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

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CERTIFICATE

This is to certify that this dissertation entitled **"Working Memory assessment in individuals with and without aphasia using distinct [synback] linguistic processing ability"** is a bonafide work submitted in part fulfillment for the degree of Master of Science (Speech-Language Pathology) of the student Registration No: 17SLP017. 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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This is to certify that this dissertation entitled **"Working Memory assessment in individuals with and without aphasia using distinct [synback] 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 [synback] 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.

Mysuru

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Dedicated to ***DAD*** *and* ***MOM***

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ABSTRACT

To comprehend and functionally use language cognitive processes such as retrieval, processing, maintaining and interpreting information or representations are necessary. 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 of adults with aphasia using Syn-back task programmed using E Prime 2.0 software. Twenty participants were included in the study, Group A consisting of 10 individuals with aphasia and Group B consisting of 10 neuro-typical individuals who were age-matched with the Group A participants. The Syn-back task is a replicate of the N-back task using five PNG and five prepositions linguistic markers with 2-4 words sentences as the stimulus. It was observed that the mean reaction time or the time taken to execute Syn-back tasks by IWA was greater compared to NTI. The neuro-typical individuals and the individuals with aphasia performed better with less reaction time for the PNG-back compared to the prepositional-back task. Similarly, the threshold of individuals with aphasia for Syn-back PNG is 3-back and Syn-back PRE threshold could not be obtained. However, the reaction time taken by the individuals with aphasia group for Prepositional-back and PNG-back was higher compared to the neuro-typical individuals. In the present study, with reference to the IWA group, the variables like the impaired language processing ability, poor working memory and training on sentence repetition, sentence comprehension and attentional control could have contributed in showing enhanced or comparable performance on Syn-back task as that of the NTA group.

Keywords: Working memory, N-back, Synback, E Prime 2.0

CHAPTER 1

INTRODUCTION

The brain is one of the most fragile parts of our body so whether or not the patient has a diffuse or focal injury, it is still a very serious disease. The problem with these types of neurological insults is that people are still suffering from cognitive-communicative disorders because the assessment procedures and rehabilitation are not done to the extent they are supposed to be till they show complete recovery or being as minimal as they can be. The Brain Injury Association Board of Directors (in 1997) accepted a definition of acquired brain injury to expand beyond the present definition of brain injury which is produced by trauma. "An acquired brain injury (ABI) is an injury to the brain that has occurred after birth." Neurological insults are among one of the most common injury-related deaths and disabilities in the United States, which occurs in all ages, races, societies, and revenues.

The brain injuries are classified under two types: traumatic and non-traumatic neurological insults. Traumatic Neurological Insults includes traumatic brain injury (TBI). The other type is a Non-traumatic Neurological Insults is one that is not caused by trauma, but caused from poisoning, a tumor, infections (encephalitis or meningitis), cell toxicity, or degenerative disease. According to North Eastern Ontario (NEO) Brain Injury Network, types of non-traumatic injuries consist of Meningitis or Encephalitis, Hypoxic Injury, electrolyte imbalance, metabolic disorder, or vascular problems.

These diverse brain insults, including traumatic brain injury and right hemisphere damage, stroke leading to aphasia, infections, and tumors, neurodegenerative diseases causing Parkinson's diseases and dementia, and prolonged acute symptomatic seizures, such as complex febrile seizures or status epilepticus (SE) lead to a condition called cognitive communicative disorder. In the present research, the interest is towards the condition called aphasia caused due to stroke.

The condition called aphasia marks an impairment of language or loss caused due to damage to the different brain areas which activate the different neural activity as a result of any sensory input (Benson & Ardila, 1996). Thus, extract the relevant phonological, grammatical and lexical information from the incoming speech stream (Friederici 2002; Hickok & Poeppel 2007; Scott & Johnsrude 2003). Based on the damage to specific brain areas there are diverse types of aphasia which include Wernicke 'aphasia, Boca's aphasia, conduction aphasia, transcortical aphasia, amnesic aphasia, etc. These conditions can affect comprehension and expression as well as reading, writing, and gestures. Aphasics also show deficits in attention span, processing, memory, word retrieval and syntax (Caspari et al., 1998). Specific language characteristics of aphasia depend on extent as well as the location of the brain damage (Davis, 2007). The impairment of comprehension and expression varies across individuals.

To comprehend and functionally use language cognitive processes such as retrieval, processing, maintaining and interpreting information or representations are necessary. One cognitive system believed to be involved in impaired language processing in aphasics is working memory. In addition, the executive function and attention (to keep the words activated in short term memory) are also necessary for language processing, for example. Working memory is an executive function which involves holding information and working within the mind. Thus, various cognitive tasks like verbal reasoning skills, learning ability, maths, and language processing are related to working memory. (Baddeley, 2003; Conway & Engle, 1996; Conway et al., 2005; Cowan, 1999; Engle, Tuholski, Just & Carpenter, 1992).

According to Benson (1994) and Grodzinsky (1990) aphasia has been defined as language-based impairment. He also suggested that language processing impairment is due to the individuals working memory deficits. Individuals with aphasia have impaired attention control process, limited working memory capacity, as well as impaired inhibitory mechanisms (Adams & Dijksstra, 1966; Brown 1958; Peterson, 1959; Pillsbury & Sylvester, 1940). Each individual's working memory includes maintenance and processing components that act simultaneously while processing language. Therefore, different measures have been used to identify the association between and language performance and working memory. For example, 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. This task was developed by Kirchner (1958), which is a continuous performance task and helps in assessing a part of working memory and its capacity. Also as working memory requires storage and manipulation of information at the same time, in n-back tasks similar procedure is carried out. Therefore, to assess WM capacity in individuals with aphasia n-back task with different types of stimulus either linguistic or non-linguistic may be suitable and suitably used one.

Thus, working memory capacity has been hypothesized as only "resource" group for attentional, linguistic, and other executive processing. According to Just and Carpenter (1992), it is stated working memory activation mediates processing and storage. This activation varies among individuals, this individual variations lead to qualitative and quantitative differences in several aspects of language comprehension. Greater capacity helps in permitting communication among syntactic and pragmatic information and for multiple interpretations. Therefore there is an association between language processing and working memory at the language comprehension level.

According to Baddeley & Hitch (1974), working memory model was earlier referred to as a verbal model. "An articulatory loop" is the first component in the model. This is believed to be associated with sub-vocal rehearsal. But, later it was termed as "phonological loop" which emphasize on storing the information rather than rehearsal, which is considered as the second component. There is head among all these components known as "Central executive" (CE) which controls all the activities. The third component considered was Visuospatial sketchpad which constitutes visual, spatial or combination of both. In the original WM model, as there were limited capacities in phonological and visuospatial sketchpad subsystem, the model failed to explain the results of various experiments. Baddeley (2000) added a fourth component called "episodic buffer" which acts as backup storage and thus interacts with short-term memory, long-term memory, and working memory.

The subjective complaints of cognitive skills which are not captured by most aphasia batteries are recognized and appreciated by experienced speech-language pathologists. However, few kinds of research are required to characterize the difficulties they report. There are very fewer procedures which are clinically feasible in identifying the underlying impairments or objectively validating the complaints of individuals with aphasia. Majority of aphasia research typically focuses on more severe and easily identified aphasia presentations.

In contrast, evidence-based evaluative resources for different types of aphasia resulting from particular sites of damage affecting specific components of the language processing system as well as impacting working memory is limited (Gutbrod, Cohen, Maier, & Meier, 1987; Caramazza, 1988; Caspari, et al., 1998; Ardila, 2003; Baddeley, 2003; Friedmann & Gvion, 2003).

For example to certain clinicians with less experience, the treatment challenges for the identified clients with aphasia are likely to be present when the severity of aphasia is mild and limited evidence are available from which to derive treatment methods (Armstrong, Fox, & Wilkinson, 2013). Hence there is a need to improve identification of persisting language difficulties in individuals with brain injury by developing sensitive assessment tools related to working memory. Following this, the research directing towards treatment outcome measurement for various types of aphasia is also in need (Kemper, McDowd, Pohl, Herman & Jackson, 2006; Frankel, Penn, & Ormund Brown 2007). There are studies showing the persisting language difficulties to be considered as the reduced working memory capacity in individuals with aphasia on comparison with the neuro-typical individuals (Wright & Shishler 2005). Few studies have assessed working memory capacity in fluent versus non-fluent aphasia. For example, working memory (WM) assessments may be a practical means for identifying high-level aphasia.

Since a variety of aphasia researchers have assessed either specific verbal WM limitations affecting phonological or syntactical and semantic processing (Caplan & Waters, 1999; Friedmann & Gvion, 2003; Martin & Ayala, 2004) or the recall of strictly verbal information (Wright, Downey, Gravier, Love, & Shapiro, 2007; Sung et al., 2009). Therefore on observation, it is difficult to separate out and interpret any proposed WM deficits since there is an existing resultant link of language skills with WM capacity. Hence there is a need to conduct extended research on WM in adults with aphasia using the present technology or software.

CHAPTER II

REVIEW

Recent researches have indicated that in aphasia the language processing difficulties could be due to the working memory deficit. The association between sentence comprehension and working memory capacity in individuals with aphasia has been studied (Caspari, LaPointe, & Katz, Parkinson, 1998). Working memory capacity was assessed using reading span task in individuals with aphasia by Daneman and Carpenter (1980). They have found a strong correlation between reading comprehension, language function, and working memory capacity. These results support that language comprehension can be expectable in individuals with aphasia based on their working memory capacities.

With reference to language comprehension, the foremost research is done to assess the aphasic's capability to understand and remember single and successively presented discourse (Yasuda & Nakamura, 2000). This study considered 3 groups of individuals with aphasia, age-matched and younger subjects. In single news story aphasics performed poorly compared to the two normal groups in comprehending single news story. Added aphasics were separated into two groups centered on the results obtained in the single news story scores. High aphasics (who scored better in a single news story) did not statistically differ from normal subjects. They have also performed poor on sentence command stimuli in a language test. This explains that aphasics perform better in discourse compares to sentence stimuli. In serially presented news story high aphasic performance was significantly reduced. Therefore aphasics have impaired abilities in comprehending serially presented news stories and the author suggested that it could be due to the fading or the loss of attention during listening to the serially presented news. Whereas in age-matched subjects and high aphasics comprehension for the story heard in the last position was poor and it could be due to the predominance of primary over recency effect. In younger group participants comprehension was better for story heard in the last signifying age-related difference in pattern.

To explain further, in any working memory task different types of information is instantaneously stored and operated. Like the sentence, comprehension requires storage and computational system in the linguistic task of syntactic processing. Therefore a question arises if the same working memory is used for both syntactic processing and for the orally mediated task that includes conscious organized processing. Caplan and Waters (1999) have studied the same in persons with specific differences in working memory and syntactic processing, individuals with aphasia and in individuals with poor short term memory and working memory and concluded that a specialized verbal working memory is available for processing syntactic structure of a sentence and there is a separate working memory to determine the sentence meaning to complete the task.

In general, brain lesions are known to elicit reorganization of function in representational cortex. Using linguistic function as an example, they show that (a) Injury-related reorganization may also be observed in the language-related cortex and (b) This reorganization not only appears in cortical space but also in the dynamic flow of activity. Compared with controls, linguistic functions were organized in an atypical manner, both in terms of spatial structures involved and in the time course of the linguistic processes, from word reading too late stages of word encoding in working memory (Angrilli, Elbert, Cusumano, Stegagno, & Rockstroh, 2003). The study consisted of 10 non-fluent aphasics and age-matched controls had to perform the phonological and semantic task and ERPs were recorded for these 2- stimulus designs. The participants had to state whether the two words were rhymed (phonological task) and semantically associated (semantic task). In phonological activation over occipital sites in normal was observed, where activation at left medial orbitofrontal locations anterior to common site of lesion was observed in individuals with aphasia. In the word encoding, task controls had significant right-left asymmetry which was absent in individuals with aphasia. Maximum inhibition over the left region at the site of lesion was observed in individuals with aphasia and disinhibition of right frontal areas and greater activation of left temporal sites was seen in controls. These results propose that the concept of language plasticity should include spatial aspects of linguistic reorganization, the reorganized temporal dynamics related to the recovery of impaired functions.

Here is an attempt made to study the temporal dynamics using working memory tasks for example verbal short term memory contributing for semantic and phonological aspects of language (Martin, Wu, Freedman, Jackson, & Lesch, 2003). The authors studied if different brain regions would be activated during the delay period in a phonological vs. a semantic retention task using an event-related functional MRI. A recognition probe procedure was used in which memory load and task (i.e. rhyme judgment vs. synonym judgment) were manipulated. In the phonological than the semantic task left inferior parietal region overlapping the supramarginal gyrus was more activated. A large left inferior and mid-frontal region and another left parietal region showed a load effect that was common to the phonological and semantic tasks. No region showed significantly greater activation in the semantic than the phonological task, though there was a trend towards a more anterior localization of the frontal load effect in the semantic task compared to the phonological task.

As in the study to conduct the fMRI procedure, the delay may take up to several seconds and may add on to many disadvantages. The next limitation of functional MRI in the study of verbal short-term memory that is, having subjects recall the list in order using spoken or written recall. There is wide-ranging behavioral literature on memory span that uses such measures, and it would be valuable to make use of this literature in planning and inferring neuroimaging tasks. The major drawback of fMRI studies is the artifacts that may be caused during the motor movements while scanning mimics the activation seen from neural activity (Birn, Bandettini, Cox, Jesmanowicz, & Shaker, 1998).

Thus, there are studies which state that there is distinct working memory for diverse types of linguistic information (Caplan & Waters, 1999). The well knows the task to assess memory and language processing ability will be a then-back task. Verner, Laures-Gore, and Shisler (2011) reported that persons with aphasia perform poor on forward and backward digit span compared to right hemisphere brain damage people with no aphasia and both the groups have performed well in digit forward than in digit backward task.

Apart from digit span, for processing particular types of linguistic information Wright, Lewis, Gravier, Downey, Shapiro, and Love (2009) measured working memory capacity in individuals with aphasia and studied whether an association is present between auditory comprehension and working memory based on the participants' performance on working memory tasks. Participants with aphasia completed three n-back tasks which included the SemBack (semantic level), SynBack (syntactic level) and PhonoBack (phonological level). In each task, two levels of n-back were administered that is 1 and 2-back. For assessing the syntactic sentence comprehension task, the Subject-relative, Object relative, Active, Passive Test of Syntactic Complexity (SOAP) was administered to all participants. As n-back task effort increased participants performance was weakened. Compared to PhonoBack and SynBack tasks, participants performed better on the SemBack. Finally, participants who performed poorer on the SynBack also had a greater struggle in understanding syntactically complex sentence structures.

Therefore n-back task has its advantage of assessing the linguistic processing ability using various type of working memory assessment procedure. This n-back task was developed by Kirchner (1958), which is a continuous performance task and helps in assessing a part of working memory and its capacity. A study was conducted by Christensen and Wright (2010) using three n-back tasks on verbal and non-verbal working memory in persons with aphasia. The aim was to check the effects of altering linguistic processing load with reference to the situation for participants with and without aphasia. Aphasics did better in 1 back task than 2-back WM task and performed poorer compared to neuro-typical individuals. Results suggested that linguistic components had an effect on the performance of working memory task and it must be considered when discussing cognitive deficits in aphasia. From the above study, it is observed that the individuals with aphasia have deficits in the cognitive system (for example Working Memory) which will affect their language sources in them which are not noticed often and concentrate more on assessment and/or intervention of language components than the cognitive processes.

Therefore, working memory (WM) capacity of aphasics and the practicality, dependability and internal consistency of n-back task should be checked. A study was conducted by Mayer and Murray (2012) using n-back task with variable stimulus type, for example, non-nameable stimuli, high frequency, and low frequency and also with various working memory load (0, 1, 2-back test). Accuracy and reaction time (RT) was analyzed for these experimental tasks, standardized performance task and also calculated the effect size. Across the stimulus type, the Aphasia and aged-matched controls showed similar results. There was significantly greater WM accuracy for nameable versus non-nameable stimuli. Individuals with aphasia were more affected by growing WM load compared to the non-aphasics. Hence, the N-back task holds well in determining WM for adults with aphasia and can quantify to a clinical population.

Studies have been conducted to check differential cognitive impairment in persons with fluent and non-fluent aphasia. The participants considered were 19 fluent aphasics and 16 non-fluent aphasics along with 36 individuals without brain damage by Dragoy, Ivanova, Kuptsova, Laurinavichyute, and Ulicheva (2014). The participants were administered eye tracking working memory task which needed only eye movements to respond and not through gestures or verbal mode followed by two language comprehension tasks. The author concluded that the working memory was reduced in participants with aphasia compared to participants without brain damage. In persons with non-fluent aphasia, cognitive deficits lead to language impairment.

Working memory is assessed using both audition and vision in 60 participants consisting of male and female students in a study by Ferreira, Brites, Azoni and Ciasca (2015). These 60 students were divided into an experimental group consisting of 30 children with the diagnosis of attention deficit hyperactivity disorder (ADHD) and 30 children without any ADHD symptoms or learning difficulties constituting a control group. The task was the repetition of words, non-words and task spans in reverse and forward order for visual and auditory data, auditory and visual tests with tasks of free serial recall in reverse and direct order. The control group was better than the experimental group. Children with ADHD performed poorer in visual working memory tasks than auditory working memory tasks with respect to the auditory and the visual working memory tasks whereas the control group has performed better in visual working memory. Both the groups, specifically the experimental group presented phonologically and semantically analogous interference effects and temporal effects. The authors have concluded stating that the poor performance of the experimental group could be due to the phonological similarity which would have triggered them to make more errors due to the acoustic confusion and the greater mental exertion and poor attention (Ferreira, 2011). The poor performance of ADHD could be because of the tendency to use the neuronal pathway which is inefficient to perform data manipulation, executive functioning and working memory tasks Farrel, (2006). Less improvement was seen in children with ADHD due to their poor usage of semantic association strategies compared to the control group (Kofler, Rapport, Bolden, et al., 2010). Both the groups have performed poor in reverse order recall, whereas the experimental group had difficulty with serial recall too and this could be due to their need for their cognitive flexibility and attention control.

Working memory is also in relation to the academic achievement according to Kofler, Rapport, Bolden, et al., (2010). The test battery of 14 tasks was used to check for the phonological loop, the visual-spatial sketchpad and the central executive skills in children with normal and low intelligent quotient (IQ) and children with poor and good school performance. Children with lower school performance showed poor working memory skill compared to better school performing children, this was irrespective of their intelligence. Therefore, to determine the academic performance the assessment of working memory is very essential. Hence, in planning intervention for children with learning disabilities, working memory assessment has to be taken into consideration.

Overall, the present data support the claim that there are cognitive deficits in aphasia and that these cognitive deficits tend to exacerbate the language impairments of persons with non-fluent aphasia types. The findings of working memory assessment have important implications both for the assessment and the treatment of individuals with aphasia and for understanding the nature of aphasia and also the clinical significance in other clinical populations too. Hence there is a need to conduct such studies with customized stimulus preparation using the existing software.

Need for the study:

Based on the literature it is understood 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 persons with aphasia will have reduced working memory ability 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 persons with aphasia, performance on the existing working memory task attributed to other problems like difficulty in performing task requiring two tasks (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 (1). Aphasia condition, (2). Phonological working memory deficit and (3) Difficulty in understanding 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 assesses working memory abilities in association with their linguistic ability. The syn back task can be used to measure the working memory ability of persons with aphasia. There are studies conducted using fMRI to determine verbal working memory abilities (Freedman, Jackson, & Lesch, Martin, Wu, 2003). They have stated that the procedure would take several minutes to administer and can be performed only by a well trained professional. Artifacts may be present due to the motor movements during scanning that may imitate the activation seen from neural activity (Birn, Bandettini, Cox, Jesmanowicz, & Shaker, 1998). Thus, the neuro-imaging procedure has its own advantages over the neuro-behavioral approaches. However, to avoid such discrepancies in the cognitive–linguistic assessments of individuals with aphasia, behavioral tests can be administered which is comparatively systematic and easy to carry out by a speech-language pathologist. Henceforth the present study is planned to assess the working memory capacity of individuals with aphasia using Synback task as a preliminary approach.

CHAPTER III

METHOD

3.1 Aim of the study

The aim of the current study was to assess working memory capacity and its effect on linguistic processing ability of adults with aphasia using Synback 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 synback task programmed using E-Prime software.
2. To study the effect of working memory abilities in processing distinct linguistic information (syntax) in the synback task programmed using E-Prime software.

3.3 Hypothesis

3.3.1 Null Hypotheses

- There is no significant difference in the working memory ability of persons with aphasia and age-matched neuro-typical adults in the synback task.
- There is no significant effect of working memory capacities in processing distinct linguistic information (syntax) in the synback 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 groups (individual with aphasia) and control group (typically developing individuals).

3.5 Participants

Ten individuals with aphasia who had suffered left middle cerebral artery ischaemic strokes were recruited for the study. These individuals in the age range of 30-60 as participant constitute a clinical group. This clinical group was again sub-grouped as Group A and Group B for the purpose of counterbalancing of the task. Time post-stroke was varied between 6 to 12 months with pre-morbid right-handedness. The Western Aphasia Battery (WAB; Kertesz, 1982) was administered to decide 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 Broca's aphasia and anomic aphasia. Auditory comprehension sub-scores had to range from 5 to 10. And/or because this was an exploratory study, we could not control for type and severity of aphasia or site of the lesion. These participants were selected for the present study because they possibly could perform the task, and were available and willing to participate in this study. They all were a native speaker of Kannada language and knowledge of other language was also noted. Persons with aphasia had no account of any previous history of neurological disorders, major psychiatric history, or material abuse. Participants had to undergo cognitive screening using MOCA. All the members had adequate 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.	Dayanandh	59/M	Broca's Aphasia	Kannada, English	Undergraduate
2.	Shashank	23/ M	Anomic Aphasia	Kannada, English	Undergraduate
3.	Jagadhambika	65/ F	Anomic Aphasia	Kannada	Undergraduate
4.	Bhagya	43/M	Transcortical Motor Aphasia	Kannada	Secondary education
5.	Palaksha	33/M	Broca's Aphasia	Kannada	Undergraduate

6.	Sudarshan Nagabushan	66/ M	Anomic Aphasia	Kannada, English	Undergraduate
7.	Chandra Kumar	53.6/M	Broca's Aphasia	Kannada	Undergraduate
8.	Manjula	73/F	Broca's Aphasia	Kannada	Secondary education
9.	Vasanthalaxmi	46/F	Anomic Aphasia	Kannada, English	Undergraduate
10.	Veena	55/F	Anomic Aphasia	Kannada, English	Undergraduate

Ten neuro-typical normal individuals were considered as participants and matched to the clinical group based on age, gender, and education forming the control group. These ten participants also were subgrouped as in the case of the clinical group. All participants demonstrated hearing and visual acuity to the normal limit on screening (after correction, if needed). This was being sufficient for task completion which was screened again during the trial phase of the task. Each participant had to sign the informed consent of AIISH ethical committee (Appendix A). The participants responded using the number 1 key button on a computer keyboard that was marked with tape in blue color for easy identification. Participants' accuracy and response time for each item were 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 person had to store the 'n' number of information in his working memory and updating the content of working memory by leaving the unwanted information and adding the new information. This task was used to measure working memory at phonological, semantic, syntactic aspects of language and the category called shape to assess the working memory at the executive function level (Wright et al, 2007). With reference to the study of Wright et al (2007), the synback task was created which replicated the N-Back using sentences as the stimuli (Table 3.2). These sentences included were five PNG markers and five prepositions and each sentence were consisting of 2-4 words.

Table 3.2**:** Sentences with PNG markers and preposition used as test stimuli- Type 1

1-Back	**2-Back**
1.ಅವನು ಊಟ ಮಾಡುತ್ತಿದ್ದಾನೆ. - ಮಾಡುತ್ತಿದ್ದಾನೆ	1.ಪುಸ್ತಕ ಟೇಬಲ್ ಮೇಲೆ ಇದೆ. - ಮೇಲೆ
2.ಅವಳು ಊಟ ಮಾಡುತ್ತಿದ್ದಾಳೆ. - ಮಾಡುತ್ತಿದ್ದಾಳೆ	2.ಪುಸ್ತಕ ಟೇಬಲ್ ಕೆಳಗೆ ಇದೆ. - ಕೆಳಗೆ
3.ಅವನು ಮಲಗಿದ್ದಾನೆ. - ಮಲಗಿದ್ದಾನೆ	3.ಅವಳು ಮರದ ಹಿಂದೆ ನಿನ್ತಿದ್ದಾಳೆ. - ಹಿಂದೆ
4.ಅವಳು ಮಲಗಿದ್ದಾಳೆ. - ಮಲಗಿದ್ದಾಳೆ	4.ಅವನು ಮರದ ಮುಂದೆ ನಿನ್ತಿದ್ದಾನೆ. - ಮುಂದೆ
5.ರಾಮು ಪುಸ್ತಕವನ್ನು ಓದುತ್ತಿದ್ದಾನೆ. - ಓದುತ್ತಿದ್ದಾನೆ	5.ಅವನು ಗಾಡಿಯ ಹತ್ತಿರ ನಿನ್ತಿದ್ದಾನೆ. -ಹತ್ತಿರ
6.ಸೀತೆ ಪುಸ್ತಕವನ್ನು ಓದುತ್ತಿದ್ದಾಳೆ. – ಓದುತ್ತಿದ್ದಾಳೆ	6.ರಮೇಶ ಅಣ್ಣನ ಜೊತೆ ನಡೆಯುತ್ತಿದ್ದಾನೆ. –ಜೊತೆ

3.6.1 Software for data collection:

The synback 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.

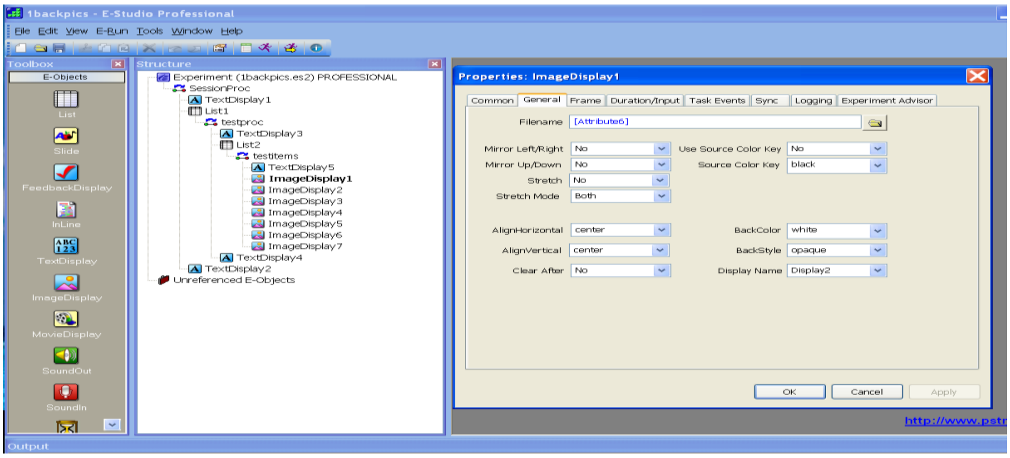

Figure 3.1: Module E-Studio for selection of the stimulus

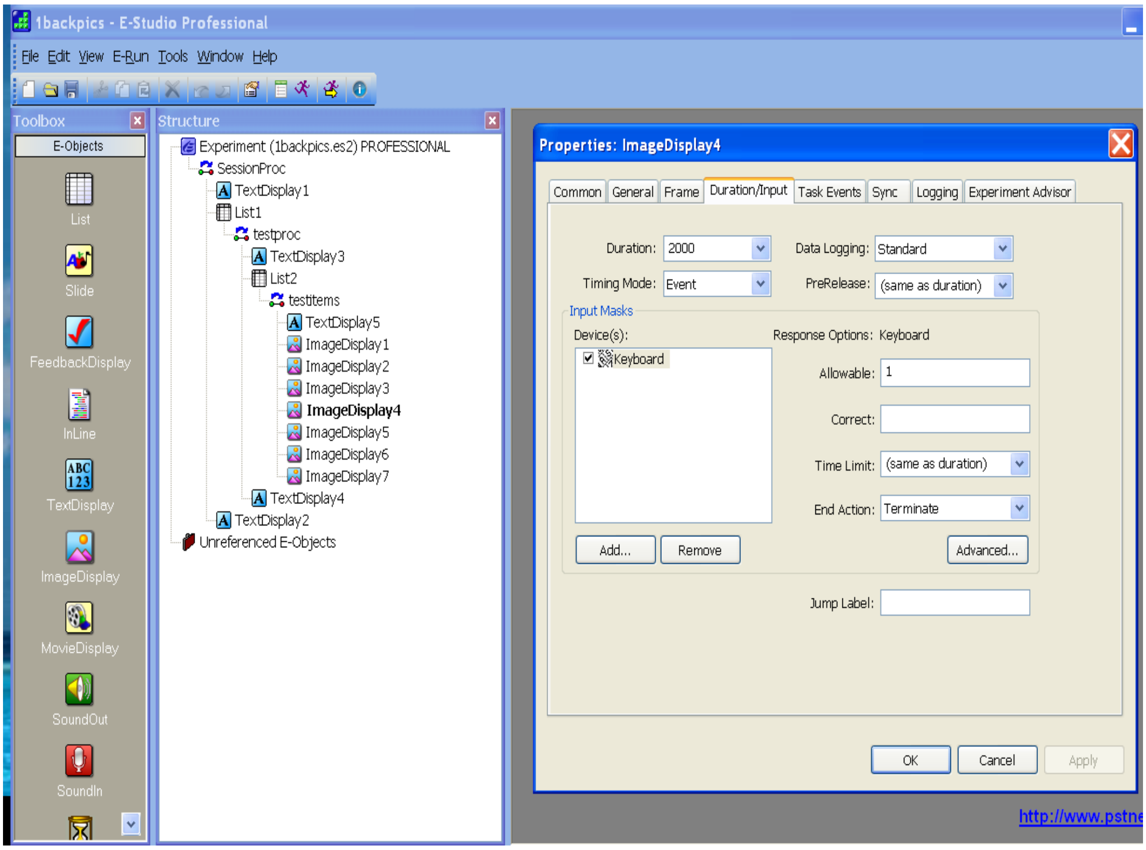

Figure 3.2: E-Studio stimulus presentation duration

Initially, the stimulus was prepared using Microsoft power point; Step I- each sentence was 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- Were 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.

The visual stimulus was 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 synback materials for Group A of the clinical and neuro-typical group begins with 2 practice items (Stimulus No. 1 of 1-back or 2-back tasks), followed by 8 experimental items (Stimulus No. 2-9 of 1-back and 2-back task) as mentioned in Table 3.2 called as Type 1 stimulus.

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 sentence stimuli were presented one by one followed by five 2-back sentence stimuli (Table 3.2). In *Type 2 stimulus* the sentence 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 3.3 which could not be used for the present study.

Table 3.3: Sentences with PNG markers and preposition used as test stimuli- Type 2

Randomised stimuli with reference to 1-Back, 2-Back and sentence type
1. ಅವನು ಊಟ ಮಾಡುತ್ತಿದ್ದಾನೆ. – ಮಾಡುತ್ತಿದ್ದಾನೆ
2. ಪುಸ್ತಕ ಟೇಬಲ್ ಮೇಲೆ ಇದೆ. - ಮೇಲೆ
3. ಅವಳು ಊಟ ಮಾಡುತ್ತಿದ್ದಾಳೆ. – ಮಾಡುತ್ತಿದ್ದಾಳೆ

4. ಪುಸ್ತಕ ಟೇಬಲ್ ಕೆಳಗೆ ಇದೆ. - ಕೆಳಗೆ

5. ಅವನು ಮಲಗಿದ್ದಾನೆ. – ಮಲಗಿದ್ದಾನೆ

6. ಅವಳು ಮರದ ಹಿಂದೆ ನಿನ್ನಿದ್ದಾಳೆ. – ಹಿಂದೆ

7. ಅವಳು ಮಲಗಿದ್ದಾಳೆ. - ಮಲಗಿದ್ದಾಳೆ

8. ಅವನು ಮರದ ಮುಂದೆ ನಿನ್ನಿದ್ದಾನೆ. – ಮುಂದೆ

9. ರಾಮು ಪುಸ್ತಕವನ್ನು ಓದುತ್ತಿದ್ದಾನೆ. – ಓದುತ್ತಿದ್ದಾನೆ

10. ಅವನು ಗಾಡಿಯ ಹತ್ತಿರ ನಿನ್ನಿದ್ದಾನೆ. –ಹತ್ತಿರ

11. ಸೀತೆ ಪುಸ್ತಕವನ್ನು ಓದುತ್ತಿದ್ದಾಳೆ. – ಓದುತ್ತಿದ್ದಾಳೆ

12. ರಮೇಶ ಅಣ್ಣನ ಜೊತೆ ನಡೆಯುತ್ತಿದ್ದಾನೆ. –ಜೊತೆ

For synback matching task, items were presented centrally following a fixation cross for the duration of 4000msec for each sentence and the participants were asked to match for 1-back and 2-back. In the matching task of this 1-back and 2-back, participants were presented with a target sentence in visual (for a limited duration of 5000msec each sentence) forms. This was followed by 8 test stimuli counterbalanced with reference to the participants or randomized according to 1-back, 2-back task and the sentence type (Table 3.2 and Table 3.3). The training and the testing stimuli were presented at the 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 screen and followed by sentence presentation. This was mainly done to make the participants more vigilant and prepare for the actual task. The sentence "ಅವನು ಊಟ ಮಾಡುತ್ತಿದ್ದಾನೆ" was the stimulus followed by a series of 5 sentences with a stimulus interval duration of 1000 milliseconds ಅವನು ಊಟ ಮಾಡುತ್ತಿದ್ದಾನೆ (target for match of 1-back task), ಪುಸ್ತಕ ಟೇಬಲ್ ಮೇಲೆ ಇದೆ (Choice), ಅವಳು ಊಟ ಮಾಡುತ್ತಿದ್ದಾಳೆ (Choice). 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. For this task, stimuli had to remain on the screen for the duration of 5000 milliseconds until a response was recorded. The participants had two trail set of sentences and then followed by the main test which was included in the same module.

3.6.2 Scoring

RT and accuracy data was recorded in the E-Prime software for the correct and wrong trials of the E-Data module of E- Prime the same is depicted in Figure 3.3. Following this was later imported to Microsoft Excel and SPSS spreadsheets for data analysis. The response of all the participants was taken as mean and individual scores to discuss further. The records of each member was examined manually 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 propositional and PNG (person-noun-gender) markers of linguistic skills (syn-back) are discussed under following headings.

4.2.1. Working memory task: Syn-back

4.2.1.1 Mean & Standard Deviation for Syn-back task of individuals with Aphasia (IWA) and neuro-typical individuals (NTI).

In this working memory tasks, participants were given 2 trials for each Syn-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 Syn-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 Syn-back.

The mean and standard deviation of Syn-back tasks (1-back, 2-back, 3-back, and 4-back) with reference to the reaction time in terms of millisecond at propositional and PNG (person-noun-gender) markers of linguistic skills were obtained 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 is taken to execute Syn-back tasks by IWA was greater compared to NTI.

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

Working memory tasks Syn- Back tasks (PNG & PRE)	**N**	**GROUPS** Individuals with Aphasia		Neuro-typical Adults	
		Mean	**SD**	**Mean**	**SD**
PNG1- Back	10	2015	1071.53	1628	976.24
PNG2- Back	10	2371	1234.66	1637	758.77
PNG3- Back	10	2200	973.31	1421	664.84
PNG4- Back	10	2256	1320.10	1589	1075.26
PRE1- Back	10	2089	1340.43	1508	971.52
PRE2- Bank	10	2376	1188.72	1796	1189.48
PRE3- Bank	10	2620	947.05	1746	869.09
PRE4- Bank	10	1592	1165.96	1073	602.00

The Figure 4.1, represents the pictographic representation of the mean score or the reaction time to execute n-back task at propositional and PNG (person-noun-gender) markers' linguistic skills of working memory tests irrespective of the Syn-backs, the neuro-typical individuals and the individuals with aphasia performed better with less reaction time for the prepositional-back task compared to PNG-back with the reaction time of 2169 msec and 2210 msec for individuals with aphasia and 1530 msec and 1568 msec for neuro-typical individuals. However, the reaction time taken by the individuals with aphasia group for Prepositional-back and PNG-back was higher compared to the neuro-typical individuals.

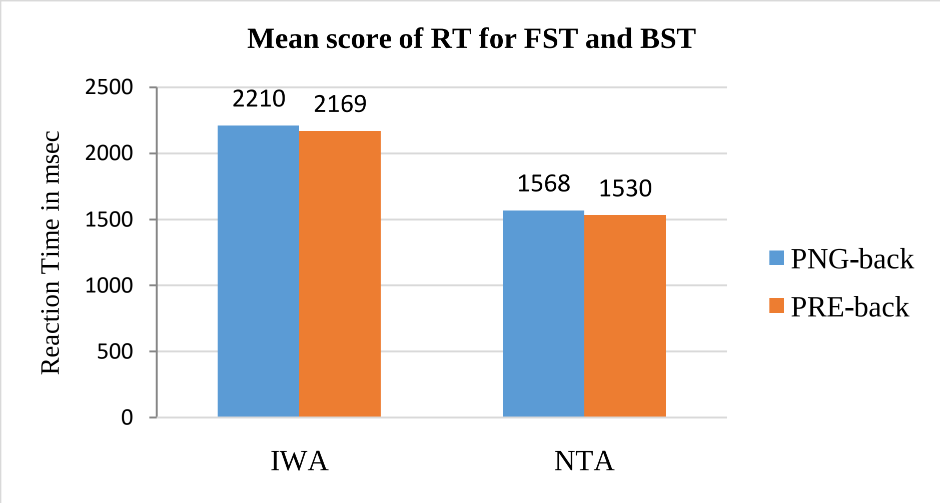

Figure 4.1. Mean scores for reaction time for PNG-back and PRE-back (Syn-back) Reaction Time of Individual with Aphasia (IWA) and Neuro-typical adults (NTA).

4.2.1.2 Frequency distribution of level/threshold/accuracy of Syn-back working memory test was compared with IWA & NTA.

Working memory test included was the Syn-back task. Syn-back, for example, is represented as 0-back, 1-back, 2-back, 3-back, 4-back. In the present study, the Syn-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 (4 back in the present study). Thus, in the present section, the performance of the two groups (IWA & NTA) on Syn-back task showing the accuracy in responding for working memory capacity is illustrated in Table 4.1. From Table 4.1 with reference to PNG (person noun gender) linguistic marker, in the **IWA group majority of the participants -10 IWA had a capacity of 3PNG-back**, 9 IWA had a capacity of 4PNG-back, 9 IWA had a capacity of 2PNG- back & 6 IWA had a capacity of 1PNG- back of syn-back task. For the **NTA group, all 10 had a capacity of 4PNG-back**, **3PNG-back, and 2PNG-back.** 8 IWA had a capacity of 1PNG-back. <u>**Therefore, the majority of IWA had a capacity of 3PNG-back and NTA had a capacity of 4PNG-back.**</u> From the same Table 4.1, with reference to PRE (prepositional) linguistic marker, in the **IWA group majority of the participants -7 IWA**

had a capacity of 3PRE-back and 2PRE- back, 6 IWA had a capacity of 1PNG- back and 4 IWA had a capacity of 4PNG-back of the syn-back task. For the **NTA group, 9 had a capacity of 2PRE-back**, 8 had a capacity of 1PRE-back and 7 had a capacity of 4PRE-back and 3PRE-back of the synback task. **Therefore, the majority of IWA and NTA did not show a specific Syn-PRE back as a threshold.** However, the majority of IWA showed 2PRE-back and NTA group also showed 2PRE-back. To study the significant differences between NTA and IWA with reference to this working memory capacity of Syn-back task the Mann-Whitney U test was administered and the descriptions are in the following sections.

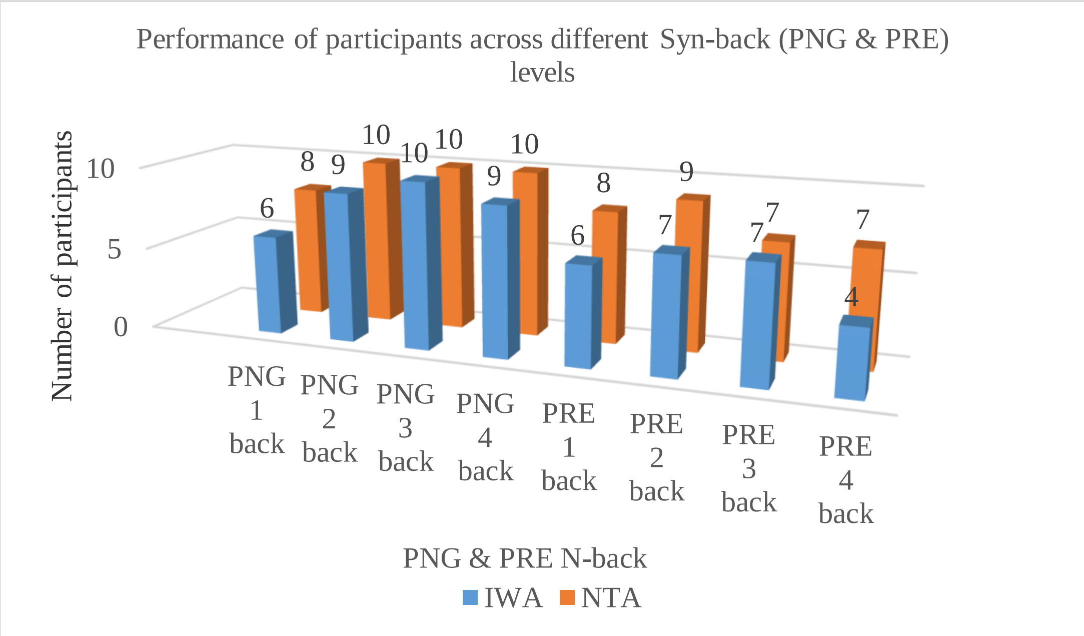

Figure 4.2. *The difference in level/accuracy/threshold of working memory (PNG and PRE) of IWA and NTI.*

4.2.1.3 Between-group comparison for Syn-back task of individuals with Aphasia (IWA) and neuro-typical individuals (NTI).

Mann-Whitney U test was administered to examine the difference in Syn-back task at propositional and PNG (person-noun-gender) markers' 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 the only 3-back task of PNG linguistic aspects of working memory task as shown in Table 4.4.

Table 4.2: *Results of Mann-Whitney Test for the Syn-back task (PNG & PRE)*

Working Memory Test Syn- Back tasks (PNG & PRE)	**/Z/ value**	***p value***
PNG1-back	1.550	0.121
PNG2-back	1.550	0.121
PNG3-back	**2.004**	**0.045***
PNG4-back	1.701	0.089
PRE1-back	1.436	0.151
PRE2-back	1.323	0.186
PRE3-back	1.853	0.064
PRE4-back	1.136	0.256

*p value<0.05

4.2.1.4 Within-group comparison for Syn-back task (PNG & PRE) of individuals with Aphasia (IWA) and neuro-typical individuals (NTI).

Wilcoxon's Signed Rank test was administered to examine the difference between PNG n-back task mean reaction time and PRE n-back mean reaction time in individuals with aphasia (IWA) group and neuro-typical individuals (NTI) group. The performances of the IWA and NTI group on the PNG n-back task and PRE n-back task are represented in Table 4.5. Statistically, there is no significant difference between PNG n-back reaction time and PRE n-back reaction time in IWA group and NTI group.

Table 4.3: *Results of Wilcoxon's Signed Rank test for PNG n-back and PRE n-back task mean reaction time in IWA and NTI*

Groups	**Parameters**	**/z/**	***p* value**
IWA	*PNG n-back mean reaction time and PRE n-back mean reaction time of IWA group*	0.365	0.715

NTI	*PNG n-back mean reaction time and PRE n-back mean reaction time of NTI group*	0.000	1.000

P value <0.0

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 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 propositional and PNG (person-noun-gender) markers of linguistic skills (syn-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** at PRE (propositional) and PNG (person-noun-gender) markers of linguistic skills (syn-back) **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 PNG3-back only of PNG (person-noun-gender) markers of linguistic skills (syn-back) and there was no significant difference seen for the propositional syn-back. 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 syn-back task of working memory test is considered in the following sections.

It was observed that with reference to **neuro-typical individuals** there was 100% of the population (*all the ten participants*) showing the accurate response for Syn-back PNG 4-back, Syn-back PNG 3-back, Syn-back PNG 2-back and for Syn-back PNG1-back there was 80% of the population (*eight participants*) showing accurate response. For the Syn-back PRE 4-back and Syn-back PRE 3-back there was 70% of the population (*seven participants*) showing accurate response and for Syn-back PRE 2-back there was 90% of the population (*nine participants*) showing accurate response and for Syn-back PRE 1-back there was only 80% of the population showing accurate response (*eight participants*). In the present study, the highest threshold of Syn-back PNG considered was Syn-back PNG 4-back and the total population *(all ten participants)* reached this highest threshold accurately. Another highest threshold of Syn-back PRE was Syn-back PRE 4-back and here only 70% *(Seven participants)* of the population could show their accurate responses. Therefore the Syn-back of PNG (Person-noun-gender marker) was better and easier to perform compared to Syn-back of PRE (Prepositional markers) for the neurotypical population.

Similarly, with reference to **individuals with aphasia**, there was 100% of the population *(all ten participants)* showing accurate response **only** for Syn-back PNG 3-back. For the Syn-back PNG 4-back and Syn-back PNG 2-back, there was 90% of the population *(nine participants)* showing accurate response. For Syn-back PNG 1-back there was 60% of the population *(Six participants)* showing accurate response. For the Syn-back of PRE 4-back, there was 40% of the population *(four participants)* showing accurate response. For Syn-back PRE 3-back and Syn-back PRE 2-back, there was 70% of the population *(seven participants)* showing accurate response. Finally, for the Syn-back PRE 1-back, there was 60% *(six participants)* of the population showing accurate response. In the present study, the highest threshold of Syn-back PNG and PRE considered was Syn-back PNG 4-back and Syn-back PRE 4 –back. But the total population (all ten individuals with aphasia) could not reach this highest threshold accurately; instead, they obtained an accurate response for Synback

PNG 3-back which could be the threshold of an individual with aphasia. And with reference to Syn-back PRE, the 100% of the population could not reach any of the level of Syn-back PRE 4-back, 3-back, 2-back, and 1-back. However, the majority (70% population) were at the level of **Syn-back PRE3-back**. Therefore the Syn-back of PNG (Person-noun-gender marker) was better and easier to perform compared to Syn-back of PRE (Prepositional markers) for the individuals with aphasia. This was similar to the findings of neuro-typical population. To conclude, the threshold of neuro-typical for Syn-back PNG is 4-back and Syn-back PRE threshold could not be obtained because of scattered responses. Similarly, the threshold of individuals with aphasia for Syn-back PNG is 3-back and Syn-back PRE threshold could not be obtained because of scattered responses as shown in Table 5.1.

Table 5.1: Accuracy scores of Syn back task of PNG and PRE linguistic markers for NTI and IWA groups.

SYNBACK TASK	**GROUPS**	
	APHASICS Accuracy score	**NEURO TYPICALS** Accuracy score
PNG 4-back	9/10	**10/10**
PNG 3-back	**10/10**	10/10
PNG 2-back	9/10	10/10
PNG 1-back	6/10	8/10
PRE 4-back	4/10	7/10
PRE 3-back	7/10	7/10
PRE 2-back	7/10	9/10
PRE 1-back	6/10	8/10

The contributing reasons could be the **linguistic deficit associated with the condition called aphasia caused after stroke leading to language processing deficits.** For example, persons with aphasia have performed poorer in verbal working memory task and equally better in spatial working memory task when compared to age-matched individuals in a study done by Christensena, Wright, and Ratiua (2018). They investigated the working memory in both verbal and spatial working memory tasks. In support to the previous literature, the results indicate that the individuals with aphasia performed poorer in the verbal working memory task and the contributing reason could be due to the domain-specific verbal processing deficits in persons with aphasia (PWA). Whereas in the spatial working memory task, PWA could perform equally well with the neuro-typicals and the contributing reason is the preserved domain-specific ability to attend visual-spatial stimuli by encoding, decoding, recall and inhibiting the irrelevant stimuli easily in comparison with the difficult verbal stimuli.

To be specific with reference to semantic short term memory deficits and phonological short term memory deficits in individuals with aphasia. Harris.L, Olson, and Humphreys (2014) conducted a study where the person had to repeat nonsense words for phonological short term memory treatment and repeat words and encouraged to think about the meaning for the treatment of phonological semantic treatment. The results obtained were better for phonological short term memory compared to phonological semantic short term memory. When these results were compared with the sentence processing measures which was done before and after each treatment approach, for the semantic anomaly judgment task improvement, was seen on phonological semantic short term memory approach and the same results were found in spoken sentence-picture matching indicating that no improvement was seen only for the repetition of nonsense words during the phonological treatment approach. In the present study, the differences in the comprehension ability of IWA participants could have contributed to the difference among the IWA group.

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 phonological and semantic short term working memory task, the sentence repetition-based working memory (SR-WM) was used for the treatment to increase the sentence repetition along with the comprehension abilities by Eom and Sung (2016). The task was carried out for 3 days in a week with 1 hour per day and the stimulus used were a set of limited vocabulary and varied syntactic length and structure. This task let to the improvement in the sentence repletion ability along with the comprehension abilities due to the increase phonological retention ability and simultaneous syntactic computational abilities. Hence the authors concluded that during the treatment of working memory, selection of the stimuli and manipulation plays a major role in the treatment and in the generalization of language abilities. Therefore the difference between the NTA group and IWA group could have been due to the stimulus selection and the treatment on sentence repetition. Therefore in the present study, the IWA group had not undergone any training with reference to sentence repetition nor sentence comprehension to show enhanced or comparable performance as that of the NTA group.

Apart from the participants with aphasia acting as a contributing factor in showing some difference between IWA group and NTI, **the then-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 tasks and not for two back tasks. Spoken picture matching was done and two individuals had improved scored statistically. This study supports the present study, where the threshold obtained for Syn-back task (PNG and PRE) for IWA was Syn PNG 1-back and for NTA group Syn PNG 4-back and Syn PRE the threshold could not be obtained due to scattered responses.

Koenig-Bruhin and Studer-Eichenberger (2007) have presented a single case study of an adult with conduction aphasia with verbal working memory impairment causing greater decay in phonological and semantic item representation. They had considered a treatment approach where the individuals were asked to repeat subject verb object sentences with increasing length. There were multiple baselines considered and at the end of the treatment approach there was increased mean length utterance in production which was observed and there was a significant improvement in the working memory tasks along with improvement in sentence repetition tasks. **Therefore the prior treatment on syntax plays a role in showing improved performance on working memory task**. In the present study, the IWA had not undergone any training on the syntax to contribute better threshold on Syn PNG-back and Syn PRE-back.

The final contributing reason could be the attentional control of IWA participants. The support for this factor would be a study by Mayer and Murray (2002). The main focus of their study was to treat an acquired reading disorder in a patient with fluent aphasia. In addition to the patients reading disorder, the patient also presented with inconsistently impaired performance on verbal and visual WM tasks, leading the authors to consider that the patient had additional difficulties at the level of attentional control aspects of WM. The authors implemented an alternating reading/WM treatment. The WM treatment involved training of storage and processing abilities, by presenting written sentences to the patient which he had to judge at the grammatical level, and for which he had to determine and maintain the semantic category of the final word. The semantic category of final words had to be recalled after a predetermined number of sentences had been presented and judged. The sentences, containing 6 to 10 words, were paired, with the last word of each consecutive sentence pair sharing the same semantic category. The sentences were presented by increasing sentence length, and by increasing the number of sentences (2, 4, or 6). In the easiest condition, only one semantic category name had to be maintained and recalled, while the most difficult condition involved the maintenance and recall of three different category names that characterized the end word of each sentence. This task is very similar to a complex reading span procedure (Daneman & Carpenter, 1980) and is considered to engage to a large extent executive and attentional control processes. The authors reported an increase in reading efficiency and in WM capacity after treatment. Post-treatment WM performance was in the normal range. Furthermore, the WM treatment involved reading sentences and hence also involved training of reading abilities. At a functional level, the patient did not report significant changes in his reading abilities. Therefore the prior training or exposure to reading task (sentence reading) would have contributed better threshold or performance on Syn PNG and Syn PRE back task in IWA.

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 (SYNTAX). 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 synback task programme using E-Prime software.
2. To study the effect of working memory abilities in processing distinct linguistic information (syntax) in the synback 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 synback task is a replicate of the N back task using five PNG and five prepositions linguistic markers with 2-4 words sentences as the stimulus. 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 synback 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 neuro-typical adults.

The mean value of the Syn 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 Syn back. Descriptive statistics mean and standard deviation of Syn-back tasks (1-back, 2-back, 3-back, and 4-back) with reference to the reaction time in terms of millisecond at propositional and PNG (person-noun-gender) 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 Syn-back tasks by IWA was greater compared to NTI.

The neuro-typical individuals and the individuals with aphasia performed better with less reaction time for the PNG-back compared to the prepositional-back task. However, the reaction time taken by the individuals with aphasia group for Prepositional-back and PNG-back was higher compared to the neuro-typical individuals with reference to PNG (person noun gender) linguistic marker, in the IWA group majority of the participants -10 IWA had a capacity of 3PNG-back. For the NTA group, all 10 had a capacity of 4PNG-back, 3PNG-back, and 2PNG-back. Therefore the threshold for Syn-PNG for IWA was 3PNG-back and for NTA was 4PNG-back. For the NTA group, 9 had a capacity of 2PRE-back, 8 had a capacity of 1PRE-back and 7 had a capacity of 4PRE-back and 3PRE-back of the synback task. Therefore, the majority of IWA and NTA did not show a specific Syn-PRE back as a threshold.

To study the significant differences between NTA and IWA with reference to this working memory capacity of Syn-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 3-back task of PNG linguistic aspects of working memory task. Wilcoxon's Signed Rank test was administered to examine the difference between PNG n-back task mean reaction time and PRE n-back mean reaction time in individuals with aphasia (IWA) group and neuro-typical individuals (NTI) group. Statistically, there was no significant difference between PNG n-back reaction time and PRE n-back reaction time in IWA group and NTI group.

Therefore the Syn-back of PNG (Person-noun-gender marker) was better and easier to perform compared to Syn-back of PRE (Prepositional markers) for the individuals with aphasia. This was similar to the findings of neuro-typical population. 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 authors by Eom and Sung (2016) stated that treatment of working memory, selection of the stimuli and manipulation plays a major role in the treatment and in the generalization of language abilities. Repetition-based working memory (SR-WM) was used for the treatment to increase the sentence repetition along with the comprehension abilities. In the present study, the IWA group had not undergone any training with reference to sentence repetition nor sentence comprehension to show enhanced or comparable performance as that of the NTA group.

The final contributing reason could be the attentional control of IWA participants. The support for this factor would be a study by Mayer and Murray (2002). The patients reading disorder, the patient also presented with inconsistently impaired performance on verbal and visual WM tasks leading the authors to consider that the patient had additional difficulties at the level of attentional control aspects of WM. The authors reported an increase in reading efficiency and in WM capacity after treatment. Post-treatment WM performance was in the normal range. Therefore the prior training or exposure to reading task (sentence reading) would have contributed better threshold or performance on Syn PNG and Syn PRE back task in IWA.

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 SYNBACK 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

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CONSENT FORM

Dissertation on

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

Information to the participants

I, Ms. Karunika Korani M.Sc. (SLP) student of AIISH doing dissertation work titled- **"Working memory assessment in individuals with and without aphasia using distinct (Synback) 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 (SYNTAX). 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 SYNBACK task of an individual with Boca's aphasia (59 years/ Male)

e Edit View Tools Help

TextDisplay4.ACC	TextDisplay4.CRESP	TextDisplay4.DurationError	TextDisplay4.OnsetDelay	TextDisplay4.OnsetTime	TextDisplay4.OnsetToOns	tTime	TextDisplay4.RESP	TextDisplay4.R	TextDisplay4.RTTime	TextDisplay5.
NULL	NULL	NULL	NULL	NULL	NULL		NULL	NULL	NULL	0
NULL	NULL	NULL	NULL	NULL	NULL		NULL	NULL	NULL	0
1	1	0	12	161609	0		1	4213	165822	NULL
1	1	1	-5	191183	0		1	3514	194697	NULL
1	1	0	-4	220056	0		1	2897	222953	NULL
0	1	0	12	248276	0		2	4401	252677	NULL
0	1	0	-4	278018	0		2	4886	282904	NULL
1	1	0	12	308244	0		1	4296	312540	NULL
1	1	0	-4	337835	0		1	3458	341293	NULL
0	1	0	12	366557	0			0	0	NULL

ne	TextDisplay4.RESP	TextDisplay4.RT
	NULL	NULL
	NULL	NULL
	1	4213
	1	3514
	1	2897
	2	4401
	2	4886
	1	4296
	1	3458
		0

PNG Accuracy and RT

PREPOSITION Accuracy and RT

APPENDIX C

The accuracy and reaction time scores of SYNBACK task of neuro-typical individual (55 years/ Male)

TextDisplay3.RTTime	TextDisplay4.ACC	TextDisplay4.CRESP	TextDisplay4.DurationError	TextDisplay4.OnsetDelay	TextDisplay4.OnsetTime	TextDisplay4.OnsetToOnsetTime	TextDisplay4.RESP	TextDisplay4.RT	T
ULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	N
ULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	N
)	1	1	0	12	107944	0	1	1292	1
)	1	1	1	-5	134592	0	1	559	1
)	1	1	0	12	160522	0	1	577	1
)	1	1	0	12	186435	0	1	815	1
)	1	1	0	-4	212599	0	1	338	2
)	1	1	0	-4	238278	0	1	389	2
)	1	1	0	12	263973	0	1	1092	2
)	1	1	0	12	290354	0	1	326	2

ie	TextDisplay4.RESP	TextDisplay4.RT	T
	NULL	NULL	N
	NULL	NULL	N
	1	1292	1
	1	559	1
	1	577	1
	1	815	1
	1	338	2
	1	389	2
	1	1092	2
	1	326	2

PNG Accuracy and RT

PREPOSITION Accuracy and RT