Non Word Repetition Abilities In Adult Who Stutter

Ankitha.S

Register No: 18SLP003

This Dissertation Submitted as a Part Fulfillment for Degree of Master of Science

(Speech- Language Pathology**)**

University of Mysore

Mysuru

ALL INDIA INSTITUTE OF SPEECH AND HEARING

MANASAGANGOTHRI, MYSURU – 570006

July, 2020

CERTIFICATE

This is to certify that this dissertation entitled **"NON WORD REPETITION ABILITIES IN ADULT WHO STUTTER"** is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech language Pathology) of the student (**Registration number: 18SLP003**). 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 or any other diploma or degree.

Dr. M. Pushpavathi
Director
All India Institute of Speech and Hearing
Manasagangothri Mysore

Mysore
July, 2020

CERTIFICATE

This is to certify that this dissertation entitled **"NON WORD REPETITION ABILITIES IN ADULT WHO STUTTER"** is a bonafide work submitted in part fulfilment for the degree of Master of Science (Speech language Pathology) of the student (**Registration number: 18SLP003**). This has been carried out under my supervision and guidance. It is also certified that this dissertation has not been submitted earlier to my other University for award of any other Diploma or Degree.

Dr. Sangeetha Mahesh
Clinical Reader & Head
Department of Clinical Services
All India Institute of Speech and Hearing
Manasagangothri Mysore

Mysore
July, 2020

DECLARATION

I hereby declare that this dissertation entitled **"NON WORD REPETITION ABILITIES IN ADULT WHO STUTTER"** is the result of my own study and has not been submitted earlier to any other university for the award of Diploma or Degree.

Mysore
July, 2020

Register No.
18SLP003

Acknowledgements

First I would like to thank my **parents** and my little brother without their support, love and encouragement nothing would have been possible. Love u so much **pappa** and **mommy.....**

I would like to extend my gratitude to **Dr. Sangeetha. Mahesh**. Thank you ma'am for constant guidance, support and immense patience.

I thank Dr. Abhishek and Ranjitha akka for helping me throughout my dissertation

The most **special person** in my life, who always been kind of my backbone. Who keeps me strong in all situations and thanks for all your love, care and support. Thank u for being there when I needed u the most. I'm lucky enough to have u in my life. Thank u for everything. Love u loads…….

A big thank u for helping and motivating me in each step, thank u for ur support when I went through a hard time, my best and super seniors ***Rashmi***^{2} and ***Sonam akka.***

I have to thank ***Sindhu akka, Rakesh anna, Namratha akka, Suppu akka, Shru akka, Akshay anna***.

I'm deeply thankful and blessed for the special and unique people in my life who support me always ***Udhay anna, Ajay anna, Raki, Sabin, Chandu (bestie) and Prassu.***

Archu, Pari, Sargu, Chethu thanks for being there for me and thank u all for making my 6yrs of AIISH life so memorable and thanks u ***Hema, Sushma, Srivi, Hannah, Thanu, Pooja, Sree and Pauline***. Love u all….

I would like to thank my lovely and best friend ***Nammi***. U have been wonderful person and thanks fr ur support, positivity and care.

My support system, best brother from another mother none other than ***Rajesh anna***. Thank u fr ur care and love. Love u so much anna.

I thank my dissertation partner Hima.

I would like to thank my sweet and favourite juniors for all the love and affections ***Appu, Bhoomi, Kasthu, Rashmi, Liki, Chuppi, Rohini, Vijji, Pallavi, Chandu, Aishu, Madhu, Sumanth(thammi), Alka kutti, Ameena, Mansi, Mithun, Harshi***. Lv u all.....

I thank all the participants of the study for their cooperation.

TABLE OF CONTENTS

List of Figures

CHAPTER I

INTRODUCTION

"Stuttering is considered by excessive repetitive disturbance in the rhythmic and smooth flow of speech, especially when this disturbance consists of repetition or prolongation of a sound or syllable and when accompanied by emotions these as fear and anxiety and behaviours such as avoidance and struggle" (Kalinowski & Saltuklaroglu, 2006).

Bloodstein (1995) stated that stuttering is unintentional, intermittent, and distressing disorder of speech affecting around 1% of the population. The primary effects contain aberrant sound interspersed prolongation and syllabic repetitions with speech patterns otherwise perceptually normal. In other words, a person can start stuttering oral communication without interruption naturally and then eventually and uncontrollably, begins to produce unpredictable results rapid oscillatory repetition of syllables (Kalinowski et al., 2004)

Stuttering is a multifactorial disorder caused by differences in the motor and linguistic systems that interfere in the forward flow of speech. The multifactor, for example, cognitive-linguistic processes and emotional systems (Smith & Kelly, 1997). Among the various cognitive-linguistic processes, the phonological processing role in the expression of stuttering was comprehensively explained by theories such as the (Postma &Kolk, 1993) Covert Repair Hypothesis and EXPLAN model given by Howell (2004). Among the various phonological processing and phonological working memory(PWM) has been linked to difficulties faced by individuals in establishing/maintaining fluent speech(Anderson & Wagovich, 2010; Wagovich, & Hall, 2006; Byrd et al., 2012).

Models related to phonological encoding in stuttering

In the field of research, numerous theories were established to explain the stuttering condition. Any of the hypotheses say that phonological encoding deficits have been one of the major causes of stuttering. Levelt (1989), reported that phonological encoding is defined as the process involving the recovery or development from each lemma or word of phonetic or articulatory plan and the whole utterance, and this process involves three components suggested by him: ***generation of word constituent segments, along with word frame sound segment will integrate, and allotment of appropriate syllable stress***. Phonological encoding process appears to be interlinked among, on the one hand, lexical processing of the motor speech system. Later, as part of model WEAVER (Levelt et al., 2001), a procedure wherein the phonological code of word (i.e. phonemes or syllable) is obtained, assemble once again into a sequential, and timely manner to permit the successful building of the phonological word is describes as phonological encoding. therefore, the language formulation process is embedded by phonological encoding, thus making it hard to separate it from the rest of the language process.

Several psycholinguistic theories of stuttering say that stuttered expression leads to delayed or interrupted phonological encoding. Nevertheless, phonological encoding remains difficult to assess without regulating speech-motor system involvement (Pelczarski et al., 2018). The individual phonemic segments and the syllabic stress occurs in the process of phonological encoding in the process of speech planning leading to articulation as stated y Levelt et al. (2018).

The relationship between phonological encoding and stuttering is emphasized by four psycholinguistic theories in the main. These theories are a hypothesis of a fault line (Wingate, 1988), By proposing that stuttering occurred due to a delay in the recovery and during speech production by encoding of syllable rhyme, the fault line was formed at the point where syllable onset was integrated with its rhyme. The neuropsycholinguistic theory (Perkins, Kent, & Curlew, 1991) outlined that temporal asynchrony between linguistic preparation, i.e. lexical, phonological and suprasegmental preparation, and time pressure was crucial in the cause of stuttering.

The role of stuttering has been established by different studies for the phonological processes. Stuttering psycholinguistic theories hypothesis that phonological encoding difficulties may delay or disrupt subsequent articulatory planning and performance, Bringing a stoppage of speech movements (stutter events). Howell (the EXPLAN model, 2004) Postulated that the temporal asynchrony in utterance between linguistic planning (PLAN) and motor execution (Ex) of subsequent syllable could lead stuttering. Stuttering could be led by the temporal asynchrony in utterance between linguistic planning (PLAN) and motor execution (Ex) of subsequent syllable as reported by Howell (2004) in the EXPLAN model. The Multifactorial Dynamic pathways Theory proposed that weak motor systems as opposed to a deficit in phonological encoding is lead to stuttering, and yet under increased phonological motor system demand may turn into less constant (Smith & Weber, 2017).

Cognitive theories postulated that stuttering originated from a cognitive-linguistic system which had not developed well the Covert repair hypothesis, for example, indicated that stuttering is derived from a phonetic planning deficiency (Postman & Kolk,1993), During covert and open speech production, the person who stutters have difficulties, which was started by Chang et al. (2009). Pelczarski and Yaruss (2014) reported the deficiency in phonological perception in person with stuttering.

The Covert Repair hypothesis (CRH) proposed that moments of stuttering is caused by delayed phonological encoding in person who do stutters lead to increase inner encoding error correction (Postman & Kolk,1993). This hypothesis based on the spreading activation of the model of production of language (Dell, 1986; O'Seaghdha, 1992). Stuttering was declared as a prosody condition (Wingate, 1984). Wingate performed research on stuttering grammatical variables and looked at different analyses and suggested stuttering as a prosodic condition.

Two theories are put forward, specifically with prosody:

1. Temporal Pattering theory; Stuttering as a disorder of timing (Kent, 19831)
2. Stuttering is a disorder of the production of prosody (Wingate, 1976)

Temporal Pattering theory:

Kent (1984) argued that stuttering is a temporal programming disorder and he speculated that individuals who stutter cannot correctly produce temporal programs and /or time structure for behavior underlying the fluent output of speech. Kent argued that speech production allows speakers to combine both segmental (linguistic) and Paralinguistic (prosodic) knowledge at the same time.

An individual who stutter can't perform smooth articulation of speech gestures. Van Riper(1982) also strongly supported this view in that he found stuttering to be a 'Disruption of the simultaneous and successive programming of muscular movement requiring the utterance of a speech sound or its relation to the next sound in a phase' and a timing disorder.

Stuttering is a disorder of production of prosody (Wingate's View)

Stuttering is the result of a deficiency in phonetic transition. He clarified that stuttering is not an event in isolated sound production, but the transition from one sound to another can be seen as stuttering (Wingate, 1969). Wingate later modified this idea by stressing 'syllable' as the main variable for the stuttering occurrence. Wingate, (1976) identified stuttering as exhibiting 'prosodic defect' as an intermittent disorder of increasing stress actualization. Several evidence indicates that stuttering is not a unitary condition, and there is a need to determine the aspect that affects the threshold for fluency in children/adults.

That has led to work on speech output in PWS from a phonological perspective. There is also evidence that there may have been a link between early stuttering and phonological deficiencies (Louko, Edwards, & Conture, 1990; Postma & Kolk, 1993; Kolk & Postma, 1997; Louko et al., 1999), which contribute to the development of covert repair hypothesis as reported by Postma and Kolk (1993).

Present theories of psycholinguistic in typical language formulation in this called 'phonological encoding' (Dell, 1986; Dell & O'Seaghdha, 1992; Shattuck-Hufnagel, 1979,1992; Levelt, Roelofs, & Meyer, 1999; Jansma & Shiller, 2004; Levelt, 1989; Roelofs, 2004;) Phonological encoding involves retrieval phonological segments rules(i.e., phoneme /syllable of a word) gradual, on time to enable phonological words to be constructed effectively. Whereas specifics of the stuttering hypothesis differed, they all hypothesized that from individual phonemes phonological words formed leads to delay/breakdown (i.e., during the phonological encoding process) a lag or breakdown occurred. There is evidence to indicate that phonological encoding aspects in individual who stutter might not be as impactful or effective, even though some of these results are ambiguous (Bosshardt & Fransen, 1996; Burger & Wijinen, 1999; Hennessey et al., 2008; Sasisekaran & de Nil, 2006; Sasisekaran et al., 2006; Weber-Fox et al., 2004; Wijnen & Boers, 1994). Few research on stuttering adults have investigated the same mechanisms. Considering that all the theoretical stuttering models are based on the completely defined adult speech system (Wingate 1988; Perkins et al., 1991; Postma & Kolk, 1993; Karniol, 1995; Kolk & Postma, 1997; Howell & Au-Yeung, 2002). Evaluating the abilities of phonological processing of adults who stutter will be able to specifically compare the findings by the theoretical models of stuttering also be helpful.

Non-word repetition tasks (NWR) were primarily used in children (e.g., Dollaghan et al., 1993; Gathercole & Baddeley, 1996; Dollaghan & Campbell, 1998) and adults to assess phonological working memory skills (Gupta, 2003). Just a handful of research in PWS contribute to non-word repetition.

Numerous studies are performed in CWS compared with CWNS, which explored how the amount of correct response, phoneme errors, and fluency differed over various syllable lengths during non-word repetition task(Hakim & Ratner, 2004; Anderson et al., 2006; Seery et al., 2006; Bakhtiar et al., 2007).

Need for the study

Psycholinguistic stuttering theories stated that a person who stutters has phonological encoding problems one such task is non-word repetition (NWR), it can be measured using different tasks. To distinctive demand on phonological working memory, the NWR task is adequate. NWR tasks have been an important tool for assessing the limits of phonological processing skills in individuals who stutter because they rely on effective phonological encoding and the ability to manipulate the difficulty of non-word stimuli to increase phonological demand.

Namasivayam and Van Lieshout (2008) conducted studies in the western forefront, suggesting that adults who stutter exhibit unique complexity in the motor learning of new sounds in sequence. Smith, Sadagopan, Walsh and Weber-fox (2010) concluded no difference in output accuracy among adults who do and do not stutter over the 1-to 4 syllable length. However, adults who stutter have shown more inconsistency in articulatory coordination during in the production of longer (i.e., 3 and 4 syllable length) nonwords which are more phonologically complex than adults who stutter, which suggest a significant interaction among phonological encoding and motor ability in production of adults who stutters (AWS) speech.

Aim

The current study aims to estimate phonological encoding abilities through the non-word repetition task in adults who stutter.

Objectives

1. To analyze and compare reaction time and accuracy for 4 syllable non–words repetition tasks in adults who do not stutter (AWNS) and adults who stutter (AWS) for vocal and nonvocal condition.
2. To analyze and compare reaction time and accuracy for 5 syllable non-words repetition tasks in adults who do not stutter and adults who stutter for vocal and nonvocal condition
3. To compare reaction time and accuracy for 4 syllable and 5 syllable non-words across groups for vocal and nonvocal conditions.
4. To analyze and compare reaction time and accuracy across degrees of severity for the non-word repetition task in AWS.

CHAPTER II

REVIEW OF LITERATURE

Very few of the models and theories hypothesized that deficits of phonological encoding in individuals who stutter, therefore phonological encoding deficits were found to be a cause of stuttering incidence. Levelt (1989) described ‘the processes which concerned is obtained or constructing an articulatory or phonetic plan from each word or lemma and the whole utterance know as phonological encoding’. Nonword repetition can be been related to the process of phonological encoding which consists of three components of generation of segments--**assignment of appropriate syllable stress, constitutes words, and the sound components combine with word frames**. Levelt; Levelt, Roelofs et al. (1989) stated that an interface serves between speech motor production and lexical processes by phonological encoding process and is important for incremental production and planning of speech. Self-monitoring of silent or inner expression occurs while phonological encoding takes place according to Levelt’s speech development model. Levelt and Levelt et al. (1989) stated that, before submitting the articulatory preparation and execution code, in the speech planning speakers track their own speech performance for speech errors. The access to the phonemes, which are the sub-lexical units, includes self-monitoring that can be considered as a natural sub-process of speech production. The breakdown in fluency takes place due to their damaged mechanism of covert monitoring for the PWS The phonological encoding process is very much related to the speech motor output according to the Gestural linguistic model (Browman & Goldstein, 1997; Saltzman & Munhall, 1989). Numerous studies have indirectly and directly supported evidence of the relationship among phonological encoding deficits and stuttering in CWS.

Phonological encoding

Baddeley (2003) included a phonological store and a sub-vocal rehearsal system as the parts of the phonological working memory system. The ability to hold material to be remembered in a phonological code is facilitated by the phonological store. The sub-vocal rehearsal system, which is a silent verbal repetition process, is required because to phonological code is prone to decay over time. The phonologically encoded material is refreshed by the sub-vocal rehearsal system and it allows such materials to be preserved in memory for a longer time. Non-word repetition tasks can be used to measure phonological working memory. It is not the only process recruited in the repetition of novel word form; in contrast, it is the ability to repeat a non-word accurately and also depends upon several other auditory-perceptual, phonological, and motor planning operations (Coady & Evans, 2008, Gathercole, 2006). The sound systems in a serial order must be encoded first by the listener after hearing the non-word. After that, the segment sequence must be stored and retrieved from the memory. Finally, the planning and execution of essential movements for the re-production of the sound segments should take place as per the study of Gupta and Tisdale (2009), further stated by Shriberg et al. (2009).

As per the recent studies, working memory(WM) has been implicated in the onset of stuttering because temporary storage and processing of incoming information is provided by WM, Baddeley (2003) visualized working memory, which is a universally recognized neurocognitive system, as a multi-component system that including three major components--central executive, visuo-spatial sketchpad, and the phonological loop. The phonological loop includes the short term storage and the rehearsal of incoming verbal information for enabling comprehension are the parts of the phonological loop. To generate articulatory plans, the phonological material must be retrieved from storage which takes place by the process of phonological encoding while speech planning (Levelt, 1989). Working memory is considered critical to phonological encoding Gathercole and Baddeley, (1993) considered working memory to be critical to phonological encoding. WM is vital to higher-level cognition (Rosen & Engle, 1997).

Oyoun et al. (2010) conducted a study in 30 typical children and 30 children with stuttering in the age group 5-13 years to assess working memory (WM) using recall abilities tests and non-word repetition tasks. Recall of word sets different in length and rhyming, digit span, letter sequences, and picture-number test. The non-word repetition test was used to assess phonological encoding through estimating a number of phonological errors produced on repeating the task, and to measure the reaction time. The results were compared to detect if working memory deficits had a role in the development of stuttering. The WM recall tests included The children who stutter (CWS) had performed poorly on some working memory tests compared to children who do not stutter (CWNS). This study concluded that children who stutter may show reduced ability to recall non-words and some working memory abilities.

Sangeetha (2018) investigated phonological encoding skills on thirty bilingual adults of whom fifteen are BAWS (Kannada-English), and others are BAWNS. The experiment involved four tasks i.e. simple motor task, picture familiarization and naming task, phoneme monitoring, and auditory tone monitoring task. Phoneme monitoring task had seventeen phonemes based on which fifty-one tri-syllabic Kannada and forty-seven tri-syllabic English nouns were prepared. Study findings showed that the simple motor task BAWS had longer reaction time and less accuracy compared to BAWNS, although no significant difference was found. Related variation in findings was found in the phoneme and auditory monitory tasks however with statistical differences. This study revealed that there was no significant difference in the phonological encoding abilities of L2 and L1. To summarize, BAWS performed poorly in the simple motor task, auditory tone, and phoneme tone monitoring task relative to BAWNS and BAWS has general monitoring deficits and phonological encoding difficulties.

Phonological working memory in adults who stutter

Working memory as a phonological encoding process was stated by Baddeley(2003) He showed the process of working memory that includes tow sub-components: a phonological store contains material to be remembered; material that is subject to decay over time. The sub-vocal rehearsal method is a silent verbal repetition mechanism that refreshes the information in a phonological code, allowing for a longer period of time to be retained in the brain, phonological encoding and sub-vocal rehearsal are also thought to have a strong effect on the memory capacity.

The non-word repetition task was used much to investigate PWM in adults and children who stutter. Researches have concluded that individuals with stuttering were less likely to be successful in nonword repetition in comparison with their fluent peers (Byrd, McGill, & Usler, 2015)., l Other studies suggested that both the adults with and without stuttering exhibited equivalent accuracy; however, the non-word repetition of shorter syllable length and that the PWM deficits were observed on only the surface of non-words of longer syllable lengths in adults with stuttering. AWS only surface on nonwords of longer syllable lengths. As an example, A nonword repetition and phoneme elision task was estimated by Byrd et al. (2012) across four-syllable lengths(two, three, four and seven)to measure the PWM abilities of adults with and without stuttering. This authors reported that only seven -syllable nonwords made the differences between the two groups. Initial attempts to repeat 7-syllable non-words AWS group were less accurate and AWS required more trials to produce nonwords accurately. Both groups demonstrated a marked decline in accuracy for the phoneme elision task as the non-words increased in duration; however, between syllable length and group there was no significant found. According to this study findings that AWS will be more beneficial from sub vocal rehearsal while repeating nonwords of shorter syllable lengths, which increased the chance of high accuracy nonword repetition (Baddeley, Chincotta, Stafford, & Turk, 2002). The results suggested that the PWM and the subvocal rehearsal systems in individuals who stutter are not efficient in retaining the integrity of the auditory input (Bosshardt, 1990; Ludlow et al., 1997; Byrd et al., 2012). In a more recent study, Byrd, McGill and Usler (2015) implemented vocal and nonvocal tasks of nonword repetition and nonword identification to explore the Phonological working memory capacity of adult who stutter. The identification of a target non-word from a subsequent set of three nonwords consists of a nonvocal nonword repetition task. The results concluded that AWS was less accurate in repeating nonwords in the initial attempt and AWS required more trails to repeat nonwords of increased syllable length accurately. However, no much difference was found between AWS and AWNS on nonvocal nonword repetition performance, this study suggested that subvocal rehearsal of nonwords in AWS is as adequate as in AWNS. The only on vocal nonword repetition task difference was found between vocal performance of these two groups which supported to the assumption of that AWS exhibit the inaccurate recall on nonword repetition task which is resulted from temporal instability in speech motor programming (Namasivayam & Van Lieshout, 2008; Smith et al., 2010;Byrd et al., 2012).

Byrd et al. (2012) explored adults who stutter phonological working memory using a phoneme elision function and nonword repetition. 14 AWS participants and 14 age and gender-matched AWNS participants were considered. The participants were instructed to repeat a set of 12 nonwords across four-syllable lengths (2, 3, 4, and 7 syllable for the nonword repetition task. The participants were repeated the same set of nonwords at each syllable length for the phoneme elision task, but were eliminated with a given target phoneme. In their initial attempts in the production of the longest nonwords (i.e., 7 syllable) AWS was found to be less successful relative to AWNS. The groups were compared in nonword repetition performance across the other syllable lengths. AWS also required a more number of attempts to produce 7-syllable nonwords accurately than adults who do not stutter. For the phoneme elision task, there was no significant interaction between group and syllable length. The authors interpreted the group differences in repeating the 7-syllable nonwords to suggest phonological working memory deficits in AWS.

Sugathan and Maruthy (2020) estimated the phonological working memory (PWM) abilities who implemented nonword repetition task and nonword identification tasks and its interaction with speech motor control in school-aged 17 children who do stutter (CWS) (Age range 7-12) and 17 gender and age-matched CWS. Less accuracy seen on the initial production of nonwords in CWS and more number of attempts required to CWS to accurately repeat the nonword. And also less accuracy found in CWS than CWNS in nonword identification task. The study results suggested that, in addition to limitations in PWM capacity, CWS has an unstable speech motor control system which may lead to dysfluent speech.

While most studies in the stuttering literature were used to test PWM skills in a person who stuttered the accuracy of nonword repetition task, a few studies have attempted to investigate how reduced working memory leads to speech dysfluencies by studying the effect of nonword syllable length on speech fluency.

Sasisekaran and Weathers (2019)investigated the processes by testing the effects of non-word length in syllables (3-, 4-, 6-syllable), phonotactics, and phonemic/phonetic complexity on dysfluencies and phonological revisions in school-age children who stutter (CWS, *n* = 13) and matched fluent controls (CWNS). Participants repeated non-words in two sessions separated by an hour. Test result revealed that significantly more dysfluencies for the

6 syllables- compared to the 3-syllables non-words and suggested that non-word length influences dysfluencies in the CWS. And also findings suggested that non-word lengths that place greater demands on phonological encoding, working memory, and speech motor demands, elicit more dysfluencies in school-age CWS. The findings failed to provide conclusive evidence that phonological complexity and phonotactics manipulations have a greater effect on dysfluencies in CWS compared to CWNS. The findings of significantly fewer phonological revisions and the lack of a significant correlation between dysfluencies and revisions in the CWS compared to the CWNS are interpreted to suggest reduced external auditory monitoring. Demands on incremental phonological encoding with increasing task complexity (the *Covert Repair Hypothesis*, Postma & Kolk, 1993) and reduced external auditory monitoring of stuttered speech can account for the dysfluencies, speech errors, and revisions in the speech of school-age CWS.

There were some data linking stuttering and phonological memory deficits. Bosshardt (1993) found that a serial short-term memory task AWS performed more poorly than normally fluent adults, and interpreted study results as suggested that adults who stutter have slower phonological encoding and rehearsal times. Ludlow, Siren and Zikria (1997) found that adults who stutter demonstrate more difficulty in learning novel phonological sequences than fluent speakers.

Coalson and Byrd (2017) Found Adults who stutter (AWS) were less accurate and more errors seen in recalling of iambic non-words than trochaic non-words in the absence of auditory cues compared to adults who do not stutter (AWNS). Fifty-two participants (26 AWS, 26 AWNS) participated in subjects produced 12 bisyllabic nonwords in the presence of corresponding auditory-orthographic cues (i.e., immediate repetition task), and the absence of auditory-orthographic cues (i.e., short-term recall task). Half of each cohort (13 AWS, 13

AWNS) were exposed to the stimuli with high-frequency trochaic stress, and half (13 AWS, 13 AWNS) were exposed to identical stimuli with lower-frequency iambic stress. These findings suggest greater vulnerability in phonological working memory in AWS, even when producing nonwords as short as two syllables.

1. **Nonword repetition in CWS**

For a case in point, Hakim and Ratner (2004) studied CWS in terms of fluency using nonword repetition task across 2-, 3-, 4-, and 5-syllable length and a comparison was made. The results revealed reduced fluency with an raise in syllable length in a few participants, whereas no sensitivity to an raise in syllable length was witnessed in the fluency of remaining participants. A dissimilarity was found in the study done by Anderson et al. (2006) in contrary to the above study who stated that the CWS experienced a problem in replicating 2- and 3-syllable nonwords which was not obvious in children's fluency of production. Of late, Sasisekaran and Weathers (2019) reported fluency of speech in young CWS between 8 and 15 years and the outcome of nonword length was determined. On the NWR task, CWS expressed disfluencies almost double the percentage at 6-syllable level which was compared to 3- and 4-syllable levels. These results of comparable rates of disfluencies between 3- and 4-syllable nonwords confirmed Anderson et al. (2006) findings which showed a dearth of systematic effect of nonword repetition of these lengths in fluency. The results were interpreted as higher demand on planning of speech and production element in CWS for nonword repetition of 6-syllable (Logan & Conture, 1995; Logan & LaSalle, 1999; Sawyer et al., 2008; Weiss & Zebrowski, 1992). Because of this review, it is comprehensible that the primary processes which contribute to the difficulty in CWS experience in repeating nonwords accurately are not well understood, and the results were mixed in nature. It is also a probability that in children and adults who stutter exhibited as a speech motor control deficits. Hence, PWM is not solely contributing to group differences in nonword repetition tasks (Sasisekaran & Weisberg, 2014; Sasisekaran et al., 2010; Smith et al., 2010). This study that estimated the association between the nonword repetition and CWS's fluency report that even with a greater difficulty face by them in repeating nonword with more level of syllables and the increased in task complexity of NWR did not affect the fluency during nonword repetition (Anderson et al., 2006; Hakim & Ratner, 2004; Oyoun et al., 2010).

Smith et al. (2010) assessed the speech motor control and phonological processes which provide behavioral and kinematic measures using nonword repetition. The accuracy of the nonword repetition behavior of CWS was compared to that of CWNS. However, the variability observed in higher lip aperture found in CWS than CWNS on kinematic measure revealed a lag in speech motor control maturation in these children. Based on the above explanations, the authors suggested that the variability in the performance among the two groups were not due to the PWM constraints but the difference found due to speech motor difficulties on nonword repetition tasks.

Hakim and Ratner (2004) study revealed that children who stutter (CWS) will have less well-developed language skills than fluent children, and disfluencies can be seen due to such relative linguistic deficiencies. The children's linguistic abilities can be measured by the Nonword repetition task which is a more sensitive measurement. In this exploratory study, 8 CWS (mean age 5:10, range 4:3–8:4) were compared to 8 typically developing children (mean age 5:9, range 4:1–8:4) for their skills in repeating the non-words of the Children's Test of Nonword Repetition (*CNRep*). Stimuli consist of 40 nonsense words: 10 words each of length 2, 3, 4, and 5 syllables. Along with these 40 stimuli, the ten 4-syllable nonwords of the *CNRep* was incorporated with a varied stress pattern; stress was placed on the final syllable. The CWS displayed poor performance than NS on the measuring the accuracy of words and Number of Phoneme Errors at all non-word lengths. Though the statistical differences were found only for 3-syllable nonwords with increasing nonword length fluency for the CWS group did not change. This research concluded that the ability shown to recall and/or replicate novel phonological sequences in stuttering children has diminished.

2. **Nonword repetition in AWS**

Several studies have implemented nonwords to investigate cognitive-linguistic and motoric processing in AWS. Sasisekaran (2013) investigated nonword repetition(NWR) and a nonword reading task were used to determine the behavioral (speech accuracy) and speech kinematic (movement variability measured as lip aperture variability index; speech duration) profiles of groups of 9 young AWS and 9 control group. Participants were made to repeat the nonwords in NWR (varying in length of the nonwords 1–4 syllables) and in nonword reading task subjects were made to read out the target nonwords varying in length (6 vs 11 syllable) only for the nonword reading task, the groups were compared in movement variability and speech duration. Findings suggested that AWS showed a lower percentage of accurate productions compared to the control group in nonword reading. AWS also showed significantly higher movement variability and longer speech durations compared to the control group in nonword reading. Study concluded that behavioral differences in nonword repetition and reading performances in AWS seem more likely to emerge when the nonwords are sufficiently challenging (e.g., longer nonwords) and multiple processes may be implicated under such circumstances, and group differences in movement variability and speech duration were evident even for the shorter nonwords suggesting that an unstable speech motor system may be a default characteristic in AWS. The speech kinematic measures which are much more sensitive indicates of nonword performance differences in AWS.

Sasisekaran (2013) study in which nonword repetition and nonword reading task were used to investigate the behavioral (speech accuracy) and speech kinematic (movement variability measured as lip aperture variability index; speech duration) total 18 subjects have participated and 9 participants in each group of AWS and AWNS for the nonword repetition task, participants were administered the Nonword Repetition Test (Dollaghan & Campbell,1998). For the reading task, participants were had to read out target nonwords varying in length (6 vs.11syllables). Findings from nonword reading revealed that a trend for the AWS to shown a lower percentage of accuracy in production compared to the control group. AWS also showed significantly higher movement variability and longer speech durations compared to the AWS in nonword reading. Differences found between AWS and control groups in phonemic encoding and /or planning and production of speech motor.

The nonword repetition task is primarily used for testing phonological encoding abilities in adults who stutter (Gupta, 2003). The major source of phonological complexity in upsetting the balance of adult speech motor systems was explored by examining the efficiency of 17 AWS and 17 matched control participants on the NWR task, the non-words varied in phonological complexity and length. The behavioral findings showed that there were no differences in the accuracy of nonword repetition between the stuttering and normally fluent groups. In contrast, in the kinematic results, drastic differences between groups were observed. Consistency indexes of inter-articulator coordination indicated that AWS displayed less consistency in their coordination behaviors over repeated productions. With the increasing length and complexity of non-words, discrepancies in co-ordinative consistency between groups have become more prominent. Coordination consistency tests indicated that AWS (but not normally fluent adults) demonstrated practice effects within-session; their coordinative performance increased five times later compared to five previous productions. At a slower rate adults who stutter produced the non-words, but in the later trails, both groups showed increased production rates, suggesting a practice effect for both groups for the duration. Smith et al. (2010) concluded that, while the AWS performed behaviorally with the same accuracy as typical fluent adults, the nonword repetition task showed significant differences in the speech motor mechanisms underlying fluent speech output in adults who stutter relative to their normally fluent peers. These findings support a multifactorial, dynamic stuttering model, in which linguistic complexity and length of utterance are variables that contribute to the probability of speech motor system breakdown.

Some of the studies have reported behavioral measures (Byrd, Vallely, Anderson, & Sussman, 2012; Ludlow, Siren, & Zikria, 1997), while some others have reported kinematic measures of task performance(e.g., Namasivayam & VanLieshout, 2008; Smith et al., 2010).

Behavioral studies

Behavioral studies of nonword repetition in adults who stutter (AWS) Ludlow et al. (1997) study tested the speech learning abilities of adults who stutter (AWS) using a nonword repetition task. Five AWS and five typically fluent speakers were considered in the study. Participants have repeated two lengthy nonwords multiple times. AWS did not show much improvement in the percentage of accurate response in repeated production of the two novel words. The authors interpreted the difference in practice effect to support the assumption that AWS has phonological encoding deficits.

Kinematic studies

Kinematic studies of nonword repetition in adults Namasivayam and van Lieshout (2008) five AWS and typically fluent speakers were considered to speech motor learning and practice effects in the investigation the temporal and spatial variability of a cyclic pattern of the lower lip, jaw and upper lip trajectories associated with multiple repetitions of two simple bisyllabic nonword /bapi/ and /bipa/-in three sessions over several days. The study revealed that AWS exhibited less evident effects of practice as higher variability of movement and

AWS demonstrated reduced strength of inter-gestural coupling between bilabial closure and tongue body gestures over days as opposed to control group participants.

Smith, Sadagopan, Walsh, and Weber-Fox's (2010) study on the role of phonological complexity in destabilizing the speech motor systems of adults who stutter (AWS) was explored the performance of 17 adults who stutter and 17 matched control participants on a nonword repetition task. The nonwords varied in length and phonological complexity. The test included 16 nonwords of 1–4 syllables in length and responses were scored as percent phonemes correct for the nonwords of each length. Behavioral results revealed that no differences found between the stuttering and normally fluent groups on the accuracy of nonword repetition. In contrast, dramatic differences were observed between groups in the kinematic data. Indices of the consistency of inter-articulator coordination showed that adults who stutter were much reduced consistently in their coordinative patterns over repeated productions of nonwords with increasing length and complexity of the nonwords, Coordination consistency measures revealed that adults who stutter (but not normally fluent adults) exhibited within-session practice effects; their coordinative consistency improved in five later compared to five earlier productions. Adults who stutter produced the nonwords at a slower rate, but both groups showed increased rates of production on the later trials, this indicated a practice effect for duration in both groups. Researchers concluded that, though the adults who stutter performed behaviorally with the same accuracy as normally fluent adults, the nonword repetition task revealed significant differences in the speech motor dynamics underlying fluent speech production in adults who stutter compared to their normally fluent peers. These results supported a multifactorial, dynamic model of stuttering in which linguistic complexity and utterance length are factors that contributed to the probability of breakdown of the speech motor system.

Assessment of Nonword repetition in the Indian context

In the Indian context, Somy (2008) investigated nonword repetition skills in 5-6yrs old Kannada speaking children with and without stuttering using non-word repetition task (bi and tri syllables). The number of phonemes correct on a nonword repetition task compared to word repetition task determined the response during word/non-word repetition task as the word/nonword length (in syllables) increased. The experiment concluded that CWS performed poorly than CWNS in the number of phonemes correct on a non-word repetition task compared to word repetition task and also found that in general both the CWS and CWNS have difficulty on non-word repetition tasks than the word repetition task.

Sweta (2012) interpreted phonological processing and speech motor control in bilingual person who stutters by using a list of non-word for repetition task (bi and trisyllabic words) in both Hindi and English(L2) by using two experimental tasks, that are nonword repetition task and tongue twister repetition task. The researcher concluded greater differences between AWNS and AWS for reaction time, total duration of stimuli, and several correct responses. To length, type of words, and language both AWNS and AWS had more problems while producing tri-syllabic compared to bi-syllabic stimuli and no overall language effect was seen in AWNS and AWS for nonword repetition task. For tongue twister repetition task both AWNS and AWS had breakdown of fluency while saying more motoric complexity in tongue twister repetition task.

To summarize on investigating of nonword repetition in CWS were performed poorer than CWNS in number of phoneme correct (bi 7 tri syllable), and also concluded that CWS and CWNS had difficulty in nonword repetition task than word repetition task. Study using nonword repetition (bi and tri syllable) nonword repetition and tongue twister repetition task, for reaction time, total duration of stimuli and several correct responses, the difference found to be more between AWS and AWNS, also in which phonological processing and speech motor control in bilingual person who stutters was determined. Both BAWS and BAWNS had more problems in producing tri syllable nonwords than bi syllables, findings revealed that both BAWS and BAWNS showed difficulty in length, type of word and language. These studies conclude that person who stutters perform poorer than a person who does not stutter in the nonword repetition task.

CHAPTER III

METHOD

The present study was aimed to measure phonological encoding abilities through non-word repetition task in adults who stutter. All the samples were audio-recorded in PRAAT software

Participants

A total of 50 participants in the age range 18 to 35years were considered in the study. Among those 25 adults who stutter (24 males and 1 female) and 25 adults who do not stutter age and gender-matched were included.

Inclusion criteria for selection of AWS: In this group, only those subjects were selected who were,

i. Native Kannada speakers
ii. diagnosed by speech-language pathologist as a stuttering with the mild severity and above the degree of severity
iii. No history of speech and /or language disorder (except stuttering) were considered in the study. Other aspects such as neurological, social, sensory issues, emotional, or psychiatric disturbance were ruled out in all the participants

Inclusion criteria for selection of AWNS

i. Twenty-five age-matched and gender-matched AWNS were included in the study
ii. All the participants were Kannada native speakers
iii. Participants have had no history of speech and /or language disorder, with no neurological, social, sensory issues, emotional, or psychiatric disturbance.

Ethical standards used in the study

- Each of the subjects selected in the study were briefed about the study, its aim, method, and duration of testing.
- An informed verbal and written consent from each participant were taken before the testing.

Materials

The materials used in the study included:

- Stuttering severity instrument –4 (SSI-4) (Riley,2009)
- Word and Nonword repetition test for children in Kannada (Swapna,2011)
- Montreal cognitive assessment (MOCA) (version 7.1 Kannada version)
- Laptop with Headphones
- DMDX software
- PRAAT software

Procedure

The experiment of the present study included 2 phases

Phase 1: Task design programming

Practice nonword and test nonword list of 4 syllables and 5 syllables were considered from ‘Word and Nonword repetition test for children in Kannada’ (Swapna, 2011). A list of 22 nonwords was pre-recorded using PRAAT software by native Kannada speaker in a sound-proofed room, at the appropriate intensity**.** The experimental word list was programmed using DMDX software.

Actual experiment included 2 conditions

- Vocal condition
- Non-vocal condition

For vocal condition, 1 practice non-word and 10 test non-words were audio-recorded using PRAAT software and programmed in DMDX software. And for non-vocal condition (initial target non-word and subsequent set of 3 non-words was audio-recorded using PRAAT software and programmed in DMDX software. Each non-word was presented for 1000ms in both the conditions.

Pilot study

The pilot study was conducted on 3 SLP's using DMDX software after programming the 2 conditions. To confirm the inter-stimulus interval and to determine the length of the experimental sessions for both vocal and nonvocal non-word repetition tasks. While doing a pilot study,30 minutes taken by each participant to complete the entire experiment. The necessity of the rest time for both conditions was also established during the testing in and around the blocks.

Phase 2: Administration of standardized test and non-word repetition task

Each of the subjects was tested individually. Montreal cognitive assessment (MOCA) (version 7.1 Kannada version) was administered to all the subjects to assess cognitive skills. Stuttering Severity Instrument-4 (Riley,2009) was administered to assess the degrees of severity for the clinical group population with stuttering.

Actual experiment includes 2 conditions

- **Vocal condition**
- **Non-vocal condition**

In both the above-mentioned condition the subjects were made to sit in a distraction-free environment and subjects were made to wear headphones which was connected to ‘Lenovo IdeaPad 320’ laptop. Subjects were given instructions about the task**.**

Vocal condition

During vocal condition participants were instructed to listen to the set of 4 syllables and 5 syllable nonwords and to repeat each of the items in both the set verbally as accurately and immediately as it presented. Practice trials for familiarizing the non-word list for both sets before the presentation of test stimuli were provided. During the practice trail, Once the participant repeats the non- word correctly with repeated attempts following (10) 4 syllables and (10) 5-syllables test nonword stimuli was presented.

The recorded non-word list was presented through headphones for both sets stimuli. The order of the presentation for both sets of non-word stimuli was counterbalanced across participants for both AWS and AWNS groups. Participant responses were audio-recorded using DMDX software.

Non-vocal condition

Non-vocal condition provides valuable insight into the phonological loop sub-vocal rehearsal system of participants without the influence of overt motor speech movement. During this condition, participants were instructed to pay attention to an audio stimulus which includes the initial target non-word, then subjects were made to identify the target non-word silently from a subsequent set of three non-words. One of the three non-words played was identical to the initial target non-word, the other two non-words were not identical to target nonword. After each presentation set, the participant was made to press a button “1,” “2,” or “3” to indicate selection of the first, second, or third identical non-word, respectively. In specific, participants were instructed that “You are about to hear a non-word and this nonword will be followed by three (one identical and two contrasting) additional non-word, press the appropriate button that matches to the target non-word".

Before the presentation of test stimuli practice trials for familiarizing the non-word list for both sets were provided. During the practice trail, Once the participant selects the correct subsequent non-word button that matches with the target non-word, the following (10) 4 syllables and (10) 5-syllables test nonword stimuli was presented. The recorded non-word list was presented through headphones for both sets. The order of the presentation for both sets of non-word stimuli was counterbalanced across participants for both AWS and AWNS groups.

Scoring

Vocal condition

The participants' responses were recorded automatically in DMDX and reaction time and accuracy was measured manually by using CheckVocal software. Production of dysfluencies, such as sound/syllable repetition and prolongation were considered for analysis.

Non-vocal Condition

The accuracy and reaction time of subjects response was calculated and noted down automatically using DMDX software.

Analysis

For analysis, the score obtained was tabulated under different headings, as follows;

VC4A- number of accurate 4-syllable non-words in vocal condition

VC4RT- score obtained for reaction time of 4-syllable non-words in vocal condition

VC5A- number of accurate 5-syllable non-words in vocal condition

VC5RT- score obtained for reaction time of 5-syllable non-words in vocal condition

NVC4A- number of accurate 5-syllable non-words in non-vocal condition

NVC4RT- score obtained for reaction time of 4-syllable non-words in non-vocal condition

NVC5A- number of accurate 5-syllable non-words in non-vocal condition

NVC5RT- score obtained for reaction time of 5-syllable non-words in non-vocal condition

The obtained data was subjected to statistical analysis using the ‘‘SPSS 20’’ software. Statistical tests such as Kolmogorov-Smirnov test and Shapiro-Wilk to assessing normality. And Mann-Whitney test, Wilcoxon Signed Rank Test was carried out to answer the research question.

Test-retest reliability

In the present study to check reliability, the test was re-administered on randomly selected10 participants (5 AWS and 5 AWNS) after a span of one week of post-initial test.

The vocal and nonvocal condition of 4syllable and 5 syllable in nonword repetition task Acceptable level of reliability was obtained for participants. Cronbach's alpha coefficient was used to obtain the reliability; intra judge reliability range from 0.75 to 0.93 for AWNS and 0.80 to 0.90 for AWS was obtained by indicating good reliability.

CHAPTER IV

RESULTS AND DISCUSSION

The current study estimated the phonological encoding abilities through non-word repetition tasks in AWS and AWNS. An attempt was made to estimate the accuracy and reaction time of the participants' responses in the nonword repetition task which included vocal and non-vocal conditions. For both the conditions, analysis and comparison were made across the groups and within the groups. Accuracy and reaction time were measured for nonwords with 4 syllables and 5 syllables. And compare of accuracy and reaction time were made across degrees of severity. The data obtained in both the conditions were analyzed and averaged using statistical measures in SPSS software version 20.

- Descriptive statistics were carried out to calculate the mean, median and standard deviation of data obtained from nonword repetition task in vocal and non-vocal condition.
- Kolmgorov-Smirnov and Shapiro-Wilk test was done to check the normality of data obtained to measure reaction time and accuracy.
- Mann-Whitney test was done to check if there is a significant difference in reaction time and accuracy for both syllable length i.e. 4syllable and 5 syllable nonword between groups.
- Wilcoxon Signed Ranks test was done to check if there's a significant difference in reaction time and accuracy for both syllable length i.e. 4syllable and 5 syllable nonword within groups.
- Kruskal Wallis test was carried out to compare accuracy and reaction time across degrees of severity in AWS.

The results are as explained below

- **a)** Comparison of reaction time in vocal condition for 4 syllable and 5 syllable nonwords between AWS and AWNS groups
- **b)** Comparison of reaction time for non-vocal condition of 4 syllables and 5 syllables between AWS and AWNS groups.
- **c)** Comparison of accuracy in vocal condition for 4 syllable between AWS and AWNS groups
- **d)** Comparison of accuracy in nonvocal condition for 4 syllable and 5 syllable nonwords between AWS and AWNS groups
- **e)** Comparison of reaction time and accuracy in vocal condition for 4 syllables and 5 syllable nonwords within AWS and AWNS groups
- **f)** Comparison of reaction time and accuracy in non-vocal condition for 4 syllables and 5 syllable nonwords within AWS and AWNS groups
- **g)** Comparison of reaction time in vocal condition and non-vocal condition for 4 syllable and 5 syllable across degrees of severity for non-word repetition task in AWS
- **h)** Comparison of accuracy in vocal and non-vocal condition for 4 syllable and 5 syllable across degrees of severity for non-word repetition task in AWS
- **i)** Comparison of reaction time in vocal condition for 4 syllable and 5 syllable across degrees of mild and moderate stuttering, moderate and severe stuttering, mild and severe stuttering for non-word repetition task in AWS
- **j)** Comparison of accuracy in vocal condition for 4 syllable and 5 syllable across degrees of mild and moderate stuttering, moderate and severe stuttering, mild and severe stuttering for non-word repetition task in AWS

Vocal condition: Reaction time

a) **Comparison of reaction time in vocal condition for 4 syllable and 5 syllable nonwords between AWS and AWNS groups**

The data was subjected to Kolmgorov-Smirnov and Shapiro-Wilk test to check normality and tests revealed that data does not follow normal distribution i.e. $p<0.05$. As both the groups were not normally distributed, a non-parametric test Mann Whitney U test was carried out to compare the difference between two independent groups i.e. AWS and AWNS. Results revealed AWS took more time to respond than AWNS for 4 syllable and 5 syllable nonword repetition task. And the findings revealed statistically significant difference for 4 syllables (/z/=5.96, p =0.00) and 5syllables (/z/= 6.00, p =0.00) for both the groups. Therefore, on comparing the values of mean, median and SD values of the vocal condition of 4syllable listed in table 4.1 and mean, median and SD values of vocal condition of 5 syllables listed in table 4.2 statistically difference were found for reaction time in vocal condition of 4syllables and 5 syllables nonwords between AWS and AWNS groups. In vocal condition out of twenty four out of twenty five AWS were considered for evaluating reaction time, because one AWS had dysfluencies at all 4 syllables and 5 syllables of vocal condition, in nonword repetition task. Greater reaction time was seen in AWS and was almost double the time taken by AWNS in vocal condition for 4 syllables and 5 syllables non-word repetition task. Standard deviation was higher for AWS than AWNS indicating that higher variability in AWS. According to Starkweather, Franklin and Smigo (1984) PWS exhibit slower reaction time than PWNS in vocal and manual reaction time task, which is similar to the findings of present study.

Table 4.1: *Mean, SD and median values for reaction time measure for vocal condition of 4 syllable nonwords between AWS and AWNS*

Groups	Vocal condition of 4 syllable non-words					
	Reaction time					
	N	Mean	SD	Median	/z/ value	p value
AWS	24	1173.89	405.19	1014.98	5.96	0.00**
AWNS	25	550.74	69.20	535.37		

Note: **= significant at 0.001 level

Table 4.2: *Mean, SD and median values for reaction time measure for vocal condition of 5 syllable nonwords between AWS and AWNS*

Groups	Vocal condition of 5 syllable non-words					
	Reaction time					
	N	Mean	SD	Median	/z/ value	p value
AWS	24	1219.56	395.40	1064.28	6.00	0.00**
AWNS	25	620.07	67.19	610.43		

Note: **= significant at 0.001 level

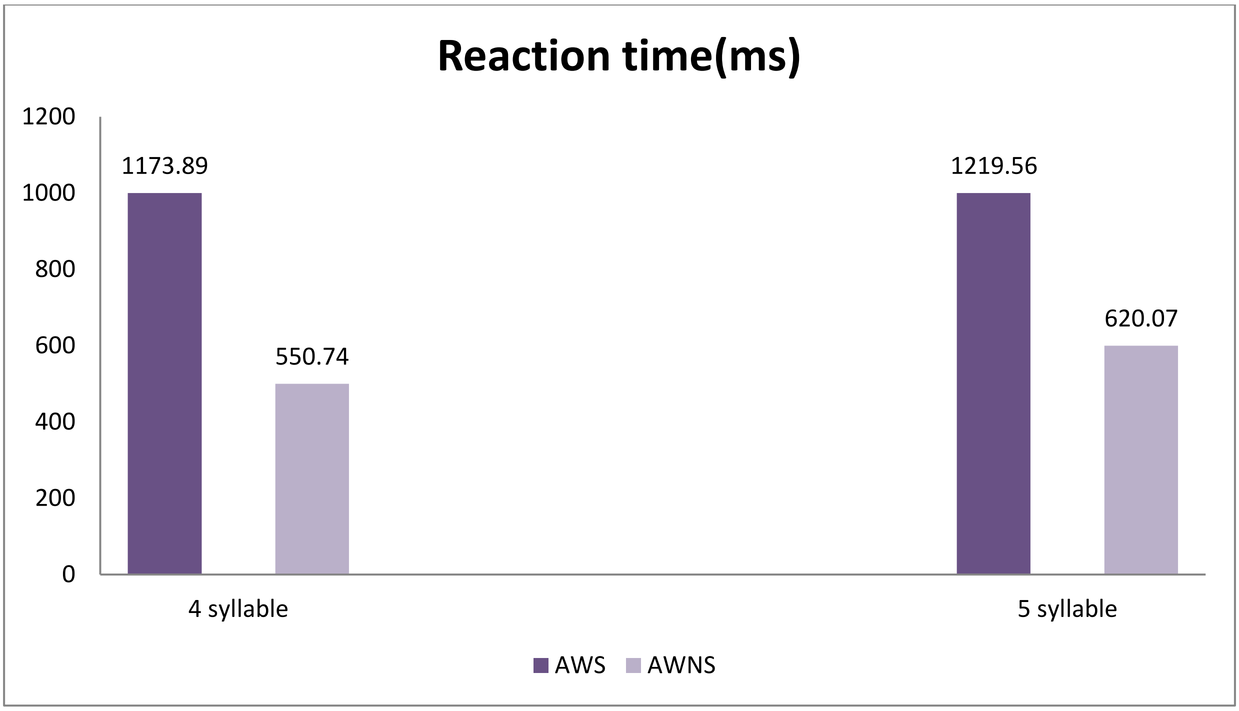

Figure 4.1: Mean values for reaction time measure of vocal condition of 4 syllables and 5 syllable nonwords between AWS and AWNS groups

In current study results found that greater reaction time in AWS than AWNS for 4 syllables and 5 syllable nonwords. In Indian context a study done by, Sangeetha and Geetha (2017) investigated phonological abilities in AWS whose results were in agreement with the study done by Sasisekaran et al. (2013) i.e. AWS may have generalized motor control deficit w.r.t to speech motor timing as they experience deficits in timing domain. According to Weber-Fox (2013) when there is less language demands, similar consistency is revealed in speech movements of AWS and AWNS. Whenever the linguistic demands of an utterance become complex, the extra processing demands affect the speech motor control system of adults who stutter to a greater degree than adults who do not stutter.

As a further support to the present study, Neuroimaging studies (Ackermann & Riecker, 2004; Yetkin et al., 1995) reported that covert speech activates a lot of the motor areas which are also involved in overt speech processes suggesting a phonetic plan for covert monitoring, For instance delayed in vocal condition non word repetition for 4 syllable and 5 syllable in AWS can be attributed to difficulties in phonological encoding which affect motor execution. Therefore, the results of current study could be related to the higher linguistic demands and phonological encoding deficits during the nonword repetition task would have led to the production of multisyllabic nonwords longer in time domain indicating speech motor control deficits in AWS.

Non-vocal condition: Reaction time

b) Comparison of reaction time for non-vocal condition of 4 syllables and 5 syllables between AWS and AWNS groups

In the non-vocal condition of 4 syllables and 5 syllable nonwords, statistical output revealed a significant difference for 4syllable (/z/=2.08, p=0.03) and 5 syllable (/z/=1.98, p=0.04) found in reaction time between both groups. On comparing the reaction time the mean, median and SD values of the non-vocal condition for 4 syllables listed in table 4.3, and mean, median and SD values of non-vocal condition for 5 syllables listed in table 4.4 for reaction time in nonvocal condition a significant statistical difference was found between AWS and AWNS.

Table 4.3 : *Mean, SD and median values for reaction time measure for non-vocal condition of 4 syllable nonwords between AWS and AWNS*

Groups	Non-vocal condition of 4 syllable non-words					
	Reaction time					
	N	Mean	SD	Median	/z/ value	p value
AWS	25	963.58	361.13	977.8	2.08	0.03*
AWNS	25	759.34	432.04	675.90		

Note : *=significant at 0.05 level

Table 4.4: *Mean, SD and median values for reaction time measure of non-vocal condition of 5 syllable nonwords between AWS and AWNS*

Groups	Non-vocal condition of 5 syllable non-words					
	Reaction time					
	N	Mean	SD	Median	/z/ value	p value
AWS	25	902.93	240.31	854.97	1.98	0.04*
AWNS	25	797.70	542.66	653.45		

Note : *=significant at 0.05 level

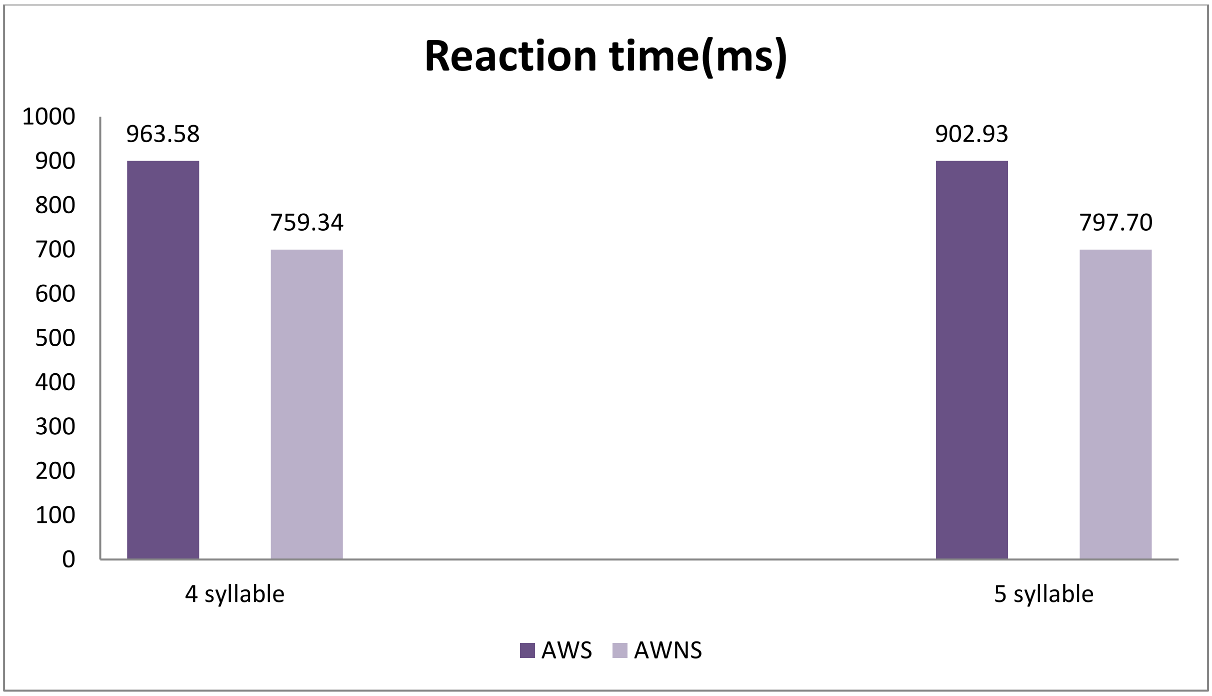

Figure 4.2: Mean values for reaction time measure of non-vocal condition of 4 syllables and 5 syllable nonwords between AWS and AWNS groups

As mentioned above there was statistically difference found for reaction time between two groups. AWS showed higher reaction time to repeat nonword than AWNS**.** Luper and Cross (1983) in their study found a higher finger reaction time (depressing the index finger of their preferred hand on a response key) and general motoric deficits in PWS than control group, the authors attributed this motoric deficit muscular tension to be the reason for slowed finger reaction time.

Rastatter and Dell (1985) suggested that higher reaction time in PWS compared to PWNS on a two choice reaction time wherein, they were asked to move their hands as quickly as possible to touch two of the picture following a presentation of the word through auditory mode. The authors here attributed the slower reaction time to delayed phonemic processing. Similar findings were found in the present study where the reaction time was longer in AWS compared to AWNS for 4 syllable and 5 syllable nonwords which could again be contributed to the delay in phonemic processing as well as the auditory delay seen in the individuals with stuttering. Daliri and Max (2015) conducted a study using auditory evoked potentials in which 12 individuals with stuttering and 12 individuals with no stuttering for tasks including both vocal and non-vocal conditions. The results revealed that a modulation in auditory processing was found in individuals with no stuttering which was statistically significant which was unlikely in individuals who had stuttering. This study offered electrophysiological evidence to the proposition of stuttering supporting the presence of dearth in modulating the cortical auditory system w.r.t speech production. Therefore, the current study's results could be considered to support the results obtained in the literature attributing to the deficits in auditory processing which could be present in these individuals who stutter.

According to a comparative study done by Sangeetha (2018) the reaction time was longer in Bilingual Adults with stuttering (BAWS) than Bilingual Adults with no stuttering (BAWNS) in a simple motor task and auditory tone. They were also slower on the phoneme monitoring task indicating a deficit in phonologic encoding and being hyper-vigilant w.r.t the task which could be the contributing factors according to the author. In the current study, similar factors could have affected the performance of the AWS which include the individuals being pressurized during the task and fail repair covert errors.

Vocal condition: Accuracy

c) Comparison of accuracy in vocal condition for 4 syllable and 5 syllable between AWS and AWNS groups

Study results revealed AWS respond less accurately than AWNS for 4 syllable and 5 syllable nonword repetition tasks. And findings revealed significant difference statistically for 4 syllable (/z/=4.30 , p=0.00) and 5syllable (/z/= 4.61 , p=0.00) in both the groups. The mean values of accuracy for the vocal condition of 4syllable is listed in table 4.5 and mean values of vocal condition of 5 syllable is listed in table 4.6. On comparing the two, a statistical difference was found for accuracy in vocal condition of 4 syllable and 5 syllable nonwords between AWS and AWNS groups. AWNS more accurately repeated 4 syllable and 5 syllable nonwords than AWS groups.

Table 4.5: *Mean, SD and median values for an accurate measure of vocal condition of 4 syllables nonwords between AWS and AWNS*

Groups	Vocal condition of 4 syllable non-words					
	Accuracy					
	N	Mean	SD	Median	/z/ value	p value
AWS	25	7.04	2.55	8.00	4.30	0.00*
AWNS	25	9.52	0.65	10.00		

Note: *= significant at 0.001 level

Table 4.6: *Mean, SD and median values for accurate measure of vocal condition of 5 syllable nonwords between AWS and AWNS*

Groups	Vocal condition of 5 syllable non-words					
	Accuracy					
	N	Mean	SD	Median	/z/ value	p value
AWS	25	5.64	2.48	6.00	4.61	0.00**
AWNS	25	8.60	1.04	9.00		

Note: **= significant at 0.001 level

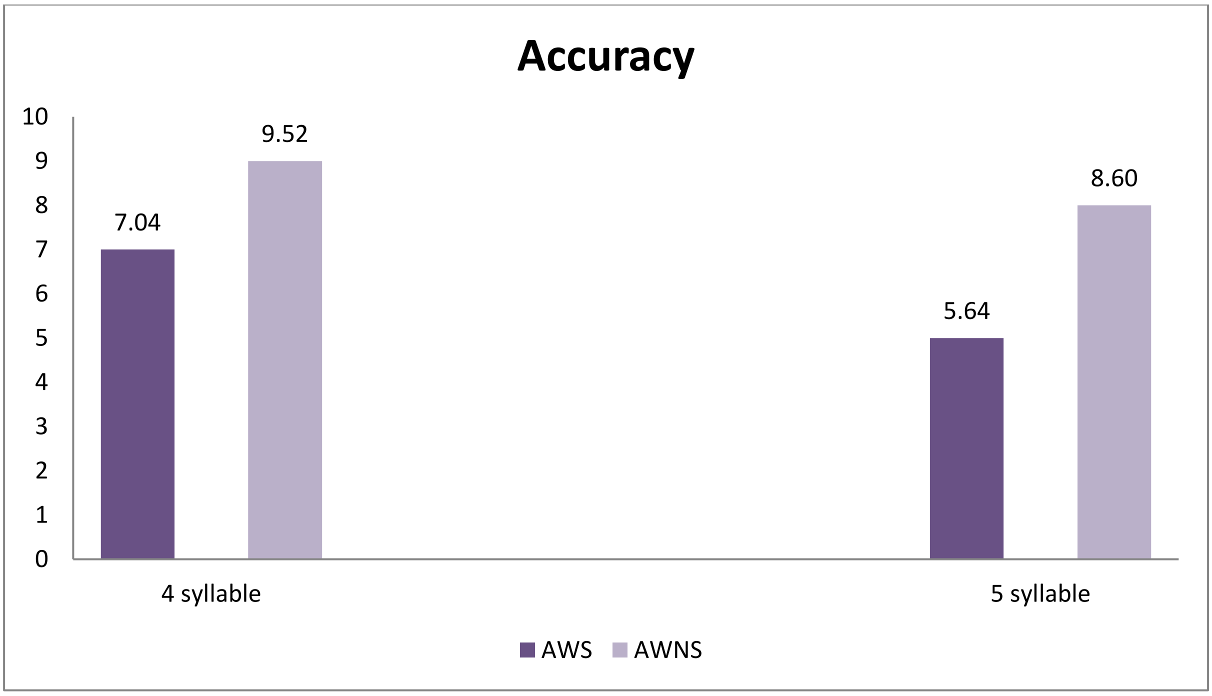

Figure 4.3: Mean values for an accurate measure of vocal condition of 4 syllables and 5 syllable nonwords between AWS and AWNS groups

The present study results are in agreement with findings of study done by Somy (2008) in which the repetition skills were measured in 5-6year old Kannada speaking children with and without stuttering using non-word repetition task (bi and tri syllables). The number of phonemes correct and no. of correct responses for word/ nonword repetition task were compared to word repetition task and the responses were determined. These responses were measured along the length (no. of syllables) of word/non-word repetition task. And the findings concluded that CWS performed poorly than CWNS on word/non-word repetition task and also had poor responses when compared to the CWNS. Therefore, in the current study the responses w.r.t accuracy obtained in the vocal condition could be attributed to the length of syllables (4 syllable and 5syllable). Lengthier the phonemes/syllables, the linguistic demand is higher leading to poor phonemic encoding and hence the poor execution.

Non-vocal condition: Accuracy

d) Comparison of accuracy in nonvocal condition for 4 syllable and 5 syllable nonwords between AWS and AWNS groups

In non-vocal condition results revealed no significant difference statistically in 4 syllable (/z/= 0.26 , p=0.79) and 5syllable (/z/=0.79, p=0.42) for both the groups. Thus, on comparing the mean, median and SD values of accuracy for the non-vocal condition of 4 syllable listed in table 4.7 and mean, median and SD values of vocal condition of 5 syllable listed in table 4.8, and no significant difference found for accuracy in non-vocal condition of 4syllable and 5 syllable non-words between AWS and AWNS groups. But comparing mean value, accuracy is more in AWNS than AWS for 4syllable and 5 syllable non-words in both the groups.

Table 4.7: *Mean, SD and median values for accurate measure of non-vocal condition of 4 syllable nonwords between AWS and AWNS*

Groups Non-vocal condition of 4 syllable non-words

	Accuracy					
	N	Mean	SD	Median	/z/ value	p value
AWS	25	8.80	1.97	10.00	0.26	0.79
AWNS	25	9.08	1.03	10.00		

Table 4.8: *Mean, SD and median values for accurate measure of non-vocal condition of 5 syllable nonwords between AWS and AWNS*

Groups Non-vocal condition of 5 syllable non-words

	Accuracy					
	N	Mean	SD	Median	/z/ value	p value
AWS	25	8.16	2.49	9.00	0.79	0.42
AWNS	25	9.12	1.01	9.00		

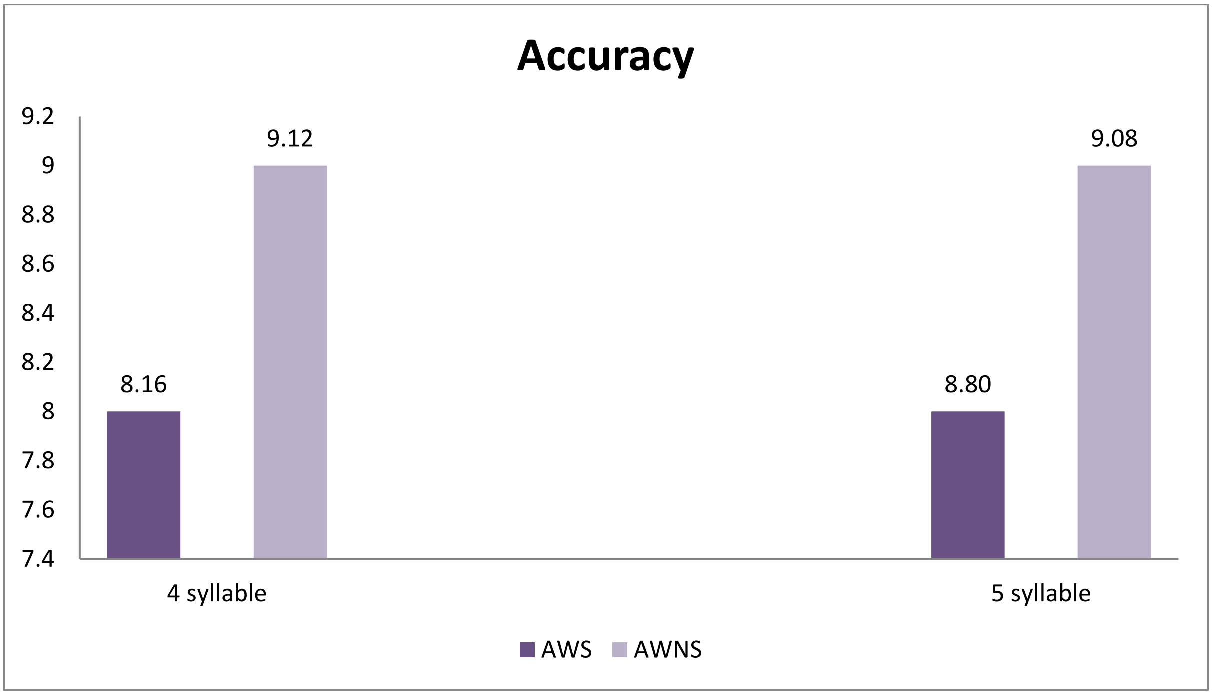

Figure 4.4: Mean values for accurate measure of non-vocal condition of 4 syllables and 5 syllable nonwords between AWS and AWNS groups

Few studies done in PWS showed that these individuals exhibited lesser accuracy during bimanual finger coordination task (Zelaznik, Smith, Franz & Ho, 1997) and self-paced tapping (Cooper & Allen, 1977). Also, a study conducted by Goldberg (1985) suggested that PWS performed poorly in synchronizing a rhythmic auditory stimulus when compared to that of PWNS. The authors indicated that this poor performance seen in PWS could be accredited to the basal ganglia (BG) and supplementary motor area (SMA) failing to create 'internal' timing cues for perception of beats in terms leading to poor accuracy. Therefore, the same reasons could be attributing in the current study when a nonvocal task is given. The individual may have limited cue for perception of the stimulus and hence, hamper the accuracy of the responses.

e) Comparison of reaction time and accuracy in vocal condition for 4 syllables and 5 syllable nonwords within AWS and AWNS

In vocal condition, to compare the reaction time and accuracy for 4 syllables and 5 syllables within both the groups, Wilcoxon Signed Rank test was carried out. The results revealed a significant difference statistically for Reaction time (AWS: /z/=2.25, p=0.02, AWNS: /z/=4.27, p =0.00). Table 4.9 indicates mean values for reaction time measure of vocal condition of 4 syllables and 5 syllable nonwords within AWS and AWNS and accuracy (AWS: /z/=3.45, p =0.00, AWNS: /z/=3.45, p =0.00) Table 4.10 represents mean values for an accurate measure of vocal condition of 4 syllables and 5 syllable nonwords within AWS and AWNS.

Table 4.9: *Mean values for reaction time measure of vocal condition of 4 syllables and 5 syllable nonwords within AWS and AWNS*

Vocal condition								
	AWS				AWNS			
	N	Reaction time (Mean)	/z/ value	p value	N	Reaction time(Mean)	/z/ value	p value
4 syllable	24	1173.89	2.25	0.02*	25	550.74	4.26	0.00**
5 syllable	24	1219.56			25	620.07		

Note : *=significant at 0.05 level **= significant at 0.001 level

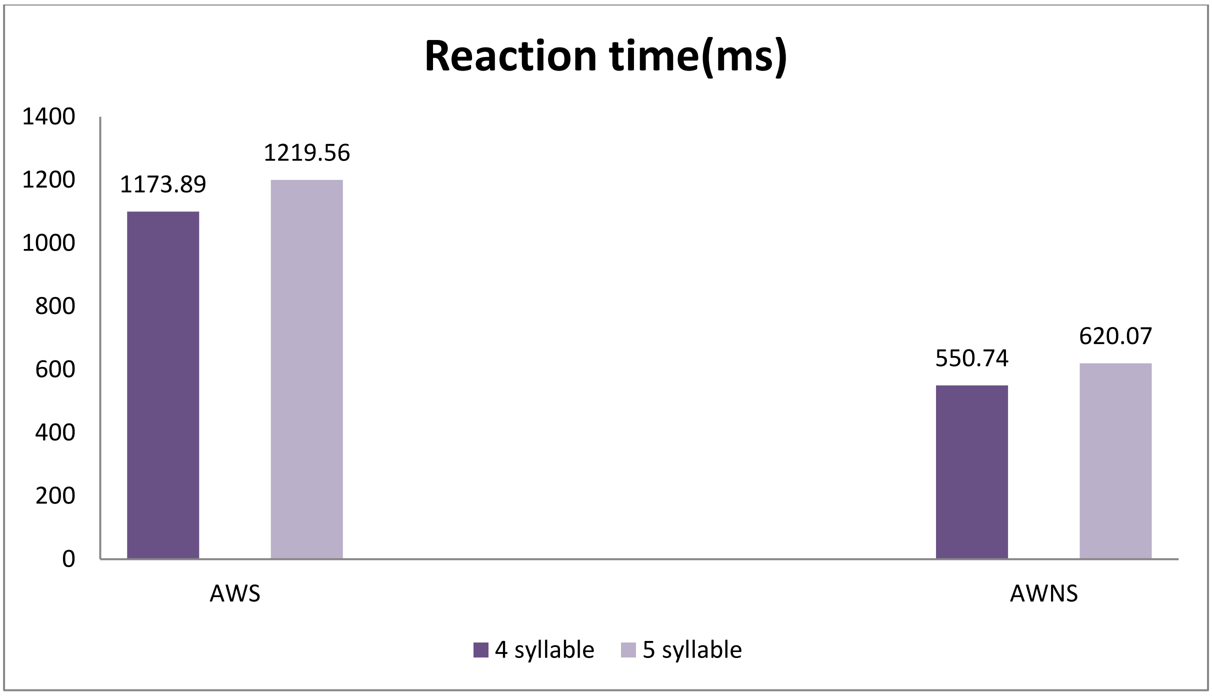

Figure 4.5: Mean values for reaction time in vocal condition for 4 syllable and 5 syllable nonwords within AWS and AWNS

The present study's result revealed that more reaction time was taken to repeat 5 syllable nonwords than 4 syllables in both the groups. Studies done by Gaines, Runyan, and Meyrs (1991); Logan and Conture (1995) revealed that where there is increase in both complexity and length, there is a decline in fluency recorded. Studies which support the present study findings (Adams, 1990; Andrews & Neilson, 1981; Kelly & Conture, 1992; Peters & Starkweather, 1990; Postma, Kolk, & Povel, 1990b; Starkweather, 1987; Starkweather & Gottwald, 1990) report that the speech fluency breakdowns are often more likely to take place in an utterance where the task demands increased level of performance. Also, another reason strong reason supporting the delay in reaction time for vocal condition in adults who stutter could be, the reduced adeptness in phonological encoding skills.

The results revealed that stuttering group was much slower in terms of reaction time w.r.t speech when compared to AWNS. Additionally, there was a significant effect of length which showed that the utterance production took longer duration in AWS when compared to AWNS. These two results are interpreted as supporting the earlier argument that delicate speech motor system in AWS is less efficient in dealing with complexity of the task.

Table 4.10: *Mean values for an accurate measure of vocal condition of 4 syllables and 5 syllable nonwords within AWS and AWNS*

Vocal condition								
	AWS				AWNS			
	N	Accuracy (mean)	/z/ value	p value	N	Accuracy (mean)	/z/ value	p value
4 syllable	25	7.04	3.45	0.01*	25	9.52	3.45	0.01*
5 syllable	25	5.64			25	8.60		

Note : *=significant at 0.05 level

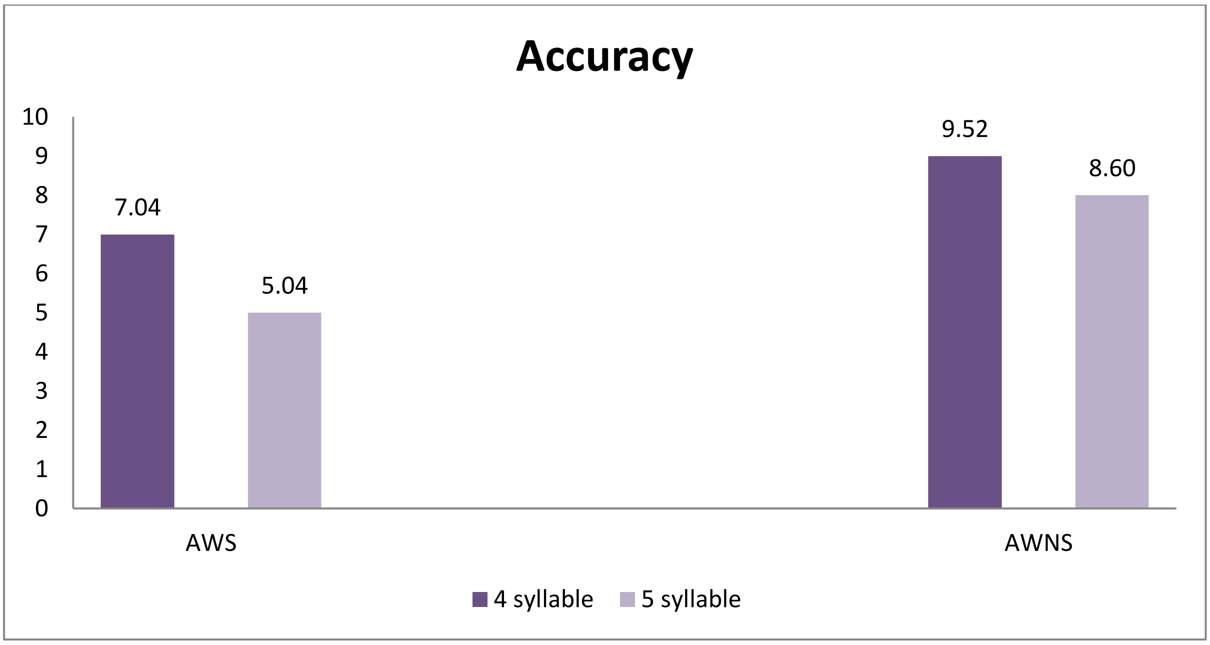

Figure 4.6**:** Mean values for accuracy in vocal condition for 4 syllable and 5 syllable nonwords within AWS and AWNS

Earlier nonword repetition studies have suggested mixed results, especially in the behavioral domain (Byrd et al., 2012; Ludlowetal, 1997; Smith et al., 2010), but based on the results of these studies, possible hypothesis is that with longer and more complex nonwords AWS are likely to experience greater difficulties. In the present study, participants', accuracy were compared in vocal condition at 4 syllable and 5 syllable nonwords within AWS and AWNS. Findings revealed that a higher accuracy for 4syllable than 5 syllables in vocal condition was obtained for nonword repetition task within AWS and AWNS.

The present study results replicate the study done by Smith, Sadagopan, Walsh, and Weber-Fox (2010) where they reported more inaccuracy observed in repetition of lengthy nonwords in AWS who also exhibited elevated articulatory incoordination in phonologically complex nonwords when compared to AWNS. Byrd et al. (2015) in their study concluded that AWS produced lesser accuracy in initial production of 7syllable over the 4 syllable nonwords when compared to AWNS. Therefore, the above results from the present study could be attributed to the deficit reported in the literature i.e. phonological encoding abilities as well as deficit in repairing the error covertly to execute appropriate production.

f) Comparison of reaction time and accuracy in non-vocal condition for 4 syllables and 5 syllable nonwords within AWS and AWNS groups

In non-vocal conditions, to compare reaction time and accuracy for 4 syllables and 5 syllables within both groups, the Wilcoxon Signed Rank test was carried out. The statistical results revealed no significant difference for reaction time(AWS: /z/=0.14, p=0.88, AWNS: /z/=0.41, p =0.67) Table 4.11 represents mean values for reaction time measure of non-vocal condition of 4 syllables and 5 syllable nonwords within AWS and AWNS. In the present study significant difference seen for accuracy within AWS group (AWS: /z/=2.35, p =0.01) respectively. But within AWNS group no statistical significant difference seen (AWNS: /z/=0.54, p=0.58). Table 4.12 indicates mean values for accurate measure of non-vocal condition of 4 syllables and 5 syllable nonwords within AWS and AWNS.

Table 4.11: *Mean values for reaction time measure of non-vocal condition of 4 syllables and 5 syllable nonwords within AWS and AWNS*

Non-vocal condition								
	AWS				AWNS			
	N	Reaction time (Mean)	/z/ value	p value	N	Reaction time(Mean)	/z/ value	p value
4 syllable	25	963.58	0.14	0.88	25	759.34	0.41	0.67
5 syllable	25	902.93			25	797.70		

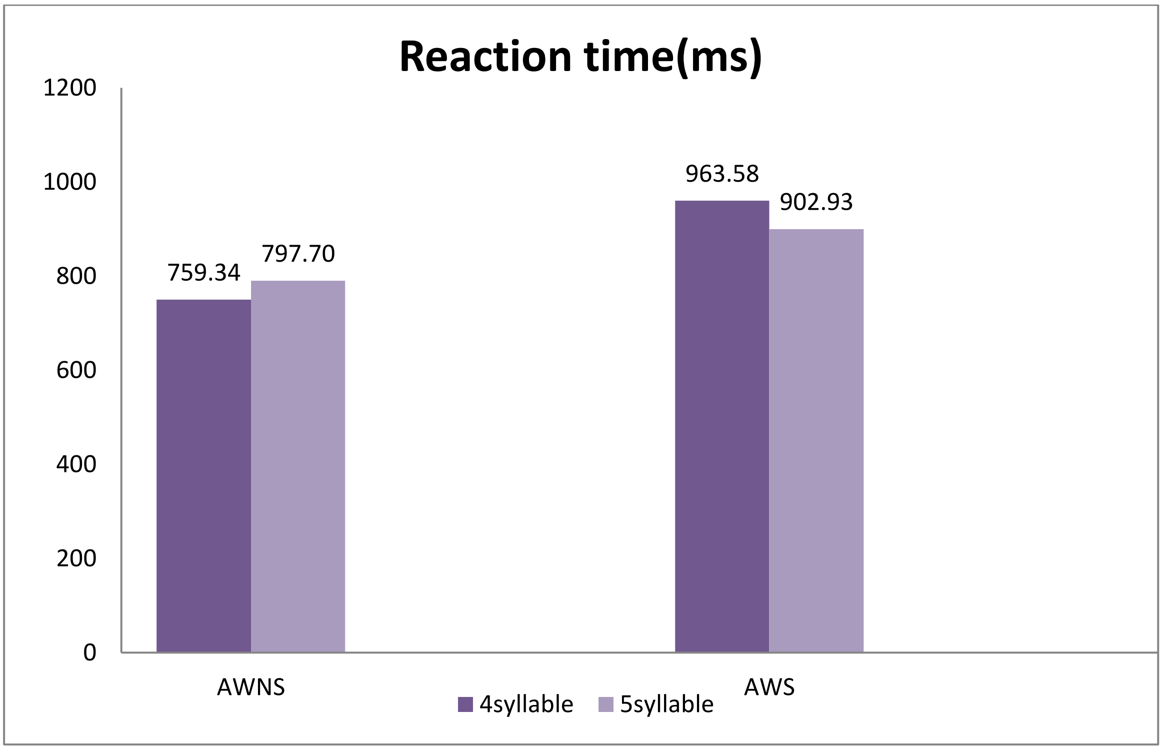

Figure 4.7: Mean values for reaction time in non-vocal condition for 4 syllable and 5 syllable nonwords within AWS and AWNS

Table 4.12: *Mean values for accurate measure of non-vocal condition of 4 syllables and 5 syllable nonwords within AWS and AWNS*

Non-vocal condition								
	AWS				AWNS			
	N	Accuracy (mean)	/z/ value	p value	N	Accuracy (mean)	/z/ value	p value
4 syllable	25	8.80	2.35	0.01*	25	9.08	0.54	0.58
5 syllable	25	8.16			25	9.12		

*=significant at 0.05 level

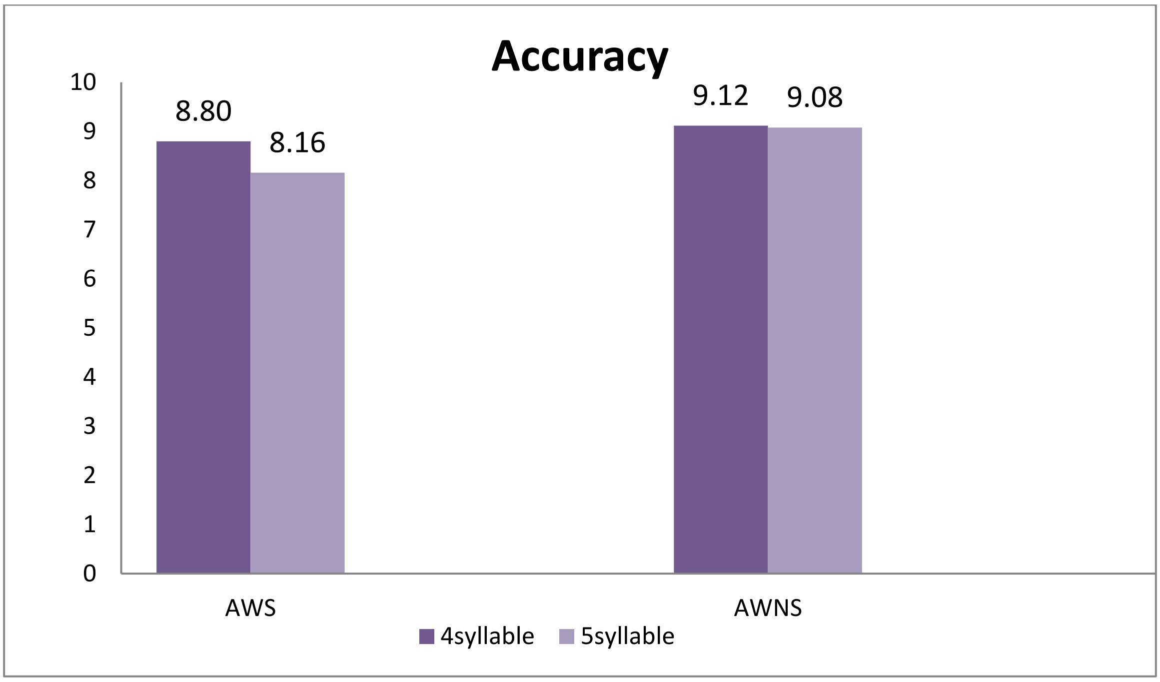

Figure 4.8: Mean values for accuracy in non-vocal condition for 4 syllable and 5 syllable nonwords within AWS and AWNS

No significant difference was seen in AWNS for 4 syllable and 5 syllable in terms of reaction time and accuracy. But, there was a significant difference found statistically in AWS for 4 syllable and 5 syllable in terms of accuracy i.e. the accuracy for 4 syllable nonwords is better than that of the 5 syllable nonword. With respect to this study, in the nonvocal condition as the phonological abilities are adequate in AWNS the responses are equal for both the 4 and 5 syllable nonwords whereas, in AWS it declines the accuracy due to the known reason of phonological encoding deficit when there is an increase in the length of syllable. Byrd et al. (2015) concluded greater accuracy seen 4 syllable than longer length nonword in which speech motor execution not required and also AWS took more attempt to repeat longer length nonwords accurately. For silent identification of nonwords, there were no speaker group differences, but both speaker groups required significantly more mean number of attempts to accurately identify 7 syllable as compared to 4 syllable nonwords. In present study findings no difference seen within AWNS but in AWS difference found, on comparison of mean value accuracy is slightly greater for 4 syllable than 7 syllable.

g) Comparison of reaction time in vocal condition and non-vocal condition for 4 syllable and 5 syllable across degrees of severity for non-word repetition task in AWS

The comparison across degrees of severity was carried out to using Kruskal-Wallis test to check whether there is a difference present in reaction time for vocal and non-vocal condition. The present results revealed adults with mild stuttering took less time to repeat 4 syllable and 5 syllable non-word than adults with moderate and severe stuttering. The difference across degrees of severity for vocal condition reaction time of 4 syllable ($\chi^2(2)=20.23$, $p=0.00$), 5 syllable ($\chi^2(2)=20.23$, $p=0.00$) were statistically significant, as severity increasing reaction time also increasing. Table 4.13 indicates the mean, SD, and median value for reaction time measure of 4 syllable and 5 syllable in vocal condition across degrees of severity.

Statistically no significant difference found for reaction time in non-vocal condition for 4 syllable ($\chi^2(2)=2.02$, $p=0.36$), 5 syllable ($\chi^2(2)=1.37$, $p=0.50$) across degrees of severity for non-word repetition task. No significant difference in non-vocal condition of 4 syllable and 5 syllable non-word reaction time. Table 4.14 indicates mean, SD and median value for reaction time measure of 4 syllable and 5 syllable in non-vocal condition across degrees of severity.

Table 4.13: *Mean, Standard deviation and Median value for reaction time measure of 4 syllable and 5 syllable in vocal condition across degrees of severity*

Vocal condition														
	Mild				**Moderate**				**Severe**				**Across degrees of severity Kruskal-Wallis test**	
	N	Reaction time(Mean)	SD	Median	N	Reaction time(Mean)	SD	Median	N	Reaction time(Mean)	SD	Median	$\chi^2(2)$ value	p value
4syllable	10	827.94	75.81	852.76	7	1101.72	148.97	1061.83	7	1740.27	136.97	1707.48	20.23	0.00**
5 syllable	10	873.07	63.38	868.61	7	1183.01	149.31	1104.37	7	1751.10	199.32	1680.18	20.23	0.00**

Note **=significant at 0.001 level

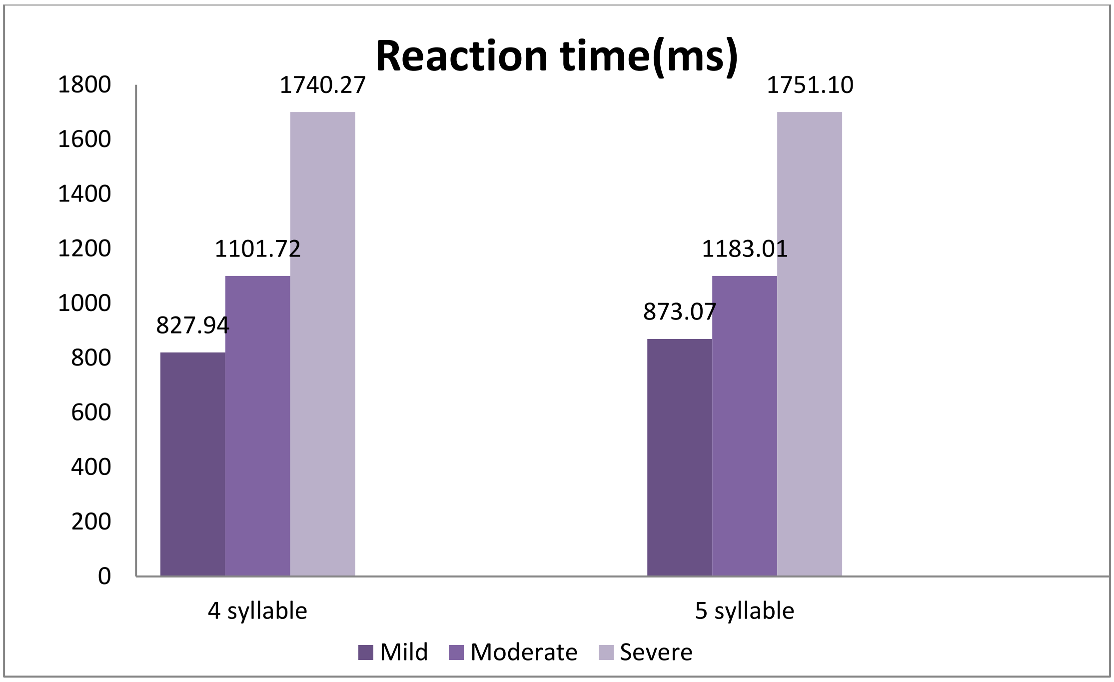

Figure 4.9: Mean value for reaction time measure of 4 syllable and 5 syllable in vocal condition across degrees of severity

The studies have indicated that the difficulty of speech timing between individuals who stutter is directly related to the severity of stuttering. A comparative study done by Archibald and De Nil (1999) in a kinematic study done on four very mild stuttering and 4 moderate/sever stuttering (totally 8 AWS) and 8 AWNS, reported a significant increase in jaw displacement from the visual to non-visual condition, found more pronounced articulatory timing disturbances in very mild stuttering than AWNS. Significant variation in groups was also found for duration of these movements with respect to the jaw. When only proprioceptive information was provided to assess articulatory movements, adults with moderate/severe stuttering took a relatively longer time to complete jaw movements. The results of this study discussed about the presence of temporal discoordination in AWS. Therefore, the present study the results found could be attributed to temporal discoordination.

Table 4.14: *Mean, Standard deviation and Median value for reaction time measure of 4 syllable and 5 syllable in non-vocal condition across degrees of severity*

Non-vocal condition														
	Mild				**Moderate**				**Severe**				**Across degrees of severity Kruskal-Wallis test**	
	N	Reaction time(ms)	SD	Median	N	Reaction time(ms)	SD	Median	N	Reaction time(ms)	SD	Median	$\chi^2(2)$ value	p value
4syllable	10	850.15	459.9	771.7	7	837.18	502.48	675.90	8	577.72	309.48	458.86	2.02	0.36
5 syllable	10	690.11	358.26	653.40	7	1027.97	690.61	887.99	8	730.70	600.95	517.75	1.37	0.50

No significant difference found in non-vocal condition of 4 syllable and 5 syllable non-word reaction time across degrees of severity. Since stuttering severity did not influence the non vocal condition since the requirement of overt speech is absent, and as there was no anxiety, fear and secondary behavior which is seen during overt speech, also cognitive load and complexity of the task was less in nonvocal condition. However, in continuation, to support this, the study done by McFarlane and Prins (1978) stated that individuals with stuttering may not have non speech motor deficit, PWS may not show slower reaction time in non speech motor related tasks.

h) Comparison of accuracy in vocal and non-vocal condition for 4 syllable and 5 syllable across degrees of severity for non-word repetition task in AWS

The comparison across degrees of severity was carried out to using Kruskal-Wallis test to check whether difference presents in accuracy in vocal and non-vocal condition. The result revealed significant difference across degrees of severity for vocal condition reaction time of 4 syllable ($\chi^2(2)=19.35$, $p=0.00$), 5 syllable ($\chi^2(2)=8.90$, $p=0.01$). Table 4.15 indicates mean, standard deviation and median value for accuracy measure of 4 syllable and 5 syllable in vocal condition across degrees of severity. The present study results found mild stutters repeated more accurately 4 syllable and 5 syllable non word than moderate and severe stutters.

The present study results revealed that statistically no difference in non-vocal condition accuracy of 4 syllable ($\chi^2(2)=2.82$, $p=0.24$), 5 syllable ($\chi^2(2)=0.21$, $p=0.89$) across degrees of severity for non-word repetition task. Table 4.16 represents mean, standard deviation and median value for accuracy measure of 4 syllable and 5 syllable in non-vocal condition across degrees of severity.

Table 4.15: *Mean, Standard deviation and Median value for accuracy measure of 4 syllable and 5 syllable in vocal condition across degrees of severity*

vocal condition														
	Mild				**Moderate**				**Severe**				**Across degrees of severity** **Kruskal-Wallis test**	
	N	Accuracy (mean)	SD	Median	N	Accuracy	SD	Median	N	Accuracy (mean)	SD	Median	$\chi^2(2)$ value	p value
4syllable	10	9.20	0.78	9.00	7	7.14	0.89	7.00	8	4.25	2.31	4.50	19.35	0.00**
5 syllable	10	6.90	2.02	7.0	7	6.42	1.27	6.00	8	3.37	2.38	3.50	8.90	0.01*

Note *=significant at 0.05 level

**=significant at 0.001 level

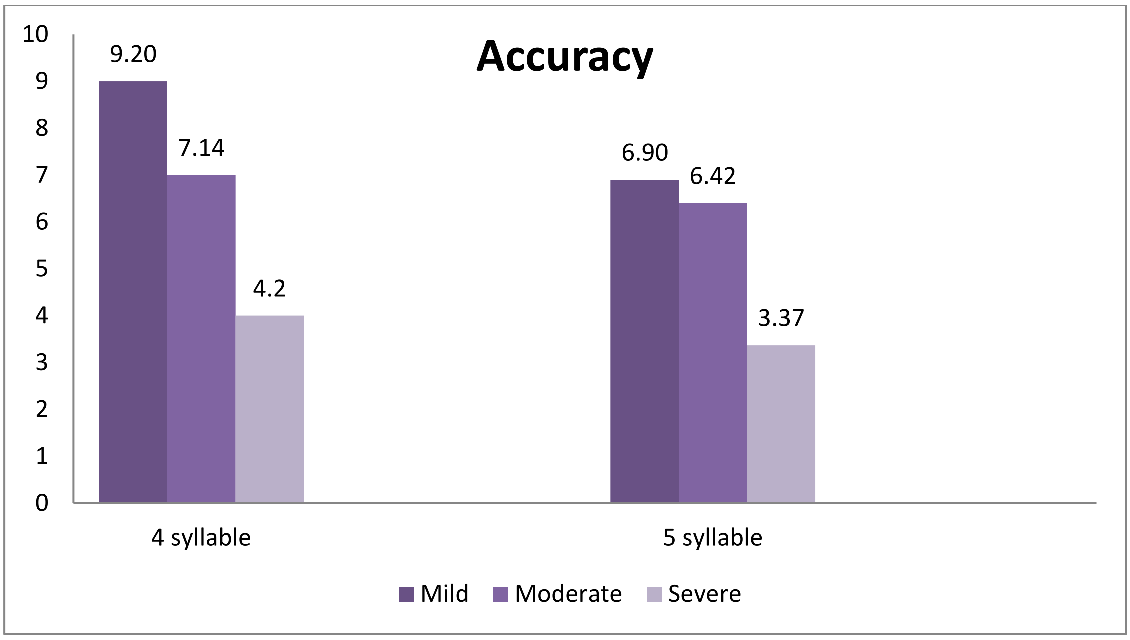

Figure 4.10: Mean value for accuracy measure of 4 syllable and 5 syllable in vocal condition across degrees of severity

In the present study as severity increases accuracy decreases across degrees of severity in vocal condition of nonword repetition task, because of the influence of core and secondary behaviors, anxiety is more in persons with severe stuttering. As the dysfluencies increase the rate of speech will be longer and all these factors result in increased voice onset time, increased articulatory programming timing and execution time or inappropriate activation of phonemes. Person with greater stuttering severity showed sound or phoneme fear in specific, they might have intentionally substituted sounds to avoid stuttering which could have led to lesser accuracy in overt speech task. Adams and Hayden (1976) stated that Voice initiation time (VIT) slower in person who stutter than those who do not stutter. Due to slow initiation of voice, person could not have been repeated longer nonwords completely within time given in the present study.

Table 4.16: *Mean, Standard deviation and Median value for accuracy measure of 4 syllable and 5 syllable in non-vocal condition across degrees of severity*

Non-vocal condition														
	Mild				**Moderate**				**Severe**				**Across degrees of severity Kruskal-Wallis test**	
	N	Accuracy mean)	SD	Median	N	Accuracy	SD	Median	N	Accuracy (mean)	SD	Median	$\chi^2(2)$ value	p value
4syllable	10	7.80	2.74	9.00	7	7.57	2.87	9.00	8	9.12	1.72	10.00	2.82	0.24
5 syllable	10	8.60	2.45	10.00	7	8.57	1.98	10.00	8	9.25	1.38	10.00	0.21	0.89

In contrast to De Nil, 1992; De Nil & Abbs, 1991's studies, the determined reaction time was lesser and better accuracy was found across severity. But in the present study, the speed-accuracy trade-off is not applicable. These findings require a further investigation in non-vocal condition reaction time and accuracy for 4 syllable and 5 syllable with a larger population, study must be carried out to investigate the influence or role of severity in AWS group.

i) Comparison of reaction time in vocal condition for 4 syllable and 5 syllable across degrees of mild and moderate stuttering, moderate and severe stuttering, mild and severe stuttering for non-word repetition task in AWS

The comparison within degrees of severity Mann Whitney test was carried out as post hoc test only for vocal condition as there is no significant difference found in non-vocal condition of 4 syllable and 5 syllable across degrees of severity. The result revealed significant difference within degrees of mild v/s moderate severity for vocal condition reaction time of 4 syllable ($\chi^2(2)=3.41$, $p=0.00$), 5 syllable ($\chi^2(2)=3.41$, $p=0.00$). In present study results found lesser reaction time taken in adults with mild stuttering to repeat 4 syllable non-words and 5 syllable non-word than adults with moderate stuttering. Table 4.17 represents mean, standard deviation and median value for reaction time measure of 4 syllable and 5 syllable in vocal condition within degrees of mild and moderate severity

The statistically significant difference found within degrees of mild and severe stuttering for vocal condition reaction time of 4 syllable ($\chi^2(2)=3.41$, $p=0.00$), 5 syllable ($\chi^2(2)=3.41$, $p=0.00$). Table 4.18 represents mean, standard deviation and median value for reaction time measure of 4 syllable and 5 syllable in vocal condition within degrees of mild and severe severity. In present results showed less reaction time seen in adults with mild stuttering to repeated 4syllable and 5 syllable non-word than adults with severe stuttering.

The result revealed significant difference within degrees of moderate and severe severity for vocal condition reaction time of 4 syllable ($\chi^2(2)=3.13$, p =0.00), 5 syllable ($\chi^2(2)=3.13$, p =0.00). In present study less reaction time seen in adults with moderate stutters to repeated 4syllable and 5 syllable non-words than adults with severe stuttering. Table 4.19 indicates mean, standard deviation and median value for reaction time measure of 4 syllable and 5 syllable in vocal condition within degrees of mild and severe severity.

Table 4.17: *Mean, Standard deviation and Median value for reaction time measure of 4 syllable and 5 syllable in vocal condition across degrees of mild and moderate stuttering*

Vocal condition					
		4 syllable	**5 syllable**	**Across degrees of severity Mann-Whitney test**	
				/z/ value	**p value**
Mild	**N**	10	10	3.41	0.00**
	Reaction time(ms) Mean	827.94	873.07		
	SD	75.81	63.38		
	Median	852.76	868.61		
Moderate	**N**	7	7		
	Reaction time(ms) Mean	1101.72	1183.01		
	SD	148.97	149.31		
	Median	1061.83	1104.3		

Note **=significant at 0.001 level

Table 4.18: *Mean, Standard deviation and Median value for reaction time measure of 4 syllable and 5 syllable in vocal condition across degrees of* mild and severe stuttering

Vocal condition					
		4 syllable	**5 syllable**	**Across degrees of severity Mann-Whitney test**	
				/z/ value	**p value**
Mild	**N**	10	10	3.41	0.00**
	Reaction time(ms) Mean	827.94	873.07		
	SD	75.81	63.38		
	Median	852.76	868.61		
Severe	**N**	7	7		
	Reaction time(ms) Mean	1740.27	1751.10		
	SD	136.97	199.32		
	Median	1707.48	1680.18		

Note *=significant at 0.001 level

Table 4.19: *Mean, Standard deviation and Median value for reaction time measure of 4 syllable and 5 syllable in vocal condition across degrees of* moderate and severe stuttering

Vocal condition					
		4 syllable	5 syllable	Across degrees of severity Mann-Whitney test	
				/z/ value	p value
Moderate	N	7	7	3.13	0.00**
	Reaction time(ms) Mean	1101.72	1183.01		
	SD	148.97	149.31		
	Median	1061.83	1104.3		
Severe	N	7	7		
	Reaction time(ms) Mean	1740.27	1751.10		
	SD	136.97	199.32		
	Median	1707.48	1680.18		

Note **=significant at 0.001 level

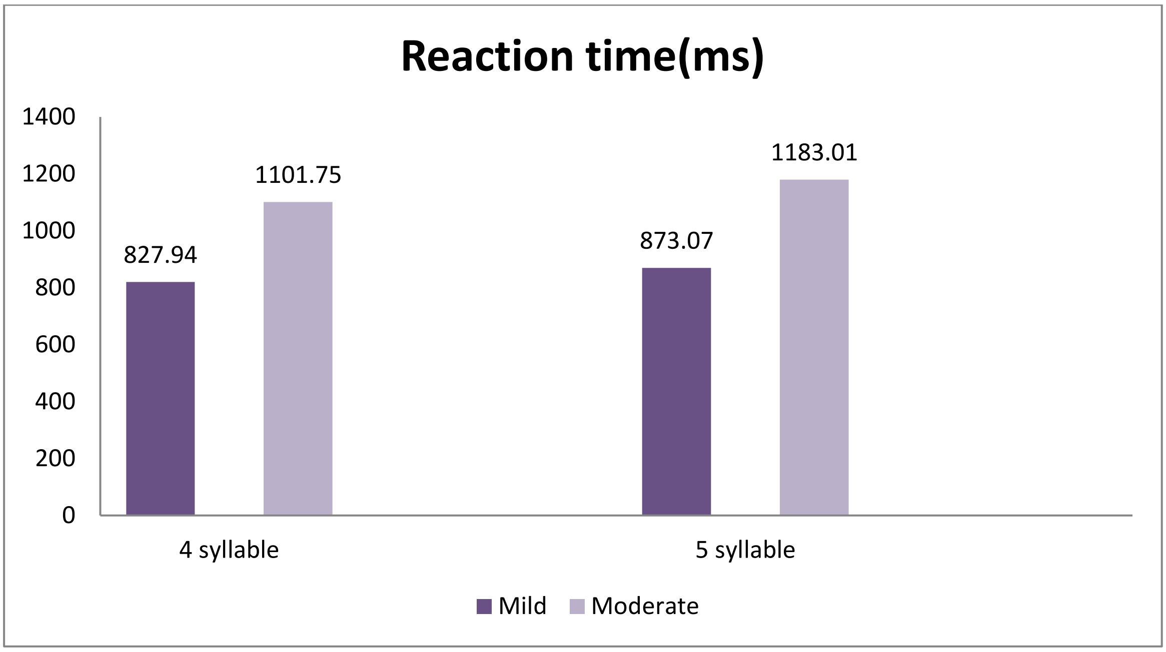

Figure 4.11: Mean value for reaction time measure of 4 syllable and 5syllable in vocal condition across degrees of mild and moderate stuttering

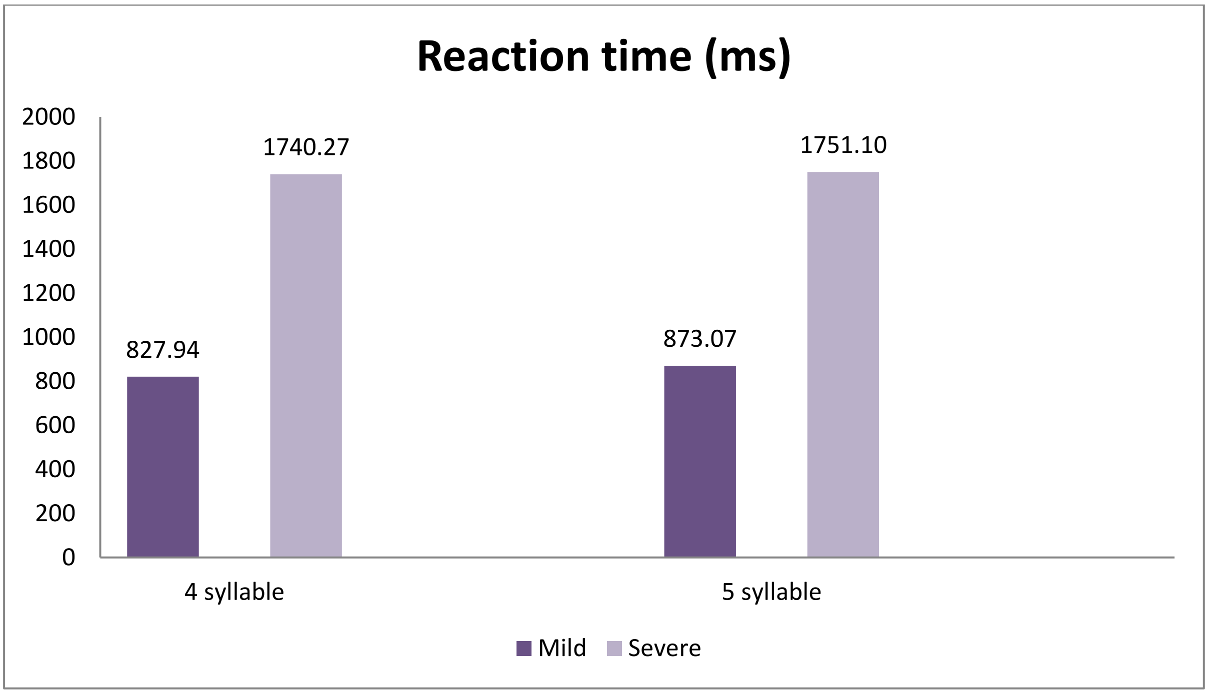

Figure 4.12: Mean value for reaction time measure of 4 syllable and 5 syllable in vocal condition across degrees of mild and severe stuttering

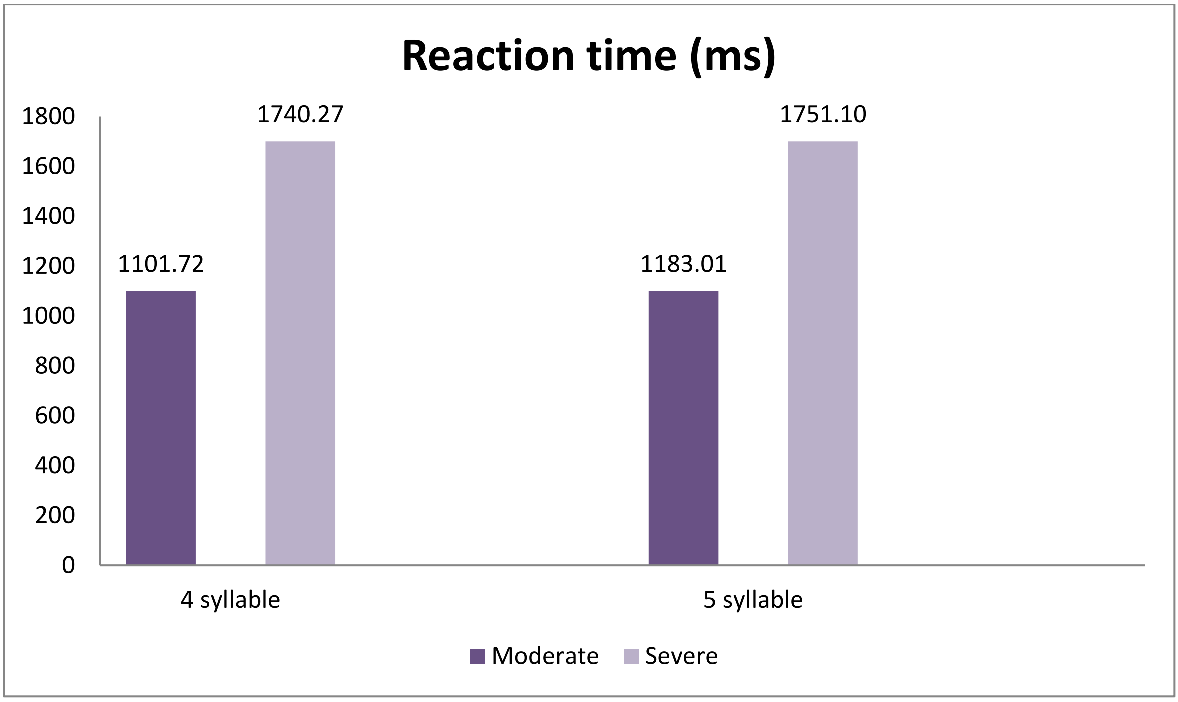

Figure 4.13: Mean value for reaction time measure of 4 syllable and 5 syllable in vocal condition across degrees of moderate and severe stuttering

The significant differences obtained across severities of stuttering which was supported in the studies done by De Nil (1992); De Nil and Abbs (1991). They stated that the adults who had to rely on proprioceptive feedback during oral execution made considerably larger minimal movement with their jaws compared to PWNS subjects. Duration of movement varied noticeably between the three groups with moderate/severe stuttering subjects exhibiting proportionally slower movements in non-visual condition than either of the other two subject groups. Due to the speed –accuracy trade-off, it would be expected that slower movements would lead in movement that has a higher degree of accuracy than those performed at a faster speed. Therefore, the subjects with moderate/severe stuttering take a more careful approach to the task in order to compensate for the perceived difficulties with task completion of tasks. This was not found in subjects with very mild stuttering. These subjects appeared not to increase the length of their movements, as done by the normally fluent control subjects. The adults with very mild and moderate/severe stuttering varied in the rigidity of their articulatory movements. Previously it was noted that articulatory movements individuals with stuttering, even though they were perceptually fluent which most often are represented by higher level of muscular tension (Van Lieshout, Peters, Starkweather & Hulstijn, 1993).

Borden (1983) measured stuttering and non stuttering performances in adults on oral and manual task of counting. Those with severe stuttering were slower in execution of both the motor tasks than those with mild stuttering and normally fluent speakers. The present study findings support the difference found across degrees of severity in vocal condition i.e. delayed reaction time and less accuracy for 4 syllable and 5 syllable in adults with severe stuttering could be due to various reasons including the articulatory kinematics and the muscular tension at various levels including the jaw, lips and tongue.

j) Comparison of accuracy in vocal condition for 4 syllable and 5 syllable across degrees of mild and moderate stuttering, moderate and severe stuttering, mild and severe stuttering for non-word repetition task in AWS

The result revealed significant difference within degrees of mild v/s moderate stuttering for vocal condition accuracy of 4 syllable ($\chi^2(2)=3.20$, p =0.00), no difference seen in 5 syllable ($\chi^2(2)=0.54$, p =0.58). Results found adults with mild stuttering more accurately repeated 4 syllable non-words than adults with moderate stuttering and 5 syllable non-word accuracy is same across mild and moderate stutters.

The result revealed significant difference within degrees of adults with mild and severe stuttering for vocal condition reaction time of 4 syllable ($\chi^2(2)=3.59$, p =0.00), 5 syllable ($\chi^2(2)=2.60$, p =0.00). In present study adults with mild stuttering repeated more accurately than the 4syllable and 5 syllable non-words when compared to adults with severe stuttering.

The present result revealed significant difference within degrees of moderate and severe severity for vocal condition reaction time of 4 syllable ($\chi^2(2)=2.70$, p =0.00), 5 syllable ($\chi^2(2)=2.52$, p =0.01). In present study adults with moderate stuttering more accurately repeated 4syllable and 5 syllable non-words than adults with severe stuttering.

Table 4.20: *Mean, Standard deviation and Median value for accuracy measure of 4 syllable and 5 syllable in vocal condition across degrees of* mild and moderate severity

Vocal condition										
	Mild				Moderate				Across degrees of severity Mann-Whitney test	
	N	Accuracy (mean)	SD	Median	N	Accuracy (mean)	SD	Median	/z/ value	p value
4 syllable	10	9.20	0.78	9.00	7	7.14	0.89	7.00	3.20	0.00**
5 syllable	10	6.90	2.02	7.00	7	6.42	1.27	6.00	0.54	0.58

Note **=significant at 0.001 level

Table 4.21: *Mean, Standard deviation and Median value for accuracy measure of 4 syllable and 5 syllable in vocal condition across degrees of* mild and severe severity

Vocal condition										
	Mild				Severe				Across degrees of severity Mann-Whitney test	
	N	Accuracy (mean)	SD	Median	N	Accuracy (mean)	SD	Median	/z/ value	p value
4 syllable	10	9.20	0.78	9.00	8	4.25	2.31	4.50	3.59	0.00**
5 syllable	10	6.90	2.02	7.00	8	3.37	2.38	3.50	2.60	0.00**

Note **=significant at 0.001 level

Table 4.22: *Mean, Standard deviation and Median value for accuracy measure of 4 syllable and 5 syllable in vocal condition within degrees of* moderate and severe severity

Vocal condition										
	Moderate				Severe				Across degrees of severity Mann-Whitney test	
	N	Accuracy (mean)	SD	Median	N	Accuracy (mean)	SD	Median	/z/ value	p value
4 syllable	7	7.14	0.899	7.00	8	4.25	2.31	4.50	2.70	0.00**
5 syllable	7	6.42	1.27	6.00	8	3.37	2.38	3.50	2.52	0.01*

Note **=significant at 0.001 level *=significant at 0.05 level

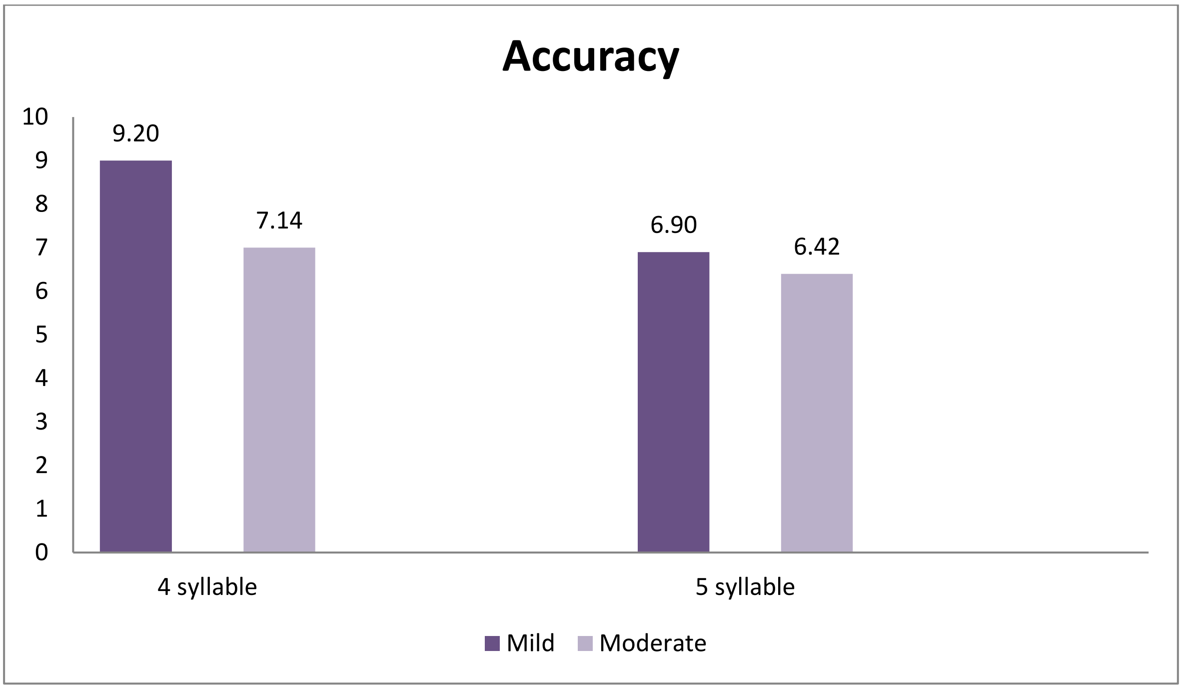

Figure 4.14: Mean value for accuracy measure of 4 syllable and 5 syllable in vocal condition within degrees of mild and moderate stuttering

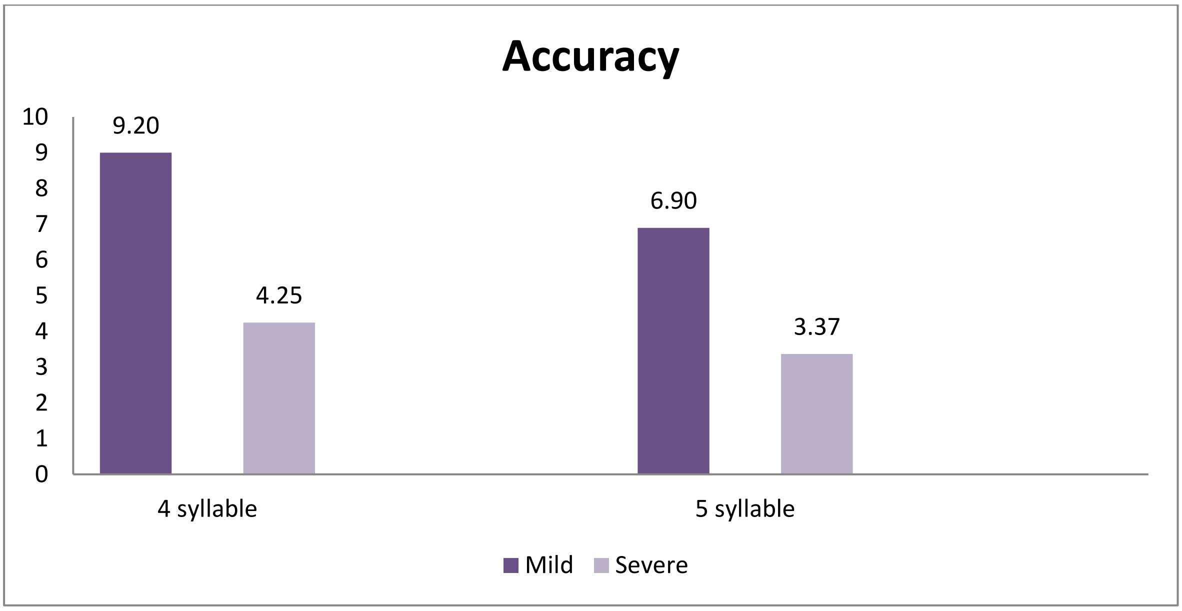

Figure 4.15: Mean value for accuracy measure of 4 syllable and 5 syllable in vocal condition within degrees of mild and severe stuttering

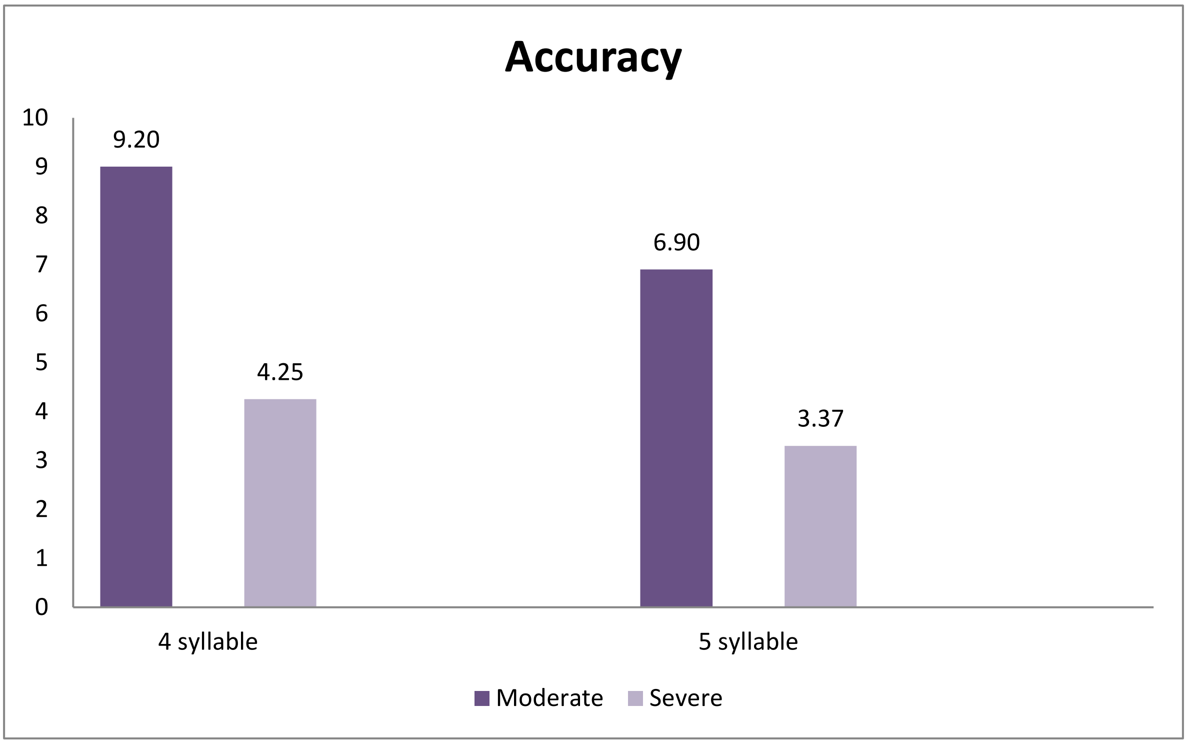

***Figure4.16**:* Mean, Standard deviation and Median value for accuracy measure of 4 syllable and 5 syllable in vocal condition within degrees of moderate and severe stuttering

Models and theories support the present study findings that the AWS have a lesser accuracy and more reaction time seen than AWNS in vocal condition for nonword repetition task. Basing the current study's result on the Covert Repair Hypothesis (Postma & Kolk, 1993) the delay in phonological encoding in AWS can be justified that there is an internal correction of encoding error which fails the phonological encoding of an utterance accurately. Also the spreading activation model (Dell, 1986; Dell & O'Seaghdha, 1991) helps in explaining the present study findings which reflects that AWS were less accurate than AWNS, as the competing phonologic unit might have greater activation strength than the target phonologic node, because of the residual activation which has been chosen recently along with the faulty activation of units. The model which explained why AWS exhibits more reaction time and less accurate in phonological encoding is Neuropsycolinguistic Model (Perkins, Kent, & Curlee 1991) which stated that the occurrence of stuttering is due to the activation of unit that contributes to the final act of speech which is ineffective, which could be applicable to present study findings in which, the AWS showed a greater reaction time and less accuracy in 4 syllable and 5 syllable of vocal condition.

Cybernetic theory of stuttering that talks about the sensory feedback disorder, sheds a light on the dysfluency in which speech error that is perceived due to delayed auditory feedback (Fairbanks, 1954; Lee, 1951). Many studies have been investigated in which processing reaction time might be influenced.

Weber-Fow et al. (2004) reported to phonological encoding capacities between stuttering adults and their normally fluent peers are relatively similar. Nevertheless, as present study findings support, the authors further suggested that the phonological encoding skills of AWS could be especially susceptible to decreased efficiency as the cognitive load needed increases compared with fluent controls. Possibly, as suggested by Smith and colleagues (e.g., Smith et al., 2010), In AWS there is critical interplay seen between phonological encoding and motor programming. This interplay will likely lead to disagreements between the subgroups over tasks that tap into these mechanisms. That is, if an interplay exists, we would just have to imagine it differs for each person who stutters; consequently, some would perform much better than others on task requiring phonological encoding and related motor programming to be used.

The individual must be able to accurately encode and then update the novel phonological string internally through subvocal rehearsal in preparation and execute the correct articulatory movements for the target nonword, so that the expression is retained long enough to enable accurate programming. The factor affecting the quality of phonological representation cannot be limited exclusively to the phonological encoding of auditory information. Although it may be accurate that phonological information presented in an auditory manner is subjects to a faster rate of decline in the stuttering person, temporal motor programming instability may also occur to such an extent that the resulting program is inaccurate and the subsequent recall is incorrect.

Shetrnberg et al. (1978) model stated that any expansion in word length would directly impact an any of the four stages. In the first stage, phonological encoding probably includes sub-processes (i) sequencing of the these segments within the syllable frame (ii) choice of segments for a word or phrase (iii) determining the intonation and temporal parameters for each syllable (Levelt, 1989). That of this sub -processes requires more time for a longer articulatory program that is needed for longer word to be constructed. Experimentally reasoning from a different angle, the number of nodes needed for organization in the phonological system is greater or longer utterance (Mackay, 1982). Along with same lines, the retrieval and unpacking stages are also adversely influenced by increasing response complexity.

CHAPTER V

SUMMARY AND CONCLUSIONS

The present study mainly aimed to determine phonological encoding abilities through non-word repetition tasks in 18-35 year old AWS compared with AWNS. The study therefore paid attention on how AWS differed from AWNS in terms of accuracy and reaction time ,difference within the AWS and AWNS groups of 4syllable and 5 syllable in vocal and nonvocal condition of nonword repetition task. Another objective was to find out the differences across degrees of severity in the reaction time and accuracy of nonword repetition task.

Native Kannada speaking AWS and AWNS groups were considered in this study in the age range of 18-35 years. Stuttering severity instrument –4 (SSI-4) (Riley,2009) and Montreal cognitive assessment (MOCA)(version 7.1 Kannada version) was carried before considering the subjects to check cognitive abilities.

Appropriate statistical analysis was carried out and the statistical output of the present study summarized as follows:

The present study results revealed that greater reaction time was evident in AWS than AWNS for 4 syllable and 5 syllable non-words. AWNS more accurately repeated 4syllable and 5 syllable nonwords than AWS in vocal condition of non-word repetition task.

AWS took more time to respond accurately than AWNS group of 4syllable and 5 syllable non-words in non-vocal condition. No significant difference was found for accuracy in non-vocal condition of 4syllable and 5 syllable non-words between AWS and AWNS groups. But comparing mean value, accuracy is more in AWNS than AWS for 4syllable and 5 syllable non-words in both the groups.

On comparison of reaction time and accuracy in vocal condition for 4 syllables and 5 syllable nonwords within AWS and AWNS groups suggested that significant difference for reaction time and accuracy, Present study result found that more reaction time taken to repeat 5 syllable nonwords than 4 syllables and higher accuracy seen for 4syllable than 5 syllables in vocal condition of nonword repetition task within AWS and AWNS groups. In nonvocal condition within AWS and AWNS' reaction time for 4 syllable and 5 syllable nonwords was same. AWS performed accurately for 4 syllable than 5 syllable, accuracy was found to be similar within AWNS group in nonvocal condition.

The comparison of reaction time and accuracy for 4 syllable and 5 syllable across degrees of severity for non-word repetition task in AWS revealed that Adults with mild stuttering took less time to repeat 4 syllable and 5 syllable non-word than moderate and severe stutters, adults with mild stuttering repeated more accurately 4 syllable and 5 syllable non words than moderate and severe stutters in vocal condition. No significant difference in non-vocal condition of 4 syllable and 5 syllable non-word for reaction time and accuracy.

On comparison of reaction time and accuracy in vocal condition for 4 syllable and 5 syllable across mild and moderate stuttering, mild and severe stuttering and moderate and severe stuttering severity for non-word repetition task in AWS

Results found lesser reaction time taken by adults with mild stuttering to repeat 4 syllable non-words and 5 syllable non-word than adults with moderate stuttering and severe stuttering. Adults with mild stuttering more accurately repeated 4 syllable non-words than adults with moderate stuttering and 5syllable non-word accuracy is same in adults with mild and moderate stuttering. Adults with mild stuttering repeated 4syllable and 5 syllable non-words more accurately than adults with severe stuttering and adults with moderate stuttering were more accurate in 4syllable and 5 syllable non-words repetition than adults with severe stuttering.

The present study reported that Kannada speaking AWS showed lesser accuracy and greater reaction time for 5 syllable non-word than 4 syllable in vocal condition within AWS and AWNS groups, wherein overt speech required and greater reaction time found in AWS for 4 syllable and 5 syllable in vocal and nonvocal condition, AWS are less accurate than AWNS for 4 syllable and 5 syllable in vocal condition but in nonvocal condition both AWS and AWNS performed similar for 4 syllable and 5 syllable accuracy. Whereas in nonvocal condition AWS showed lesser accuracy for 5 syllable than 4 syllable nonwords, AWNS accurately responded in same percentage for 4 syllable and 5 syllable and reaction time is same within both the groups for 4 syllable and 5 syllable. Within AWS and AWNS reaction time was more and less accurate for 5syllable.

Adults with mild stuttering showed greater in accuracy and lesser reaction time for vocal condition of 4 syllable and 5 syllable than moderate and severe stutterers, moderate stutterers were showed greater in accuracy and lesser reaction time for vocal condition of 4 syllable and 5 syllable than severe stutterers, but in nonvocal condition no difference found between degrees of severity.

The present study result explicitly support a stuttering models, the moments of stuttering is caused by delayed phonological encoding in person who do stutters lead to increase inner encoding error correction (Postman & Kolk,1993) and wherein the performance of speech motor system is impaired by the speaker's linguistic aims and the length of the utterance to be produced. The present study revealed that phonological encoding abilities is poor in AWS and more difficulties found in repetition of 5syllable than 4 syllable nonwords.

In future study, comparison within degrees of severity could be done on nonvocal condition of 4 syllable and 5 syllable in nonword repetition task. As limited study have been done in nonvocal condition on comparing degrees of severity in AWS. In summary, the current experiment strongly supports the hypothesis that phonological influences play an important role in stuttering influencing speech motor performance.

5.1 Clinical implications

- This study contribute towards a more detailed understanding of phonological encoding skills in adults who stutter with 4 syllable and 5 syllable nonwords while using nonword repetition task.
- The current study also helps in understanding of adults who stutters' abilities in repeating increased in length of nonwords.
- This study helps in checking how adults who stutter are accurate and react with respect to time domain compared to normal group.
- Overall knowledge about phonological working memory, extension of variation were compared to that of normal group.

5.2 Limitations

- To compare reaction time and accuracy across degrees of severity in AWS for nonword repetition task, sample size was less experiment should have been conducted on larger sample.
- Unequal distribution of participants across degrees of severity.
- The present study only focused on adult population.
- The comparison was not made between 4 syllable and 5 syllable across degrees of severity.

5.3 Future directions

- The study can be done across degrees of severity in AWS, to check how reaction time and accuracy varies across degrees of severity with equal distribution of sample size.
- The study can be done to check phonological encoding abilities across age groups
- The study can be conducted to estimate reaction time and accuracy by comparing vocal and non-vocal condition in nonword repetition task.
- How groups would perform with increasing syllable length of nonwords can be evaluated.

REFERENCES

Adams, M. R. (1990). The demands and capacities model I: Theoretical elaborations. *Journal of Fluency Disorders*, *15*(3), 135-141.

Ackermann, H., & Riecker, A. (2004). The contribution of the insula to motor aspects of speech production: A review and a hypothesis. Brain and Language, 89(2), 320–328

Andrews, G., and Neilson, M. (November 1981). Stuttering: A state of the art seminar. Paper presented at the Annual Conference of the American SpeechLanguage-Hearing Association, Los Angeles, CA.

Anderson,J.D.,Wagovich,S.A.,&Hall,N.E.(2006).Nonwordrepetitionskillsinyoungchildrenwhodoanddo notstutter. *Journal ofFluencyDisorders, 31(3), 177–199.*

Archibald, L., & De Nil, L. F. (1999). The relationship between stuttering severity and kinesthetic acuity for jaw movements in adults who stutter. *Journal of Fluency Disorders*, *24*(1), 25-42.

Baddeley, A. (2003). Working memory and language: an overview. *Journal of Communication Disorders, 36* (3), 189-208.

Baddeley, A., Chincotta, D., Stafford, L., & Turk, D. (2002). Is the word length effect in STM entirely attributable to output delay? Evidence from serial recognition. *The Quarterly Journal of Experimental Psychology Section A*, *55*(2), 353-369.

Bakhtiar, M., Abad, D. A. & Sadegh, S. P. (2007). Nonword repetition ability of children who do and do not abstract and covert repair hypothesis. *Indian Journal of Medical Sciences, 61,* 462-470.

Bloodstein, O. (1969). A handbook on stuttering.

Borden, G.J. (1983). Initiation versus execution time during manual and oral counting by stutterers. Journal of Speech and Hearing Research 26, 389– 396.

Bosshardt, H. G. (1990). Subvocalization and reading rate differences between stuttering and nonstuttering children and adults. *Journal of Speech, Language, and Hearing Research*, *33*(4), 776-785.

Bosshardt, H. G., & Fransen, H. J. M. (1996). On-line sentence processing in adults who stutter and who do not stutter. *Journal of Speech and Hearing Research, 39*, 785-797.

Browman, C. P., & Goldstein, L. (1997). The gestural phonology model. *Speech production: Motor control, brain research and fluency disorders*, 57-71.

Burger, R. & Wijnen, F. (1999). Phonological encoding and word stress in stuttering and nonstuttering subjects. *Journal of Fluency Disorders, 24,* 91-106.

Byrd, C. T., Vallely, M., Anderson, J. D., & Sussman, H. (2012). Nonword repetition and phoneme elision in adults who do and do not stutter. *Journal of fluency disorders*, *37*(3), 188-201.

Byrd, C. T., McGill, M., & Usler, E. (2015). Nonword repetition and phoneme elision in adults who do and do not stutter: Vocal versus nonvocal performance differences. *Journal of fluency disorders*, *44*, 17-31.

Coady, J. A., & Evans, J. L. (2008). Uses and interpretations of non-word repetition tasks in children with and without specific language impairments (SLI). *International Journal of Language & Communication Disorders*, *43*(1), 1-40.

Coalson, G. A., & Byrd, C. T. (2017). Nonword repetition in adults who stutter: The effects of stimuli stress and auditory-orthographic cues. *PloS one*, *12*(11), e0188111.

Cross, D. E., & Luper, H. L. (1983). Relation between finger reaction time and voice reaction time in stuttering and nonstuttering children and adults. *Journal of Speech, Language, and Hearing Research*, *26*(3), 356-361.

Daliri, A., & Max, L. (2015). Modulation of auditory processing during speech movement planning is limited in adults who stutter. *Brain and Language*, *143*, 59-68.

Dell, G. S. (1986). A spreading-activation theory of retrieval in sentence production. *Psychological review*, *93*(3), 283.

Dell, G. S., & O'Seaghdha, P. G. (1992). Stages of lexical access in language production. *Cognition*, *42*(1-3), 287-314.

De Nil, L.F. (1992). Articulatory sequencing revisited: Do stutterers and nonstutterers differ? ASHA 34(10), 128.

De Nil, L.F., & Abbs, J.H. (1990). Influence of rate on stutterers' articulatory movements: A microbeam study. ASHA 32, 72

Dollaghan, C., Biber, M., & Campbell, T. (1993). Constituent syllable effects in a nonsense-word repetition task. *Journal of Speech, Language, and Hearing Research*, *36*(5), 1051-1054.

Dollaghan, C., & Campbell, T. F. (1998). Nonword repetition and child language impairment. *Journal of Speech, Language, and Hearing Research*, *41*(5), 1136-1146.

Gathercole, S. E., & Baddeley, A. D. (1996). *The children's test of nonword repetition*.

Gathercole, S. E. (2006). Nonword repetition and word learning: The nature of the relationship. *Applied psycholinguistics*, *27*(4), 513.

Gupta, P., & Tisdale, J. (2009). Does phonological short-term memory causally determine vocabulary learning? Toward a computational resolution of the debate. *Journal of memory and language*, *61*(4), 481-502.

Gupta, P. (2003). Examining the relationship between word learning, nonword repetition, and immediate serial recall in adults. *The Quarterly Journal of Experimental Psychology Section A*, *56*(7), 1213-1236.

Hakim, H. B. & Ratner, N. B. (2004). Nonword repetition abilities of children who stutter: An exploratory study. *Journal of Fluency Disorders, 29*, 179-199.

Hennessey, N. W., Nang, C. Y., & Beilby, J. M. (2008). Speeded verbal responding in adults who stutter: Are there deficits in linguistic encoding? *Journal of Fluency Disorders, 33*(3), 180-202

Howell, P. & Au-Yeung, J. (2002). The EXPLAN theory of fluency control and the diagnosis of stuttering. In E. Fava (Ed.), *Current issues in linguistic theory series: Patholgy and therapy of speech disorders* (pp. 75-94). Amsterdam: John Benjamins.

Howell, P. (2007). The effects of gated speech on the fluency of speakers who stutter. *Folia Phoniatrica et Logopaedica*, *59*, 250–255.

Jansma, B. M., & Schiller, N. O. (2004). Monitoring syllable boundaries during speech production. *Brain and Language, 90(1-3)*, 311-317.

Kalinowski, J., Saltuklaroglu, T., Guntupalli, V., & Stuart, A. (2004). Gestural recovery and the role of forward and reversed syllabic repetitions as stuttering inhibitors in adults. *Neuroscience letters*, *363*(2), 144-149.

Kalinowski, J., & Saltuklaroglu, T. (2006). Stuttering (San Diego, CA: Plural).

Karniol, R. (1995). Stuttering, language, and cognition: A review and a model of stuttering as suprasegmental sentence plan alignment (SPA). *Psychological Bulletin, 117*, 104-124.

Kent, R. D. (1984). Stuttering as a deficiency in temporal programming. In W. H. Perkins & R. Curlee (Eds.), *Nature and treatment of stuttering: New directions.* San Diego: College Hill .

Kelly, E.M., and Conture, E.G. (1992). Speaking rates, response time latencies, and interrupting behaviors of young stutterers, nonstutterers, and their mothers. Journal of Speech and Hearing Research 35, 1256-1267.

Kleinow, J., & Smith, A. (2000). Influences of length and syntactic complexity on the speech motor stability of the fluent speech of adults who stutter. *Journal of speech, language, and hearing research*, *43*(2), 548-559.Press.

Kolk, H., & Postma, A. (1997). Stuttering as a covert repair phenomenon. Nature and Treatment of Stuttering: New Directions, (edited by Curlee RF, et al).

Levelt, W. (1981). JM 1989. Speaking: From intention to articulation. *MA: The MIT Press, Cambridge*.

Levelt, W. J. .M., Roelofs, A. & Meyer, A.S. (1999). A theory of lexical access in speech production. *Behavioral and Brain Sciences, 22*, 1-75.

Levelt, W. J. (2001). Spoken word production: A theory of lexical access. *Proceedings of the National Academy of Sciences*, *98*(23), 13464-13471.

Logan, K. J., & Conture, E. G. (1995). Length, grammatical complexity, and rate differences in stuttered and fluent conversational utterances of children who stutter. *Journal of Fluency Disorders*, *20*(1), 35-61.

Logan, K. J., & LaSalle, L. R. (1999). Grammatical characteristics of children's conversational utterances that contain disfluency clusters. *Journal of Speech, Language, and Hearing Research*, *42*(1), 80-91.

Louko, L. J., Edwards, M. L., & Conture, E. G. (1990). Phonological characteristics of young stutterers and their normally fluent peers: Preliminary observations. *Journal of Fluency Disorders*, *15*(4), 191-210.

Louko, L. J., Conture, E. G., & Edwards, M. L. (1999). Treating children who exhibit co-occurring stuttering and disordered phonology. *Stuttering and related disorders of fluency*, 124-138.

Ludlow, C. L., Siren, K., Zikria, M., Hulstijn, W., Peters, H. F., & van Lieshout, P. H. (1997). Speech production learning in adults with chronic developmental stuttering. *Speech production: Motor control, brain research and fluency disorders*, 221-230.

Ludlow, L. C., Siren, K., & Zikria, M. (1997). Speech motor control and stuttering.

Luper, H. L., & Cross, D. E. (1978). Finger reaction times of stuttering and nonstuttering children and adults. In *convention of the American Speech and Hearing Association, San Francisco*.

Lu, C., Long, Y., Zheng, L., Shi, G., Liu, L., Ding, G., & Howell, P. (2016). Relationship between speech production and perception in people who stutter. *Frontiers in human neuroscience*, *10*, 224.

Mahesh B.V.M (2010). Performance with stuttering on self select reaction time paradigm using speech and non speech tasks. An unpublished dissertation submitted to university of Mysore; Mysore.

Namasivayam, A. K., & Van Lieshout, P. (2008). Investigating speech motor practice and learning in people who stutter. *Journal of fluency disorders*, *33*(1), 32-51.

Oyoun, H. A., El Dessouky, H., Shohdi, S., & Fawzy, A. (2010). Assessment of working memory in normal children and children who stutter. *Journal of American Science*, *6*(11), 562-6.

Pelczarski, K. M., & Yaruss, J. S. (2014). Phonological encoding of young children who stutter. *Journal of fluency disorders*, *39*, 12-24.

Pelczarski, K. M., Tendera, A., Dye, M., & Loucks, T. M. (2019). Delayed Phonological Encoding in Stuttering:

Perkins, W. H., Kent, R. D., & Curlee, R. F. (1991). A theory of neuropsycholinguistic function in stuttering. *Journal of Speech, Language, and Hearing Research*, *34*(4), 734-752.Evidence from Eye Tracking. *Language and Speech*, *62*(3), 475-493.

Peters, H., and Starkweather, C.W. (1990). The interaction between speech motor coordination and language processes in the development of stuttering: Hypotheses and suggestions for research. Journal of Fluency Disorders 15, 115-125.

Postma, A., Kolk, H., and Povel, D-J. (1990b). Speech planning and execution in stutterers. Journal of Fluency Disorders 15, 49-59.

Postma, A., & Kolk, H. (1993). The covert repair hypothesis: Prearticulatory repair processes in normal and stuttered disfluencies. *Journal of Speech and Hearing Research, 36*, 472–487.

Rastatter, M. P., & Dell, C. W. (1985). Simple motor and phonemic processing reaction times of stutterers. *Perceptual and Motor Skills, 61*, 463–466.

Roelofs, A. (1992). A spreading-activation theory of lemma retrieval in speaking. *Cognition*, *42*(1-3), 107-142.

Roelofs, A. (2000). WEAVER++ and other computational models of lemma retrieval and word-form encoding. *Aspects of language production*, 71-114.

Roelofs, A. (2004). Seriality of phonological encoding in naming objects and reading their names. *Memory and Cognition,* 32, 212–222.

Rosen, V. M., & Engle, R. W. (1997). The role of working memory capacity in retrieval. *Journal of Experimental Psychology: General*, *126*(3), 211.

Saltzman, E. L., & Munhall, K. G. (1989). A dynamical approach to gestural patterning in speech production. *Ecological psychology*, *1*(4), 333-382.

Sangeetha M. & Geetha M.P.(2017). Phonological encoding in children who stutter. AIISH research fund project in All India institute of speech and Hearing ,Mysore.

Sangeetha M.(2018). Phonological Encoding in Bilingual Adults with Stuttering. AIISH research fund project in All India institute of speech and Hearing ,Mysore.

Sasisekaran, J., & De Nil, L. F. (2006). Phoneme monitoring in silent naming and perception in adults who stutter. *Journal of Fluency Disorders, 31*(4), 284-302.

Sasisekaran, J., De Nil, L. F., Smyth, R., & Johnson, C. (2006). Phonological encoding in the silent speech of persons who stutter. *Journal of Fluency Disorders, 31*(1), 1-21.

Sasisekaran, J., Smith, A., Sadagopan, N., & Weber-Fox, C. (2010). Nonword repetition in children and adults: Effects on movement coordination. *Developmental Science*, *13*(3), 521-532.

Sasisekaran, J. (2013). Nonword repetition and nonword reading abilities in adults who do and do not stutter. *Journal of fluency disorders*, *38*(3), 275-289.

Sasisekaran, J., Brady, A., & Stein, J. (2013). A preliminary investigation of phonological encoding skills in children who stutter. *Journal of fluency disorders*, *38*(1), 45-58.

Sasisekaran, J., & Weisberg, S. (2014). Practice and retention of nonwords in adults who stutter. *Journal of fluency disorders*, *41*, 55-71.

Sasisekaran, J., & Weathers, E. J. (2019). Disfluencies and phonological revisions in a nonword repetition task in school-age children who stutter. *Journal of communication disorders*, *81*, 105917.

Sasisekaran, J., Basu, S., & Weathers, E. J. (2019). Movement kinematics and speech accuracy in a nonword repetition task in school-age children who stutter. *Journal of communication disorders*, *81*, 105916.

Sawyer, J., Chon, H., & Ambrose, N. G. (2008). Influences of rate, length, and complexity on speech disfluency in a single-speech sample in preschool children who stutter. *Journal of fluency disorders*, *33*(3), 220-240.

Seery, C. H., Watkins, R. V., Ambrose, N. & Throneburg, R. (2006, November). *Nonwords repetition by school age children who stutter.* Poster session presented at the ASHA Convention, Miami,

Silverman, S. W., & Ratner, N. B. (1997). Syntactic complexity, fluency, and accuracy of sentence imitation in adolescents. *Journal of Speech, Language, and Hearing Research*, *40*(1), 95-106.Florida.

Shattuck-Hufnagel, S. (1979). Speech errors as evidence for a serial ordering mechanism in sentence production. In W. Cooper & E. Walker (Eds.), *Sentence processing: Psycholinguistic studies presented to Merrill Garrett* Hillsdale, NJ: Lawrence Erlbaum Associates.

Shattuck-Hufnagel, S. (1992). The role of word structure in segmental serial ordering. *Cognition*, *42*(1-3), 213-259.

Shriberg, L. D., Lohmeier, H. L., Campbell, T. F., Dollaghan, C. A., Green, J. R., & Moore, C. A. (2009). A nonword repetition task for speakers with misarticulations: The Syllable Repetition Task (SRT). *Journal of Speech, Language, and Hearing Research*.

Smith, A., & Kelly, E. (1997). Stuttering: A dynamic, multifactorial model. *Nature and treatment of stuttering: New directions*, *2*, 204-217.

Smits-Bandstra, S., Luc, F., & Saint-Cyr, J. A. (2006). Speech and nonspeech sequence skill learning in adults who stutter. *Journal of fluency disorders*, *31*(2), 116-136.

Smith, A., Sadagopan, N., Walsh, B., & Weber-Fox, C. (2010). Increasing phonological complexity reveals heightened instability in inter-articulatory coordination in adults who stutter. *Journal of fluency disorders*, *35*(1), 1-18.

Smith, A., & Weber, C. (2017). How stuttering develops: The multifactorial dynamic pathways theory. *Journal of Speech, Language, and Hearing Research*, *60*(9), 2483-2505.

Somy(2008). Non word repetition skills in 5-6years old Kannada speaking children with and without stuttering.An unpublished dissertation submitted to university of Mysore; Mysore.

Starkweather, C. W., Franklin, S., & Smigo, T. M. (1984). Vocal and finger reaction times in stutterers and nonstutterers: Differences and correlations. *Journal of Speech, Language, and Hearing Research*, *27*(2), 193-196.

Starkweather, C.W. (1987). Fluency and stuttering. Englewood Cliffs, NJ: Prentice-Hall.

Starkweather, C.,and Gottwald, C. (1990). The demands and capacities model II: Clinical applications. Journal of Fluency Disorders 15, 143-157.

Sugathan, N., & Maruthy, S. (2020). Nonword repetition and identification skills in Kannada speaking school-aged children who do and do not stutter. *Journal of Fluency Disorders*, *63*, 105745.

Swapna.N.(2010). Word and Non word repetition test for children in Kannada. AIISH research fund project in All India institute of speech and Hearing ,Mysore.

Sweta Uttakalika, (2012).Phonological processing and speech motor control in bilingual adults with stuttering An unpublished dissertation submitted to university of Mysore; Mysore.

Van Lieshout, P.H., Peters, H.F., Starkweather, C.W., & Hulstijn, W. (1993). Physiological differences between stutterers and nonstutterers in perceptually fluent speech: EMG amplitude and duration. Journal of Speech and Hearing Research 36, 55–63.

Weber-Fox, C., Spencer, R. M. C., Spruill, J. E., III, & Smith, A. (2004). Phonologic processing in adults who stutter: Electrophysiological and behavioral evidence. *Journal of Speech-Language and Hearing Research, 47*(6), 1244-1258.

Weiss, A. L., & Zebrowski, P. M. (1992). Disfluencies in the conversations of young children who stutter: Some answers about questions. *Journal of Speech, Language, and Hearing Research*, *35*(6), 1230-1238.

Wijnen, F. & Boers, I. (1994). Phonological priming effects in stutterers. *Journal of Fluency Disorders, 19,* 1-20.

Wingate, M.E. (1988). The structure : A psycholinguistic study. New York: Yairi, E., & Lewis, B. (1984). Disfluencies at the onset of stuttering. *Journal of Speech, Language, and Hearing Research*, *27*(1), 154-159.

Wingate, M. E (1984b). Definition is the problem. *Journal of Speech and Hearing Disorders*. 49, 429-431.

Zelaznik, H. N., Smith, A., Franz, E. A., & Ho, M. (1997). Differences in bimanual coordination associated with stuttering. *Acta Psychologica*, *96*(3), 229-243.