. in this study we have used the keyboard as response mode. Step VII- The program file was saved in my documents. The stimulus module appears as an icon and was saved in the same folder. Step VIII- Administering the test, the module had to be opened and the 'run' key had to be selected. Step IX- Before beginning any task, recording the identity number of every participant had to be typed. Step X- The end of the test results was saved as a separate icon in the stimulus folder with the same identity number specified at the beginning of the test.

Thus, the visual stimuli were presented to the individuals via a flat-screen monitor. Participants were seated about 50 cm from the computer screen. The administration of the set of sem-back materials for Group A of the clinical and neuro-typical group begins with 1 practice items (Stimulus No. 1 of 1-back or 2-back tasks) (Table 3.2), followed by 12 experimental items (Stimulus No. 2-13 of 1-back and 4-back task) as mentioned in Table 3.3 called the test stimuli.

Table 3.3: Sem-back stimulus for n-back of three lexical categories

Semantic categories	Stimuli for N-back task
FRUITS:	Banana, apple, mango, **grapes** – grapes Jackfruit, pear, **guava**, orange – guava Pineapple, **pomegranate**, mango, apple – pomegranate **Orange,** pear, papaya, grapes – orange
VEHICLES:	Cycle, car, bike, **train** – train Bus, airplane, **lorry**, auto – lorry Train, **bus**, bike, cycle – bus **Auto,** airplane, cycle, bus – auto
BODY PARTS:	Nose, tongue, head, **stomach** – stomach Tongue, stomach, **head**, nose – head Lips, **mouth,** hand, leg – mouth **Eyes,** leg, tongue, ears – eyes

For individuals with aphasia and neuro-typical the stimulus was randomized and presented in two different ways: Type-1 stimulus, where all the five 1-back semantic category stimuli were presented one by one followed by five 2-back semantic category stimuli (Table 3.2). In Type 2 stimulus the semantic category stimuli were presented in randomized order, that is 1-back followed by 2-back. The randomized stimuli are the Type 2 stimulus as shown in Table 3.4 which could not be used for the present study.

Table 3.4: Sem-back stimulus for 1-back and 2-back task of three lexical categories (Type - II)

Lexical Items	**Randomised**
I. Body parts	1. Eyes, leg, **hand –** hand 2. Eyes, leg, **ear,** nose – ear 3. Leg, hand, **ear** – ear 4. hand, ear, **leg**, eyes – leg 5. hand, ear, **nose** - nose 6. nose, eyes, **hand**, ear – hand 7. Ear, leg, **eyes -** eyes 8. Leg, nose, **eyes,** hand – eyes 9. nose, ear**, leg –** leg 10. hand, ear, **nose**, eyes – nose
II. Fruits	1. Apple, mango, **banana** – banana 2. Apple, mango, **banana**, pineapple – banana 3. mango, banana, **pineapple** – pineapple 4. Mango, banana, **pineapple**, grapes – pineapple 5. banana, pineapple, **grapes** – grapes 6. Banana, pineapple, **grapes,** apple – grapes 7. Apple, banana, **mango** – mango 8. pineapple, grapes, **apple,** mango - apple 9. Pineapple, grapes, **apple** – apple 10. grapes, banana, **mango**, pineapple – mango

III. Vehicles	1. Car, auto**, lorry** – lorry 2. Auto, car**, lorry**, aeroplane – lorry 3. Aeroplane, train**, car** – car 4. Train, lorry, **aeroplane,** auto – aeroplane 5. Train, car, **aeroplane** – aeroplane 6. Lorry, auto, **train**, car – train 7. Auto, lorry**, train** – train 8. Aeroplane, train, **car**, lorry – car 9. Car, aeroplane, **auto** – auto 10. Car, aeroplane, **auto**, train – auto

For Sem-back matching task, items were presented centrally following a fixation cross for duration of 4000msec for each picture (lexical category) and the participants were asked to match for 1-back, 2-back, 3-back and 4-back. In the matching task of this 1-back to 4-back, participants were presented with a target picture in visual (for a limited duration of 4000msec each picture) forms. This was followed by 12 test stimuli counter balanced with reference to the participants or randomized according to 1-back to 4-back task and the picture type (Table 3.2. and Table 3.3). The training and the testing stimuli were presented centre of fixation to the computer screen. For example, initially the + sign was presented and the participants had to focus at the center of the scene and followed by sentence presentation. This was mainly done to make the participants more vigilant and prepare for the actual task. For example, the picture 'Eyes', 'leg', '**hand**', stomach **(test stimuli) – 'hand' (target stimuli) (an example of 2-back task)**. Thus, the stimulus were followed by a series of 5 pictures of the lexical items with the stimulus interval duration of 1000 msec (1^{st}, 2^{nd}, 3^{rd} and 4^{th} pictures were stimulus and 5^{th} one was the target): Participants had to indicate their response for match as 1-back or 2-back by means of a key press (Number Key -1) on a standard US keyboard, which was marked with blue tape for easy identification. Thus, the stimuli were counterbalanced and distributed equally across the participants (two sub-groups) and cross 12 set formed from three semantic category stimuli. For this task, stimuli remained on the screen for duration of 2000 msec until a response was given by the participants.

3.6.2 Scoring

RT and accuracy data were recorded in the E-Prime software itself for the correct and wrong trials of the E-Data module of E- Prime the same is depicted in Figure 3.3. Following this, later imported to Microsoft Excel and SPSS spreadsheets for data analysis. The responses of all the participants were taken as mean and individual scores to discuss further. The records of each member were then examined by hand to record the reaction times (RT) associated with correct and wrong responses so that the mean RT of one participant representing correct responses was considered for comparison amongst the other participants.

Note Pad file N-Back Task (1-Back task)
Reaction Time: 520 msec Accuracy 1

Figure 3.3: E-Data module of E- Prime depicting the RT and accuracy

CHAPTER IV

RESULTS

4.2. Section B: Assessment of Working Memory task

The performance of individuals with aphasia and neuro-typical individuals are explained under two aspects like reaction time and level/threshold/accuracy for the working memory test. Results of the present study for working memory tasks at the semantic category of linguistic skills in terms of fruits, vehicles and body parts are discussed under following headings.

4.2.1. Working memory task: Sem-back

4.2.1.1 Mean & Standard Deviation for Sem-back task of individuals with Aphasia (IWA) and neuro-typical individuals (NTI). In this working memory tasks, participants were given two trials for each Sem-back to account for accurate response. These correct performances of test items were only considered for the statistical analysis. Following the administration of the 1-back, 2-back, 3-back and 4-back tasks, mean value for each of these Sem-back was obtained by taking an average of two trials. Subsequent to this average of all the levels were taken to calculate the total mean value for Sem-back.

The mean and standard deviation of Sem-back tasks (1-back, 2-back, 3-back and 4-back) with reference to the reaction time in terms of millisecond at the semantic category of fruits, vehicles and body parts for individuals with Aphasia (IWA) and neuro-typical individuals (NTI) using descriptive statistics and the results are shown in Table 4.1. From the table, it is observed that the mean reaction time (in terms of milliseconds) or the time taken to execute Sem-back tasks by IWA was greater compared to NTI.

Table 4.1: Results of descriptive statistics for Sem-back task of individuals with Aphasia (IWA) and neuro-typical individuals (NTI).

Working memory tasks		**GROUPS**			
Sem- Back tasks		**Individuals with Aphasia**		**Neuro-typical Adults**	
	N	**Mean**	**SD**	**Mean**	**SD**
Sem F4	10	2222	666.28	1714	534.60
Sem F3	10	2084	696.80	1618	434.17
Sem F2	10	2047	1039.62	1976	965.32
Sem F1	10	2369	1071.22	1770	474.29
Sem V4	10	1950	589.76	1377	270.29
Sem V3	10	1864	655.82	1393	335.26
Sem V2	10	1898	511.63	1522	336.71
Sem V1	10	1782	488.70	1477	476.74
Sem B4	10	1700	517.26	1311	221.38
Sem B3	10	1876	868.70	1260	442.01
Sem B2	10	2026	1007.78	1343	598.03
Sem B1	10	1908	817.68	1505	156.24

(Fruit-F, Vehicles-V and Body Parts-B)

The Figure 4.1 represents the pictographic representation of the mean score or the reaction time to execute n-back task at the semantic category of linguistic skills in terms of fruits, vehicles and body parts of working memory tests, the neuro-typical individuals performed better for the semantic category body parts, vehicles and fruits. Individuals with aphasia performed better with less reaction time for the semantic category vehicles, body parts and fruits. However, the reaction time taken by the individuals with aphasia group for the three semantic categories was higher compared to the neuro-typical individuals.

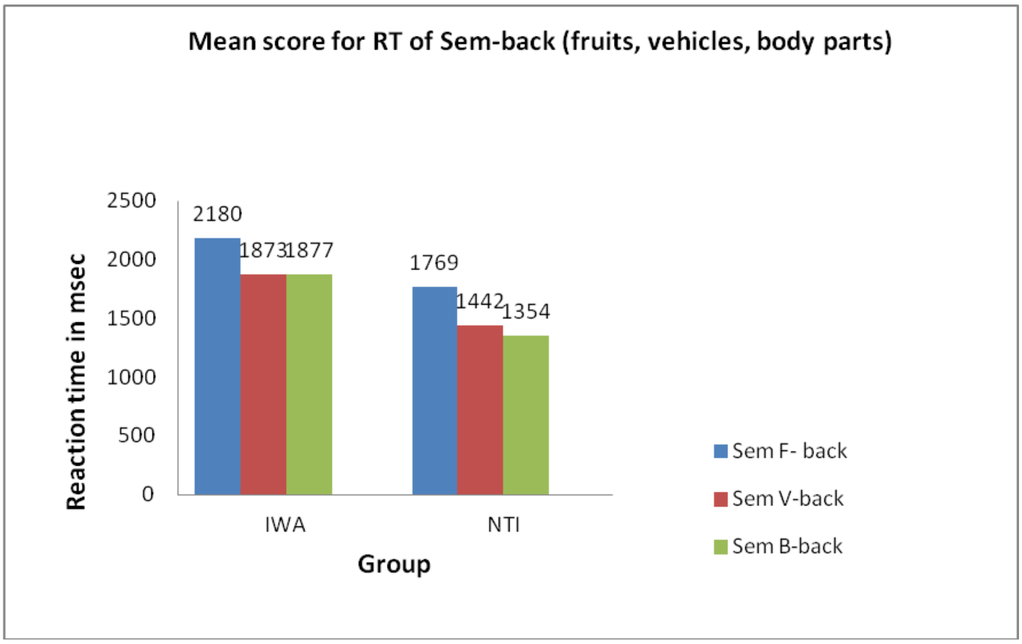

Figure 4.1. Mean scores for reaction time for Sem-back Reaction Time (Semantic categories-fruits, vehicles and body parts) of individual with Aphasia (IWA) and Neuro-typical adults (NTA).

4.2.1.2 Frequency distribution of level/threshold/accuracy of Sem-back working memory test was compared with IWA & NTA. Working memory test included was the Sem-back task. Sem-back for example is represented as 0-back, 1-back, 2-back, 3-back, 4-back for the semantic categories like fruits, vehicles and body parts. In the present study, the Sem-back task corresponded with the accuracy and reaction time of individuals' (Aphasia and neuro-typical) response to working memory capacity starting with 0-back till the n^{th} back of individual capacity (only till 4 back task is considered in the present study). Thus, in the present section, the performance of the two groups (IWA & NTA) on Sem-back task is depicted graphically to show the accuracy of working memory capacity. From the Figure 4.2, in the IWA group 5 participants (AA1, BA4, AA5, AA7, AA9 performed accurately till the 4-back levels of Sem-back task of semantic categories 'fruits', 'vehicles' and 'body parts'. The participant AA3 performed accurately till the 4-back level for the semantic category 'fruit' and 'body part' but for the semantic category 'vehicle' the participant could perform till 3-back. The participant AA8 performed accurately till 4-back level for the semantic category 'fruits' and for 'vehicle' and 'body part' till 3-back. The participant AA10 performed accurately till 3-back for the semantic category 'fruits', 'vehicle' and 'body parts'. The participant BA6 performed accurately till 2-back for the semantic category 'fruits' and 'body parts' and for 'vehicle' the level was 1-back.

Among the total 10 IWA, only five could perform till 4-back and the rest of them had scarred response for all the semantic categories. With reference to semantic category, for 'fruits' 7 IWA had accuracy till 4-back level, for 'vehicles' 5 IWA had accuracy till 4-back level and for 'body parts' 6 IWA had accuracy till 4-back. **Therefore, the semantic category "fruit" was the easiest Sem-back task to perform compared to the "body parts" and "vehicles" Sem-back task.** The same is pictographically represented in the following Figure 4.2.

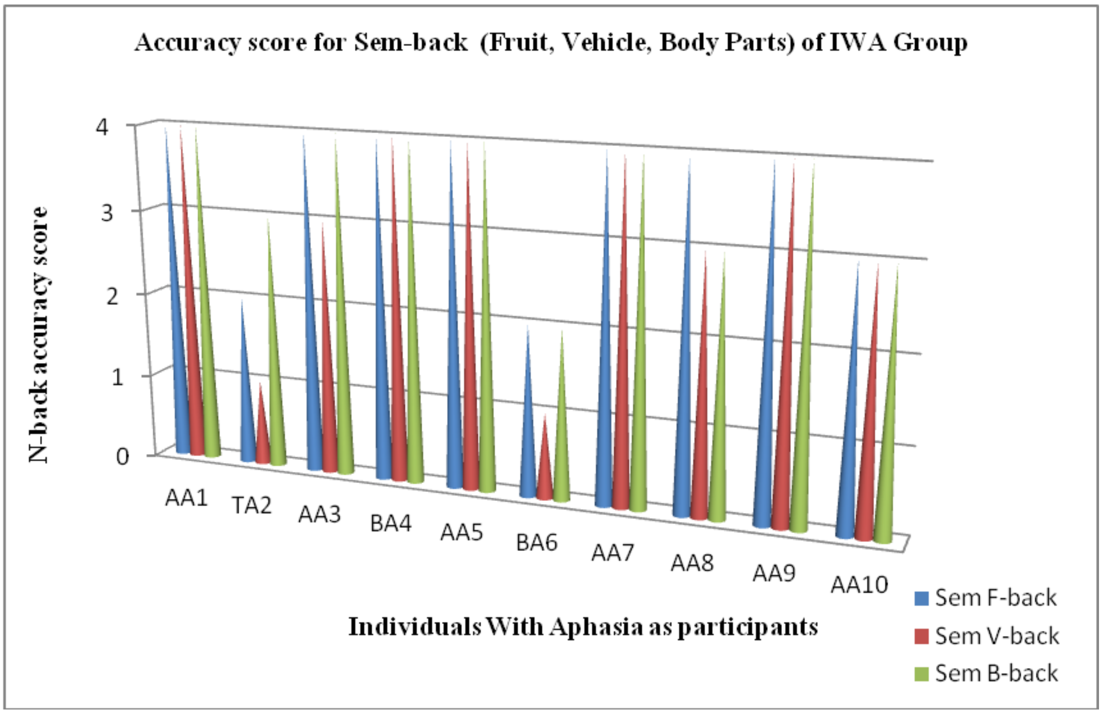

Figure 4.2. Difference in level/accuracy/threshold of working memory of IWA.

With reference to in the NTA group 7 participants (N1, N2, N4, N6, N7, N8 & N10) performed accurately till the 4-back levels of Sem-back task of semantic categories 'fruits', 'vehicles' and 'body parts'. The participant N3 performed accurately till the 4-back level for the semantic category 'fruit' and 'body part' but for the semantic category 'vehicle' the participant could perform till 3-back. The participant N5 performed accurately till 4-back level for the semantic category 'vehicle' and for 'fruits' and 'body part' till 3-back and 2-back respectively. The participant N9 performed accurately till 4-back for the semantic category 'vehicle' and 'body parts' and for the semantic category 'fruit' till 3-back.

To summarize, among the total 10 NTA, only seven could perform till 4-back and the rest of them had scarred response for all the semantic categories. With reference to semantic category, for 'fruits' 8 NTA had accuracy till 4-back level, for ‘vehicles’ 9 NTA had accuracy till 4-back level and for ‘body parts’ 9 NTA had accuracy till 4-back. **Therefore, the semantic category “fruit” had slight poorer performance on Sem-back task compared to the “vehicles” and “body parts” Sem-back task. Whereas, participants with aphasia showed good performance for the semantic category “Fruit” compared to “body parts” and “vehicle”.** The same is pictographically represented in the following Figure 4.3.

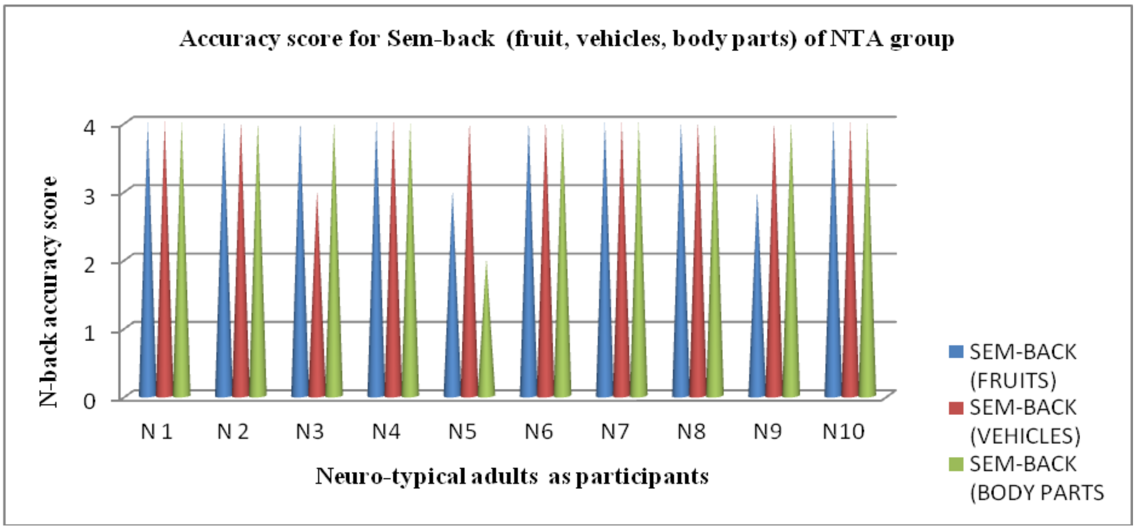

Figure 4.3. Difference in level/accuracy/threshold of working memory of NTI.

4.2.1.3 Between-group comparison for Sem-back task of individuals with Aphasia (IWA) and neuro-typical individuals (NTI). Mann-Whitney U test was administered to examine the difference in Sem-back task for the semantic categories (fruits, vehicles and body parts) of the linguistic skills of working memory tests between the individuals with aphasia group and group with neurotypical individuals. There was a significant difference between the groups for the working memory capacity of only Sem V4-back task of semantic aspects of linguistic skill of working memory task as shown in Table 4.2.

Table 4.2: Results of Mann-Whitney Test for the Sem-back task (Semantic categories-fruits, vehicles and body parts)

Working Memory Test Sem- Back tasks	**/Z/ value**	**p value**
SemF4RT	1.878	0.060
SemF3RT	1.663	0.096
SemF2RT	0.000	1.000
SemF1RT	0.907	0.364
SemV4RT	**2.419**	**0.016***
SemV3RT	1.796	0.072
SemV2RT	1.470	0.142
SemV1RT	1.512	0.131
SemB4RT	1.796	0.072
SemB3RT	1.739	0.082
SemB2RT	1.663	0.096
SemB1RT	0.680	0.496

(Fruits-F, Vehicles-V, Body Parts- BP) *p value<0.05

4.2.1.4 Within-group comparison for Sem-back task (Semantic categories-fruits, vehicles and body parts) of individuals with Aphasia (IWA) and neuro-typical individuals (NTI). Friedman’s test was administered to examine the difference between Sem-back tasks of semantic categories fruits, vehicles and body parts by considering the reaction time measurement in individuals with aphasia (IWA) group and neuro-typical individuals (NTI) group. The performances of the IWA and NTI group on the Sem-back tasks of semantic categories fruits, vehicles and body parts are represented in Table

4.3. Statistically there is significant difference among the semantic categories fruits, vehicles and body parts reaction time of Sem-back tasks in IWA group and NTI group.

Table 4.3: Results of Friedman's test for sem-back tasks of semantic categories fruits, vehicles and body parts reaction time in IWA and NTI group.

Groups	Parameters	Chi square value	p value
IWA	Sem-back tasks of semantic categories fruits, vehicles and body parts reaction time	21.51	0.028*
NTI	Sem-back tasks of semantic categories fruits, vehicles and body parts reaction time	23.67	0.014*

*P value <0.05

CHAPTER V

DISCUSSION

The study aimed to measure working memory in individuals with aphasia and neuro-typical adults and to identify whether a relationship existed between working memory ability and linguistic processing ability (Semantics) in individuals with aphasia. It is believed that the linguistic processing difficulty in the individual with aphasia is due to the underlying working memory deficit. Hence, the present study was done to substantiate these findings in individuals with aphasia using working memory task at the semantic (categories like fruits, vehicle and body parts) markers of linguistic skills (Sem-back). Working memory tasks were employed to find the presence of cognitive impairment and to explore whether there is any possible relationship between impaired linguistic skills (aphasia symptoms) and working memory. The results of the working memory assessment are discussed under the following sections.

5.4. Working memory task

5.4.1 Between-group comparison (Individuals with Aphasia and Neuro-typical Adults):

5.4.1.1 Working memory and Language processing difficulties in IWA. In this present study, an attempt has been made to determine if working memory tasks can differentiate people with aphasia and neuro-typical individuals. To explain in detail about the performance of aphasia participants in the WM task, it was observed that aphasia participants had a pronounced difficulty in performing a working memory task. The **reaction time taken to**

execute semantic markers of linguistic skills (Sem-back task for fruits, vehicle and body parts) **of a working memory test was higher for IWA group compared to the NTA group (Appendix B & C)**. There was a significant difference between the IWA and NTA groups at working memory test of the semantic category "vehicles" at the level 4-back and there was no significant difference seen for the other semantic categories like "Fruits" and "Body Parts". The sample size for the clinical and control group was restricted to ten in number and for the purpose of a comprehensive discussion of the results a **level/**accuracy for the Sem-back task of working memory test is considered in the following sections.

To summarize, it was observed that with reference to **individuals with aphasia(IWA)** only five could perform till 4-back and the rest of them had scarred response for all the semantic categories. With reference to semantic category, for 'fruits' seven IWA had accuracy till 4-back level, for 'vehicles' five IWA had accuracy till 4-back level and for 'body parts' six IWA had accuracy till 4-back. **Therefore, the semantic category "fruit" was the easiest Sem-back task to perform compared to the "body parts" and "vehicles" Sem-back task.** Among the **neuro-typical adults (NTA)**, only seven could perform till 4-back and the rest of them had scarred response for all the semantic categories. With reference to semantic category, for 'fruits' 8 NTA had accuracy till 4-back level, for 'vehicles' 9 NTA had accuracy till 4-back level and for 'body parts' 9 NTA had accuracy till 4-back. **Therefore, the semantic category "fruit" had slight poorer performance on Sem-back task compared to the "vehicles" and "body parts" Sem-back task in NTA**

group. Whereas, participants with aphasia showed good performance for the semantic category "fruit" compared to "body parts" and "vehicle".

Therefore, the threshold of Sem-back for semantic category "Fruit", "Vehicle" and "Body Part" was 4-back for majority of NTA participants (8-9), whereas for fifty percentage of population with IWA (5) had a threshold of 4-back. Therefore, the NTA were better than IWA on all the semantic categories of Sem-back task. The contributing reasons for the present results can be discussed as follows.

The first contributing reason could be the **association between the verbal WM and linguistic processing ability of IWA.** There are a studies which have assessed the association between the different types of verbal WM and STM deficits and Specific language functions like lexical processing, sentence comprehension, repetition and reading, use of complex-span and n-back tasks (Laures-Gore, Marshall, & Verner, 2011; Martin & Ayala, 2004; Salis, Kelly, & Code, 2015) in IWA. The other studies reports on visuospatial and verbal deficits, the etiology, frequency and lesion correlates of modality-independent and modality dependent as a contributing factor for the STM/WM impairment.

Aphasia language impairment is also caused by poor short-term memory and working memory according to Portagas et al (2011). The author has found a significant correlation between the measures of language impairment/aphasia score and the spatial and verbal forward-backward memory task, working memory task and short term memory task. The author reports a possible primary deficit to be information retention rather than impairment in working memory.

Apart from the participants with aphasia acting as a contributing factor in showing some difference between IWA group and NTI, the n-back task would have also contributed to the differences. For example, in a study by Zakaria, Keresztes, Marton, Wartenburgerv (2018), where they trained individuals with working memory tasks and checked to see if their language abilities improved with training. In the working memory treatment, N-back tasks were considered wherein one visual stimulus i.e. alphabets were displayed along with verbal stimulus, in the other task verbal-visual stimuli along with the distracters had been presented. The training was given to the persons and in the results, they have found improvement in one back task and not for two back tasks. Therefore, there could be **some effect of speech-language training (semantic/phonological or syntactic aspects of language) the aphasia patient undergoes during their course of intervention** also act as a contributing factor for the present results.

Wright et al. 2007 reported that sem-back task was consistently easiest than syn-back task. The reaction time was showed a supra-additive effect for several tasks as the difficulty level changed. The reaction time was consistently demonstrated longer for older subjects than the younger subjects, but they showed no difference in criterion or sensitivity. The surprising loss in difference between Phono- and Shape-Back could indicate that regardless of modality the sensory information processed similarly, in contradiction to Baddeley's model of a phonological loop and a separate visuo-spatial scratchpad. This theory is supported or disputed by data from PWA – if aphasic participants do not show significant deficit in *shape*-back, but significant deficit in *phono*-back, Baddeley's theory would be restored. The result of the present study is in support with the hypothesis of equal performance by IWA on different sensory information. However, within one single sensory information, **there is an observable difference as seen in the present study where the semantic category "fruit" is easy to perform for IWA whereas difficult for NTA.**

However the aphasic patients showed a significant deficit in both *shape*-back and *phono*-Back equally, a united theory of WM would be further indicated Wright et al.(2007). The overall data give a strong baseline for comparison of the performance between aphasic participants. It is also observed that the results of neuro typical individual adults were consistent across the semantic category whereas it is scattered for individuals with aphasia.

The study by Gonçalves and Mansur, (2009), reported no difference in years of schooling or depressive symptom scores in their participants in the age range of 30-45 years and 60-74 years. There was no effect on intra-group stimulus. Individuals from both the G1 and G2 groups processed di and tri-syllables similarly. There was no significant difference between G1 and G2 groups on any N-Back parameters: total score, span, number of intrusions, for either di or tri-syllable presentations. There was no age effect was found on this task. But, in the present study there is heterogeneity with reference to age of the individuals with aphasia(IWA) verses neruo-typical(NTI) considered for the study. This could have contributed for difference in their performances on Sem-back task

The poorer performance of IWA on the working memory tasks is not only a result of their language impairment but the **additional cognitive deficits that may be independent of language** (Christensen et al. (2010)) would contribute for poorer performance. Across the three n-back task stimuli, both normal and aphasic groups performed significantly worse on the 2-back compared to the 1-back tasks. These results are consistent with previous findings indicating that processing load is increased as the number of stimuli to be recalled increases (Jonides et al., 1997; Wright et al., 2007). Hence, in the present study, **the processing load might be different for different semantic categories which have contributed to show different thresholds. The individuals** with aphasia could not easily encode the semantically loaded Sem-back stimuli because the semantic and or phonological access could be inadequate.

The other contributing reason for any working memory task is the inter stimulus interval. This inter-stimulus interval required to processing and storing and repeating the information is very poor in IWA compared to NTA as observed in the present study. In addition, the impaired attention control processing as well as impaired inhibitory mechanisms would have contributed for the difference seen between IWA and NTA group (Caspari et al., 1998; Hula & McNeil, 2008; Murray, 1999).

CHAPTER VI

SUMMARY AND CONCLUSION

The present study aimed to investigate the working memory capacity of adults with aphasia in comparison with neuro-typical individuals using distinct linguistic processing abilities (SEMANTICS). The objectives of the study were as follows:

1. To examine the working memory capacity in individuals with aphasia and age-matched neuro-typical adults in the Sem-back task programme using E-Prime software.

2. To study the effect of working memory abilities in processing distinct linguistic information (Semantic) in the Sem-back task programme using E-Prime software.

Twenty participants were included in the study, Group A consisting of 10 individuals with aphasia and Group B consisting of 10 neurotypical individuals who were age-matched with the Group A individuals. These aphasics were between the age ranges of 30-60 years with the auditory comprehension scores from 5-10. All the participants were native Kannada speakers who as well know how to read and write. All of them had undergone a screening test using MOCA and were checked for adequate dexterity control which would be necessary for performing the task. It was made sure that all the individuals had hearing and visual acuity within the normal limits.

Psychology Software Tool's E-Prime software (version 2.0) was used to perform the test. The Sem-back task is a replicate of the N back task using three semantic categories (fruits, vehicles and body parts) linguistic markers with 12 set of stimuli. These stimuli were presented to the participants on a flat screen monitor and they were seated 50 cm from the screen. The task begins with two practice trials and then followed by the main stimulus. For sem-back matching task, items were presented centrally following a fixation cross for the duration of 4000 msec for each sentence and the participants were asked to match for 1-back and 2-back. Participants had to indicate their response for a match as 1-back or 2-back or 3-back or 4-back by means of a key press (Number Key -1) on a standard US keyboard, for easy identification the key was marked with blue tape. RT and accuracy data were recorded in the E-Prime software. The performance was scored based on the accuracy and the reaction time of the individuals with aphasia and the neurotypical adults.

The mean value of the Sem-back task was obtained by taking an average of two trials and later all of the levels were taken to calculate the total mean value of Sem back. Descriptive statistics mean and standard deviation of Sem-back tasks (1-back, 2-back, 3-back, and 4-back) with reference to the reaction time in terms of millisecond at three semantic categories (fruits, vehicles and body parts) markers of linguistic skills were obtained for individuals with Aphasia and neuro-typical individuals. It was observed that the mean reaction time (in terms of milliseconds) or the time taken to execute Sem-back tasks by IWA was greater compared to NTI.

To study the significant differences between NTA and IWA with reference to this working memory capacity of Sem-back task the Mann-

Whitney U test was administered. There was a significant difference between the groups for the working memory capacity of the only 4-back task of semantic (category "vehicle") linguistic aspects of working memory task. Friedman's test was administered to examine the difference between Sem-back tasks of semantic categories fruits, vehicles and body parts by considering the reaction time measurement in individuals with aphasia (IWA) group and neuro-typical individuals (NTI) group. There was significant difference found among the semantic categories for both the groups.

Therefore, the semantic category "fruit" had slight poorer performance on Sem-back task compared to the "vehicles" and "body parts" Sem-back task in NTA group. Whereas, participants with aphasia showed good performance for the semantic category "fruit" compared to "body parts" and "vehicle". Therefore, the threshold of Sem-back for semantic category "Fruit", "Vehicle" and "Body Part" was 4-back for ninety-eight of NTA participants (eight to nine), whereas for fifty percentage of population with IWA (five) had a threshold of 4-back. Therefore, the NTA were better than IWA on all the semantic categories of Sem-back task. The contributing reasons for the present results can be discussed as follows.

The contributing reasons could be the linguistic deficit associated with the condition called aphasia caused after stroke leading to language processing deficits. Aphasia language impairment is also caused by poor short-term memory and working memory according to Portagas et al (2011). The other contributing reason could be the **association between the verbal WM and linguistic processing ability of IWA.** The other studies report of visuospatial and verbal deficits, the etiology, frequency, and lesion correlates of modality-independent and modality dependent as a contributing factor for the STM/WM impairment. The **effect of speech-language training (semantic/phonological or syntactic aspects of language) the aphasia patient undergoes during their course of intervention** also act as a contributing factor for the present results.

The result of the present study is in support with the hypothesis of equal performance by IWA on different sensory information. However, within one single sensory information, **there was an observable difference as seen in the present study where the semantic category "fruit" is easy to perform for IWA whereas difficult for NTA.** It was also observed that the results of neuro typical individual adults were consistent across the semantic category whereas it is scattered for individuals with aphasia.

There was no age effect was found on the n-back task according to literature. But, in the present study there is heterogeneity with reference to age of the individuals with aphasia verses neruo-typical considered for the study. This could have contributed for difference in their performances on sem-back task. The poorer performance of IWA on the working memory tasks is not only a result of their language impairment but the **additional cognitive deficits that may be independent of language** (Christensen et al. (2010)) would contribute for poorer performance. **The processing load might be different for different semantic categories which have contributed to show different thresholds. The individuals** with aphasia could not easily encode the semantically loaded Sem-back stimuli because the semantic and or phonological access could be inadequate.

The other contributing reason for any working memory task is the inter stimulus interval. This inter-stimulus interval required to processing and storing and repeating the information is very poor in IWA compared to NTA (Caspari et al., 1998; Hula & McNeil, 2008; Murray, 1999) and also observed in the present study

Implications

Further, the same study can be carried out among individuals with aphasia, sub groups of aphasia with good reading and writing abilities in comparison with neurotypical adults. This would provide a further insight to the results and the possible reason behind the reduced performance in n-back task of individuals with aphasia showing evident linguistic processing deficits. The software based SEMANTIC task can be used as the treatment procedure to improve working memory abilities in individuals with aphasia and to the elderly population with reduced cognitive-communicative abilities.

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APPENDIX A

All India Institute of Speech and Hearing, Naimisham Campus, Manasagangothri, Mysore – 570006.

CONSENT FORM

Dissertation on

Working memory assessment in individuals with and without aphasia using distinct (Semback) linguistic processing ability

Information to the participants

I, Ms. R. Deepa. M.Sc. (SLP) student of AIISH doing dissertation work titled- **"Working memory assessment in individuals with and without aphasia using distinct (Sem-back) linguistic processing ability."** under the guidance of Dr. Hema N., Assistant Professor, Dept. of Speech – Language Sciences, AIISH, Mysore – 6. The aim of the study is to investigate the working memory capacity of adults with aphasia in comparison with neuro-typical individuals using distinct linguistic processing abilities (SEMANTICS). I need to collect data from 20 individuals in the age range of 20-60 and above. The individual has to perform a task assessing their working memory using software. I assure you that this data and personal information of the participant will be kept confidential. There is no influence or pressure of any kind by us or the investigating institute to your participation and the research procedure is different from routine medical or therapeutic care activities. There is no risk involved to the participants but your cooperation in the study will go a long way in helping us in understanding discourse in individuals with Dementia and it will, thus assist in assessment and treatment of these individuals.

Informed Consent

I have been informed about the aims, objectives and the procedure of the study. I understand that I have a right to refuse participation as participant or withdraw my consent at any time.

I, ____, the undersigned, give my consent to be participant of this investigation/study/program.

Signature of participant/guardian Signature of investigator

(Name and Address)

Date

APPENDIX B

The accuracy and reaction time scores of SEMBACK task of an individual with Anomic aphasia (46 years/ Female)

TextDisplay7.RESP	TextDisplay7.RT
NULL	NULL
1	3062
1	4476
2	2589
	0
1	2789
2	1688
	0
2	2036
2	2409
1	1883
2	2605
1	2094

Fruits

Vehicles

Body Parts

APPENDIX C

The accuracy and reaction time scores of SEMBACK task of neuro-typical individuals

(32 years/ Female)

TextDisplay7.RESP	TextDisplay7.RT
NULL	NULL
1	1792
1	1518
1	1472
1	1572
1	1638
1	1602
1	1594
1	1648
1	1499
1	1584
1	1506
1	1429

Fruits

Vehicles

Body Parts